Received: 3 April 2018 | Revised: 29 August 2019 | Accepted: 27 September 2019

DOI: 10.1111/eje.12470

WILEY

ORIGINAL ARTICLE

Knowledge about nanotechnology and intention to use nanomaterials: A comparative study among dental students in Norway and Romania

Victoria Xenaki[1,2] | Mihaela Cuida Marthinussen[1,3] | Daniela Elena Costea[4,5] | Andreea Cristiana Didilescu[6] | Cristiano Susin[7] | Mihaela Roxana Cimpan[1] | Anne Nordrehaug Åstrøm[1]

[1]Department of Clinical Dentistry, Faculty of Medicine, University of Bergen, Bergen, Norway

[2]Centre for International Health, Faculty of Medicine, University of Bergen, Bergen, Norway

[3]Oral Health Centre of Expertise in Western Norway, Hordaland, Norway

[4]Department of Clinical Medicine and Center for Cancer Biomarkers CCBio, Faculty of Medicine, University of Bergen, Bergen, Norway

[5]Department of Pathology, Haukeland University Hospital, Bergen, Norway

[6]Faculty of Dental Medicine, "Carol Davila" UMP, Bucharest, Romania

[7]Dental College of Georgia, Augusta University, Augusta, GA, USA

Correspondence
Victoria Xenaki, Department of Clinical Dentistry, Faculty of Medicine, University of Bergen, Bergen, Norway.
Email: Victoria.Xenaki@uib.no

Funding information
The study was supported by Clinical Dental Research group, Department of Clinical Dentistry, University of Bergen and the Research Council of Norway project NorNANoREG (239199/O70).

Abstract

Background: The introduction of innovative nanotechnologies in medicine and dentistry may initiate a need for curriculum revision at the universities. The aim of this study was to assess dental students' knowledge and attitudes related to nanotechnology. Covariates of students' intention to use nanomaterials in their future dental practice were evaluated using the theory of planned behaviour (TPB).

Methods: Dental students at Norwegian and Romanian Universities were invited to participate. A self-administered structured questionnaire including socio-demographics and Ajzen's TPB components was used.

Findings: A total of 212 out of 732 dental students participated in the survey: 52 Norwegian and 160 Romanian. Most students reported to have little knowledge about nanotechnology (Norwegians = 44.2% vs Romanians = 46.9%, $P < .05$). More than 90% of the students in both countries reported that they wanted to get more information about nanotechnology. Mean knowledge score was similar for Norwegian and Romanian students (4.4 ± 1.7 vs 4.2 ± 1.4, $P > .05$). Romanian students had more positive attitude, stronger subjective norms and stronger perceived behavioural control towards nanotechnology compared to their Norwegian counterparts. Intention to use nanomaterials in the total sample was most strongly influenced by attitude towards the use of dental nanomaterials (beta = 0.42, $P < .001$).

Conclusion: Dental students in Norway and Romania demonstrated limited knowledge about nanotechnology. Intention to use nanomaterials was primarily influenced by attitudes. A clear desire for more information about the application of nanotechnology in dentistry was expressed by the respondents indicating a need for curriculum modification.

KEYWORDS
dental students, knowledge, nanotechnology, theory of planned behaviour

1 | INTRODUCTION

Nanotechnology is an interdisciplinary field of research with broad applications defined "as the manipulation of matter with at least one dimension sized from 1 to 100 nanometres, where unique phenomena enable novel applications" (National Nanotechnology Initiative).[1] Although nanotechnology has generated great enthusiasm due to its potential to solve many problems, questions remain regarding ethical issues, as well as potential health and environmental risks.[2-5]

Several studies have investigated knowledge and perceptions of nanotechnology in the general population as well as among experts in different countries. Surveys among the general public have shown that most of the respondents were rather unfamiliar with nanotechnology.[6-9] At the same time, the general public seemed to have positive and seldom indifferent or ambiguous attitudes towards nanotechnology.[6-10] A survey among experts in the United States (US) revealed that respondents rated the risks of nanotechnology substantially lower than the benefits. They considered human health and use in weapons risk as the most important and expected the greatest benefits to come in medicine and in the development of new materials for various applications.[11] Other surveys, aimed to compare experts and laypersons' opinion, have shown that laypersons perceived greater risks associated with nanotechnology than did experts.[12-14] Yet, on some issues, such as environmental pollution and new health problems, the scientists were more concerned than the public.[14] A few studies among students have shown that the respondents were very enthusiastic about nanotechnology and that they had a critical view on the potential risks and benefits of its applications.[15,16]

Studies investigating factors influencing attitude towards nanotechnology have shown that gender and level of education played an important role and that men gave greater support to nanotechnology than did women.[7,10,12,15] Moreover, people with higher education had more positive attitudes towards nanotechnology than their lower educated counterparts.[7,10] It has also been shown that people from countries with strong religious beliefs were less likely to morally accept nanotechnology compared to people with less strong religious beliefs.[17] Another study revealed that people who were "hierarchical" and "individualistic" in their cultural worldviews were more optimistic about nanotechnology compared to those who hold "egalitarian" and "communitarian" worldviews when exposed to balanced information about nanotechnology.[18] Obviously, there is a need for further studies considering peoples' knowledge and perception of nanotechnology, especially among those who will be directly exposed to and work with nanomaterials.

Recently, nanotechnology has been introduced into medicine through a diversity of new materials with applications ranging from diagnosis to treatment.[19,20] In dentistry, nanosized particles are used in the manufacturing of dental materials, such as composites, adhesive systems, impression materials and dental implants.[21-23] Although rapid advances are expected, there are yet no empirically based estimates of the acceptance of nanotechnology in medicine and dentistry. In this context, it is largely unknown how familiar dental students are with this modern technology, their attitude towards it, and whether or not they intend to use nanomaterials in their future dental practice. A social cognition approach facilitates research considering individuals' perception of what influences their behavioural choices. One widely used social cognition model is the theory of planned behaviour (TPB).[24]

1.1 | The theory of planned behaviour

The theory of planned behaviour (TPB) is a social psychological theory to predict and explain social behaviours in terms of specifying the relationship between a set of behavioural socio-cognitive determinants, which in turn mediates the effect of any external variable.[24] TPB assumes that people make decisions based on reasoned considerations of available information and reflect upon the consequences of performing a particular behaviour. Specifically, the TPB hypothesises that the stronger the intention to perform a particular behaviour, the higher is the probability that this behaviour will actually be performed. In turn, behavioural intention is determined by joint influences of three conceptually independent constructs—attitudes towards the behaviour, subjective norms with respect to the behaviour and perceived behavioural control (Figure 1).[24] Attitude reflects individuals' favourable or unfavourable evaluation of performing the particular behaviour. Subjective norm refers to the perceived social pressure to perform or not to perform the behaviour. Perceived behavioural control reflects the perceived ease or difficulty of performing the behaviour. According to the TPB, attitudes, subjective norms and perceived behavioural control influence behaviour indirectly through intention, which is recognised to be the immediate predictor of actual performance of the behaviour.[24] The TPB has shown predictive success with a wide range of health- and consumer-related behaviours in various populations and contexts.[25] This theory constitutes a promising framework for understanding socio-cognitive factors underlying dental students' decision to use or not to use nanomaterials in their future dental practice.

1.2 | Aims

Focusing on dental students in Norway and Romania, this study aimed to assess students' level of knowledge about nanotechnology and to explore socio-cognitive factors underlying their intention to use nanomaterials in future dental practice using the theory of planned behaviour (TPB).[24]

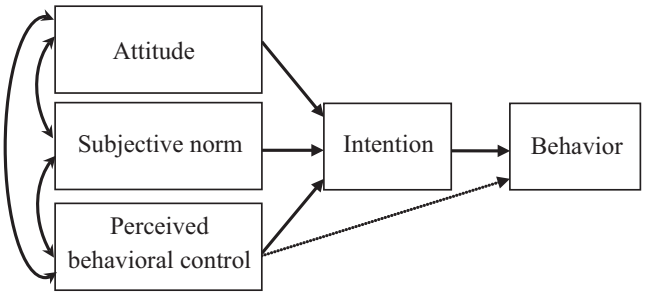

FIGURE 1 The theory of planned behaviour [24]

2 | SUBJECTS AND METHODS

2.1 | Subjects and study design

The present cross-sectional study was conducted between November 2013 and October 2014. It is based on convenient samples of senior dental students attending their fourth and fifth years at the universities of Bergen and Tromsø in Norway and the "Carol Davila" University of Medicine and Pharmacy in Bucharest, Romania. Junior students were not included since they did not complete a course in dental materials and thus were assumed to have little experience of and knowledge about nanotechnology applications in dentistry.

2.2 | Ethical approval

The ethical approval for the survey was obtained from the Norwegian Centre for Research Data and from the Board of the Faculty of Dental Medicine, "Carol Davila" University of Medicine and Pharmacy, Bucharest, Romania. Participation in the study was voluntary. The questionnaire was supplemented by an informed consent letter providing general information about the study.

2.3 | Questionnaire development

Data were collected using a self-administered questionnaire with questions based on previous studies of perception and knowledge.[6,26]

Socio-demographic characteristics were assessed in terms of age, gender and work experience. *Students' familiarity with nanotechnology* was assessed by the question "How much knowledge do you consider that you have about the application of nanotechnology in dental practice?". The response categories were (0) No knowledge, (1) Little, (2) Moderate, (3) Much, (4) Very much. Students with "little, moderate, much and very much" knowledge were asked to answer eight questions, three regarding the definition of nanoparticles and their physico-chemical characteristics and five regarding the current applications of nanotechnology in dentistry. For example, "Nanoparticles in dentistry are described as particles that are less than 100 nm in size." The response categories were (0) I agree, (1) I do not agree and (2) I do not know. "Nanoparticles are already being used in toothpastes, resin composites, bonding systems, impression materials, endodontic materials," with response alternatives (0) Yes, (1) No, (2) I do not know. Each correct answer was counted as 1 and each incorrect or "I do not know" as 0. The sum of correct answers was presented as a knowledge score with the range from 0 to 8. The higher the score, the better the students' knowledge. Students with "No" knowledge were invited to answer *five items* regarding the current applications of nanotechnology in dentistry, though these results were not included in the knowledge score.

Need for information was measured by three items: 1. How much information about the use of nanotechnology in dentistry do you receive through lectures and seminars at your University? ((0) No, (1) Little, (2) Moderate, (3) Excessive), 2. How is the information about the use of nanotechnology in dentistry presented in lectures and seminars at your University? ((0) I do not know, (1) In a more positive light, (2) In a more negative light, (3) In a balanced manner) and 3. Do you want to get more information about the application of nanotechnology in dentistry in the dental curriculum? ((0) No, (1) Yes). The 3 items were analysed independently without creating a sum score.

Components of Ajzen's TPB were measured in terms of attitudes, subjective norms and perceived behavioural control. Intention was assessed in relation to using nanomaterials in future dental practice. In accordance with recommendations from Ajzen (1991), each TPB construct was measured considering the four elements of action (using), target (nanomaterials), context (in dental practice) and time (future).[24] The *intention to use nanomaterials* was measured by one item: "I intend to use nanomaterials in my future dental practice." Responses were indicated on a four-point scale: (1) Strongly disagree, (2) Disagree, (3) Agree and (4) Strongly agree. *Attitude towards nanotechnology in dentistry* was assessed by four items, for example "In my opinion nanotechnology in dentistry can help to prevent and cure diseases." Responses were indicated on a four-point scale ranging from 1 (Strongly disagree) to 4 (Strongly agree). A sum score of attitudes was constructed from the four items. The higher the score, the more positive the attitude. *Attitude towards the use of nanomaterials in future dental practice* was assessed by four items—three positively and one negatively worded, for example "In my opinion, use of restorative dental nanomaterials in my future practice is advantageous." Responses were indicated on a four-point scale ranging from 1 (Strongly disagree) to 4 (Strongly agree). A sum score was constructed after the negatively worded item was reversibly scored. The higher the score, the more positive the attitude. Subjective norms were measured by one item—"My teachers and colleagues want me to use restorative dental nanomaterials in my future dental practice." Responses were indicated on a four-point scale ranging from 1 (Strongly disagree) to 4 (Strongly agree). Perceived behavioural control was measured by one item—"How easy or difficult do you think it will be for you to apply restorative dental nanomaterials in your future dental practice?". Responses were indicated on a four-point scale ranging from 1 (Very difficult) to 4 (Very easy).

A pilot study to test the questionnaire was conducted among 10 PhD students at the Faculty of Dentistry, University of Bergen. The wording of some questions was adjusted according to the comments received. The questionnaire was constructed in English for Norwegian students and translated into Romanian for Romanian students.

2.4 | Data collection

The questionnaires were administered in two ways, online and paper. Online questionnaires were used in all the universities enrolled in the study. At the "Carol Davila" University of Medicine and Pharmacy, the online survey had to be complemented by paper questionnaires, since the online response rate was low.

The online questionnaire was constructed by a web-based tool—"Skjemaker"—developed and maintained by the IT department at University of Bergen. An invitation to participate in the survey was sent through e-mail, and the students were given three weeks to complete the questionnaire. Following this period, two reminders were sent at a two-month interval. In addition, at the "Carol Davila" University of Medicine and Pharmacy paper questionnaires were distributed to the students at the beginning of a lecture and collected at the end. Students who did not deliver the questionnaire were considered as refusing to participate in the survey. In order to increase the response rate, a lottery was drawn among those students who completed the questionnaires.

2.5 | Statistical analysis

Data were analysed using the Statistical package for Social Sciences 22 (SPSS Inc). Bivariate analyses were conducted by the use of independent sample *t* test and chi-square test for continuous and categorical variables, respectively. Pearson's correlation was used to examine bivariate linear relationship between the TPB variables. Socio-cognitive determinants of behavioural intention were identified by multiple linear regression analyses. Standardised regression coefficients (betas) were calculated to assess the independent effect of each TPB construct on the outcome of intention. The fit of the model was reported in terms of the squared multiple correlation coefficient (R^2). Internal consistency reliability was evaluated using Cronbach's alpha. Significance level was set at 5%.

3 | RESULTS

A total of 212 dental students, 52 students in Norway and 160 students in Romania, participated in the survey. The response rates were 39% (52/ 132) and 27% (160/ 600) in Norway and Romania, respectively. Table 1 depicts the percentage distribution of students by socio-demographic characteristics and country. Of the participating Norwegian students, 13.5% (n = 7) belonged to the younger age group (18-22 years) and 34.6% (n = 18) were males. The corresponding figures for Romanian participants were 73.1% (n = 117) and 22.5% (n = 36), respectively. A total of 46.2% of the Norwegian students vs 92.5% of the Romanian students were in their 4th study year ($P < .001$) (Table 1).

TABLE 1 Percentage distribution of students by socio-demographic characteristics and country of residence

	Norway n (%)	Romania n (%)
Age		
Younger (18-22)	7 (13.5)	117 (73.1)**
Older (23-52)	45 (86.5)	43 (26.9)
Sex		
Male	18 (34.6)	36 (22.5)^{ns}
Female	34 (65.4)	124 (77.5)
Study year		
4th year	24 (46.2)	148 (92.5)**
5th year	28 (53.8)	12 (7.5)
Work experience		
No	21 (40.4)	49 (30.6)^{ns}
Yes	31 (59.6)	111 (69.4)
Total	52 (100)	160 (100)

**$P < .001$.
Abbreviation: ns, not significant.

3.1 | Knowledge

About half of the students in Norway and Romania reported to have little knowledge about nanotechnology (44.2% vs 46.9%, $P < .001$, respectively) (Table 2). A much higher percentage of Romanian students reported to have no knowledge about nanotechnology compared to Norwegian students (38.1% vs 15.4%, $P < .001$). Among the respondents who confirmed having little and more knowledge, lectures and seminars were the most frequently reported source of information; Norwegian students stated this source more frequently than their Romanian counterparts (95.5% vs 65.7%, $P < .001$). Internet was the second most popular source of information. Whereas the majority of participants reported that they received no or little information about nanotechnology at the university, students from Norway were significantly more likely than those from Romania to have received moderate/excessive amount of information on the subject (21.2% vs 6.3%, $P < .05$). A desire to learn more about nanotechnology was expressed by more than 90% of all students.

Respondents were asked about how the information about nanotechnology was presented at the university. A balanced way of presenting the information by academicians was reported by 53.8% of Norwegian and 32.3% of Romanian students (Table 2). A positive way of presenting the information was reported by 32.7% and 22.8% of Norwegian and Romanian participants, respectively. None of the Norwegian students and 2.5% of Romanian students replied that the information was presented negatively.

Approximately 70% of the participants in Norway and Romania were able to identify the correct definitions (Table 3). Whereas approximately 10% of students responded that nanoparticles can be more toxic, more than 70% acknowledged that nanoparticles could more easily penetrate tissues and cells. Students were well aware that nanoparticles are already being used in resin composites and bonding systems, but only about one-third of them were aware of their possible presence in toothpastes, impression and endodontic materials. The only significant difference between Norwegian and Romanian students concerned the application of nanoparticles in bonding systems ($P < .05$).

The mean knowledge sum score did not differ significantly between Norwegian and Romanian students (4.4 ± 1.7 and 4.2 ± 1.4) indicating limited knowledge of the subject matter (Table 4). Respondents from both countries had favourable attitudes towards

TABLE 2 Percentage distribution of students by knowledge and country of residence

	Norway n (%)	Romania n (%)
How much knowledge about nanotechnology do you have?		
No	8 (15.4)	61 (38.1)*
Little	23 (44.2)	75 (46.9)
Moderate	19 (36.5)	18 (11.3)
Much/very much	2 (3.8)	6 (3.8)
Where did you receive the information from?[a]		
Lectures/seminars	42 (95.5)	65 (65.7)**
Books	14 (31.8)	17 (17.2)[ns]
Journals	12 (27.3)	19 (19.2)[ns]
Newspapers	1 (2.3)	4 (4.0)[ns]
Internet	15 (34.1)	48 (48.5)[ns]
Radio/TV	4 (9.1)	2 (2.0)[ns]
Classmates	7 (15.9)	22 (22.2)[ns]
How much information about nanotechnology did you receive at the university?		
No/Little	41 (78.8)	150 (93.8)*
Moderate/Excessive	11 (21.2)	10 (6.3)
How is the information about nanotechnology presented at the university?		
Positively	17 (32.7)	36 (22.8)[ns]
Negatively	0 (0.0)	4 (2.5)
In a balanced way	28 (53.8)	51 (32.3)
I do not know	7 (13.5)	67 (42.4)
Do you want to receive more information about nanotechnology?		
Yes	47 (90.4)	157 (98.1)[ns]
No	5 (9.6)	3 (1.9)

**$P < .001$, *$P < .05$.

Abbreviation: ns, not significant.

[a]The question is answered by students who reported to have little or more knowledge about nanotechnology.

nanotechnology in general (11.5 ± 1.6 for Norwegian and 11.4 ± 2.0 for Romanian students) as well as towards the use of dental nanomaterials (10.7 ± 1.4 and 10.9 ± 1.8 for Norwegian and Romanian students, respectively). Students reported moderately strong control perceptions and intentions to use nanomaterials, and moderate normative pressure. According to the independent sample *t* test, no significant differences were found between Norwegian and Romanian students. Internal consistency reliability in terms of Cronbach's alpha was 0.54 for attitudes towards nanotechnology in Norway and 0.70 in Romania, and 0.62 and 0.70 for attitudes towards the use of nanomaterials in Norway and Romania, respectively.

3.2 | Prediction of intention to use nanomaterials using the theory of planned behaviour

In the bivariate analysis (Table 5), positive Pearson's correlations were observed between the intention to use nanomaterials on one hand and attitudes towards nanotechnology in dentistry (0.35, $P < .05$), attitudes towards the use of dental nanomaterials (0.48, $P < .001$), subjective norms (0.46, $P < .001$) and perceived behavioural control (0.33, $P < .05$) on the other hand among Norwegian students. Corresponding correlations were stronger, except for subjective norms, among students from Romania (0.45, $P < .001$; 0.63, $P < .001$; 0.42, $P < .001$; 0.36, $P < .001$ for all four constructs, respectively).

Students' intention to use nanomaterials was regressed on attitudes, subjective norms and perceived behavioural control using multiple linear regression analysis stratified by country (Table 6). Attitude towards the use of dental nanomaterials was the strongest predictor of intention among Norwegian (beta = 0.26, $P > .05$) and Romanian (beta = 0.47, $P < .001$) students as well as in the merged Norwegian-Romanian sample (beta = 0.42, $P < .001$). Subjective norms were the second strongest predictor among Norwegians (beta = 0.23, $P > .05$), Romanians (beta = 0.19, $P < .001$) and in the merged sample (beta = 0.19, $P < .001$), followed in descending order by attitudes towards nanotechnology and perceived behavioural control. When added into the model as an independent variable, country of residence was not statistically significantly associated with intention to use nanomaterials. The TPB explained, as expressed by *R* squared, 32%, 45% and 42% of students' intention among Norwegians, Romanians and in the total merged sample, respectively.

4 | DISCUSSION

4.1 | Knowledge about nanotechnology and sources of information

Consistent with the results from previous studies, the Norwegian and Romanian dental students recognised themselves to be quite unfamiliar with nanotechnology.[6,7] Interestingly, a higher proportion of Norwegian than Romanian students reported having moderate knowledge about nanotechnology (Table 2). Participants from both countries seemed to underestimate the toxicological effects of nanoparticles. Although most of the students agreed that nanoparticles penetrate cells easier than larger particles of the same material, few students agreed that nanoparticles can be more toxic when compared to the larger particles (Table 3). A possible explanation can be a lack of knowledge regarding toxicity in general and nano-toxicity in particular. Additionally, few students demonstrated general knowledge regarding the application of nanomaterials in dentistry. Most of the respondents knew that nanoparticles are used in resin composites and bonding systems. Still, around one-third of the students were not aware of the application of nanoparticles in toothpastes, endodontic and impression materials. These findings suggest that dental students in Norway and Romania have limited knowledge about the broad application of nanotechnology in dentistry.

For most of the Norwegian and Romanian students, lectures and seminars were the main source of information about

TABLE 3 Percentage distribution of students by correct answers for knowledge test and country of residence

	Norway n (%)	Romania n (%)
Nanoparticles are described as particles that are less than 100 nm in size[a]	31 (70.5)	68 (69.4) [ns]
Nanoparticles can be more toxic than the larger particles of the same material[a]	6 (13.6)	10 (10.2) [ns]
Due to their small size, nanoparticles can penetrate tissues and cells easier than larger particles of the same material[a]	31 (70.5)	74 (75.5) [ns]
Nanoparticles are already being used in:		
Toothpaste	18 (34.6)	68 (44.2)[ns]
Resin composites	46 (88.5)	129 (81.1)[ns]
Bonding systems	40 (76.9)	83 (52.9)*
Impression materials	16 (30.8)	36 (24.0)[ns]
Endodontic materials	20 (38.5)	49 (32.7)[ns]

*$P < .05$.
Abbreviation: ns, not significant.
[a]The question is answered by students who reported to have little or more knowledge about nanotechnology.

TABLE 4 Knowledge score, attitudes, subjective norms, perceived control and intention according to country of residence

				Norway			Romania		
	Item	Range	Theoretical range	Mean	SD	α	Mean	SD	α
Knowledge score[a]	8	0-8	low-high	4.4	1.7		4.2[ns]	1.4	
Attitudes towards nanotechnology	4	4-16	low-high	11.5	1.6	0.54	11.4[ns]	2.0	0.70
Attitudes towards the use of nanomaterials	4	4-16	low-high	10.7	1.4	0.62	10.9[ns]	1.8	0.70
Subjective norms	1	1-4	low-high	2.6	0.7		2.5[ns]	0.6	
Perceived control	1	1-4	low-high	2.9	0.6		2.7[ns]	0.6	
Intention to use nanomaterials	1	1-4	low-high	3.0	0.5		2.9[ns]	0.7	

Abbreviation: ns, not significant.
[a]Based on replies of students who reported to have little or more knowledge about nanotechnology.

TABLE 5 Bivariate Pearson's correlations of TPB variables with intention to use nanomaterials in future dental practice

Variable	Norway	Romania
Attitude towards nanotechnology	0.35*	0.45**
Attitude towards the use of nanomaterials	0.48**	0.63**
Subjective norms	0.46**	0.42**
Perceived behavioural control	0.33*	0.36**

**$P < .001$, *$P < .05$.
Abbreviation: ns, not significant.

nanotechnology (Table 2). At the same time, most of the students from both countries considered that they received no/little information at the University and that they would like to receive more. It is important to note that students had different perception about how the information about nanotechnology was presented by the lecturers: positively, in a balanced way or negatively. These findings suggest that even though participants received information mainly from the same source (university lectures/seminars), their perception of it was different. Introducing information about nanotechnology to students may be a challenging process since the question of nanosafety has not been completely answered. Discussion of such a controversial topic might result in misinterpretations indicating that more attention should be paid to the mode of presentation of teaching materials so that students could have a better understanding about the benefits and risks associated with nanotechnology.

4.2 | Predicting intention to use nanomaterials-the TPB

Most of the respondents (77.5% in Romania and 86.5% in Norway) intended to use nanomaterials in their future dental practice (data not presented). The results of the multivariate linear regression revealed that the combination of attitudes, subjective norms and

TABLE 6 Covariates of intention to use nanomaterials by country of residence and in the total sample

	Norway		Romania		Total	
Model	R^2	Beta	R^2	Beta	R^2	Beta
Step 1						
Attitude towards nanotechnology		0.19		0.15*		0.16**
Attitude towards the use of nanomaterials		0.26		0.47**		0.42**
Subjective norm		0.23		0.19**		0.19**
Perceived behavioural control		0.07		0.04		0.04
	0.32		0.45		0.42	
Step 2						
Country						−0.06
					0.42	

**P < .001, *P < .05.
Abbreviation: ns, not significant.

perceived behavioural control provided a better explanation of intention to use nanomaterials among the Romanian than among the Norwegian students. According to the findings depicted in Table 6, the TPB predictors did reach statistical significance only among Romanian students and in the merged sample, probably due to low statistical power in the Norwegian sample. Attitude towards the use of dental nanomaterials was the strongest predictor of students' intention, while attitude towards nanotechnology in dentistry had weaker but still considerable impact. In accordance with the TPB, students with positive attitudes were motivated to use innovative dental materials in their prospective dental practice. The present findings correspond with those of a study from New Zealand where attitudes turned out to be the strongest predictor of intention to buy meat genetically modified by nanotechnology.[27] The results of the modelling followed the common pattern of TPB studies with attitude as the strongest predictor of intention as suggested by a meta-analytic review by Conner and Armitage.[25] Subjective norms were the second strongest predictor of intention indicating that a strong approval from students' colleagues and/or teachers regarding the use of nanomaterials is important for their motivation. Thus, social opinion about the application of innovative technology plays an important role in students' perceptions. Contrary to a number of studies across health-related behaviours,[28] perceived behavioural control did not significantly predict the intention to use nanomaterials and ranked last among the theoretical determinants. The TPB analysis helps uncover specific perceptions that can affect students' intention to use nanomaterials in the future. Thus, intention to use nanomaterials in future dental practice among Norwegian and Romanian students can change to become stronger or weaker by providing information that modifies behavioural and normative beliefs, since the intention to use nanomaterials was most strongly determined by attitudes and subjective norms. Notably, however, care should be taken when providing information about nanomaterials, so that the students base their intentions to use them on reliable sources and scientific evidence.

4.3 | Need for curriculum modification

The limited level of students' knowledge about the use of nanotechnology in dentistry together with their willingness to receive more information about this innovative technology during the academic process suggested that there is a need for a curriculum adjustment. The focus should be set on nanomaterials applications as well as the associated benefits and risks. It should be noted that more needs to be known about the effects of nanomaterials on human health and the environment in order to better evaluate the risks associated with their applications.

4.4 | Limitations

Self-selection of the students to participate in a survey might have biased the present results. Probably only those students who were interested in and familiar with nanotechnology responded to the survey invitation. This might be an explanation of the low response rate. Two reminders were sent to Norwegian students in order to increase the number of replies. Moreover, in Romania only 16% of students replied to the online invitation. We assumed that the reason was not only the unwillingness to answer, but low usage of the university e-mail and lack of experience in completing online questionnaires. Therefore, the online survey was complemented by a paper survey.

Since students were included after they had completed the course in Biomaterials, participants from Norway were slightly older than those from Romania due to the difference in the curricula. At the time when the survey was conducted, Norwegian students had the Biomaterials course in their 4th and Romanian in their 3rd year of studies.

This study might have limited generalisability. In Norway, students from two universities were invited to participate in the survey, but only 6 students from the University of Tromsø replied. In Romania, dental students were recruited from one University only. Although the representativeness of the findings is unknown, we

believe that the study captured main patterns of dental students' knowledge about and attitudes towards nanotechnology.

5 | CONCLUSION

The present findings suggest that there is a limited level of knowledge about nanotechnology among dentals students in Norway and Romania. Students expressed willingness to receive more information about nanotechnology during their academic studies. Thus, there seems to be a need for curriculum modification in which the use of this innovative technology in dentistry should be addressed. The findings suggest further that the TPB is applicable to the prediction of students' intention to use nanomaterials in the context of dentistry. The intention to use nanomaterials in future dental practice was primarily influenced by attitudes followed by subjective norms, whereas perceived behavioural control had no impact. The theory of planned behaviour provided a better explanation of intention to use nanomaterials among the Romanian than among the Norwegian students. These findings suggest that educational messages should focus on students' attitudes and beliefs they hold about advantages and disadvantages associated with the use of nanomaterials. In general, information about nanotechnology should be presented in a balanced manner, so that students could adequately assess the benefits and risks connected with its applications.

ACKNOWLEDGEMENTS

The authors would like to thank Stein Atle Lie for valuable advises concerning statistical analysis, Helge Opedal for the help to program the online questionnaire, PhD students at the Department of Clinical Dentistry, University of Bergen, for participating in a pilot testing and providing valuable comments and dental students at the University of Bergen, University of Tromsø and "Carol Davila" University of Medicine and Pharmacy for taking their time to answer the questionnaire.

ORCID

Victoria Xenaki https://orcid.org/0000-0001-9391-2153

REFERENCES

1. What it is and how it works. Available from: http://www.nano.gov/nanotech-101/what. Accessed 07 Apil 2017.
2. Pidgeon N, Harthorn BH, Bryant K, Rogers-Hayden T. Deliberating the risks of nanotechnologies for energy and health applications in the United States and United Kingdom. *Nat Nanotechnol*. 2009;4(2):95-98.
3. Service RF. Nanotechnology - calls rise for more research on toxicology of nanomaterials. *Science*. 2005;310(5754):1609.
4. Allouni ZE, Hol PJ, Cauqui MA, Gjerdet NR, Cimpan MR. Role of physicochemical characteristics in the uptake of TiO"2 nanoparticles by fibroblasts. *Toxicol In Vitro*. 2012;26(3):469-479.
5. Vamanu CI, Cimpan MR, Hol PJ, Sornes S, Lie SA, Gjerdet NR. Induction of cell death by TiO2 nanoparticles: studies on a human monoblastoid cell line. *Toxicol In Vitro*. 2008;22(7):1689-1696.
6. Retzbach A, Marschall J, Rahnke M, Otto L, Maier M. Public understanding of science and the perception of nanotechnology: the roles of interest in science, methodological knowledge, epistemological beliefs, and beliefs about science. *J Nanopart Res*. 2011;13(12):6231-6244.
7. Vandermoere F, Blanchemanche S, Bieberstein A, Marette S, Roosen J. The morality of attitudes toward nanotechnology: about God, techno-scientific progress, and interfering with nature. *J Nanopart Res*. 2010;12(2):373-381.
8. Cobb MD, Macoubrie J. Public perceptions about nanotechnology: risks, benefits and trust. *J Nanopart Res*. 2004;6(4):395-405.
9. Castellini OM, Walejko GK, Holladay CE, Theim TJ, Zenner GM, Crone WC. Nanotechnology and the public: effectively communicating nanoscale science and engineering concepts. *J Nanopart Res*. 2007;9(2):183-189.
10. Bainbridge WS. Public attitudes toward nanotechnology. *J Nanopart Res*. 2002;4(6):561-570.
11. Besley JC, Kramer VL, Priest SH. Expert opinion on nanotechnology: risks, benefits, and regulation. *J Nanopart Res*. 2008;10(4):549-558.
12. Ho SS, Scheufele DA, Corley EA. Value predispositions, mass media, and attitudes toward nanotechnology: the interplay of public and experts. *Sci Commun*. 2011;33(2):167-200.
13. Siegrist M, Keller C, Kastenholz H, Frey S, Wiek A. Laypeople's and experts' perception of nanotechnology hazards. *Risk Anal*. 2007;27(1):59-69.
14. Scheufele DA, Corley EA, Dunwoody S, Shih TJ, Hillback E, Guston DH. Scientists worry about some risks more than the public. *Nat Nanotechnol*. 2007;2(12):732-734.
15. Nerlich B, Clarke DD, Ulph F. Risks and benefits of nanotechnology: How young adults perceive possible advances in nanomedicine compared with conventional treatments. *Health Risk Soc*. 2007;9(2):159-171.
16. Gardner G, Jones G, Taylor A, Forrester J, Robertson L. Students' risk perceptions of nanotechnology applications: implications for science education. *Int J Sci Educ*. 2010;32(14):1951-1969.
17. Scheufele DA, Corley EA, Shih TJ, Dalrymple KE, Ho SS. Religious beliefs and public attitudes toward nanotechnology in Europe and the United States. *Nat Nanotechnol*. 2009;4(2):91-94.
18. Kahan DM, Braman D, Slovic P, Gastil J, Cohen G. Cultural cognition of the risks and benefits of nanotechnology. *Nat Nanotechnol*. 2009;4(2):87-90.
19. Emerich DF, Thanos CG. Nanotechnology and medicine. *Expert Opin Biol Ther*. 2003;3(4):655-663.
20. Saunders SA. Current practicality of nanotechnology in dentistry. Part 1: Focus on nanocomposite restoratives and biomimetics. *Clin Cosmet Investig Dent*. 2009;1:47-61.
21. Hannig M, Hannig C. Nanomaterials in preventive dentistry. *Nat Nanotechnol*. 2010;5(8):565-569.
22. Mitra SB, Wu D, Holmes BN. An application of nanotechnology in advanced dental materials. *J Am Dent Assoc*. 2003;134(10):1382-1390.
23. Subramani K, Ahmed W. *Emerging Nanotechnologies in Dentistry: Processes, Materials and Applications*. Oxford, UK: Elsevier; 2011:15-80.
24. Ajzen I. The theory of planned behavior. *Organ Behav Hum Dec*. 1991;50(2):179-211.
25. Armitage CJ, Conner M. Efficacy of the theory of planned behaviour: a meta-analytic review. *Brit J Soc Psychol*. 2001;40:471-499.

26. Autio-Gold JT, Tomar SL. Dental students' opinions and knowledge about caries management and prevention. *J Dent Educ*. 2008;72(1):26-32.
27. Cook AJ, Fairweather JR. Intentions of New Zealanders to purchase lamb or beef made using nanotechnology. *Brit Food J*. 2007;109(9):675-688.
28. Godin G, Kok G. The theory of planned behavior: a review of its applications to health-related behaviors. *Am J Health Promot*. 1996;11(2):12.

How to cite this article: Xenaki V, Marthinussen MC, Costea DE, et al. Knowledge about nanotechnology and intention to use nanomaterials: A comparative study among dental students in Norway and Romania. *Eur J Dent Educ*. 2019;00:1–9. https://doi.org/10.1111/eje.12470