

The hierarchical cluster analysis of oral health attitudes and behaviour using the Hiroshima University - Dental Behavioural Inventory (HU-DBI) among final year dental students in 17 countries

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Objective: To explore and describe international oral health attitudes/ behaviours among final year dental students. **Methods:** Validated translated versions of the Hiroshima University–Dental Behavioural Inventory (HU–DBI) questionnaire were administered to 1,096 final-year dental students in 17 countries. Hierarchical cluster analysis was conducted within the data to detect patterns and groupings. **Results:** The overall response rate was 72%. The cluster analysis identified two main groups among the countries. Group 1 consisted of twelve countries: one Oceanic (Australia), one Middle-Eastern (Israel), seven European (Northern Ireland, England, Finland, Greece, Germany, Italy, and France) and three Asian (Korea, Thailand and Malaysia) countries. Group 2 consisted of five countries: one South American (Brazil), one European (Belgium) and three Asian (China, Indonesia and Japan) countries. The percentages of ‘agree’ responses in three HU–DBI questionnaire items were significantly higher in Group 2 than in Group 1. They include: “I worry about the colour of my teeth.”; “I have noticed some white sticky deposits on my teeth.”; and “I am bothered by the colour of my gums.” **Conclusion:** Grouping the countries into international clusters yielded useful information for dentistry and dental education.

Key words: Oral health attitudes/behaviour, cross-national comparison, cluster analysis, dendrogram, questionnaire, dental students, educational methodology, statistical approach

Dental students play a significant role in public life, eventually becoming the future leaders in dentistry. First-year dental students do not have the advantage of dental knowledge and so practise average oral self-care regimens among their contemporaries. As dental

education progresses, dental students are expected to be role models for patients and undergo motivational behavioural changes with respect to their own oral self-care regimens. Final-year dental students are equipped with a certain level of dental knowledge and skill and

practise the current standard of clinical care. The patterns of oral health attitudes and behaviour in final-year dental students are, therefore, particularly significant¹.

In recent years, international relationships in dentistry have grown stronger through journals, books, academies, seminars, and researcher exchange programmes². Global dental education and health promotion are also being developed³. Considering these current world trends in dentistry, it is helpful to conduct multinational comparisons of health attitudes and behaviours among final-year dental students. Although there are available reports regarding oral hygiene habits among young people in many countries, few studies have been undertaken for final-year dental students in an international setting⁴⁻⁹.

Collecting international data is quite dynamic and challenging. Comparisons of oral health care in countries with similar social systems, language, and culture are relatively easy to do because the criteria for function, diagnosis, and treatment are similar. However, comparisons of oral health care in countries having different healthcare bases, coupled with language barriers, are complicated and time-consuming. Therefore, it is necessary to find a standard instrument for objective evaluation. Thus, we adopted the Hiroshima University–Dental Behavioural Inventory (HU–DBI).

The HU–DBI, which poses 20 agree-disagree questions, was developed by Kawamura to examine oral health attitudes and behaviours of patients^{10,11}. The HU–DBI has been translated from Japanese into English, Finnish, Chinese, Flemish, Portuguese, French, German, Greek, Italian, Malayan, Thai, and Korean for cross-cultural comparisons. Results of these translated versions, including established reliability, have been reported previously^{4,5,12-14}.

The complete data set of the HU–DBI questionnaire results was diverse. Because it was difficult to conduct factor analysis, which is popular in dental research, hierarchical cluster analysis was conducted instead, to detect patterns and groupings within the data^{15,16}.

The aim of this study was, therefore, to compare the oral health attitudes and behaviours using the Inventory among final-year dental students in 17 countries and to identify similarities and differences among countries using hierarchical cluster analysis.

Materials and methods

The HU–DBI questionnaire: reliability of translation

The original HU–DBI questionnaire was written in Japanese and translated from Japanese into English, Finnish, and Chinese for cross-cultural comparisons. The English version of the HU–DBI (*Table 1*) was translated into Flemish, Portuguese, French, German, Greek, Italian, Korean, Malayan, and Thai between 1990 and

1992. Back-translations of these nine translated versions were completed by bilinguals except for the Flemish and Malayan versions. These nine translated versions were again compared with the English version by the co-authors, and then the reliability of the translations was studied by data collected by bilinguals in each country. Bilinguals were asked to answer the English version first and then answer their mother-tongue version after several hours. Reliability of the translated version was measured by percentage coincidence. Results of these translated versions, including methods and reliability, have been reported previously^{4,5,12-14}.

Sample and percentage of ‘agree’ responses in 20 HU–DBI questionnaire items in 17 countries

Substantial portions of the original data set have already been published^{4,12,13,17-19}. One thousand and ninety-six final-year dental students enrolled in 17 dental schools were invited to take part in this survey using translated versions of the HU–DBI questionnaire in their mother tongues at the beginning of the academic year. The following dental schools participated in this study: Melbourne University (Australia, 1991); Catholic University Leuven (Belgium, 1998); Universidade Federal de Goiás (Brazil, 2000); West China University of Medical Sciences (China, 1997); Helsinki International Institute for Oral Health (Finland, 1998); l’Université Paris 5 (France, 1999); University of Tübingen (Germany, 1998); University of Athens (Greece, 1998); Mahasaraswati University (Indonesia, 1990); Queen’s University

Table 1 The HU–DBI Questionnaire (English translated version)
Answer as “Agree” or “Disagree”

| No. | Item Descriptions |
|-----|--|
| 1 | I don't worry much about visiting the dentist. |
| 2 | My gums tend to bleed when I brush my teeth. |
| 3 | I worry about the colour of my teeth. |
| 4 | I have noticed some white sticky deposits on my teeth. |
| 5 | I use a child sized toothbrush. |
| 6 | I think that I cannot help having false teeth when I am old. |
| 7 | I am bothered by the colour of my gums. |
| 8 | I think my teeth are getting worse despite my daily brushing. |
| 9 | I brush each of my teeth carefully. |
| 10 | I have never been taught professionally how to brush. |
| 11 | I think I can clean my teeth well without using toothpaste. |
| 12 | I often check my teeth in a mirror after brushing. |
| 13 | I worry about having bad breath. |
| 14 | It is impossible to prevent gum disease with toothbrushing alone. |
| 15 | I put off going to the dentist until I have toothache. |
| 16 | I have used a dye to see how clean my teeth are. |
| 17 | I use a toothbrush which has hard bristles. |
| 18 | I don't feel I've brushed well unless I brush with strong strokes. |
| 19 | I feel I sometimes take too much time to brush my teeth. |
| 20 | I have had my dentist tell me that I brush very well. |

of Belfast (Northern Ireland, UK, 1998/1999); Tel Aviv University (Israel, 1999); Sapienza University (Italy, 1999); Hiroshima University (Japan, 1997); Wonkwang University (Korea, 1998); University of Malaya (Malaysia, 1999); Chiang Mai University (Thailand, 1998); and University of Leeds (England, UK, 1998). Students were asked by faculties to remain in class at the end of the lecture to participate in this survey on a voluntary basis. No attempt was made to follow up with students who were absent on the day of the survey. The HU-DBI questionnaire, consisting of 20 agree-disagree questions regarding oral health attitudes and behaviours of patients, was distributed to students. The HU-DBI focused on oral health attitudes, oral hygiene behaviours, and self-reported oral health and dental visits^{1,10,13}. Students completed the questionnaire on the premises in 17 countries, which were then collected and mailed to Hiroshima University in Japan. The percentages of 'agree' responses in 20 HU-DBI questionnaire items were calculated.

The hierarchical cluster analysis procedure

The complete data set of the HU-DBI questionnaire results was diverse, making it difficult to conduct factor analysis, which is popular in dental research. A cluster analysis of cases resembles discriminant analysis in one respect, that the researcher seeks to classify a set of objects into groups or categories, but in cluster analysis, neither the number nor the members of the groups are known. That is, in cluster analysis researchers begin with

no knowledge of group membership and often do not know just how many clusters there are. A cluster analysis of variables resembles factor analysis because both procedures identify related groups of variables. Clustering is a good technique to use in exploratory data analysis when the researcher suspects that the sample is not homogeneous. Therefore, hierarchical cluster analysis to detect patterns and groupings within the data was conducted^{15,16}.

The hierarchical cluster analysis procedure was used to provide distance measures for defining how different or alike two countries are¹⁶. When two cases are very similar, the distance measure value is small. This cluster analysis compared 17 countries with respect to the variables assessed in the HU-DBI. Percentages of 'agree' responses for each item in the HU-DBI were used in cluster analysis as individual representative values. The squared Euclidean distance and the complete linkage method were used in the analysis of clustering. The squared Euclidean distance between two cases (A and B) on 20 variables (x_1, x_2, \dots, x_{20}) was computed by: $(x_{1A} - x_{1B})^2 + (x_{2A} - x_{2B})^2 + \dots + (x_{20A} - x_{20B})^2$. In this study, cases represented 17 countries and variables represented percentages of 'agree' responses in 20 HU-DBI questionnaire items. Distances were rescaled to numbers between 0 and 25 and summarised in a dendrogram, which made grouping countries possible. The percentages of 'agree' responses of the HU-DBI questionnaire items were compared by t-test and ANOVA. Statistical analyses were conducted using SPSS 10.0J (SPSS Inc., Chicago, Illinois).

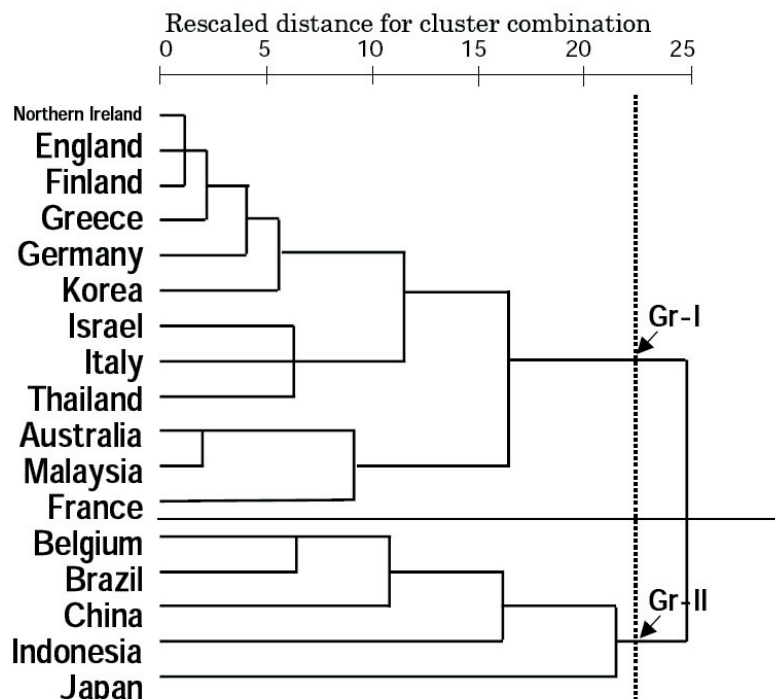


Figure 1. Dendrogram in the hierarchical cluster analysis

Results

Table 2 shows distributions of respondents by country. Of the 1,096 enrolled, 784 responded, making the mean response rate 72%. Percentages of 'agree' responses in 20 questionnaire items in 17 countries are summarised in Table 3, which was the data set used to start cluster analysis. In Table 3 cases represent countries and variables represent percentages of 'agree' responses. In the hierarchical cluster analysis procedure, the agglomeration schedules in clusters of countries were completed by using SPSS software. Distance coefficient was measured and the data was summarised in a dendrogram for grouping countries, which identified two main groups:

- Group 1 included 12 countries: Northern Ireland, England, Finland, Greece, Germany, Korea, Israel, Italy, Thailand, Australia, Malaysia, and France.
- Group 2 included 5 countries: Belgium, Brazil, China, Indonesia, and Japan.

The percentages of 'agree' responses in three questionnaire items were significantly higher in Group 2 than in Group 1. They included:

- "I worry about the colour of my teeth." (Item 3, $P < 0.01$)
- "I have noticed some white sticky deposits on my teeth." (Item 4, $P < 0.01$)
- "I am bothered by the colour of my gums." (Item 7, $P < 0.001$).

Discussion

Group 1

Hierarchical cluster analysis is useful to detect patterns and grouping with the data. Northern Ireland, England, and Finland had the highest similarity but when Germany and Korea were added to these three the similarity among all five countries was less than the similarity among the original three. Israel, Italy, and Thailand showed a medium degree of similarity.

Australia and Malaysia showed a high degree of similarity but when France was added, the similarity among all three was less than that between the original two.

Group 2

Belgium and Brazil showed a medium degree of similarity, however, when China was added to these two, the similarity among all three was less than the similarity between the original two. Finally, Indonesia and Japan were added to Belgium, Brazil, and China.

The foundation of any value of this large scale international collaboration is the reliability of translation of questionnaire used. There were high levels of reliability between the Japanese version and translated versions

as noted above. Percentage coincidence less than 70% was identified in the following translated versions: two items in Flemish (Items 10 and 13), Greek (Items 6 and 14), and Malayan (Items 1 and 15); and one item in Portuguese (Item 7), German (Item 13), and Korean (Item 6).

Our previous research regarding oral health attitudes and behaviour among first-year dental students in 17 countries and Hong Kong can be compared to this study¹⁵. Due to lack of data from Hong Kong in this study, one-to-one comparisons are not statistically feasible. However, a remarkable difference in grouping between first- and final-year dental students was seen between Japan and Korea; the first-year group showing a small distance in the dendrogram whereas the final-year group showed a large distance^{2,15}. Also, in this paper, Japan was included in Group 2 and Korea in Group 1. First-year dental students were found to have no advantage of dental knowledge and practised average oral self-care regimens similar to the community and yet Japan and Korea are geographical neighbours in East Asia. Western medicine and dentistry were introduced to both countries after World War II. This change may suggest effectiveness before and after dental education, however it cannot be proved. Dental education in Korea is very dynamic and many curricular reforms are in progress. For example, dental education in both countries had consisted of a six-year programme, not including undergraduate study. However, since 2003, five of the eleven dental schools in Korea have implemented a new curriculum, combining four years of undergraduate study (bachelor's degree) and four years of dental study at the graduate level, similar to the current USA system. In addition, the Dental Education Eligibility Test will be implemented in the near future².

This study is exploratory and descriptive in nature. Only one dental school participated in each country at different times from 1991 to 2000. Conducting a dynamic international study is very challenging and there are several limitations to this study. First, there is a ten-year difference in data collections between Australia (1991) and Brazil (2000). However, the effects on the self-care of Australian students are asserted as minimal because of no major recent change in Australian dental curricula. Second, the response rates in China and Italy were less than 50%. The response rate varied between 42% (Italy) and 96% (Germany), since the survey was conducted on a voluntary basis. Further, for example, students in externship rotations were not included in Belgium. One-half of the enrolled students were asked to participate in this study in Finland. Cluster analysis is fit for exploring; however, it is important to note that China and Italy do not represent the whole figures. Third, among Items 3, 4, and 7, the percentage coincidence of the Portuguese version was less than 70 percent in Item 7. The Portuguese version was used in this study in Brazil. It is noted that this specific data in

Table 2 Distribution of respondents by country

| Case | Country | Area | Year Surveyed | Dental School | Length of dental education (Years) | Final Year Dental Student | | |
|-------|------------------|-------------|---------------|--|------------------------------------|---------------------------|----------|----------------|
| | | | | | | Responded | Enrolled | Rate Responded |
| 1 | Australia | Oceania | 1991 | Melbourne University | 5 | 36 | 53 | 68% |
| 2* | Belgium | Europe | 1998 | Catholic University Leuven | 5 | 29 | 51 | 57% |
| 3 | Brazil | S. America | 2000 | Universidade Federal de Goiás | 5 | 39 | 60 | 65% |
| 4 | China | Asia | 1997 | West China University of Medical Sciences | 5 | 29 | 66 | 44% |
| 5** | Finland | Europe | 1998 | Helsinki International Institute for Oral Health | 5 | 16 | 17 | 94% |
| 6 | France | Europe | 1999 | l'Université Paris 5 | 5 | 62 | 71 | 87% |
| 7 | Germany | Europe | 1998 | University of Tübingen | 5 | 67 | 70 | 96% |
| 8 | Greece | Europe | 1998 | University of Athens | 5 | 103 | 150 | 69% |
| 9 | Indonesia | Asia | 1990 | Mahasaraswati University | 5 | 46 | 82 | 56% |
| 10 | Northern Ireland | Europe | 1998-1999 | Queen's University of Belfast | 6 | 28 | 31 | 90% |
| 11 | Israel | Middle East | 1999 | Tel Aviv University | 5 | 41 | 58 | 71% |
| 12 | Italy | Europe | 1999 | Sapienza University | 5 | 21 | 50 | 42% |
| 13 | Japan | Asia | 1997 | Hiroshima University | 6 | 81 | 83 | 98% |
| 14 | Korea | Asia | 1998 | Wonkwang University | 6 | 48 | 69 | 70% |
| 15 | Malaysia | Asia | 1999 | University of Malaya | 5 | 35 | 49 | 71% |
| 16 | Thailand | Asia | 1998 | Chiang Mai University | 6 | 76 | 85 | 89% |
| 17 | England | Europe | 1998 | University of Leeds | 5 | 27 | 51 | 53% |
| Total | | | | | | 784 | 1096 | 72% |

*Students in externship rotation were not included.

** A half of the enrolled students were asked to participate in this study.

Table 3 Percentage of "Agree" response in 20 HU-DBI Questionnaire Items in 17 countries

| Case | Country | Variable (The HU-DBI Questionnaire Item Number) | | | | | | | | | | | | | | | | | | | |
|------|------------------|---|----|----|-----|----|----|----|----|----|----|----|----|-----|----|----|----|----|----|----|----|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
| 1 | Australia | 53 | 3 | 56 | 20 | 36 | 6 | 14 | 8 | 89 | 17 | 25 | 72 | 75 | 47 | 3 | 53 | 8 | 3 | 22 | 58 |
| 2 | Belgium | 86 | 3 | 97 | 7 | 0 | 10 | 69 | 14 | 90 | 52 | 34 | 76 | 97 | 29 | 7 | 48 | 11 | 14 | 14 | 86 |
| 3 | Brazil | 15 | 5 | 92 | 56 | 10 | 3 | 87 | 10 | 77 | 23 | 54 | 67 | 100 | 26 | 13 | 49 | 5 | 3 | 41 | 64 |
| 4 | China | 66 | 21 | 79 | 62 | 28 | 31 | 83 | 45 | 90 | 3 | 17 | 41 | 45 | 61 | 31 | 55 | 21 | 3 | 17 | 62 |
| 5 | Finland | 69 | 31 | 25 | 25 | 0 | 6 | 0 | 0 | 88 | 6 | 6 | 63 | 50 | 13 | 0 | 63 | 0 | 6 | 6 | 75 |
| 6 | France | 10 | 57 | 64 | 36 | 33 | 8 | 14 | 0 | 98 | 3 | 24 | 94 | 41 | 10 | 2 | 13 | 49 | 31 | 48 | 95 |
| 7 | Germany | 22 | 15 | 7 | 9 | 28 | 4 | 1 | 3 | 90 | 17 | 22 | 88 | 12 | 40 | 4 | 69 | 7 | 16 | 19 | 75 |
| 8 | Greece | 71 | 13 | 18 | 5 | 2 | 10 | 3 | 1 | 68 | 6 | 45 | 83 | 46 | 40 | 12 | 64 | 1 | 7 | 31 | 80 |
| 9 | Northern Ireland | 75 | 7 | 21 | 7 | 0 | 0 | 4 | 4 | 79 | 14 | 7 | 57 | 32 | 29 | 4 | 54 | 29 | 4 | 21 | 54 |
| 10 | Indonesia | 98 | 17 | 43 | 100 | 9 | 30 | 39 | 9 | 26 | 17 | 9 | 87 | 93 | 91 | 11 | 43 | 0 | 1 | 57 | 47 |
| 11 | Israel | 83 | 5 | 27 | 5 | 32 | 49 | 5 | 22 | 66 | 10 | 59 | 78 | 78 | 63 | 12 | 41 | 7 | 10 | 10 | 79 |
| 12 | Italy | 19 | 14 | 10 | 5 | 19 | 10 | 24 | 19 | 48 | 5 | 33 | 95 | 57 | 33 | 10 | 10 | 24 | 5 | 14 | 76 |
| 13 | Japan | 77 | 15 | 56 | 94 | 40 | 8 | 44 | 14 | 88 | 6 | 77 | 71 | 25 | 25 | 27 | 96 | 27 | 12 | 73 | 19 |
| 14 | Korea | 56 | 17 | 21 | 46 | 0 | 8 | 2 | 2 | 60 | 6 | 13 | 79 | 28 | 38 | 50 | 65 | 10 | 21 | 4 | 33 |
| 15 | Malaysia | 3 | 6 | 49 | 23 | 23 | 0 | 14 | 3 | 80 | 9 | 17 | 66 | 83 | 43 | 17 | 71 | 0 | 3 | 51 | 82 |
| 16 | Thailand | 57 | 18 | 50 | 40 | 13 | 29 | 12 | 32 | 44 | 5 | 17 | 69 | 45 | 82 | 28 | 7 | 4 | 15 | 37 | 44 |
| 17 | England | 59 | 0 | 26 | 4 | 0 | 4 | 19 | 7 | 81 | 0 | 15 | 56 | 26 | 15 | 11 | 78 | 4 | 7 | 7 | 67 |

Brazil is less reliable. Considering these three limitations of this study, cluster analysis is the best statistical approach because it is a multivariate procedure for detecting groupings in the data. It is acknowledged, however, that convenience sampling may overestimate the impact of certain areas. As this was an explorative study, and one restricted to final-year dental students, this weakness in research design may be considered acceptable.

Statistical significance in the percentage of 'agree' responses in HU-DBI items 3, 4, and 7 was observed

between Group 1 and Group 2. The percentage of 'agree' responses in Item 3, "I worry about the colour of my teeth" was 31 and 73% in Groups 1 and 2, respectively. The percentage of 'agree' responses in Item 4, "I have noticed some white sticky deposits on my teeth" was 19 and 64% in Groups 1 and 2, respectively. The percentage of "agree" responses in Item 7, "I am bothered by the colour of my gums" was 9 and 64% in Groups 1 and 2, respectively.

Group 2 endorsed with a high degree of concurrence the above three particular items (Items 3, 4, and 7), Item 4 (noticing white sticky deposits) might be an expected and objective observation of a developing dental professional based on education rather than cultural influence. However, Items 3 and 7 (colour of teeth and gums) are of particular interest as it is subjective, being influenced by cultural norms, aesthetic concern, and the level of oral health education. Culture is bi-directional in its influence. Core individual and group health beliefs impact on priorities in types of oral health care treatment offered and selective use of treatment recommendations. Both patients and dentists may have selective priorities regarding what is considered important to treat. Underlying cultural and socioeconomic factors may be influencing these concerns about the colour of teeth and gums in the group of final-year dental students.

The percentage of 'agree' responses in Item 3 was 97, 92, 79, 43, and 56% in Belgium, Brazil, China, Indonesia, and Japan, respectively. The percentage of 'agree' responses in Item 7 was 69, 87, 83, 39, and 44% in Group 2 countries, Belgium, Brazil, China, Indonesia, and Japan, respectively. The two primary groupings of nations did not fall along north/south destinations, and did not have apparent regional content.

In Item 3, tooth colour is determined by the paths of light inside the tooth and absorption along these paths²⁰. Anatomical structures in enamel and dentine vary in each individual, whereas environmental lighting varies by countries and cultures. For example, fluorescent lighting is prominent in all rooms in Japanese and Chinese homes. Bright lights are preferred at all times, even in bedrooms and living rooms. Whereas many Indonesian homes in Jakarta use light bulbs and neon lights. The majority of environmental lighting in Belgium is provided by light bulbs and halogen. Indonesian and Belgians prefer brightness. Situations of environmental lighting in Brazil vary depending on socioeconomic situation, however, the amount of natural light throughout the year is abundant. Lighting intensity enhances visibility and assessment of tooth colour. It is acknowledged, however, that these observations are based on the collective experiences of authors and thus have no empirical basis.

Research conducted regarding colour of gingiva and mucosa is limited, compared with the amount of research regarding colour of teeth²¹. For instance, Jones and McFall reported that gingival colour was lighter in individuals with blonde hair than in individuals with brown hair; gingival colour was darker in individuals with darker eye colour, and gingival colour was lighter in individuals with geographic origins that are commonly associated with lighter-complexioned people²². However, the two primary groupings of nations do not fall along lines of hair colour. The reason why Group 2 countries showed a high degree of significance in Items 3 and 7 is not clear and presents a research opportunity for the future.

Our previous research involving first-year dental students showed statistical significance in the percentage of 'agree' responses in HU-DBI items 3, 4, 13, 14 and 15¹⁵. There were four groups and the countries were classified differently. It is interesting that statistical significance was observed in Items 3 and 4 in both first- and final-year dental students. This study presented the practical implications of cluster analysis methodology, which can be used at divisional, departmental, school, state, national, and international levels. Customised approaches in dental research and education may have a more pervasive influence and this study gives useful information for exploring international dental education, developing dental curricula, healthcare policies, and international research collaborations.

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