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ORIGINAL RESEARCH

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Understanding nutrition students' knowledge, perceived barriers and their views on the future role of nutritionists regarding sustainable diets

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Abstract

Nutrition professionals are important stakeholders in sustainable food systems with skills to promote the connection between health, food production, environment, culture and economics. Higher education institutions are increasingly recognising the importance of teaching about sustainability, yet there exists a gap in the literature detailing the awareness of sustainability issues by nutrition students. This study aimed to ascertain the level of knowledge of sustainable diets (SDs), the perceived barriers to their adoption in their own diets, students' experience of university-based teaching about SDs and their views on the future role of the nutrition profession in relation to SD amongst nutrition students on Association for Nutrition (AfN)-accredited degrees. The study assessed environmental and sustainable food literacy (SFL) through an online questionnaire and explored the issues in more detail in virtual or face-to-face interviews in 2019. Quantitative data were analysed using descriptive statistics (Kruskal-Wallis, Jonckheere-Terpstra, independent *t*-test, Spearman, Pearson Correlations). Qualitative data were analysed using the Braun and Clark (2006) six-step approach to thematic analysis. The questionnaire responses ($n = 51$) represented 17 AfN-accredited undergraduate courses (35% of AfN-accredited universities in 2019). The majority (76%) of students had received an introduction, partaken in a module or received teaching on SDs throughout their whole degree. Students were predominantly environmentally literate, yet had a fragmented understanding of SDs, focusing on the environmental aspects of SDs. There was no correlation between SFL and reported sustainability content of university courses, highlighting a need for more effective teaching on sustainability topics. Additionally, no relationship between self-reported diet intake and SFL was found. Students identified a lack of knowledge and education as barriers preventing them from adopting sustainable practices in the present and future. To integrate sustainability into their future practice more consistently and effectively, nutrition students require more structured, holistic sustainability education and knowledge.

KEYWORDS

Association for Nutrition, barriers to practice, nutrition education, nutrition students, sustainable diets, university level education

INTRODUCTION

Food system sustainability is an urgent issue. The food system is the intricate network of activities, resources and people that brings food from farm to table and beyond (Parsons et al., 2019). However, current global food systems are unsustainable and are linked to negative effects on malnutrition (Global Nutrition Report, 2022) and public health (Murray et al., 2020), and transgress many planetary boundaries (Rockström et al., 2020). These issues illustrate the need to accelerate the transition to more sustainable food systems that contribute to food security and nutrition without undermining environmental, economic, social and cultural functions currently and for future generations (Global Panel on Agriculture and Food Systems for Nutrition, GLOPAN, 2023; von Braun et al., 2021).

A vital outcome of sustainable food systems is healthy dietary patterns, linked to citizen's choices which are influenced by experiences, personal drivers (e.g. knowledge, habits, preferences) and sociocultural patterns (e.g. norms, values, beliefs) (Monterrosa et al., 2020). The quality and quantity of these choices are in turn influenced by the availability, accessibility and affordability of foods within the 'food environment' (Contento, 2008). Similar to sustainable food systems, sustainable diets (SDs) promote health and wellbeing, while achieving economic, sociocultural and environmental requirements (FAO & WHO, 2019).

Awareness and knowledge of SDs have grown, notably in sub-populationss, such as women (Kenny et al., 2023) and young men (Whittall et al., 2023). Regardless of this rise, a Food Standards Agency poll found that less than half (48%) of consumers know what a SD consists of, although over half would like to improve their diets to make them more sustainable (54%) (Heard & Bogdan, 2021). Given their education and competencies in food, nutritional adequacy and healthy eating (Pettinger, 2018), nutrition professionals are in a strong position to influence people's choices and food policy (Goodridge et al., 2022; Innes et al., 2018; Mason & Lang, 2018). SD have also been highlighted as a 'professional growth area' (Goodridge et al., 2022; Pettinger, 2018).

Professional associations such as the British Dietetic Association (BDA) and Association for Nutritionists (AfN) in the United Kingdom help to protect the public by setting rigorous standards of practice and the accreditation of undergraduate and postgraduate degrees (AfN, 2022; BDA, 2023). In relation to sustainable food systems, the AfN recently updated their core competency 'Food or Feed Chain' to 'Food Systems' to include more accessible language (AfN, 2023) and a more holistic assessment of food systems knowledge. This growth in SDs within the profession can also be linked to growing awareness and interest from registered dietitians (RD) and nutritionists, especially in Australia (Burkhart et al., 2020), Canada (Carlsson, Callaghan et al., 2019), United Kingdom (Pettinger et al., 2018) and the United States (Heidelberger et al., 2017).

Despite interest and evidence to support the need for action, there is a lack of evidence exploring whether nutrition students in the United Kingdom are professionally equipped for a future that involves sustainable food systems. As such, this study aims to ascertain the level of knowledge of SDs amongst students on AfN-accredited courses, explore the barriers that prevent students from using SDs in practice in their own diets, their experience of university-based teaching about SDs and their views on the future role of the nutrition profession in relation to SDs.

METHODS

Design

The philosophical assumption that guided this research was pragmatism (i.e. knowledge is created through justified statements that have resulted from taking action and experiencing the outcomes Morgan, 2014). With this interpretive framework in mind, the researchers focussed on mixed methods of data collection and the practical implications for the research aims (Creswell & Poth, 2018). Mixed methods were employed in a sequential model, following a similar approach by Ede et al. (2011, Figure 1). This approach involves using quantitative data collection, followed by qualitative data to explore the research aims in more depth with a few cases (Molina-Azorin, 2016), and as such, allowing for a better understanding of the research aims than either approach alone (Creswell & Plano Clark, 2007). The researchers triangulated the methods to interpret the findings to offer credibility and validity to the findings (Lincoln & Guba, 1985).

Phase 1: Questionnaire

A self-administered, online questionnaire (S1), adapting Ede et al. (2011) and Innes et al. (2018) questionnaires, was developed. The questionnaire had four sections: introduction to the questionnaire with demographic queries, environmental literacy assessment, sustainability of individual diet and 'sustainable food literacy' assessment. Students were provided a brief introduction to the questionnaire and a definition of SDs by Burlingame and Dernini (2010). Demographic data covered university level, degree title, university, entry qualifications, age, sex, degree of sustainability education and environmental organisation membership. 'Environmental literacy' (EL) refers to the capability of making environmentally responsible behaviours (Innes et al., 2018). The environmental literacy components model suggests that higher levels of environmental knowledge tend to increase

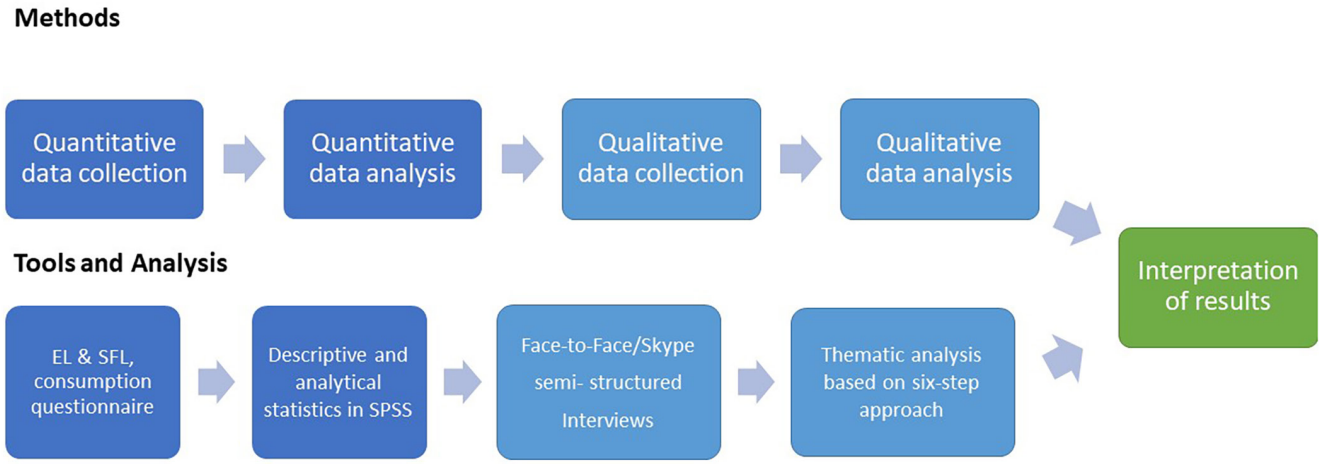

FIGURE 1 The mixed methods study design along with tools and analysis used. EL, environmental literacy; SFL, sustainable food literacy.

personal responsibility and sustainable behaviours (Teksoz et al., 2011). As such, the Innes et al. (2018) questionnaire was chosen since it incorporated several aspects of SD knowledge, attitude and literacy and was the only EL assessment tool that was discipline-specific. The original questionnaire by Innes et al. (2018) consisted of eight food-related sustainability statements; however, this was narrowed for the purpose of the study before piloting to the four most relevant statements, as the authors felt more would have placed a time constraint on the students during the lead up to the exam period. Students were asked to indicate the extent to which they agreed or disagreed with the four statements.

The third section of the questionnaire included a food frequency table, where students noted eating habits by number of times they ate the eight food categories in a week, purchase considerations based on certain criteria such as price, taste, country of origin, as well as self-rated sustainability of their diets (in 25% intervals) (S1, Section C).

Lastly, 'sustainable food literacy' (SFL) refers to the capability of making sustainable food choices (Innes et al., 2018). This section established the SFL score of each participant based on nine multiple-choice questions from Innes et al. (2018) and other literature (Gerber et al., 2013; Kim et al., 2015; Macdiarmid, 2013; Springmann et al., 2018). Following the analysis, question 10 was disregarded, since the multi-choice options were found to be incorrect. At the end of the questionnaire, students could indicate whether they would participate in an interview at a later stage.

Procedure

The questionnaire was developed, peer-reviewed and piloted in December 2018 by a group of 10 first-year Liverpool John Moores University (LJMU) BSc Nutrition students. Students were asked to fill out the questionnaire and provide feedback written or verbally during the session. Limited changes, except for grammatical errors were made to the questionnaire because of testing.

Data analysis

Questionnaire data were analysed using SPSS. v25 (Armonk, NY: IBM Corp). Each participant was given a score (0–16 points) for their EL (8 points described a neutral stance, lower scores indicated broadly higher EL and vice versa; Shephard et al., 2009), and a score (0–9 points) for their SFL (4.5 indicated a neutral understanding, lower scores indicated lower SFL and vice versa). Descriptive and analytical statistics (Kruskal-Wallis, Jonckheere-Terpstra, independent *t*-test, Spearman and Pearson correlation) were performed and alpha was set at $p < 0.05$.

Phase 2: Semi-structured interviews

Semi-structured interviews were used to complement the questionnaire and investigated students' opinions, knowledge of SDs, teaching received on sustainability, the perceived challenges of providing SD advice in the future and views on the role of the nutrition profession. Semi-structured interviews were chosen for the method's ability to yield in-depth and detailed information while allowing the students the freedom to express their views (Gillham, 2000).

Procedure

The interview schedule was developed by the first and third authors and based on Ede et al. (2011) and Pettinger et al. (2018) research and a wider review of the

literature-(S2). The interview schedule comprised of two sections: (1) understanding students' own views on SDs and the barriers to their implementation and (2) their experience of university-based teaching about SDs and their confidence in applying sustainability in practice. Students were interviewed either face-to-face on LJMU premises or online via Skype by the first author and had previously indicated their willingness to be interviewed in the Phase 1 questionnaire. The first author had received training in qualitative research as part of a final-year research methods module delivered at the university. Interviews were recorded and transcribed verbatim.

Data analysis

Data were analysed using the thematic analysis method proposed by Braun and Clarke (2006), which is a powerful tool for seeking an understanding of a set of experiences, thoughts or behaviours (Clarke & Braun, 2014). Interview transcriptions were annotated and analysed line by line for important meanings and understandings and then re-read multiple times by the first author. The first and third authors employed an inductive approach to collate key points into categories and overarching themes (Braun & Clarke, 2006). Any disputes were settled with the second author. The barriers mentioned by the students were categorised into structural (outside the individual's control) and behavioural (related to the individual's emotional, cognitive or social capacities) to understand where students did and did not have personal control.

Recruitment

Final-year students in AfN-accredited undergraduate nutrition courses were purposively sampled (Denscombe, 2017). At the time of the study, there were 49 AfN-accredited universities (AfN, 2023a). AfN requirements state that students must have competencies within the food chain (AfN, 2023b), as such, final-year students were more likely to have received teaching on this topic compared to first- and second-year students. Recruitment started in January 2019 through the AfN e-newsletter, emails to programme leaders on the Accredited Undergraduate Degree Programme specifications and to student societies, and through the first author's personal Twitter account. The study aimed to recruit 100 student questionnaires and 10 semi-structured interviews.

Ethics approval

Ethical approval (ethics number: 18/SSLN_Marsh/NU/07) for the study was obtained from the research Supervisor at LJMU. Prior to the questionnaire and interviews, all students were required to read the Participant Information and give their consent for being involved and for the interview to be recorded.

RESULTS

The results are described through the phases of the study, whereby Phase 1 involved the questionnaire, answering the research objective regarding knowledge of SDs, university content of SDs and self-reported sustainability of diets and Phase 2 involved the semi-structured interview, deepening the responses to knowledge of SDs, the barriers students face in adopting SDs, their experience of university-based teaching about SDs and their views on the future role of the nutrition profession in relation to SDs.

Phase 1: Questionnaire

The online questionnaire yielded 52 responses, although one response was excluded due to item non-response giving a total of 51 responses (females = 87%). Most students were aged 18–25 years (75%). Seventeen universities were represented from 49 AfN-accredited universities (35%) (AfN, 2018a, 2018b). Most students (78%) were not members of any environmental organisations but 18% said they were interested in joining one in the future.

Knowledge of sustainable diets

The mean score for SFL was 4 out of 9 points (SD = 1.6) and the EL score was 6 out of 16 points (SD = 2.5). A Pearson Correlation found no significant correlation between the two ($r = -0.193$, $p = 0.176$) although a Jonckheere-Terpstra Test for ordinal alternatives found a significant trend between Q2 of EL; 'The so called 'ecological crisis' facing humankind has been greatly exaggerated' and SFL (TJT = 318.500, $z = -2.199$, $p = 0.028$) indicating that SFL scores decreased as students answered with environmentally literate answers (closer to mildly and strongly disagree). Students were predominantly 'green' in their environmental literacy, answering either strongly disagree or mildly disagree to all EL questions (Figure 2).

Students were asked if they had received education on sustainability issues in their degree, and 76% answered that sustainability content had either been briefly introduced, included in a module or throughout the entire degree. While AfN-accredited courses require taught modules on the food chain, in which SDs may feature, 24% of students either could not remember receiving or had not received any teaching.

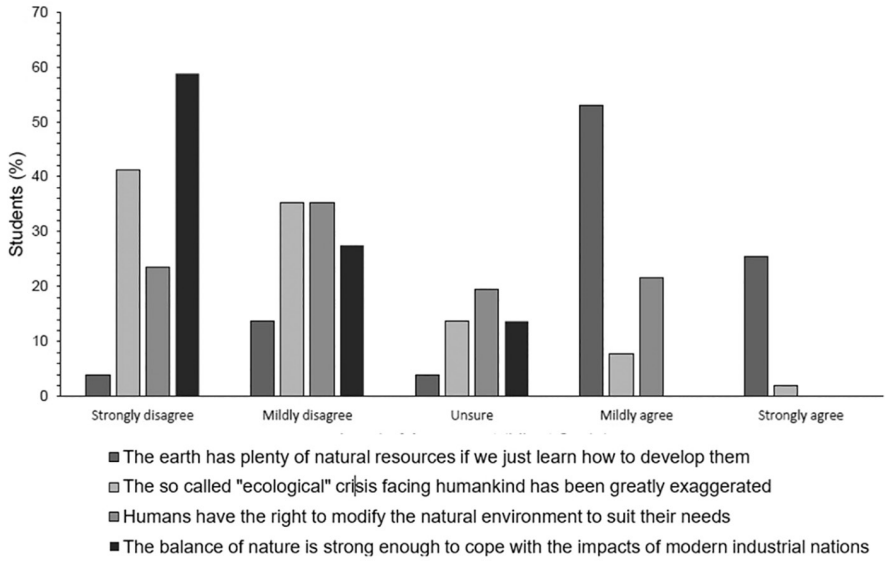

FIGURE 2 Frequency of level of agreement to environmental literacy statements.

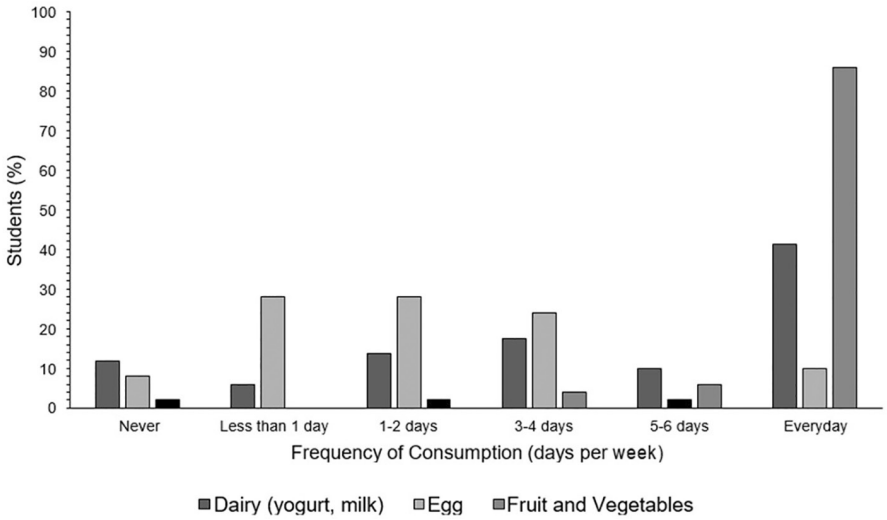

FIGURE 3 Frequency of consumption of dairy, eggs, fruit and vegetables.

A Kruskal-Wallis *H*-test showed that there was a statistically significant difference between levels of SFL and the sustainability content in university ($X2(5) = 11.510$, $p = 0.042$), however, a Jonckheere-Terpstra Test for ordinal alternatives found no statistically significant trend in the data (TJT = 445.50, $z = -0.446$, $p = 0.656$). This signified that SFL did not increase as university content on sustainability increased. A pairwise comparison found a significant difference between 'No, I haven't heard of these topics' and 'Yes, but I have heard about it out of university' ($p = 0.032$), indicating university content did not influence SFL, but whether the student had been exposed to the topic did.

Self-reported sustainability of diets

Under half (45%) of the students considered their diets to be 50% sustainable, while only 22% considered their diets to be 75% sustainable. A Pearson's Correlation found no significant relationship between SFL and self-reported sustainability of diet ($r = -0.188$, $p = 0.410$). Frequency of consumption results indicate that nutrition students eat red meat infrequently (78% either never or less than once a week), with the majority eating some type of meat between 1 and 2 days a week (Figure 4). Fruit and vegetable and grains intake were more frequent with most students eating these every day (Figure 5), while dairy, egg, nuts and plant-based proteins were consumed less frequently (Figures 3 and 5).

A Spearman's correlation was run to determine the relationships between SFL and self-reported dietary intake. However, only a moderately strong, negative correlation was found between SFL and red meat intake ($r = -0.445$, $p = 0.001$) and poultry ($r = -0.395$, $p = -0.004$), suggesting that students with higher intakes of red meat and poultry were more likely to have

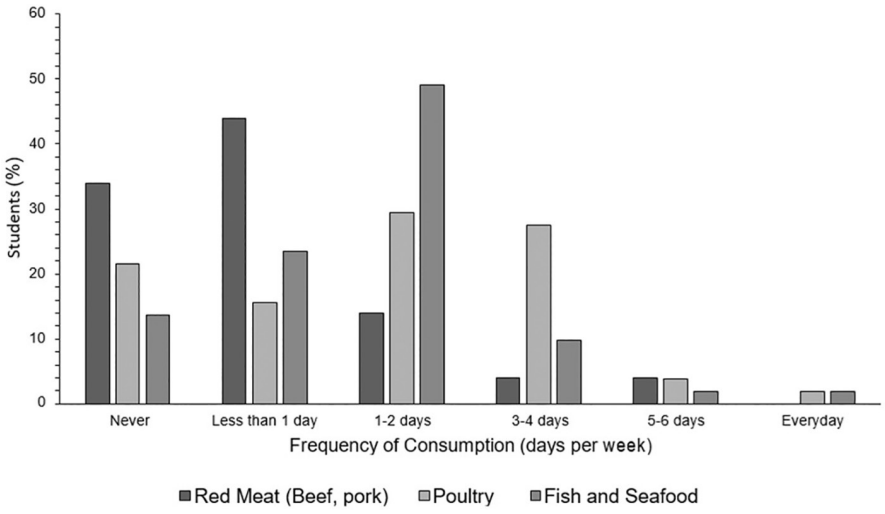

FIGURE 4 Frequency of consumption red meat, poultry, fish and seafood.

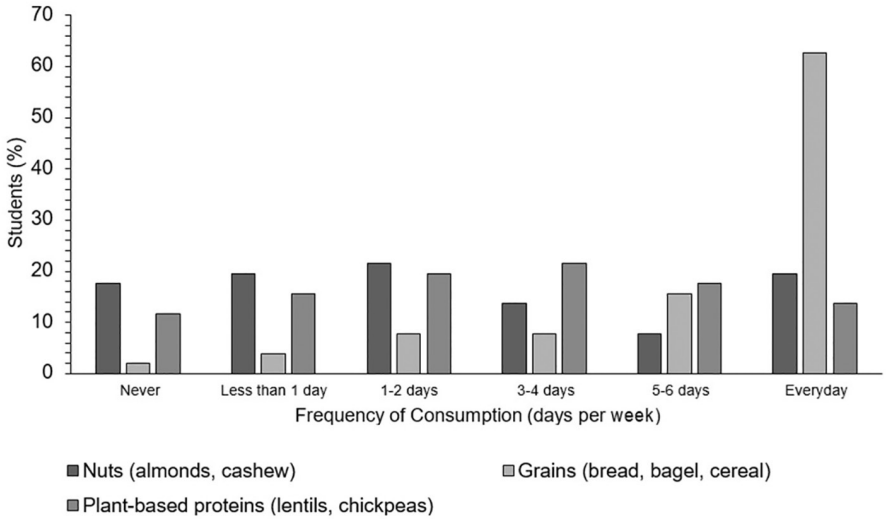

FIGURE 5 Frequency of consumption of nuts, plant-based proteins and grains.

lower SFL scores compared to students who ate less animal-based products.

Phase 2: Semi-structured interviews

Six out of 10 intended interviews (females = 83%) were conducted between January and February 2019, and as such, data saturation was not reached due to the limited timeframe of the study and participant interest. Four themes emerged from the data; (1) Knowledge of SDs; (2) Barriers to using SDs; (3) Suggested changes to education and (4) The future of nutrition professionals and their roles in sustainability.

Knowledge of sustainable diets

The interviews yielded four sub-themes related to how students define SDs, their understanding of trade-offs between sustainability elements, assumptions they had and the varying degree of confidence in their knowledge of the topic.

Defining sustainable diets

All students defined SD as having low to minimal impacts on the environment:

> …something that just really doesn't wreak havoc on the environment so quickly…—Student 2 (F).

'Resource intensive', a measure of the amount or number of resources (e.g. water, land, energy etc.) needed to produce something, was another common concept and was used by the majority to define an unsustainable diet:

> …foods you can grow in a large area and it doesn't take much resources to grow.—Student 5 (F).

All students described sustainable foods as plant-based foods and unsustainable foods as animal-based foods. However, they differed when describing the possible implications of unsustainable diets: deforestation, air and water pollution, water usage, trawling for fishing and biodiversity loss (plants and animals). Other perceptions included references to sustainability as the ability to continue producing food for future generations, the importance of food security and the basic human right to food. A few students mentioned nutrition and health in relation to SDs and that they are diets people are able to maintain over a long period of time, contrary to very restrictive, popular diets.

Trade-offs

While various interpretations of SDs were mentioned, all students remarked on the complexity of the topic. On the other hand, only a few noted that SDs are context-specific and may involve trade-offs, as described by these quotes:

> …it depends on like where you are, what the product is and what the diet is, because it is very specific.—Student 4 (F),

> …I wouldn't say that everyone would need to just completely switch and I don't think that up take would be great either.—student 6 (M).

Awareness and assumptions

Most students were aware of current SD issues, collectively mentioning topics such as food miles, place of origin, plastic pollution, recycling and food waste, social and economic sustainability (e.g. Brexit), responsible sourcing and the emergence of alternative protein products (e.g. plant-based proteins and insects). Students also used these topics to define what they perceived as a SD. A few students expressed assumptions that may show a misunderstanding of SDs and could suggest possible biased assumptions. Whether these assumptions came from university or external sources is unknown. Quotes include:

> …[processed] foods are not sustainable, anything that is not in its raw form.—Student 3 (F),

> …palm oil at the minute…, making sure that they're [consumers/clients] not using that.—Student 5 (F).

Confidence is key

Most students indicated a low to moderate level of confidence, (between 3 and 7 out of 10) in providing advice to future clients on SDs. Despite the awareness of their limited knowledge, most students were aware of where to find evidenced-based information to supplement their knowledge on the topic or refer on to other professionals with more expertise as exemplified by the following quotes:

> …I just wouldn't know enough… I wouldn't feel comfortable giving someone the wrong advice…—Student 2 (F),

> …I would feel confident enough to research more about it [sustainable diets] and look it up.—Student 4 (F),

> …I would definitely refer on to someone who is more that area of work [sustainable diets].—Student 6 (M).

Confidence in knowledge or behaviours in relation to sustainability may also affect the student's behaviours. As such, students were asked to consider the sustainability of their own food behaviours. Most students perceived their diets as moderately (5/10) sustainable, collectively mentioning reasons such as using local produce, recycling, limiting food waste, limiting excessive packaging, growing their own produce and eating more plant-based products. A few students suggested they knew of steps to take to 'increase their score', and while many of them thought about sustainability as an issue, they felt this was not reflected in their actions or behaviours:

> …I thought about it [sustainability] a lot more but it hasn't really changed my buying behaviours.—Student 3 (F).

Barriers to applying sustainable diets

Both structural and behavioural barriers were identified during the interviews (S5). Structural barriers mentioned included monetary and location/access, as evidenced by one quote, where the student mentions that local produce (often seen as more sustainable) is more expensive than produce coming from abroad (often seen as less sustainable):

> …buying local produce is surprisingly more expensive than buying something that has been shipped from Mexico…—Student 2 (F).

Behavioural barriers to SDs highlighted by a few of the students included personal habits and preferences taking priority for meat-based dishes:

> …I think I would like to do more [eat sustainably] but I'm quite a fussy eater…so it's easier for me to cook the meat-based dishes…—Student 5 (F).

Behavioural barriers also involved social relationships, especially conflicting priorities of family members or friends and housemates, as evidenced by a female student who felt sustainable eating was not a priority for her family:

> When I'm living…with my family it [buying sustainably] is definitely not as often as I like it, it is very difficult to me because it's not a priority for them…—Student 2 (F).

Education as a major barrier

Most students had received at least one module that included topics related to sustainability, typically entitled 'food supply chain'. However, there were contrasting opinions on how well the topic was covered in these modules:

> …It [sustainable diets] was taught a lot within the modules and they do try to bring it in a lot…—Student 1 (F),

> …I think it's embarrassing; we don't learn as much as we should.—Student 2 (F),

> Definitely not as much as I thought there would be going into the degree.—Student 4 (F).

Lack of education was also seen as one of the most prominent barriers to understanding and implementing SDs by the students. When asked how they could increase their confidence in advocating for SDs, all students except for one stated the need for more sustainability education, especially social and economic aspects of sustainability, which overwhelmingly were quoted as a gap in the curricula:

> …if I had more education on it [sustainable diets] I would definitely use it with other people…—Student 2 (F),

> …so more of that side [social] would be interesting.—Student 5 (F).

Lastly, one student highlighted the importance of learning about SDs, as an opportunity to provide nutrition students with a more holistic view and appreciation of nutrition:

> It was great to have it [teaching on sustainable diets] and understand a little bit more, you get more of a round[ed]aspect.—Student 6 (M).

Suggested changes to education

A few students felt that the teaching on sustainability during their degrees was less integrated and structured than it should be, and was often conducted on an impromptu basis:

> … [Lecturer] mentioned things ad hoc through some of the sessions. But that wasn't structured, that was kind of her choosing…, we would talk about some things that were hot topics…—Student 3 (F).

Overall, most suggested there should be scope to include all five pillars of sustainability (i.e. environment, economic, social, health and wellbeing) into the curricula. A few students noted continued professional development (CPD) as a suitable avenue in which they would like to see SDs taught, as well as having a specific and accessible hub of resources for nutritionists on SDs, much like the One Blue Dot by the BDA (2019).

However, not all students felt more education in sustainability was necessary and suggested that due to the varying emphasis of different nutrition degrees (e.g. nutritional sciences, food science), some degrees may include more content on SDs than others. When asked how much content they were taught, two students suggested it was lower because of the specific focus of their degrees:

> …[sustainable diets was less of a focus]…I think that's because of my course because I do food science as well…—Student 4 (F),

> …[their degree] is a biochemistry based degree. So that's why it's very much lacking in that [sustainable diet content] and it was just in first year.—Student 6 (M).

The future of nutrition professionals and their roles in sustainability

There was clear agreement regarding the future roles nutritionists have in relation to SDs. However, whether students would implement sustainability principles in the future depended on their personal interests. Most of the students alluded to the responsibilities that nutrition professionals have in advocating for SDs, such as working collectively with other health professionals (e.g. RDs), combining healthy eating and sustainability

advice, developing sustainable food products and providing balanced arguments and advice to the public:

> …I think we [nutritionists] all have a responsibility….—Student 3 (F),

> …nutritionists have a role in it because at the end of the day people come to you for advice or you provide advice about someone's diet.—Student 1 (F).

DISCUSSION

This research examined the level of SD knowledge in nutrition students in the United Kingdom, finding good levels of environmental literacy but poor levels of SFL and no correlation between the sustainability content of university courses and SFL. It also looked at the barriers that prevent students' use of this knowledge in practice, and their views on the future role of the profession regarding SDs. This is, to the authors' knowledge, the first study to ascertain the knowledge of SDs in a group of nutrition students in the United Kingdom.

Knowledge of sustainable diets

The nutrition student's knowledge of SDs can be separated into environmental literacy, SFL and general terminology. Environmental literacy involves an individual's understanding and motivation to make environmentally responsible decisions (Fang et al., 2022) and evidence suggests higher levels of environmental knowledge lead to more sustainable behaviours (Teksoz et al., 2011). This study found that nutrition students were generally EL, despite scoring low on SFL. This suggests that students may have been aware of the wider environmental issues but not those related specifically to food systems. In contrast, research on American college students reported low EL (Lloyd-Strovas et al., 2017), though this may have been due to differences in instruments used to measure EL and sample size.

All students were able to define SDs as having low to minimal impacts on the environment, although they found it difficult to provide a comprehensive definition as provided by FAO and WHO (2019). Only a few students alluded to dimensions of SDs other than environmental (e.g. health, social, economic), the complexities of the dimensions and potential trade-offs (Benvenuti et al., 2021; Springmann et al., 2018), such as nutrition contribution and environmental impact (Steenson & Buttriss, 2021). There were also indications of misconceptions regarding the sustainability of certain food products or production methods. Misconceptions include the necessity for the complete dietary exclusion of palm oil (Meijaard et al., 2020), and the impact of transportation of foods and degree of processing (Poore & Nemecek, 2018). This combination of limited technical knowledge but familiarity with certain dimensions (i.e. environmental) related to SDs has also been observed in nutrition/dietetics students in the United Kingdom (Pettinger et al., 2018), in Australia (Burkhart et al., 2020), health sciences students in Spain (Irazusta-Garmendia et al., 2023), as well as in a more general university population in Spain (de Moraes Prata Gaspar et al., 2023), Europe, North America, Australia (Ede et al., 2011) and New Zealand (Innes et al., 2018). These studies used mixed methods (Ede et al., 2011) as well as qualitative (Pettinger et al., 2018) and quantitative approaches (Burkhart et al., 2020; de Moraes Prata Gaspar et al., 2023; Innes et al., 2018; Irazusta-Garmendia et al., 2023).

Lastly, in the interviews, only two students stated that they felt confident about advocating for SDs, attributing their confidence to the modules taken at university. These students were able to define SDs more comprehensively when compared with other students, suggesting that increased knowledge and awareness of SDs and issues will help nurture more confidence in advocating for SDs (Innes et al., 2018).

Self-reported dietary intake and sustainable diet knowledge

Students were asked to self-report their dietary intake via a food frequency questionnaire in Phase 1. The results showed nutrition students reported low levels of meat, poultry and seafood intake, consistent with other nutrition students (Verwey et al., 2022) and general university populations in three countries (Sweden, United Kingdom, Canada; Ede et al., 2011). However, this was not found in another study of British university students that reported two-thirds being frequent meat consumers using food frequency questionnaires (Sprake et al., 2018) or in a student cohort using food card transaction data (Morris et al., 2020). Students also reported high intakes of fruit, vegetables and grains, which was expected since research, although limited, suggests that increased nutrition knowledge can have a positive association with dietary intake. With regards to the *environmental literacy model* put forward by Teksoz et al. (2011), where high levels of knowledge encourage concerns, positive attitudes and enhanced personal responsibilities towards more sustainable practices, it was expected that students engaging in more sustainable practices such as increased plant-based protein intake and reduced red meat intake would have higher SFL scores. Students who ate more red meat and poultry had lower SFL scores, but there was no correlation between self-reported sustainability of diets and SFL scores. This could be a reflection of the fragmented understanding of SDs, as seen in the interviews, as well as the potential limitations of self-reporting

sustainable behaviours since there can be a slight tendency to overreport (Kormos & Gifford, 2014).

University education and sustainable diet knowledge

Students were asked about the sustainability content of their degrees with three-quarters of students saying they had received at least some teaching on the topic. However, there was no relation with students' SFL scores, although previous exposure (or not) to the issues, irrespective of university teaching, was associated with higher SFL, suggesting that overall exposure via alternative channels and not university content influenced SFL scores. This is not consistent with previous literature (Cotton & Alcock, 2013; Innes et al., 2018; Maher & Burkhart, 2017), which found that specific modules on EL and SDs and general university attendance foster knowledge and awareness of sustainability topics. This discrepancy could be due to other studies such as Innes et al. (2018) and Maher and Burkhart (2017) assessing action-based activities (e.g. problem-solving, blogging about action-orientated reflective questions), which have been found to better influence behaviour (Maurer & Bogner, 2020). Our results could also have been due to our small sample size and the self-reported nature of university content (Elston, 2021). Self-reports may be exaggerated due to social desirability biases (i.e. students exaggerating the extent of their sustainability content at university) (Kormos & Gifford, 2014).

Barriers to adopting sustainable diets

While students reported low to moderate confidence levels in their knowledge of SDs, students identified their main barriers as lack of education (discussed in the next section) and lack of knowledge. This supports previous quantitative research on dietitians (Heidelberger et al., 2017), university students (AlBlooshi et al., 2022; Ede et al., 2011) and university staff (Harmon et al., 2011), as well as qualitative research in university staff (Ralph & Stubbs, 2014), university students (Ede et al., 2011) and young adults in the United Kingdom (Whittall et al., 2023).

Education and university experience

The students in phase 1 of this study represented 35% of AfN-accredited degrees (in 2019). Most students had been taught at least one module which included SD-related topics, typically titled 'food supply chain'. This contrasts with a recent review in Australia, where only 8% of identified degrees included modules on sustainable food systems (Carino et al., 2019). While the Nutrition Society of Australia has a voluntary register for nutritionists similar to the AfN, there is no accreditation scheme for university nutrition degree courses (Nutrition Society of Australia, NSA, 2023). The food/feed chain competency has been an AfN competency requirement since its development, hence the higher rate of sustainability modules in the United Kingdom, also highlighting the important role accreditation has in ensuring topics such as sustainable food systems are appropriately covered in nutrition degrees (McCormack et al., 2023).

This study found a lack of correlation between university sustainability content and students' SFL, indicating the current ineffectiveness of teaching for increasing students' SFL. Additionally, students had contrasting opinions on how well the topic was covered, with many suggesting that a more structured and holistic approach to their education around SD topics was needed, especially incorporating socioeconomic dimensions of sustainability. Mason and Lang (2018) have suggested a framework of 'omni-standards' of sustainability, which refers to the inclusion of all aspects of sustainability ('omni' from Latin for all). These should include concrete examples of social values, health, economy, quality, environment and governance dimensions of sustainability. The students' suggestions also echo the Critical Dietetics approach presented by (Carlsson, Mehta et al., 2019). This approach aims to apply systems and holistic thinking to the way nutrition and dietetic education, practice and scholarship are developed. However, there is a gap at the university level, with recent reviews finding no assessments of food chain competencies in nutrition education (O'Donovan et al., 2022), no consistency in teaching approaches to SDs (McCormack et al., 2023) and little granularity into the topic (Higgins et al., 2023). Two studies have reported incorporating sustainability more holistically in multiple courses in a dietetic programme over several years (McCormack et al., 2023). Spiker et al. (2021) conducted a pilot intervention study using a variety of teaching approaches across four university sites that included internships and graduate programmes and found an increase in confidence but not in knowledge. On the other hand, Navarro et al. (2020) focused on scaffolding various teaching approaches across seven courses, while focusing on developing systems-thinking competence. They found an increase in SD knowledge, which was not reflected in their intended behaviour. However, there are many more competences that are required for more holistic sustainability competent nutrition professionals, such as nonlinear thinking, developing critical perspectives on food, health and sustainability, collaboration of multidisciplinary teams, openness to non-traditional knowledge (Carlsson, Callaghan et al., 2019), as well as other skills such as collaboration with non-traditional stakeholders (Baungaard et al., 2021) and the ability to adopt different roles (Den Boer et al., 2021).

On the other hand, students stated that they knew where to read about SDs, to increase their confidence in the future. Moreover, as part of the AfN competency requirements, students are taught and expected to use evidence-based sources for their assignments as well as professional practice (AfN, 2023c). This suggests that although education in sustainability topics could be improved, students are nevertheless still developing the necessary skills to find evidence-based research on the topic.

Lastly, students also mentioned the need for more CPD opportunities. Since CPD was highlighted as an opportunity (Heidelberger et al., 2017; Pettinger, 2018; Wegener, 2018), the interest and materials available on SDs for nutrition professionals has increased dramatically. Nutrition students and professionals have access to free webinars, events and courses from consultancies (MyNutriWeb, 2023), learned societies (Academy of Nutrition and Dietetics, 2023; Nutrition Society of Australia, NSA, 2023), non-profit organisations (British Nutrition Foundation, 2023; The Nutrition Society, 2023) and massive open online courses (MOOCs) (Future Learn, 2020, UN Climate Change Learning Partnership, 2023; University of Aberdeen, 2023).

Future role of nutrition professionals

Despite their limited understanding of the five pillars of SDs, a strong interest and clear responsibility were reaffirmed throughout the interviews, in line with studies amongst dietetic students (Burkhart et al., 2020; Pettinger et al., 2018) and RDs (Heidelberger et al., 2017), suggesting that forthcoming nutrition professionals understand the roles and responsibilities they have for the future in terms of sustainability.

RECOMMENDATIONS

This study found no correlation between the sustainability content of university courses and student's SFL, as such there is a need to make sustainability content in nutrition university courses more effective. The following recommendations for educators are highlighted below.

Holistic integration of sustainability

Interest and action in integrating sustainability into nutrition education is seen with the rise of courses and activities, particularly around environmental literacy. Educators should continue to develop curricula that integrate new AfN competencies, covering 'omni-standards' of sustainability (see Mason & Lang, 2018), across multiple courses/years and integrate authentic professional tasks that students may encounter in future roles (e.g. food system policy analysis).

Future-relevant skills

Holistic sustainability integration in nutrition education will help to future-proof the skills of nutrition professionals. Educators should foster competencies such as systems and non-linear thinking, collaboration with non-traditional stakeholders and policy coherence, alongside the required competencies stipulated by the AfN.

Share best practice

The diverse opinions on sustainability education across nutrition degrees in the United Kingdom highlight the breadth and diversity of education. Educators shaping holistic nutrition degrees should share insights, outcomes and best practices in various formats (e.g. research articles, opinions, case studies, webinars, conferences, learning days). As case studies are developed with examples of practical application of SDs and food systems knowledge, the AfN can highlight these as additional examples of AfN core competency 3: Food systems.

Continued professional development

SD and food systems CPD should continue, to stay relevant and reflexive to the evolving science. While most CPD opportunities have focused on factual knowledge, future activities should consider skills required for action such as systems and nonlinear thinking and collaboration.

LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

The strengths of this study lie in the mixed methods approach used and the novelty of the topic, as there currently exists a scarcity of literature on SD knowledge in a UK nutrition student context. Limitations are that while the study took a similar approach to other studies (Hawkins et al., 2015; Worsley et al., 2014), the sample size was small, convenient and possibly influenced by self-selection bias (Elston, 2021). Granular data on the sustainability content at university (question 6 in S1) was not available due to storage issues. In addition, the section of the questionnaire investigating environmental literacy only used 4 of the 8 questions from the original validated questionnaire (Innes et al., 2016), potentially undermining the validity of this measure. Finally, the

number of interviews conducted was too small to reach data saturation, although it was determined that there was sufficient information to provide an adequate understanding of the key research objectives. The results therefore may not be representative of the entire nutrition student population in the United Kingdom. Despite the limitations outlined above, future research is warranted on this topic. Further studies with a larger sample of nutrition and dietetic students and professionals across the United Kingdom, investigating different types of knowledge (e.g. action or effectiveness-related knowledge vs. factual knowledge) (see Maurer & Bogner, 2020) in students and incorporating other dimensions of sustainability such as socioeconomic elements into their studies and/or professional practices. Additional studies investigating the attitudes and practices of university educators on SDs in a UK context are warranted, as well as the evaluation of outcomes in nutrition-specific sustainability training programmes, and multi-disciplinary training opportunities between for nutrition, other health care, agriculture, engineering and public policy students to collaborate on sustainable food system topics.

CONCLUSION

This study contributes to the limited understanding of SD competency in future nutrition professionals. It explores barriers to adoption, university experience and student views on the nutrition profession's future role related to SDs. This study highlighted that most nutrition students had heard of SDs, were generally environmentally literate and exhibited moderate knowledge of SDs. However, there was a lack of correlation between student's SFL and sustainability content at university, highlighting a need for more effective teaching on the topic. Students also demonstrated a fragmented understanding of SDs, focusing mostly on the environmental dimensions of sustainability. Nevertheless, major barriers such as a lack of knowledge and limited education were cited as limiting the students from effectively engaging with the topic at present and in the future. To further the knowledge of SDs for the nutrition professions, educators should integrate holistic sustainability teaching into nutrition degrees, sharing best practices, in order to future-proof students with relevant skills and for the nutrition community to continue developing sustainable food system-related CPD. The authors hope the findings from this study are used to inform curricula on nutrition degrees.

AUTHOR CONTRIBUTIONS

Cathrine Baungaard and Lucinda Richardson drafted the conception and design of the study. Cathrine Baungaard oversaw the research, data collection, analysis of the data and statistical analyses. Cathrine Baungaard created the manuscript, while Lucinda Richardson and Katie E. Lane offered amendments and critical evaluation of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

Data are available on request due to privacy/ethical restrictions.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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