

1 International, multi-disciplinary, cross-section study of pain knowledge and  
2 attitudes in nursing, midwifery and allied health professions students

3  
4 Jagjit Mankelow<sup>a, m</sup>

5 Cormac G. Ryan<sup>a</sup>

6 Paul C. Taylor<sup>a</sup>

7 Maire-Brid Casey<sup>b</sup>

8 Jenni Naisby<sup>c</sup>

9 Kate Thompson<sup>d</sup>

10 Joseph G. McVeigh<sup>e</sup>

11 Chris Seenan<sup>f</sup>

12 Kay Cooper<sup>g</sup>

13 Paul Hendrick<sup>h</sup>

14 Donna Brown<sup>i</sup>

15 William Gibson<sup>j</sup>

16 Mervyn Travers<sup>j,k</sup>

17 Norelee Kennedy<sup>l</sup>

18 Cliona O’Riordan<sup>l</sup>

19 Denis Martin<sup>a</sup>

20  
21 a. Teesside University, England

22 b. University College Dublin, Ireland

23 c. Northumbria University, England

24 d. Leeds Beckett University, England

25 e. University College Cork, Ireland

26 f. Glasgow Caledonian University, Scotland

27 g. Robert Gordon University, Scotland

28 h. University of Nottingham, England

29 i. University of Ulster, Northern Ireland

30 j. The University of Notre Dame Australia, Western Australia

31 k. Curtin University, Western Australia

32 l. University of Limerick, Ireland

33 m. Corresponding author

34  
35 **Abstract**

36  
37 **Background:** Persistent pain is a highly prevalent, global cause of disability.  
38 Research suggests that many healthcare professionals are not well equipped  
39 to manage pain, and this may be attributable at least in part to undergraduate  
40 education. The primary aim of this study was to quantify and compare first  
41 and final year nursing, midwifery and allied health professional (NMAHP)  
42 students’ pain related knowledge and attitudes.. The secondary aim was to  
43 explore what factors influence students’ pain related knowledge and attitudes.

44 **Methods:** In this cross-sectional study, 1154 first and final year healthcare  
45 students, from 12 universities in five different countries completed the Revised

46 Neurophysiology of Pain Quiz (RNPQ) [knowledge] and the Health Care  
47 Providers Pain and Impairment Relationship Scale (HC-PAIRS) [attitudes] .

48 **Results:** Physiotherapy was the only student group with statistically and  
49 clinically improved pain related knowledge [mean difference, 95% CI] (3.4, 3.0  
50 to 3.9, p=0.01) and attitudes (-17.2, -19.2 to 15.2, p=0.01) between first and  
51 final year. Pain education teaching varied considerably from course to course  
52 (0 to 40 hours), with greater levels of pain related knowledge and attitudes  
53 associated with higher volumes of pain specific teaching.

54 **Conclusions:** There was little difference in pain knowledge and attitudes  
55 between all first and final year NMAHP students other than physiotherapy.  
56 This suggests that for most NMAHP disciplines, undergraduate teaching has  
57 little or no impact on students' understanding of pain. There is an urgent need  
58 to enhance pain education provision at the undergraduate level in NMAHPs.

59 The study protocol was prospectively registered at ClinicalTrials.Gov  
60 (NCT03522857), <https://clinicaltrials.gov/ct2/show/NCT03522857>.

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## 64 **BACKGROUND**

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66 Pain is amongst the most common reason patients engage with health care<sup>1,2,3</sup>. Pain, the  
67 unpleasant sensory and emotional experience associated with actual or potential tissue  
68 damage, can be classified by duration of symptoms as acute, sub-acute or chronic pain<sup>4,5</sup>.  
69 High rates of pain are present globally. For example, chronic pain affects 28 million people in  
70 the UK alone<sup>6</sup> and is often associated with significant disability<sup>7</sup>. Similarly, over three million  
71 Australians identify as living with chronic pain. The economic burden amounts to AUD 73.2  
72 billion each year including AUD 48.3 billion in lost productivity<sup>8</sup>. But the issue cannot be  
73 adequately captured by dollars lost. Chronic pain negatively affects quality of life affecting  
74 physical, mental, and social health<sup>9</sup>. The Prevalence Impact and Cost of Chronic Pain  
75 (PRIME) study conducted in Ireland reported a chronic pain prevalence rate of 35.5%. Over  
76 37% of those with pain reported moderate to severe pain-related disability<sup>10</sup>.

77

78 Multiple disciplines are involved in the management of pain, therefore it is vital that all health  
79 care professionals (HPC) in every health care discipline are well equipped to manage this  
80 problem and have a good knowledge of pain and positive attitudes towards function in those  
81 with pain. Furthermore, it is imperative that this management is evidence-based and  
82 guideline-compliant to ensure consistent high-quality care which is individualised<sup>11,12</sup>.

83

84 Existing research suggests that many HCPs across the disciplines are not well equipped to  
85 manage pain. Non-evidence based and inconsistent patterns of pain management occur

86 frequently in various health care settings which results in the high use of resources<sup>13-16</sup>.  
87 Clinicians often do not feel confident or able to treat patients with persistent pain<sup>17-19</sup>.  
88 Furthermore, there is evidence to suggest that HCPs' attitudes about the functional ability of  
89 people in pain influences their management recommendations, and this in turn influences  
90 patients' attitudes about pain and their health outcomes<sup>20-24</sup>. Patients often have a biomedical  
91 understanding of their pain and link it to structural damage. These attitudes seem to be  
92 influenced by their HCPs' pain knowledge and attitudes which are often also biomedical.<sup>25,26</sup>  
93 It is important that HCPs' pain attitudes and knowledge are evidence-based<sup>12</sup>. However, it is  
94 widely recognised that this is not always the case. It has been suggested that a part of this  
95 problem may be the absence of adequate pain education in pre-registration training<sup>27-29</sup>.  
96 Knowledge is accepted as a component of attitudes, which are key indicators of behaviour<sup>30</sup>.  
97 It has been proposed that improved understanding of pain amongst clinicians would improve  
98 the delivery of evidence-based care, leading to better patient outcomes<sup>31</sup>.

100 The inadequacy of pain education in health care curricula has been observed throughout  
101 Europe, New Zealand and Australia, the USA and Canada<sup>32-34</sup>. The first step towards  
102 addressing the deficiency in pain education among HCPs would be to assess current pain  
103 understanding amongst HCP students. A number of studies have explored this issue, however,  
104 these studies are generally limited to single institutions, discrete regions or only a small  
105 number of health care disciplines, reducing the generalisability of the findings<sup>35-39</sup>. If some  
106 disciplines were found to have poorer pain-related understanding than others, this difference  
107 could be explored, and pain education resources could be targeted accordingly.

109 The primary aim of this study was to quantify and compare nursing, midwifery and allied  
110 health professional (NMAHP) students' knowledge and attitudes about pain management in  
111 the first and the final year of their studies across a range of disciplines in multiple institutions  
112 and countries. The secondary aim was to explore some of the factors that may influence  
113 students' pain related knowledge and attitudes towards the functional ability of people with  
114 pain.

## 116 **Method**

### 118 *Design*

120 In this observational, cross-sectional study the attitudes and knowledge of first and final year  
121 NMAHP students were collected using two questionnaires to establish the change during  
122 undergraduate health care degree courses. The attitudes and knowledge of students were  
123 compared. The questionnaires were administered in the first semester for first years and as  
124 close as possible to the completion of the degree course in the case of final year students.  
125 Data on participants' age, gender, and year of study and course of study were collected.

### 127 **Ethics**

129 Ethical approval for this study was initially granted by Teesside University's (TU) School of  
130 Health and Social Care Research Ethics and Governance Committee local ethics project  
131 number 114/17. Each of the other eleven collaborating Universities obtained permission from  
132 their respective University's research ethics and governance committee. The study protocol  
133 was prospectively registered at ClinicalTrials.Gov NCT03522857,  
134 <https://clinicaltrials.gov/ct2/show/NCT03522857>.

### 136 **Participants and recruitment**

138 First year and final year BSc and MSc pre-registration students were recruited between the  
139 period of October 2017 to September 2019, from 12 universities and six disciplines across  
140 Australia, England, Northern Ireland, the Republic of Ireland and Scotland. NMAHP

141 disciplines were selected based on those frequently involved in pain management, and  
142 included physiotherapy, occupational therapy, paramedics, diagnostic radiography,  
143 midwifery, and nursing. To meet the inclusion criteria for participation, individual students  
144 needed to be in the first or final year of their studies within one of the aforementioned  
145 disciplines.

146  
147 Collaborating universities were invited to take part through informal networks, via on-site  
148 academics acting as local pain education “champions”. Pain champions disseminated the  
149 recruitment invitation to local programme leaders for delivery to students and either  
150 disseminated and collected surveys physically or directed students to the online survey. A  
151 reminder email was sent two weeks later. Additionally, where possible, the local champions  
152 delivered short presentations to student groups to raise awareness of the study. Paper  
153 questionnaires were made available at these presentations and a confidential drop box at a  
154 different location from the distribution site was provided for questionnaire collection. The site  
155 of questionnaire distribution and collection were kept separate in order to ensure that students  
156 did not feel obliged to participate in the study. Participants were asked to complete the survey  
157 only once when they received a reminder email. The participant information sheet explained  
158 to prospective participants that consent was implied by completion of the survey.

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160 Participating universities were invited to provide information about the extent and format of  
161 pain education within the disciplines surveyed. Where possible respondents were asked to  
162 quantify the time spent teaching pain education specifically and whether this involved one-off  
163 lectures or complete modules with credit values. This data was then compiled and categorised  
164 according to hours of pain education delivery. It was agreed that the public would be blind to  
165 students University of study, so that institutional variation is quantifiable but specific  
166 institutions could not be directly compared.

## 167 **Outcome measures**

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169 The survey contained two questionnaires: 1) the 12-item Revised Neurophysiology  
170 Questionnaire RNPQ<sup>40</sup> to measure pain knowledge, and 2) the 13-item Health Care Providers  
171 Pain and Impairment Relationship Scale HC-PAIRS<sup>41</sup> to measure attitudes towards chronic  
172 pain. These questionnaires together were estimated to take less than 10 minutes to complete.  
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### 175 *The Revised Neurophysiology of Pain Questionnaire RNPQ*

176  
177 This 12-item questionnaire was used to assess knowledge of pain neurophysiology.  
178 Responses are marked ‘yes’, ‘no’ or ‘undecided’ the latter being important to prevent  
179 respondents from guessing the answer. Scores range from 0-12 with high scores indicating a  
180 good knowledge of pain neurophysiology. The RNPQ was developed from the original 19-  
181 item Neurophysiology of Pain Test<sup>42</sup>. It was found to have reasonable internal consistency  
182 person separation index =0.84 and good test-retest reliability with an intra-class correlation  
183 coefficient value of ICC =0.97. The RNPQ has now been used consistently in patient, student,  
184 clinician and clinical administration staff studies since its inception<sup>43-47</sup>. Furthermore, it is a  
185 discipline generic rather than a discipline specific questionnaire, therefore fit for a multi-  
186 disciplinary group. There is no established minimally clinically important difference MCID  
187 for the RNPQ. However, this can be tentatively estimated as half the baseline SD presented in  
188 previous studies<sup>48-51</sup>. Based upon data from Catley *et al.* (2013)<sup>40</sup> the MCID for RNPQ  
189 knowledge was set at 0.9 points or 7.3%.

### 190 191 *The 13-item modified Health Care Providers Pain and Impairment Relationship Scale HC- 192 PAIRS*

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194 The modified HC-PAIRS<sup>41</sup> measures HCPs’ attitudes towards patients with chronic pain and  
195 their functional ability. It features a 7-point Likert scale in 13-items with scores ranging from

13 to 91, the lower score indicates a more positive attitude towards pain. Psychometric properties of the HC-PAIRS are well established. Excellent internal consistency has been demonstrated Cronbach's  $\alpha=0.92^{52}$  as well as good test-retest reliability [ICC=0.84] 95% confidence interval 0.78-0.89. Latimer, Maher and Refshauge (2004)<sup>53</sup> also observed its adequate responsiveness to change. Overall, the psychometric properties of the HC-PAIRS are superior to other tools and hence it is consistently widely used<sup>52, 54-56</sup>. A previous study about student HCPs estimated an MCID of 4.5 for the HC-PAIRS<sup>57</sup>. However, Dworkin *et al.* (2008)<sup>51</sup> advise that MCIDs should be population specific, thus, for this study, the MCID was set at 4.2 points 4.6% based upon half the baseline values for HC-PAIRS data from student HCPs (Colleary *et al.* 2017)<sup>43</sup>. Originally designed to question attitudes about chronic low back pain Houben *et al.* (2004)<sup>41</sup> suggest that it is a good measure of chronic pain generically.

## Data analysis

Missing data for the HC-PAIRS was managed as follows: data sets were retained if they were full sets or had only one answer missing<sup>41,57</sup>. Those with more than one unanswered question were discarded from the data set. Missing answers were replaced with a neutral response, 4<sup>57</sup>. There are no recommendations within the literature regarding how missing data from the RNPQ should be handled. Thus, for consistency, a similar approach to that of the HC-PAIRS was taken in that a single missing answer in a questionnaire was replaced with a '0' value indicating an incorrect answer. Questionnaires with more than once missing answer were discarded.

Data were analysed using SPSS version 26.0. The data were found to have a normal distribution after a visual inspection of histograms and Q-Q plots, and statistical analysis via the Shapiro-Wilk test. Descriptive statistics are presented as the mean and 1SD. Data were analysed using two-way ANOVA with year of study first or final, and discipline of degree Physiotherapy; Occupational therapy; Nursing; Midwifery; Paramedic; Radiographer as independent variables for the HC-PAIRS and RNPQ separately. The interaction effects of the two independent variables year of study\*discipline of degree were also investigated. In addition, a series of post-hoc independent samples t-tests were undertaken to identify where differences lay between individual disciplines and the first and final year of study in each discipline. Correlation analyses were also undertaken as part of a secondary analysis to explore the association between hours of pain education teaching, and knowledge and/or attitude scores, adjusting for age, gender, year of study and discipline. A p-value of <0.05 was considered statistically significant.

## Results

### Response rate

There were 1156 respondents from the 12 universities out of 4067 invitations to participate, representing a 28% response rate. Eight incomplete paper questionnaires were removed for HC-PAIRS six sets and RNPQ two sets as they were almost entirely incomplete. In addition, 162 RPNQ questionnaire data sets were removed as an incorrect version of the questionnaire was accidentally circulated due to human error. This left 1154 respondents who completed and returned surveys adequately, and whose data were analysed. Fifteen of these respondents had left one question unanswered in one of their surveys, nine in the HC-PAIRS questionnaire and eight in RNPQ.

Participants had a mean (SD) age of 26 (8) years, were predominantly female 82% and studying at BSc level 83%. A breakdown of surveys returned can be seen in Table 1, by University and by discipline. Nursing students were categorised together irrespective of speciality as not all respondents disclosed their area of speciality. Some universities returned more surveys than others, and some disciplines had a higher response rate than others, with

251 physiotherapists and nursing students returning the largest numbers of surveys. The overall  
 252 response rate was lower amongst final year students except in nursing which was heavily  
 253 dominated by a strong return at one University.

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**Table 1. Number of respondents per University and breakdown of number of respondents in first and final year by discipline**

University Code	Number of responses	Disciplines Surveyed	First year respondents	Final year respondents
1	11	Occupational therapists	43	34
2	134			
3	8	Physiotherapists	266	104
4	514			
5	12	Paramedics	68	9
6	126			
7	51	Midwives	32	11
8	47			
9	11	Nurses	235	312
10	120			
11	97	Diagnostic radiographers	31	9
12	23			
<b>Total</b>	<b>1154</b>	<b>Total</b>	<b>675</b>	<b>479</b>

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#### HC-PAIRS

The two-way ANOVA for HC-PAIRS found a significant independent effect of both year of study  $p=0.001$  and discipline  $p=0.001$ . Table 2 lists the mean HC-PAIRS attitude scores for individual professions. First year mean values ranged from 54.4 to 60.0 lower values indicating more positive attitudes. In final year they ranged from 37.5 to 56.1. Between first and final year the greatest improvement in attitudes to pain was shown by physiotherapy students, with a mean difference 95% confidence interval [CI] of -17.2 [-19.2 to -15.2] points. All of the other professions showed clinically insignificant, less than or equal to the MCID, and statistically insignificant changes from first to final year. This is with the exception of nursing which showed a clinically insignificant but statistically significant improvement -2.2 [3.6 to -0.7]  $p=0.03$ . A two-way ANOVA revealed that there was a statistically significant interaction ( $p<0.01$ ) between the effects of the two independent variables year of study\*discipline of degree.

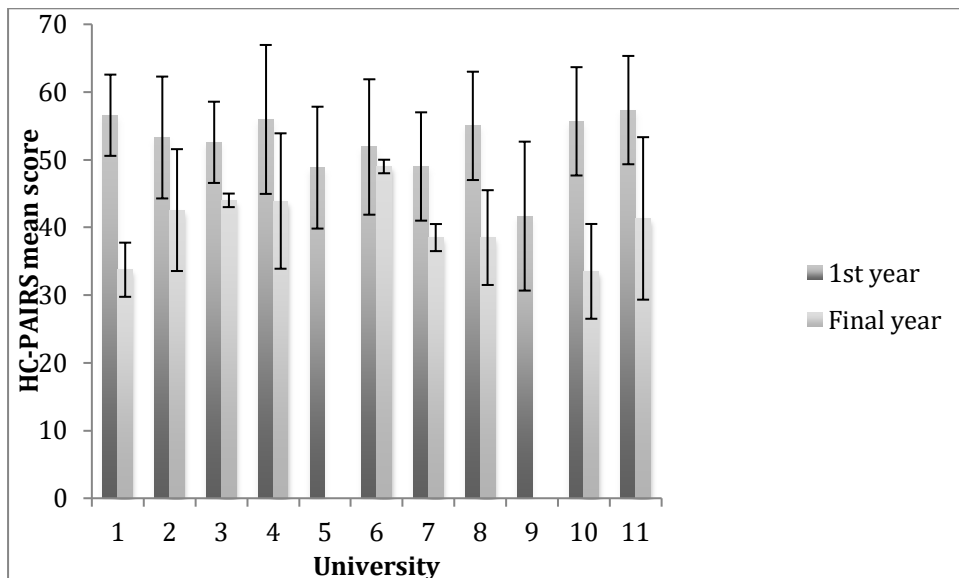
**Table 2 HC-PAIRS, pain attitude scores for first and final year by profession**

Profession n=total number	1 <sup>st</sup> Year Mean (SD)	Final Year Mean (SD)	Mean Difference	95% CI	P-value
<b>OT n=77</b>	56.4 (8.6)	52.8 (7.3)	-3.7	-7.4 to 0.1	0.51
<b>Physiotherapy n=370</b>	54.7 (8.8)	37.5 (9.1)	-17.2	-19.2 to -15.2	0.01*

<b>Paramedics n=77</b>	55.7 (8.2)	52.1 (8.3)	-3.6	-9.4 to 2.3	0.23
<b>Midwifery n=43</b>	60.0 (9.6)	56.1 (8.6)	-3.9	-10.5 to 2.7	0.24
<b>Nursing n=547</b>	57.1 (8.0)	55.0 (8.5)	-2.2	-3.6 to -0.7	0.03*
<b>Diagnostic Radiography n=40</b>	54.4 (9.0)	51.6 (8.9)	-2.9	-9.7 to 4.1	0.40

278 **Legend:** SD, standard deviation; CI, confidence interval; HC-PAIRS, Health Care Providers  
279 Pain and Impairment Relationship Scale. P-values were calculated using independent t-tests.  
280 \* Indicates statistical significance at  $p < 0.05$ .

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282 As physiotherapy was the only discipline that showed a clinically and statistically significant  
283 change from first to final year, secondary analysis was carried out within that discipline to  
284 explore if all universities performed equally well as shown in Figure 1. Seven of the eight  
285 universities, which had first and final year respondents, showed a difference between the year  
286 groups, exceeding the MCID of -4.2, ranging from -8 to -23 units. University 6 had a mean  
287 change of less than -4.2. This may have been an artefact of the very small number of  
288 respondents from this sub-group. There were only 17 first year respondents and only two final  
289 year respondents thus it was not representative of the final year. Two universities, codes 5 and  
290 9, had only first year participants and not final years; one University did not have any  
291 physiotherapy respondents code 12.



293  
294 **Figure 1** First and final year mean SD HC-PAIRS scores for physiotherapy cohorts in  
295 Universities 1-11 12 did not include any physiotherapists

296  
297 **RNPQ**

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299 Two-way ANOVA for RNPQ found a significant independent effect of year of study  $p = 0.044$   
300 and discipline  $p = 0.025$ . Table 3 lists the mean RNPQ knowledge scores for individual

301 professions with higher scores indicating better knowledge of pain neurophysiology. The  
 302 minimum mean (SD) score in the first year was 5.7 (2.0) and the maximum was 7.3 (1.8).  
 303 Final year scores ranged from a minimum of 5.7 (2.1) and maximum 9.1 (2.0). The biggest  
 304 improvement in pain knowledge between first and final year is shown by physiotherapy  
 305 students with a change of 3 points, a difference which was statistically significant  $p=0.01$ . All  
 306 the other professions showed clinically small less than or equal to the MCID and statistically  
 307 insignificant differences from first to final year. A two-way ANOVA revealed that there was  
 308 a statistically significant interaction ( $p<0.01$ ) between the effects of the two independent  
 309 variables year of study\*discipline of degree.

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*Table 3 RNPQ pain knowledge scores for first and final year by profession*

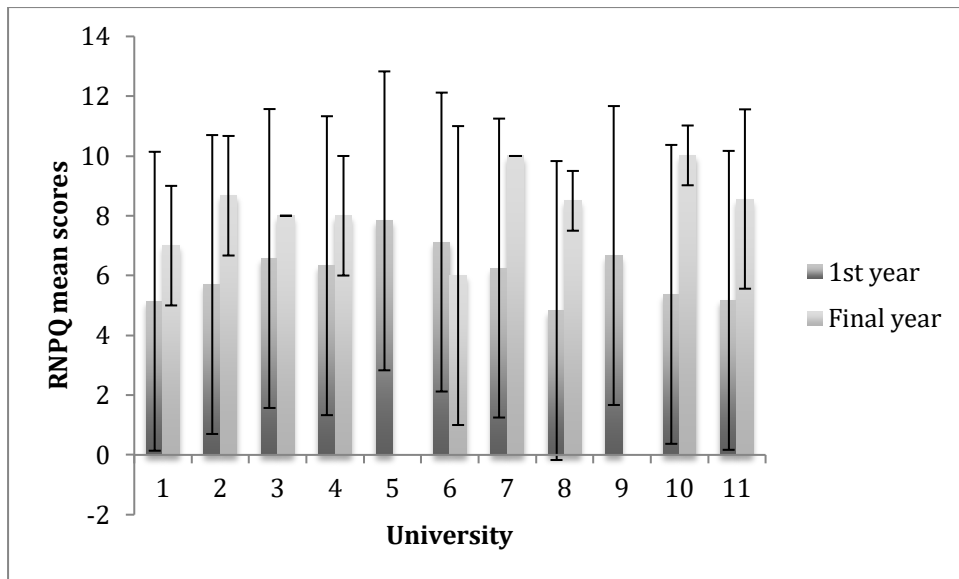
Profession Total numbers, n=	1 <sup>st</sup> Year Mean (SD)	Final Year Mean (SD)	Mean Difference	95% CI	P-value
Occupational Therapy n=77	5.9 (1.8)	6.4 (1.6)	0.5	0.3 to 1.3	0.26
Physiotherapy n=370	5.7 (2.0)	9.1 (2.0)	3.4	3.0 to 3.9	0.01*
Paramedics n=77	6.1 (1.5)	5.7 (2.1)	-0.4	-0.9 to 1.8	0.48
Midwifery n=43	6.1 (2.0)	7.00 (1.4)	0.9	0.6 to 2.3	0.24
Nursing n=547	5.9 (2.0)	6.2 (2.0)	0.3	0.1 to 0.7	0.06
Diagnostic Radiography n=40	7.3 (1.8)	6.0 (2.1)	-1.3	-0.4 to 3.0	0.13

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**Legend:** RNPQ, revised Neurophysiology Questionnaire; SD, standard deviation; CI, confidence interval; P-values were calculated using independent t-tests. \* Indicates statistical significance at  $p<0.05$ .

Once again, as they were the only discipline to have demonstrated a statistical and clinical difference between first and final year cohorts, secondary analysis of the physiotherapy data were carried out to explore if some universities made greater gains than others. The minimum mean difference was 1.1 95%CI [2.9 to 5.2] and the maximum mean difference was 4.7 [4.0 to 5.3] see Figure 2. Thus, the size of pain knowledge improvement was not consistently high in all physiotherapy cohorts at all of the universities sampled, but always exceeded the MCID of 0.9 points.





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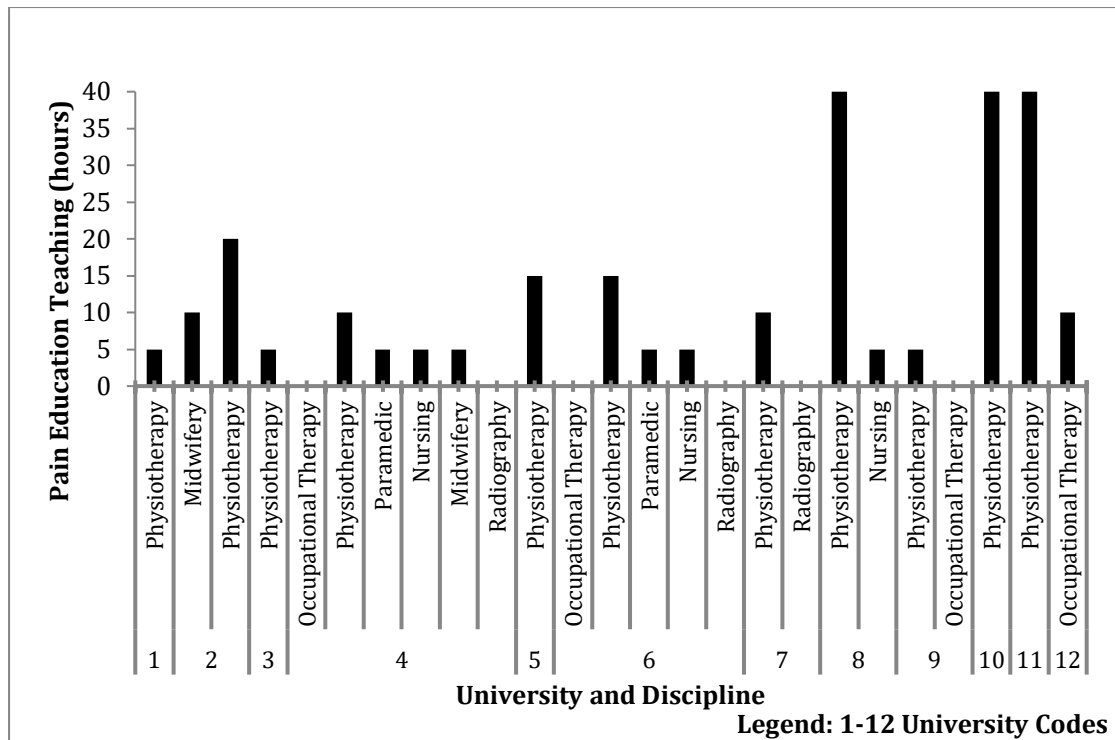
*Figure 2 First and final year mean RNPQ scores for physiotherapy cohorts in Universities 1-11 12 did not include any physiotherapists*

**Secondary analysis**

Multiple linear regression analyses were completed to explore the association between hours of pain education in all of the disciplines studied, and knowledge and attitude scores respectively, adjusting for age, gender, year of study and discipline.

For both dependent variables, pain knowledge and pain attitudes, hours of pain education teaching was found to be an independent predictor though the strength of the relationship was small (RNPQ  $\beta$  value=0.11,  $p=0.01$  and HC-PAIRS  $\beta$  value =0.15,  $p=0.001$ ).

The amount of focused pain teaching at the time of data collection varied considerably between universities and disciplines. Figure 3 reflects this difference with physiotherapy departments generally delivering the greatest amounts of pain education teaching.



344 **Figure 3** Approximate hours of pain education teaching in each discipline and University

347 **Discussion**

348  
 349 There has been recent suggestion that there is a need to shift understanding about pain on a  
 350 societal level in order to optimise and contemporise care<sup>58</sup>. HCPs will be a key sector of  
 351 society to focus upon as they will influence the pain understanding of others. Furthermore,  
 352 targeting HCP students, whose understanding may be more malleable, may be the optimal  
 353 point at which to target HCPs. An important step in this process is to survey pain attitudes and  
 354 knowledge amongst future health care workers to quantify current levels of understanding and  
 355 identify if training could be enhanced. Accordingly, this study compared the pain knowledge  
 356 and attitudes in first and final year students, across six disciplines, at 12 institutions, in five  
 357 countries. To date, this is the largest, international cross-sectional study to quantify the  
 358 knowledge and attitudes about pain amongst NMAHP students. There were differences in  
 359 pain knowledge and attitudes between year of study and between disciplines. There was also  
 360 a year of study\*discipline interaction effect. Of the six disciplines, physiotherapy had the  
 361 greatest mean differences between the first and final year for both the RNPQ and the HC-  
 362 PAIRS which were clinically and statistically significant. In contrast there was little  
 363 difference between first and final year values for both knowledge and attitudes scores in the  
 364 other disciplines.

365  
 366 The nursing cohorts showed the least improvement in attitudes with a mean difference of -2.2,  
 367 well below the MCID of 4.2 of all disciplines, yet statistical testing showed the difference to  
 368 be significant  $p=0.03$ . It is likely that this was due to the larger sample size for the nursing  
 369 group and thus greater statistical power. However, the magnitude of the difference is well  
 370 below the MCID and thus likely to be clinically unimportant.

371  
 372 Direct comparison with existing literature is difficult as a large portion of the literature uses  
 373 different outcome measures, and studies using similar outcome measures include  
 374 physiotherapy students only. The improvement in attitudes for physiotherapy students over  
 375 the duration of a degree programme, as measured by the HC-PAIRS, in this study are greater  
 376 than previously reported<sup>36, 60, 61</sup>, but scores were not quite as high as the changes measured in  
 377 RCTs following targeted, brief pain science education interventions directly addressing

378 knowledge and attitudes in physiotherapists<sup>43</sup> and NMAHPs<sup>47</sup>. This suggests there is scope  
379 for greater changes on the observed degree programmes in this study.

380

381 Whilst Carroll *et al.*, (2020)<sup>39</sup> found greater improvement amongst their nursing cohorts'  
382 attitudes (1.6% - 7% amongst different nursing specialities) than in this study, 2.4%, our  
383 findings accord with Amponsah *et al.* (2020)<sup>62</sup> and Leahy *et al.* (2019)<sup>63</sup> that final year nurses  
384 have considerable deficits in pain knowledge and attitudes. Mukoka, Olivier and Ravat  
385 (2019)<sup>62</sup> found more positive attitudes in their nursing and occupational therapy students but  
386 not as positive among their physiotherapy students. Overall the findings from this study  
387 generally concur with the existing body of literature that suggests there is a deficiency in pain  
388 knowledge and attitudes towards pain in final year HCP students. Many previous studies  
389 noted an improvement in HCP students' knowledge and attitudes from first to final year<sup>38, 62,</sup>  
390 <sup>65</sup>, and while we found this among physiotherapy students, it was not the case overall.  
391 Worryingly, Ryan *et al.*, (2010)<sup>61</sup> noted that non-health care students demonstrated a 3.9 point  
392 3.7% mean difference in HC-PAIRS 15-point questionnaire from first to final year. This is  
393 similar if not better than the difference seen for the health care students in the current study,  
394 apart from physiotherapy students. The comparatively poor difference in pain attitudes  
395 demonstrated for most disciplines other than physiotherapy in this study may be attributable  
396 in part to a biomedical model-based curricula impeding the natural small biopsychosocial  
397 shift with time seen in the non-health care programme sample studied by Ryan *et al.* (2010)<sup>61</sup>.

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399 There were larger volumes of pain specific teaching on the physiotherapy courses relative to  
400 the other NMAHP disciplines in the current study (Figure 3). This is perhaps unsurprising as  
401 physiotherapists may be perceived to play a larger role in pain management than some of the  
402 other disciplines. The larger differences between first and final year in physiotherapy are  
403 likely in part due to the higher volumes of pain specific teaching. Within our data, there was a  
404 moderate/high correlation between difference in attitudes and knowledge and higher volumes  
405 of pain teaching  $r=0.5$ ,  $p=0.16$  and  $r=0.7$ ,  $p=0.03$  respectively. This provides a rationale for  
406 larger volumes of pain teaching within NMAHP curricula.

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408 An additional factor influencing student pain knowledge and attitudes that has not been  
409 explored in this study is the effect of clinical placements. This aspect of health care education  
410 warrants further investigation as it may positively or negatively<sup>66</sup> influence pain management  
411 behaviours.

412

413 Thompson *et al.* (2018)<sup>27</sup> propose an array of reasons that inhibit the implementation of  
414 effective pain education into pre-registration health care programs. These authors suggest that  
415 all health care disciplines have different curricula pressures placed upon them by internal and  
416 external bodies, and pain education may not yet be recognised as a priority topic for these  
417 health care disciplines. Furthermore, professional opportunities to manage pain are not always  
418 the focus of some disciplines and some disciplines may play a larger role in the care pathway  
419 than others and thus arguably may need higher levels of knowledge and attitudes relative to  
420 other disciplines. However, each discipline involved in this study may encounter people with  
421 pain directly and as such it is important that they all have appropriate knowledge and attitudes  
422 to provide patients with clear and consistent high quality basic pain management advice For  
423 example, in diagnostic radiography patient interaction may be limited, nevertheless, even if  
424 interactions are brief, correct communication is critical<sup>67,68</sup>. Kyei *et al.* (2014)<sup>69</sup> observe the  
425 need for good radiographer communication skills because there is only a short time frame  
426 available to establish a relationship with patients. Furthermore, the reports that an extended  
427 scope radiographer may be required to complete are often shown to patients and it is  
428 important that these report any anomalies within the context of age-related changes and the  
429 possibility that an individual's pain may not always be linked to the findings<sup>70-73</sup>. Ultimately,  
430 failures from a key team member in a pain management multi-disciplinary team can affect the  
431 pain management efforts of the whole team and thus patient outcome.

432

433 **Limitations**

434

435 The observational, cross-sectional nature of this study means that no claim of cause and effect  
436 can be made. Measuring students in the first and final year meant it was impossible to identify  
437 at what points in training pain knowledge and attitudes changed, and thus understand what  
438 aspects of training may influence change. Future studies should employ a longitudinal design,  
439 measuring students yearly to identify potential triggers for improving knowledge and attitudes  
440 towards pain, taking into account student placements and their impact. In addition, a  
441 longitudinal study would help to establish if the cross-sectional differences seen in this study  
442 are comparable to changes in the same cohort of students followed over the course of their  
443 degree. There is a need for pain management behaviours resulting from education to be  
444 investigated specifically, though changes in knowledge and attitudes can be predictors of  
445 behaviour Ajzen, (2020)<sup>30</sup>.

446

447 Some universities and disciplines returned more responses than others, thus there may be a  
448 response bias in this snapshot of pain knowledge and attitudes in students.

449

450 There was not an *a priori* sample size calculation. Instead, the researchers attempted to recruit  
451 as many participants as possible from the institutions involved. As such it is possible that the  
452 study is underpowered for some disciplines and may explain the lack of statistical differences  
453 between first and final year students for some disciplines. However, the magnitude of the  
454 differences between first and final year, would be less likely to be influenced by sample size  
455 and those differences were small and well below the MCID for all except the physiotherapy  
456 group.

457

458 In a small minority of cases the number of participants in sub-groups were very small. In such  
459 cases the sub-analysis was exploratory and should be interpreted with caution.

460

461 The differing sample sizes may have been due, in part, to final year students being on clinical  
462 placements at different times, and thus being less receptive to email invitations to participate  
463 in this study. Other factors may have been survey fatigue; the National Students Survey NSS  
464 was underway in the England, Scotland and Northern Ireland at a similar time to data  
465 collection, as well as individual module feedback surveys at many universities. Despite this,  
466 every attempt was made to access final year students at the end of their degree programme,  
467 including extending the study for a further year of data collection.

468

469

470 Participant self-selection may have influenced sample size. The pain champion at each of the  
471 universities may not have equally reflected all disciplines. The majority of pain champions  
472 were physiotherapists. This may have accounted for the larger numbers of physiotherapists  
473 relative to other disciplines for example only two universities represented paramedic training  
474 whilst 11 universities represented physiotherapy. Arguably medical doctors, such as general  
475 practitioners GPs and anaesthesiologists, will have more involvement in pain management  
476 than some NMAHPs and it would be illuminating to include this health care discipline in  
477 future studies of student knowledge and/or attitudes.

478

479 In one quarter of the physiotherapy courses investigated there was up to 40 hours of pain  
480 education teaching and this is reflected in the difference in knowledge and attitudes in first  
481 and final year physiotherapy students. This volume of teaching may not be reflective of all  
482 physiotherapy courses, and may inflate the overall variance between disciplines. Furthermore,  
483 the time spent teaching pain education is of interest, but the content of that education is also  
484 important (Mankelow *et al.* 2021). This study did not investigate the content of pain  
485 education being delivered and future studies should investigate the impact of educational  
486 content on pain related knowledge and attitudes.

486

487 **Conclusions**

488

489 To date, this is the largest investigation of HCP student pain related knowledge and attitudes  
490 amongst NMAHPs, including 12 universities and six disciplines in five countries. Only  
491 physiotherapy students showed statistically and clinically significant improvements in pain  
492 related attitudes and knowledge from first to final year. The differences were correlated with  
493 the volume of pain teaching received. Given that clinicians with more positive attitudes  
494 towards pain are more likely to make evidence-based recommendations, in turn improving  
495 patient outcomes, this study highlights the need to improve NMAHP pain education.

496

497

#### 498 **Declarations**

499

#### 500 **Author Contribution**

501 JM, PT, CR and DM conceived the idea. All authors collected data and JM, CR and DM  
502 analysed the data under supervision of. JM, PT, CR and DM drafted the paper. All authors  
503 contributed to the interpretation of results and in making an important intellectual  
504 contribution to the manuscript. All authors read and approved the final manuscript.

505

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508 used for dissemination of this study.

509

#### 510 **Competing interests Statement**

511 There are no competing interests for any contributing authors.

512

#### 513 **Availability of Data and Materials Statement**

514

515 The datasets used and/or analysed during the current study are available from the  
516 corresponding author on reasonable request.

517

#### 518 **Ethics approval and consent to participate**

519

520 Ethical approval for this study was granted by Teesside University's TU School of Health and  
521 Social Care Research Ethics and Governance Committee local ethics project number 114/17.  
522 Each of the other eleven collaborating universities obtained permission from their respective  
523 University's research ethics and governance committee. Informed consent was obtained from  
524 all subjects. All methods were carried out in accordance with relevant guidelines and  
525 regulations.

526

#### 527 **Consent for publication**

528

529 Not applicable.

530

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532

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534 collection.

535

#### 536 **Abbreviations**

537

538 ANOVA – Analysis of variance

539 AUD – Australian Dollar

540 BSc – Bachelor of Science

541 CI – Confidence Interval

542 GBD – Global Burden of Disability

543 GP – general practitioner  
544 HCP – Health Care Professionals  
545 HC-PAIRS – Health Care Providers Pain and Impairment Relationship Scale  
546 IASP – International Association for the Study of Pain  
547 MCID – Minimally clinically important difference  
548 N - number  
549 NMAHP – Nursing, Midwifery and Allied Health Professionals  
550 NSS – National Student Survey  
551 PRIME – Prevalence Impact and Cost of Chronic Pain  
552 RNPQ – Revised Neuro Physiology Questionnaire  
553 SD – Standard deviation  
554 SPSS – Statistical Package for the Social Sciences  
555 TU – Teesside University  
556 UK – United Kingdom

557

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## 562 **References**

563

564 1. Mäntyselkä P, Kumpusalo E, Ahonen R, Kumpusalo A, Kauhanen J, Viinamäki H, et al.  
565 Pain as a reason to visit the doctor: a study in Finnish primary health care. *Pain*. 2001; doi:  
566 10.1016/s0304-39590000361-4.

567

568 2. Finley CR, Chan DS, Garrison S, Korownyk C, Kolber MR, Campbell S, et al. What are  
569 the most common conditions in primary care? Systematic review. *Canadian Family*  
570 *Physician*. 2018;64(11):832–840.

571

572 3. Lim YZ, Chou L, Au RTM, Seneviwickrama KLMD, Cicuttini FM, Briggs AM. People  
573 with low back pain want clear, consistent and personalised information on prognosis,  
574 treatment options and self-management strategies: a systematic review. *Journal of*  
575 *Physiotherapy*. 2019; 65(3):124–135.

576

577 4. IASP Subcommittee on Taxonomy. Pain terms: a list with definitions and notes on usage.  
578 Recommended by the IASP Subcommittee on Taxonomy. *Pain*. 1979;6:249–52.

579

580 5. Jess M-A, Hamilton S, Ryan C, Wellburn S, Alexanders J, Spence D, Martin D. Exploring  
581 the origin of pain subclassification, with emphasis on low back pain: a systematic scoping  
582 review. *JBIS Database of Systematic Reviews and Implementation Reports*. 2020; doi:  
583 10.11124/JBISRIR-D-19-00383.

584

585 6. Fayaz A, Croft P, Langford RM, Donaldson LJ, Jones GT. Prevalence of chronic pain in  
586 the UK: A systematic review and meta-analysis of population studies, *BMJ Open*. 2016; doi:  
587 10.1136/bmjopen-2015-010364.

588

589 7. GBD 2017 Global Burden of Disease Study. Seattle. 2017. [Accessed on 1 Mar 2021].  
590 Available from:

591 [http://www.healthdata.org/sites/default/files/files/policy\\_report/2019/GBD\\_2017\\_Booklet.pdf](http://www.healthdata.org/sites/default/files/files/policy_report/2019/GBD_2017_Booklet.pdf)

592 %0A<http://ghdx.healthdata.org/sites/default/files/record-attached->

593 [files/IHME\\_GBD\\_2017\\_DISABILITY\\_WEIGHTS\\_Y2018M11D08.XLSX](http://ghdx.healthdata.org/sites/default/files/record-attached-files/IHME_GBD_2017_DISABILITY_WEIGHTS_Y2018M11D08.XLSX).

594

595 8. Deloitte Access Economics. The Cost of Pain in Australia: PainAustralia. 2019. [Accessed  
596 on 1 Mar 2021]. Available from: [https://www.painaustralia.org.au/static/uploads/files/the-](https://www.painaustralia.org.au/static/uploads/files/the-cost-of-pain-in-australia-final-report-12mar-)  
597 [cost-of-pain-in-australia-final-report-12mar-](https://www.painaustralia.org.au/static/uploads/files/the-cost-of-pain-in-australia-final-report-12mar-)

wfxbrfyboams.pdf?fbclid=IwAR0OaQTiCWV6XNqTWIM3Yg6uO\_w2\_q7J6Pzj9rj0M2svm  
osNtJ-FhuDGqOo.

600

601 9. Dueñas M, Ojeda B, Salazar A, Mico JA, Failde I. A review of chronic pain impact on  
602 patients, their social environment and the health care system. *Journal of Pain Research*. 2016;  
603 doi: 10.2147/JPR.S105892.

604

605 10. Raftery MN, Sarma K, Murphy AW, la Harpe DD, Normand C, McGuire BE. Chronic  
606 pain in the Republic of Ireland—Community prevalence, psychosocial profile and predictors  
607 of pain-related disability: Results from the Prevalence, Impact and Cost of Chronic Pain  
608 PRIME study. Part 1. *Pain*. 2011;1525:1096–103.

609

610 11. Gardner T, Refshauge K, McAuley J, Hübsher M, Goodall S, Smith L. Goal setting  
611 practice in chronic low back pain. What is current practice and is it affected by beliefs and  
612 attitudes? *Physiotherapy Theory and Practice*. 2017;3410:795–805.

613

614 12. Stevans JM, Delitto A, Samannaaz SK, Patterson CG, Smith CN, Schneider MJ, et al.  
615 Risk Factors Associated With Transition From Acute to Chronic Low Back Pain in US  
616 Patients Seeking Primary Care. *JAMA Neurology*. 2021; doi:  
617 10.1001/jamanetworkopen.2020.37371.

618

619 13. Toye F, Seers K, Allcock N, Briggs M, Carr E, Andrews JA, Barker K. Patients  
620 experiences of chronic non-malignant musculoskeletal pain: A qualitative systematic review.  
621 *British Journal of General Practice*. 2013; doi: 10.3399/bjgp13X675412.

622

623 14. Hart OR, Uden RM, McMullan JE, Ritchie MS, Williams TD, Smith BH. A study of  
624 National Health Service management of chronic osteoarthritis and low back pain. *Primary  
625 Health Care Research & Development*. 2015;162:157–166.

626

627 15. Arumugam V, MacDermid JC, Walton D, Grewal R. Attitudes, knowledge and behaviors  
628 related to evidence-based practice in health professionals involved in pain management.  
629 *International Journal of Evidence-Based Healthcare*. 2018;162:107–118.

630

631 16. Cowell I, O'Sullivan P, O'Sullivan K, Poyton R, McGregor A, Murtagh G. Perceptions of  
632 physiotherapists towards the management of non-specific chronic low back pain from a  
633 biopsychosocial perspective: A qualitative study. *Musculoskeletal Science and Practice*.  
634 Elsevier Ltd. 2018;38:113–119.

635

636 17. Upshur C, Luckmann R, Savageau J. Primary care provider concerns about management  
637 of chronic pain in community clinic populations. *Journal of General Internal Medicine*. 2006;  
638 216:652–5.

639

640 18. O'Rorke JE, Chen I, Genao I, Panda M, Cykert S. Physicians comfort in caring for  
641 patients with chronic nonmalignant pain. *American Journal of Medical Science*.  
642 2007;3332:93–100.

643

644 19. Synnott A, O'Keefe M, Bunzli S, Dankaerts W, O'Sullivan P, O'Sullivan K.  
645 Physiotherapists may stigmatise or feel unprepared to treat people with low back pain and  
646 psychosocial factors that influence recovery: A systematic review. *Journal of Physiotherapy*.  
647 2015;612:68–76.

648

649 20. Parsons S, Harding G, Breen A, Foster N, Pincus T, Vogel S, et al. The Influence of  
650 Patients and Primary Care Practitioners Beliefs and Expectations About Chronic  
651 Musculoskeletal Pain on the Process of Care; A Systematic Review of Qualitative Studies.  
652 *Clinical Journal of Pain*. 2006;231:91–98.

- 653  
654 21. Darlow B, Fullen BM, Dean S, Hurley DA, Baxter GD, Dowell A. The association  
655 between health care professional attitudes and beliefs and the attitudes and beliefs, clinical  
656 management, and outcomes of patients with low back pain: A systematic review. *European*  
657 *Journal of Pain*. 2012;161:3–17.  
658  
659 22. Gardner T, Refshauge K, Smith L, McAuley J, Hübsher M, Goodall S. Physiotherapists'  
660 beliefs and attitudes influence clinical practice in chronic low back pain: a systematic review  
661 of quantitative and qualitative studies. *Journal of Physiotherapy*. 2017;633:132–143.  
662  
663 23. Gibbs M, Morrison N, Marshall P. Biomedical beliefs explain the clinical decisions made  
664 by exercise-based practitioners for people with chronic low back pain. *SPINE*. 2021; doi:  
665 10.1097/BRS.0000000000003698.  
666  
667 24. Mankelow J. Exploring healthcare students pain knowledge and attitudes towards  
668 function in people with pain. PhD thesis. Teesside University. 2021.  
669  
670 25. Lin IB, O'Sullivan PB, Coffin JA, Mak DB, Toussaint S, Straker LM. Disabling chronic  
671 low back pain as an iatrogenic disorder: A qualitative study in Aboriginal Australians. *BMJ*  
672 *Open*. 2013; doi: 10.1136/bmjopen-2013-002654.  
673  
674  
675 26. Setchell J, Costa N, Ferreira M, Makovey J, Nielsen M, Hodges PW. Individuals  
676 explanations for their persistent or recurrent low back pain: A cross-sectional survey. *BMC*  
677 *Musculoskeletal Disorders*. 2017; doi: 10.1186/s12891-017-1831-7.  
678  
679 27. Thompson K, Johnson MI, Milligan J, Briggs M. Twenty-five years of pain education  
680 research-what have we learned? Findings from a comprehensive scoping review of research  
681 into pre-registration pain education for health professionals. *Pain*. 2018;15911:2146–21.  
682  
683 28. Hogans BB, Watt-Watson J, Wilkinson P, Carr ECJ, Gordon DB. Perspective: update on  
684 pain education. *Pain*. 2019;1599:1681–1682.  
685  
686 29. Polacek C, Christopher R, Mann M, Udall M, Craig T, Deminski M, et al. Healthcare  
687 professionals perceptions of challenges to chronic pain management. *American Journal of*  
688 *Managed Care*. 2020;264:E135–E139.  
689  
690 30. Ajzen I. The theory of planned behavior: Frequently asked questions. *Human Behavior*  
691 *and Emerging Technologies*. 2020; doi:10.1002/hbe2.195.  
692  
693 31. Chief Allied Health Professions Officers Team. Allied Health Professions into Action:  
694 Using Allied Health Professionals to transform health, care and wellbeing. NHS England.  
695 2017. [Accessed on 1 March 2021]. Available from: [https://www.england.nhs.uk/wp-](https://www.england.nhs.uk/wp-content/uploads/2017/01/ahp-action-transform-hlth.pdf)  
696 [content/uploads/2017/01/ahp-action-transform-hlth.pdf](https://www.england.nhs.uk/wp-content/uploads/2017/01/ahp-action-transform-hlth.pdf).  
697  
698 32. Briggs E, Carr E, Whittaker M. Survey of undergraduate pain curricula for healthcare  
699 professionals in the United Kingdom, *European Journal of Pain*. 2011: [Accessed on 1 March  
700 2021]. Available from: [www.britishpainsociety.org](http://www.britishpainsociety.org).  
701  
702 33. European Federation of IASP Chapters. The Pain Management Core Curriculum for  
703 Undergraduate Medical Education. 2013. [Accessed on 1 Mar 2021] Available from:  
704 [https://europeanpainfederation.org/wp-](https://europeanpainfederation.org/wp-content/uploads/2018/10/CoreCurriculumPainManagement-EFIC-June-2013_FINAL1.pdf)  
705 [content/uploads/2018/10/CoreCurriculumPainManagement-EFIC-June-2013\\_FINAL1.pdf](https://europeanpainfederation.org/wp-content/uploads/2018/10/CoreCurriculumPainManagement-EFIC-June-2013_FINAL1.pdf).  
706  
707 34. Briggs EV, Battelli D, Gordon D, Kopf A, Ribeiro S, Puig MM, Kress HG. Current pain



- 708 education within undergraduate medical studies across Europe: Advancing the Provision of  
709 Pain Education and Learning APPEAL study. *BMJ Open*. 2015; doi: 10.1136/bmjopen-2014-  
710 006984.
- 711
- 712 34. Shipton EE, Bate F, Garrick R, Steketee C, Shipton EA, Visser EJ. Pain medicine content,  
713 teaching and assessment in medical school curricula in Australia and New Zealand. *BMC*  
714 *Medical Education*, 2018;181:139–161.
- 715
- 716 35. Ali N, Thomson D. A comparison of the knowledge of chronic pain and its management  
717 between final year physiotherapy and medical students. *European Journal of Pain*.  
718 2009;131:38–50.
- 719
- 720 36. Morris H, Ryan C, Lauchlan D, Field M. Do medical student attitudes towards patients  
721 with chronic low back pain improve during training? A cross-sectional study. *BMC Medical*  
722 *Education*. 2012;121:2–7.
- 723
- 724 37. Eyob T, Mulatu A, Abrha H. Knowledge And Attitude Towards Pain Management  
725 Among Medical And Paramedical Students Of An Ethiopian University. *Journal of Pain &*  
726 *Relief*. 2014; doi: 10.4172/2167-0846.1000127.
- 727
- 728 38. Adillón C, Lozano È, Salvat I. Comparison of pain neurophysiology knowledge among  
729 health sciences students: a cross-sectional study. *BMC Research Notes*.  
730 2015;doi:10.1186/s13104-015-1585-y.
- 731
- 732 39. Carroll SP, Augeard N, Tennant J, Seenan C. How do the attitudes, confidence,  
733 knowledge and understanding differ in pre-registration healthcare students towards treating  
734 people with chronic pain: an observational, cross-sectional study. *European Journal of*  
735 *Physiotherapy*. 2020; doi: 10.1080/21679169.2020.1746830.
- 736
- 737 40. Catley MJ, O'Connell NE, Moseley GL. How good is the neurophysiology of pain  
738 questionnaire? A rasch analysis of psychometric properties, *Journal of Pain*. 2013;148:818–  
739 827.
- 740
- 741 41. Houben RMA, Vlaeyen JWS, Peters M, Ostelo RWJG, Wolters PMJC, Stomp-van den  
742 Berg SGM. Health care providers attitudes and beliefs towards common low back pain: factor  
743 structure and psychometric properties of the HC-PAIRS. *Clinical Journal of Pain*.  
744 2004;201:37–44.
- 745
- 746 42. Moseley L. Unraveling the barriers to reconceptualization of the problem in chronic pain:  
747 The actual and perceived ability of patients and health professionals to understand the  
748 neurophysiology. *Journal of Pain*. 2003;44:184–189.
- 749
- 750 43. Colleary G, O'Sullivan K, Griffin D, Ryan CG, Martin DJ. Effect of pain neurophysiology  
751 education on physiotherapy students understanding of chronic pain, clinical recommendations  
752 and attitudes towards people with chronic pain: a randomised controlled trial, *Physiotherapy*.  
753 2017;1034:423–429.
- 754
- 755 44. Alodaibi F, Alhowimel A, Alsobayel H. Pain neurophysiology knowledge among  
756 physical therapy students in Saudi Arabia: A cross-sectional study, *BMC Medical Education*.  
757 2018; doi: 10.1186/s12909-018-1329-5.
- 758
- 759 45. Louw A, Podalak J, Zimney K, Schmidt S, Puentedura EJ. Can pain beliefs change in  
760 middle school students? A study of the effectiveness of pain neuroscience education.  
761 *Physiotherapy Theory and Practice*. 2018;347:542–550.
- 762

- 763 46. Maguire N, Chesterton P, Ryan C. The effect of pain neuroscience education on sports  
764 therapy and rehabilitation students knowledge, attitudes, and clinical recommendations  
765 toward athletes with chronic pain. *Journal of Sport Rehabilitation*. 2019;285:438–443.  
766
- 767 47. Mankelov J, Ryan CG, Taylor PC, Martin DJ. The effect of pain neurophysiology  
768 education on healthcare students knowledge, attitudes and behaviours towards pain: A mixed-  
769 methods randomised controlled trial. *Musculoskeletal Science and Practice*. 2020; doi:  
770 10.1016/j.msksp.2020.102249.  
771
- 772 48. Cohen J. *Statistical power analysis for the behavioural sciences*. 2nd Ed. Hillsdale NJ:  
773 Lawrence Earlbaum Associates. 1988.  
774
- 775 49. Norman GR, Sloan JA, Wyrwich KW. Interpretation of changes in health-related quality  
776 of life: The remarkable universality of half a standard deviation. *Medical Care*.  
777 2003;415:582–592.  
778
- 779 50. Copay AG, Glassman SD, Subach BR, Berven S, Schuler TC, Carreon LY. Minimum  
780 clinically important difference in lumbar spine surgery patients: a choice of methods using the  
781 Oswestry Disability Index, Medical Outcomes Study questionnaire Short Form 36, and Pain  
782 Scales. *Spine Journal*. 2008;86: 968–974.  
783
- 784 51. Dworkin RH, Turk, DC, Wyrwich KW, Beaton D, Cleeland CS, Farrar JT, et al.  
785 Interpreting the Clinical Importance of Treatment Outcomes in Chronic Pain Clinical Trials:  
786 IMMPACT Recommendations. *Journal of Pain*. 2008;92:105–121.  
787
- 788 52. Moran RW, Rushworth WM, Mason J. Investigation of four self-report instruments  
789 FABT, TSK-HC, Back-PAQ, HC-PAIRS to measure healthcare practitioners attitudes and  
790 beliefs toward low back pain: Reliability, convergent validity and survey of New Zealand  
791 osteopaths and manipulative physio. *Musculoskeletal Science and Practice*. 2017;32:44–50.  
792
- 793 53. Latimer, J, Maher C, Refshauge K. The Attitudes and Beliefs of Physiotherapy Students  
794 to Chronic Back Pain. *Clinical Journal of Pain*. 2004; 201:45–50.  
795
- 796 54. Evans DW, Breen AC, Pincus T, Sim J, Underwood M, Vogel S, Foster NE. The  
797 effectiveness of a posted information package on the beliefs and behavior of musculoskeletal  
798 practitioners: The UK chiropractors, osteopaths, and musculoskeletal physiotherapists low  
799 back pain management COMPLEMENT randomized trial. *Spine*. 2010;358:858–866.  
800
- 801 55. Briggs AM, Slater H, Smith AJ, Parkin-Smith GF, Watkins K, Chua J. Low Back Pain-  
802 related Beliefs and Likely Practice Behaviours Among Final-year Cross-discipline Health  
803 Students, *European Journal of Pain*. 2013;175:766–775.  
804
- 805 56. Macdonald RJD, Vaucher P, Esteves JE. The beliefs and attitudes of UK registered  
806 osteopaths towards chronic pain and the management of chronic pain sufferers - A cross-  
807 sectional questionnaire based survey. *International Journal of Osteopathic Medicine*. 2018;  
808 doi: 10.1016/j.ijosm.2018.07.003.  
809
- 810 57. Domenech J, Sánchez-Zuriaga D, Segura-Ortí E, Espejo-Tort B, Lisón JF. Impact of  
811 biomedical and biopsychosocial training sessions on the attitudes, beliefs, and  
812 recommendations of health care providers about low back pain: A randomised clinical trial.  
813 *Pain*. 2011;15211:2557–2563.  
814
- 815 58. Chalmers KJ, Madden VJ. Shifting beliefs across society would lay the foundation for  
816 truly biopsychosocial care. *Journal of Physiotherapy*. 2019;653:121–122.  
817

- 818 60. Quinn T, Ryan C, Jones D. Physiotherapy students attitudes towards the functional ability  
819 of patients with chronic low back pain. *Pain and Rehabilitation*. 2014;3737:20–23.  
820
- 821 61. Ryan C, Murphy D, Clark M, Lee A. The effect of a physiotherapy education compared  
822 with a non-healthcare education on the attitudes and beliefs of students towards functioning in  
823 individuals with back pain: An observational, cross-sectional study. *Physiotherapy*.  
824 2010;962:144–150.  
825
- 826 62. Amponsah AK, Kyei-Dompim J, Kyei EF, Oduro E, Afaya RA, Aphoto CK. Final Year  
827 Nursing Students Knowledge and Attitudes regarding Childrens Pain, Pain Research and  
828 Management. 2020; doi: 10.1155/2020/7283473.  
829
- 830 63. Leahy A, O'Keeffe, M, Robinson K, O'Sullivan K. The beliefs of healthcare students  
831 about the harmfulness of daily activities for their back: a cross-sectional study. *European*  
832 *Journal of Physiotherapy*. 2019; doi: 10.1080/21679169.2019.1630854.  
833
- 834 64. Mukoka G, Olivier B, Ravat S. Level of knowledge, attitudes and beliefs towards patients  
835 with chronic low back pain among final year school of therapeutic sciences students at the  
836 university of the Witwatersrand – A cross-sectional study. *South African Journal of*  
837 *Physiotherapy*. 2019; doi: 10.4102/sajp.v75i1.683.  
838
- 839 65. Goodrich C. Students and faculty members knowledge and attitudes regarding pain  
840 management: a descriptive survey. *Journal of Nursing Education*. 2005;453:140–142.  
841
- 842 66. Springer S, Gleicher H, Hababou H. Attitudes and beliefs about musculoskeletal pain and  
843 its association with pain neuroscience knowledge among physiotherapy students in Israel.  
844 *Israel Journal of Health Policy Research*. 2018; doi: 10.1186/s13584-018-0266-4.  
845
- 846 67. Karran EL, Hillier SL, Yau Y-H, McAuley JH, Moseley GL. A quasi-randomised,  
847 controlled, feasibility trial of GLITtER Green Light Imaging Interpretation to Enhance  
848 Recovery-a psychoeducational intervention for adults with low back pain attending secondary  
849 care. *PeerJ*. 2018; doi: 10.7717/peerj.4301.  
850
- 851 68. Jarvik JG, Meier EN, James KT, Gold LS, Tan KW, Kessler LG. The Effect of Including  
852 Benchmark Prevalence Data of Common Imaging Findings in Spine Image Reports on Health  
853 Care Utilization Among Adults Undergoing Spine Imaging: A Stepped-Wedge Randomized  
854 Clinical Trial. *JAMA network open*. 2020; doi: 10.1001/jamanetworkopen.2020.15713.  
855
- 856 69. Kyei KA, Antwi WK, Opoku SY, Hemans S, Anim-Sampong S, Engel-Hills P.  
857 Radiographers knowledge, attitude and challenges on pain management. *The South African*  
858 *Radiographer*. 2014;521:22–25.  
859
- 860 70. Carragee EJ, Todd AF, Miller JL, Carragee JM. Discographic, MRI and psychosocial  
861 determinants of low back pain disability and remission: a prospective study in subjects with  
862 benign persistent back pain. *The Spine Journal*. 2005; doi: 10.1016/j.spinee.2004.05.250.  
863
- 864 71. Suri P, Boyko EJ, Goldberg J, Forsberg CW, Jarvik JG. Longitudinal associations  
865 between incident lumbar spine MRI findings and chronic low back pain or radicular  
866 symptoms: Retrospective analysis of data from the longitudinal assessment of imaging and  
867 disability of the back LAIDBACK. *BMC Musculoskeletal Disorders*. 2014; doi:  
868 10.1186/1471-2474-15-152.  
869
- 870 72. Brinjikji W, Diehn FE, Jarvik JG, Carr CM, Kallmes DF, Murad MH, Luetmer PH. MRI  
871 findings of disc degeneration are more prevalent in adults with low back pain than in  
872 asymptomatic controls: A systematic review and meta-analysis. *American Journal of*

873 Neuroradiology. 2015;3612:2394–2399.  
874  
875 73. Brinjikji W, Luetmer PH, Comstock B, Bresnahan BW, Chen LE, Deyo RA, Halabi S,  
876 Turner JA, Avins AL, James K, Wald JT, Kallmes DF, Jarvik JG. Systematic Literature  
877 Review of Imaging Features of Spinal Degeneration in Asymptomatic Populations. American  
878 Journal of Neuroradiology. 2015;364:811–816.  
879  
880 74. Mankelov J, Ryan C, Taylor P, Atkinson G, Martin D. A Systematic Review and Meta-  
881 Analysis of the Effects of Biopsychosocial Pain Education upon Health Care Professional  
882 Pain Attitudes, Knowledge, Behavior and Patient Outcomes. Journal of Pain. 2022;23:1-24.  
883 doi: 10.1016/j.jpain.2021.06.010.  
884  
885  
886