Survey of Data Science in UK Medical School Curricula

Contents

Introduction 1

Results 2

Students' survey Result 2

Staff survey Results 12

Discussion 21

Student Survey Discussion 21

School-by-School Analysis 23

Course-type Analysis 24

Intra-school Analysis 25

Staff Survey Discussion 27

Inter-School and Intra-School Analysis 29

Limitations 31

Student Survey 31

Staff Survey 31

Recommendations 32

References 34

Appendix 35

Appendix 1 (Importance) 35

Artificial Intelligence 35

Virtual Reality 36

Big Data Analytics 36

Precision Medicine 37

The Internet of Things 38

Appendix 2 (Training) 39

Clinical Trials 39

Statistical testing and plotting data 39

Using statistics software e.g. SPSS, Excel, STATA, R, Python etc 40

Basic Computer programming e.g. in R or Python 40

Artificial Intelligence / Machine Learning 41

Big Data Analytics / Real World Evidence 41

Appendix 3 (Staff Learning Objectives) 42
Clinical Trials 42
Big Data Analytics/ Real World Evidence 42
Basic Computer programming e.g. in R or python 43
Artificial Intelligence / Machine Learning 43
Using statistics software e.g. SPSS, STATA, Excel, R, Python etc..... 44
Statistical testing and plotting data 44

Introduction

The rapid digitisation of Healthcare, alongside the generation of enormous health data daily, has seen a major shift in how health data is utilised, holding the potential to improve healthcare (Mijwil et al., 2022). The rise of Electronic Health Records (EHR) Clinical Decision Support Systems (CDSS), disease surveillance, artificial intelligence and the use of wearable devices in healthcare (Gutiérrez-Aguado et al., 2023; Mehta & Pandit, 2018; Raghupathi & Raghupathi, 2014), which are all data reliant, is a clear indication of the trajectory of modern healthcare (Reddy & Sharma, 2016).

According to Mehta and Pandit (2018), to maximise the potential of digitalisation in healthcare and to improve the quality of the care rendered, health professionals should be trained in data science and should possess analytical skills. The absence of these information technology skills will not only hinder quality care, but could also present new challenges like inefficient integration of modern healthcare system and misinterpretation of health reports (Goodman et al., 2010; Wang et al., 2018).

In Germany, efforts are being made to ensure that the potential of health data is harnessed and one of such efforts includes ensuring that clinical personnels are well trained in the data science domain to ensure that healthcare and research intersects in a continuous bid to improve healthcare (Gehring & Eulenfeld, 2018). Additionally, medical students and professionals are encouraged to gather relevant knowledge in data science to equip and enable them participate and take responsibility in patient care in the digital world of modern healthcare (Park et al., 2019).

During the summer of 2023, a short survey was carried out by HDR UK, Medical Schools Council, NHS England, and NHS Education Scotland in order to establish the amount of data science training provided to medical students in medical schools in the United Kingdom (UK).

Results

Student Survey Results

A total of 175 students responded to the survey across 19 medical schools in the United Kingdom with the University of Dundee having the most respondents with 21 responses. University of Buckingham and University of Nottingham had the least respondents with one respondent each.

Noteworthily, University of St. Andrews and University of Dundee appeared individually, with a third category of St. Andrews / Dundee (ScotGEM) also appearing on the final list which takes the schools count to 20 schools (see fig. 1)

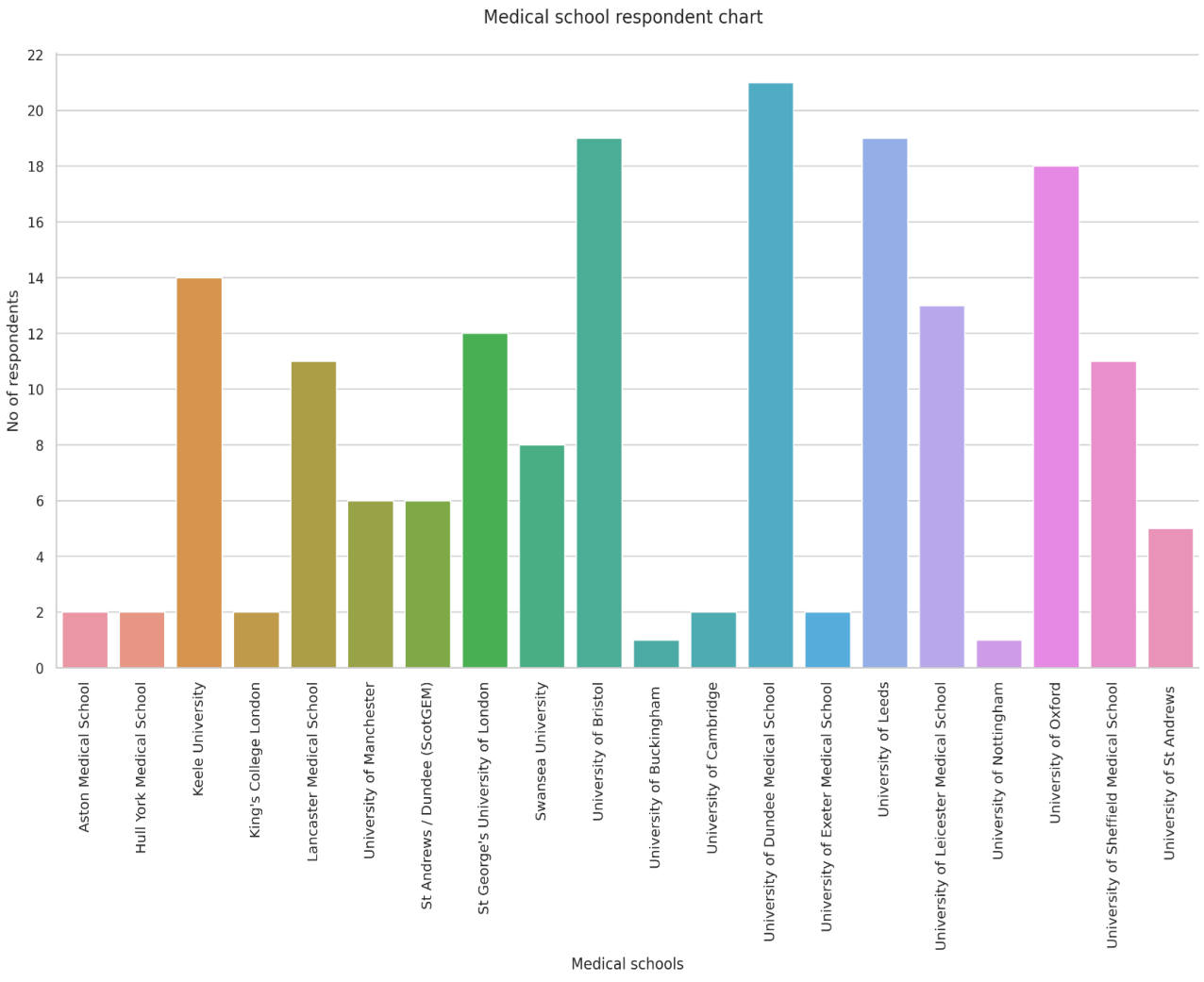

Fig. 1 Student survey response distribution across schools.

Has any of the teaching you received so far at medical school described itself as data science?

When respondents were asked if any teaching has been referred to as Data Science, 80 per cent stated that has not been the case, with only 6.3 per cent saying yes to the question. A further 13.7 per cent indicated that they were not sure.

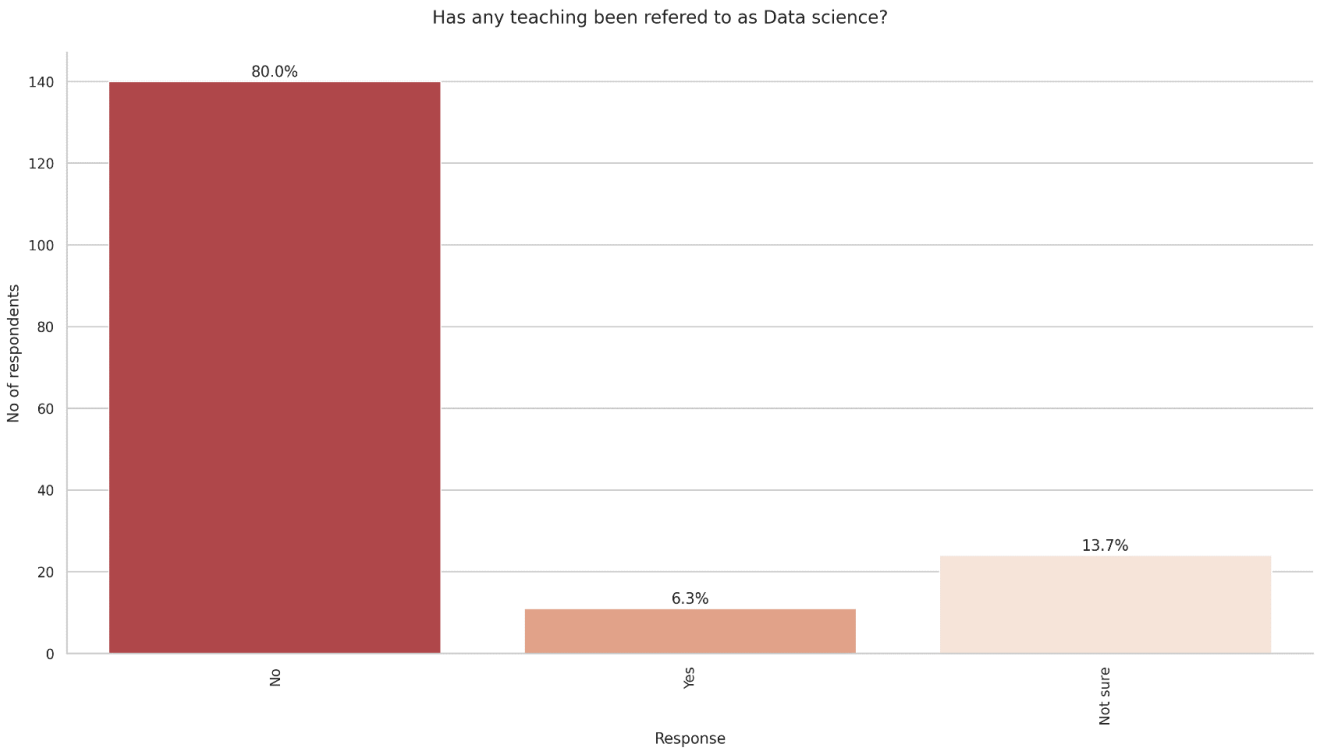

Fig. 2 Has any of the teaching you received so far at medical school described itself as data science?

To what extent to you agree or disagree with the following statement: "My university will specifically test my knowledge of data science during my medical degree assessments."?

24 per cent of respondents state that some form of data science knowledge is tested in their medical degree assessments, with 53.1 per cent disagreeing. 11.4 per cent were indecisive with another 11.4 per cent stating that they do not know.

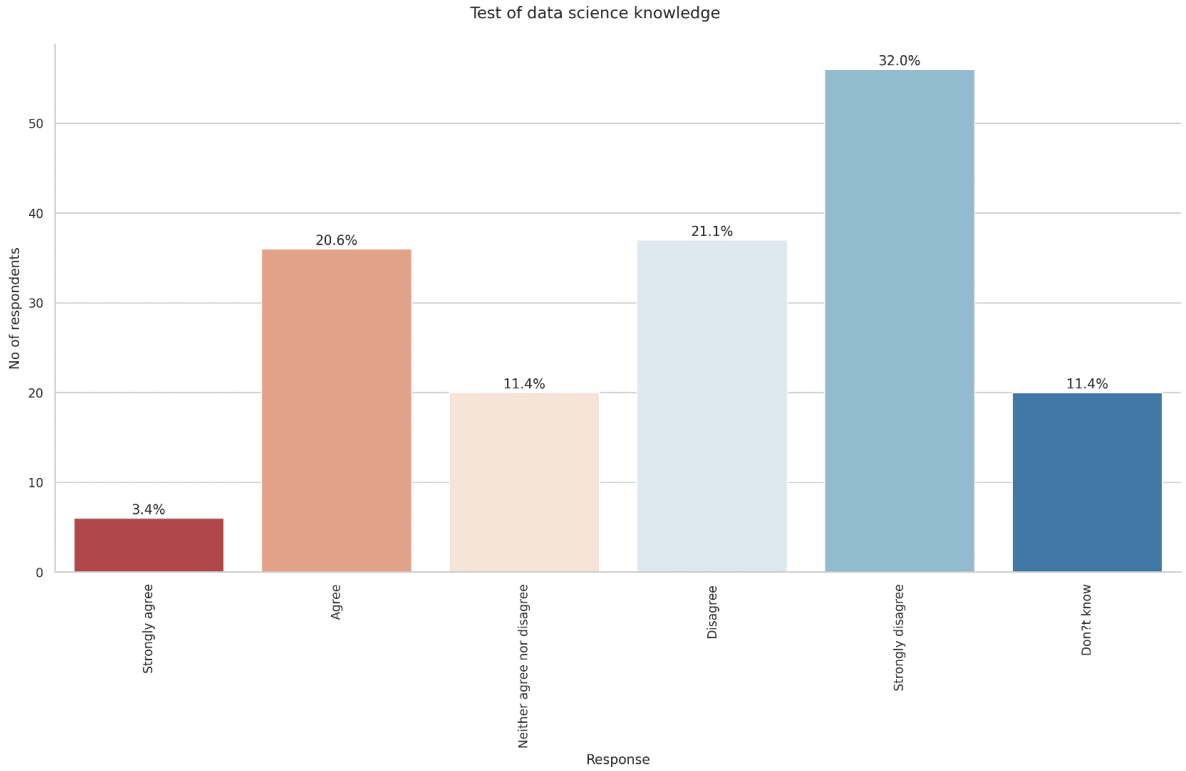

Fig. 3 To what extent to you agree or disagree with the following statement: “My university will specifically test my knowledge of data science during my medical degree assessments.”?

In the future, how important do you believe data science will be in medicine?

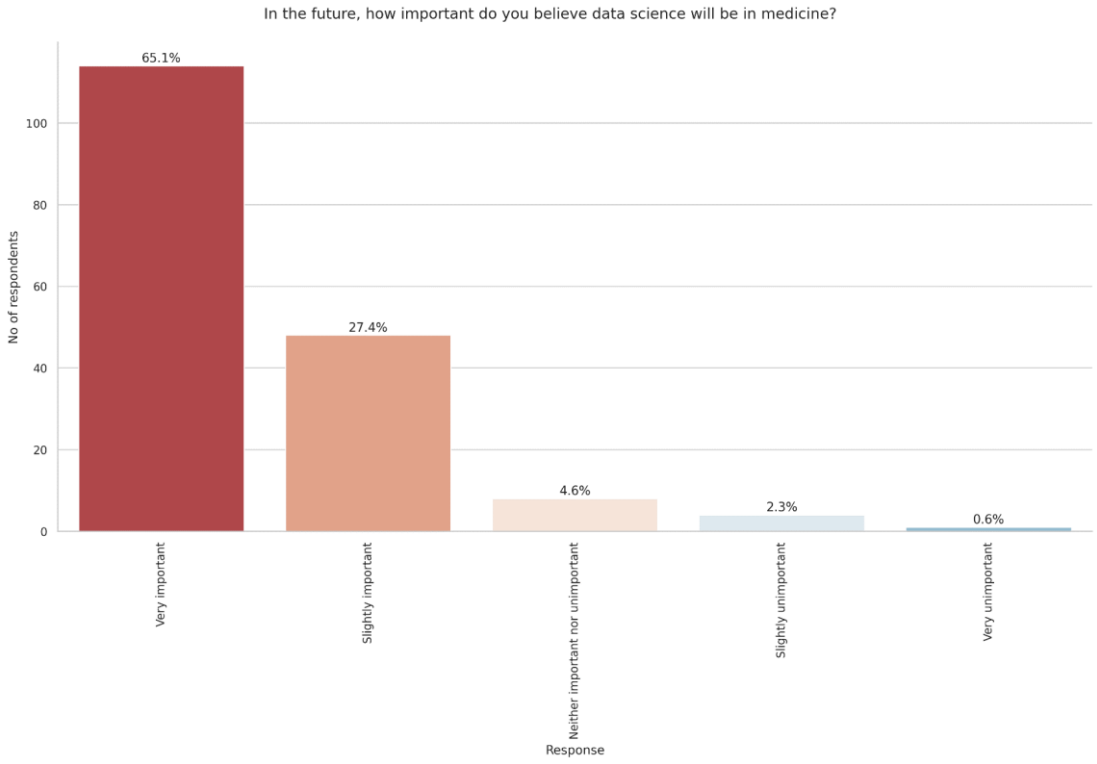

Fig. 4 In the future, how important do you believe data science will be in medicine?

The level of data science training provided within my medical degree is:

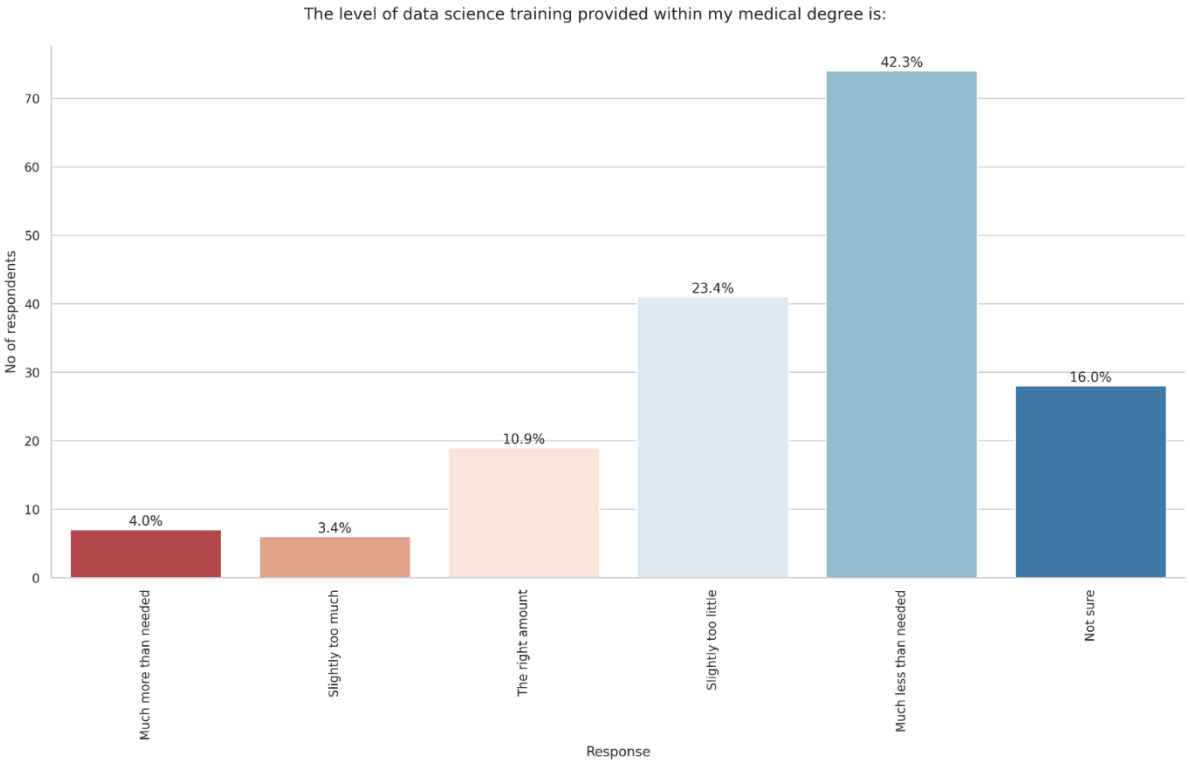

Fig. 5 The level of data science training provided within my medical degree is

School-by-School Analysis:

A threshold was set at 15 respondents to carry out a school-by-school analysis for the level of data science training and test carried out in each school.

Chart for data science training in schools with 15+ respondents

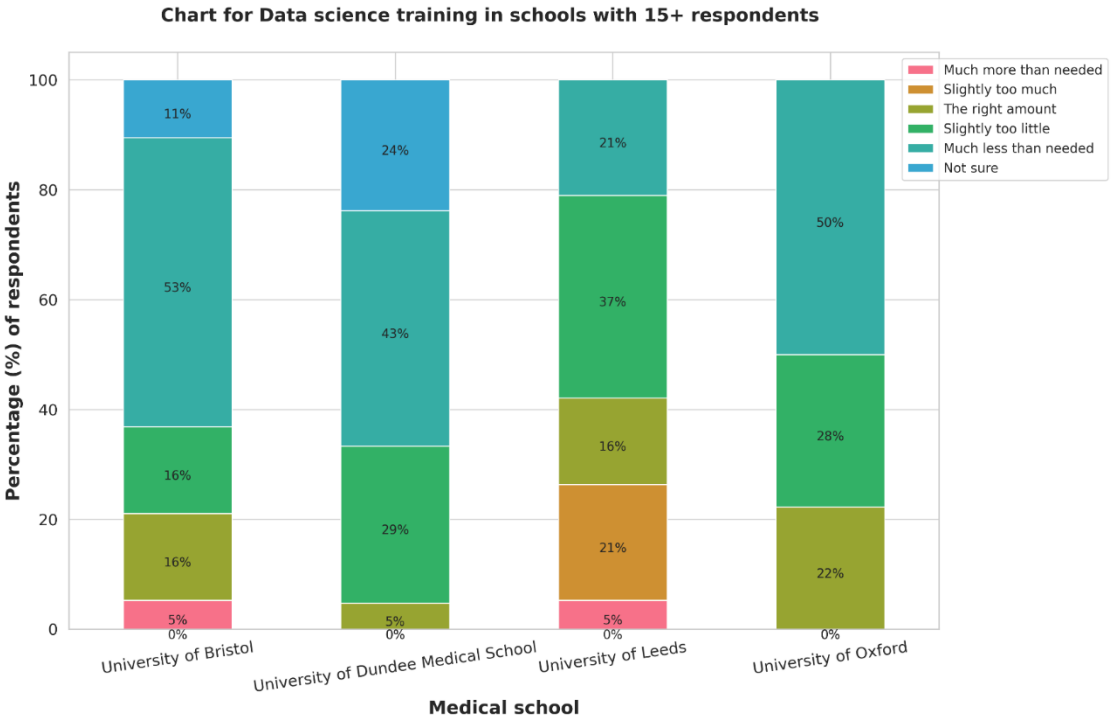

Fig. 6 Chart for data science training in schools with 15+ respondents

Chart for data science test in schools with 15+ respondents

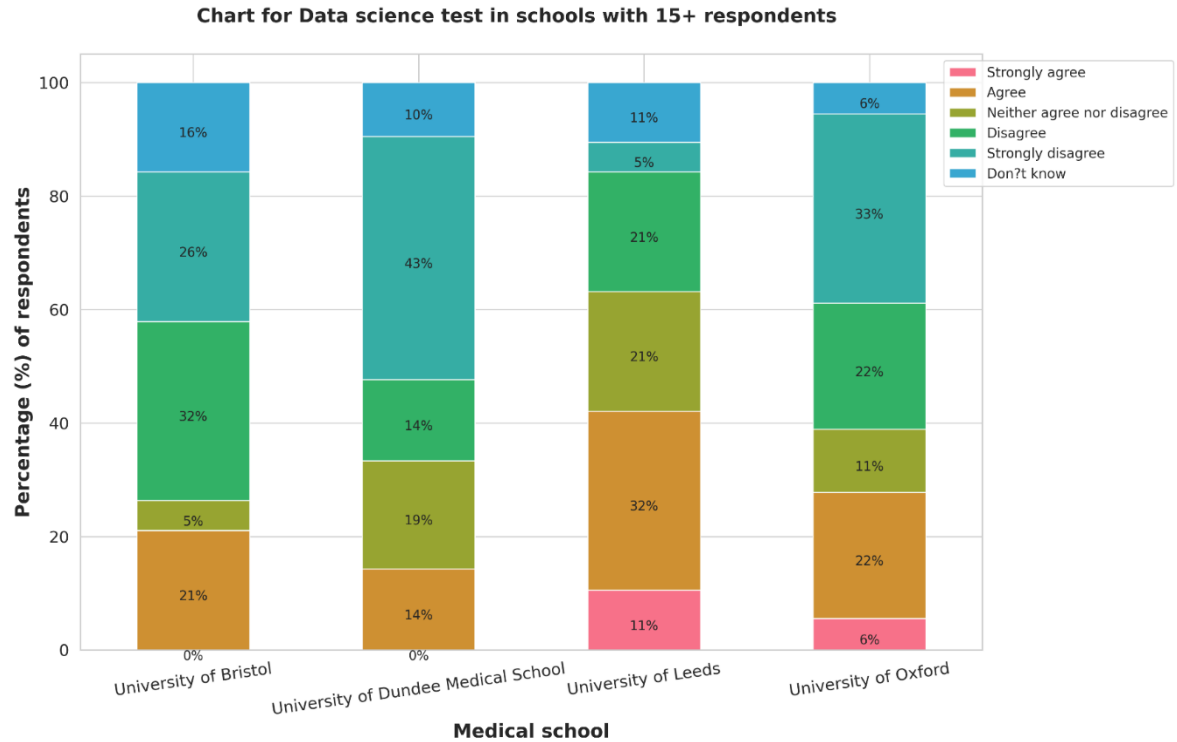

Fig. 7 Chart for data science test in schools with 15+ respondents

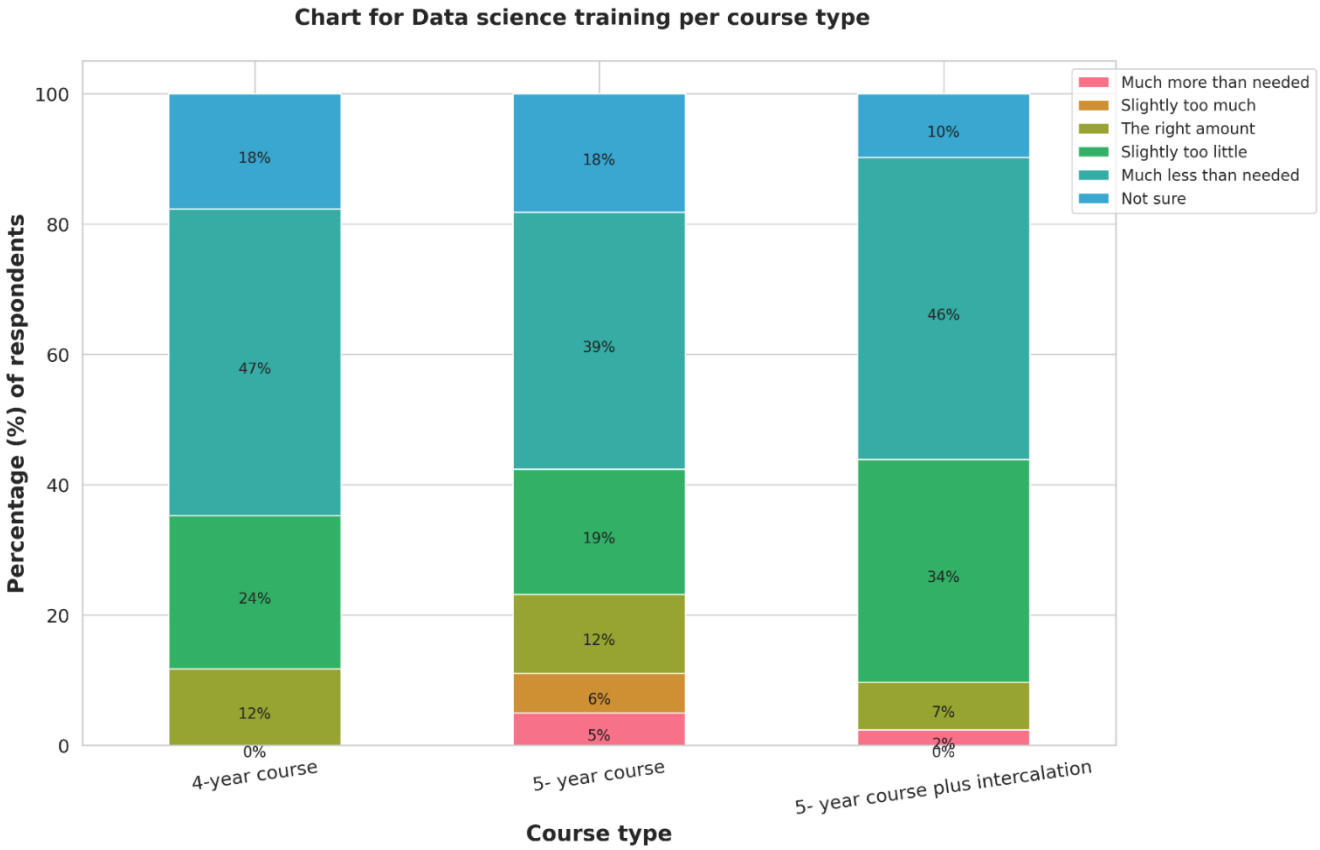

Fig. 8 Chart for data science training per course type

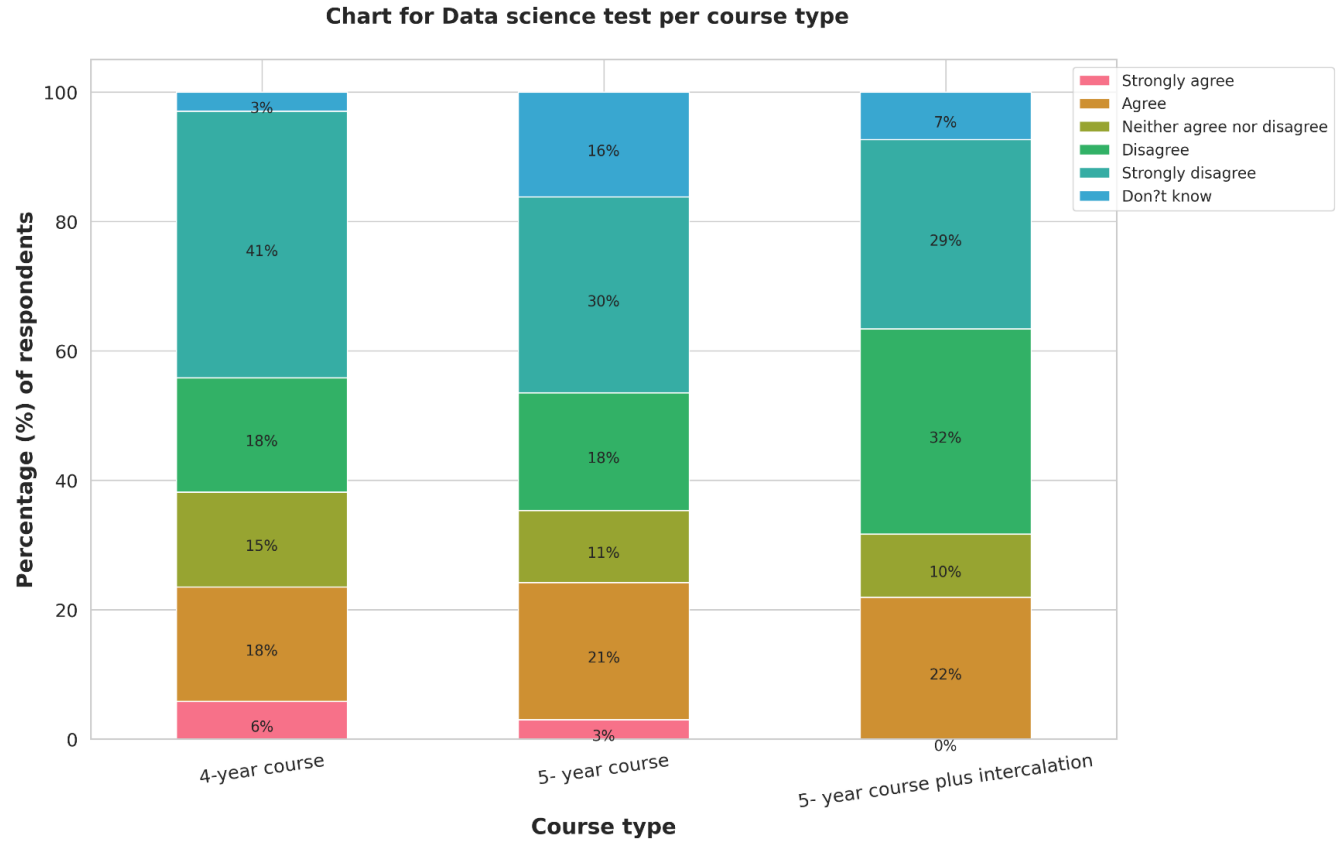

Fig. 9 Chart for data science test per course type

Fig. 10 Chart for the level of data science training provided within medical degree for University of Bristol

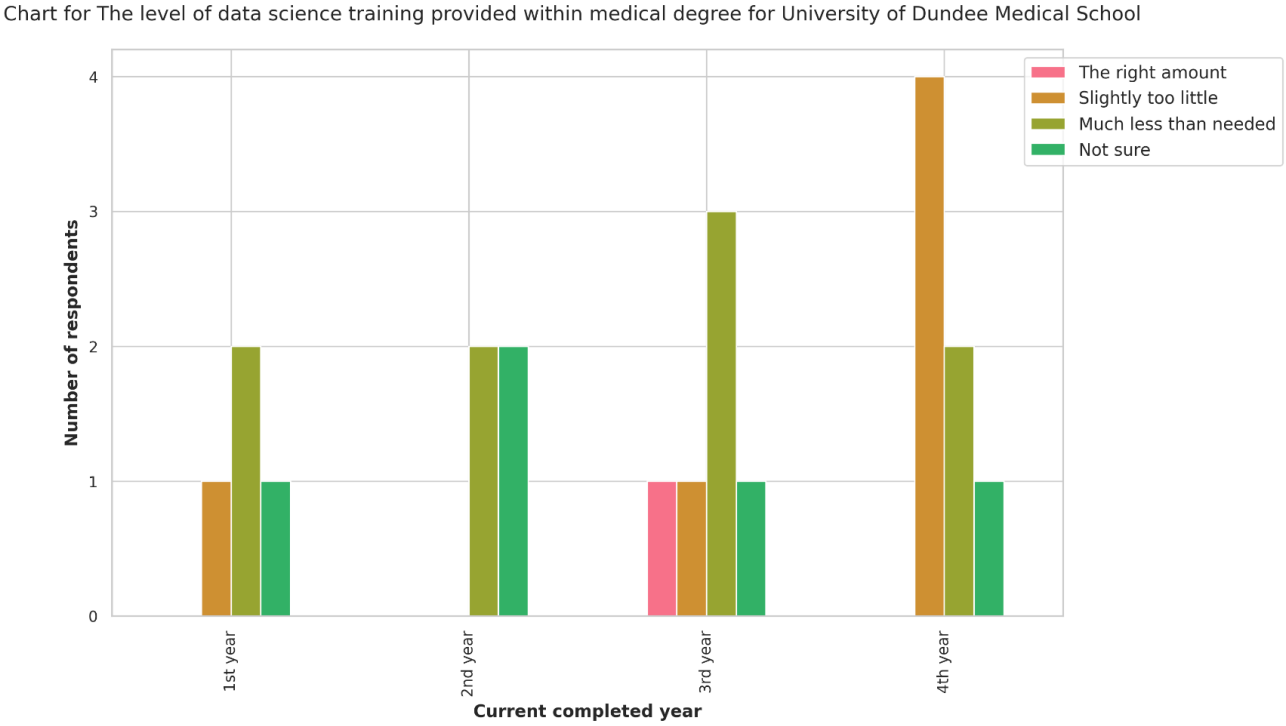

Fig. 11 Chart for the level of data science training provided within medical degree for University of Dundee Medical School

Fig. 12 Chart for the level of data science training provided within medical degree for University of Leeds

Fig. 13 Chart for the level of data science training provided within medical degree for University of Oxford

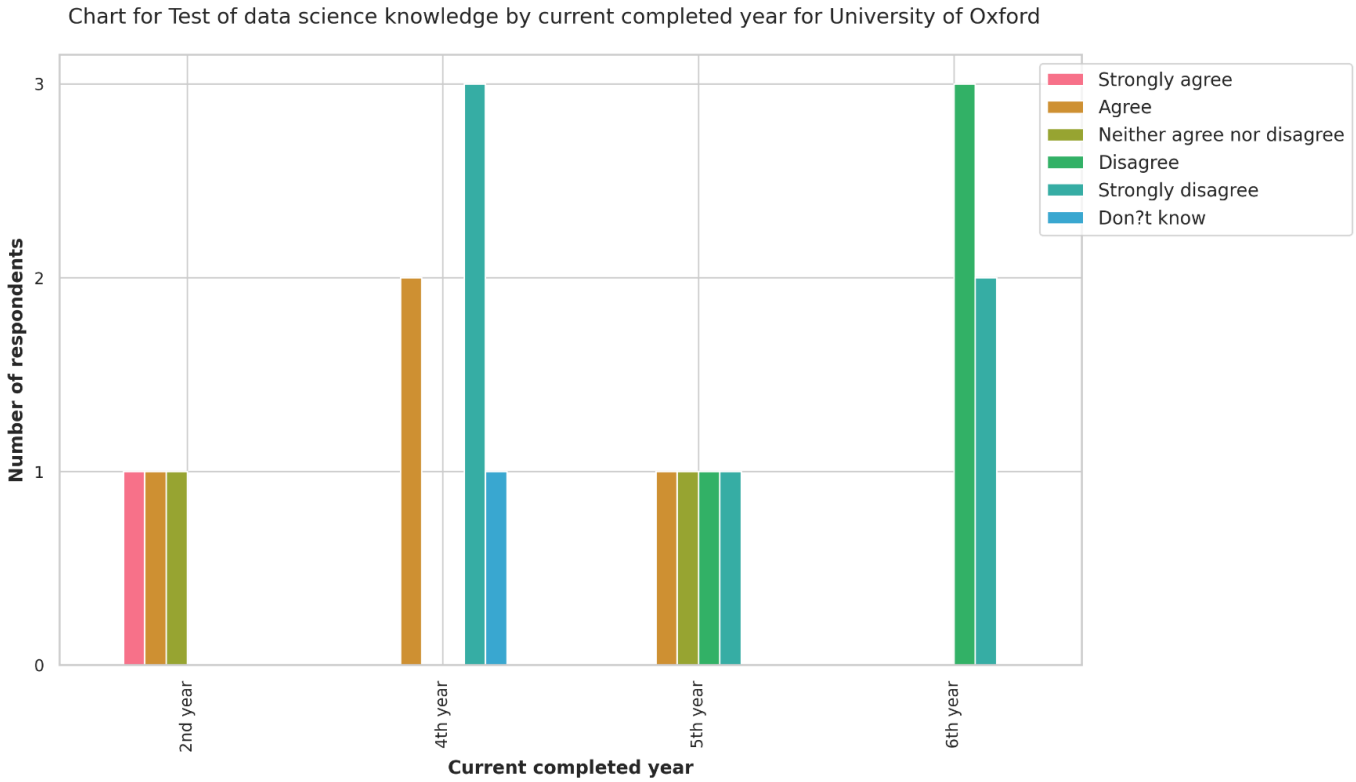

Fig. 14 Chart for test of data science knowledge by current completed year for University of Oxford

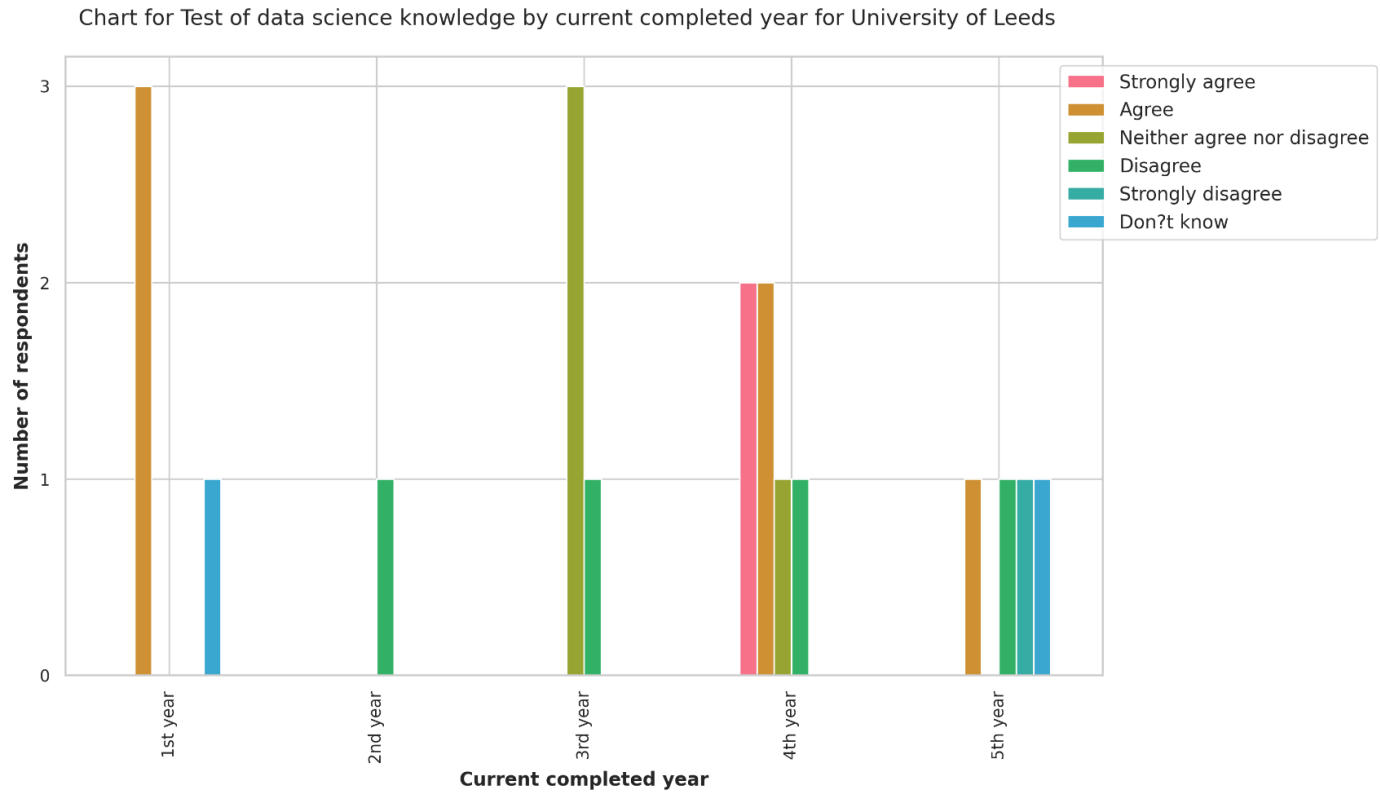

Fig. 15 Chart for test of data science knowledge by current completed year for University of Leeds

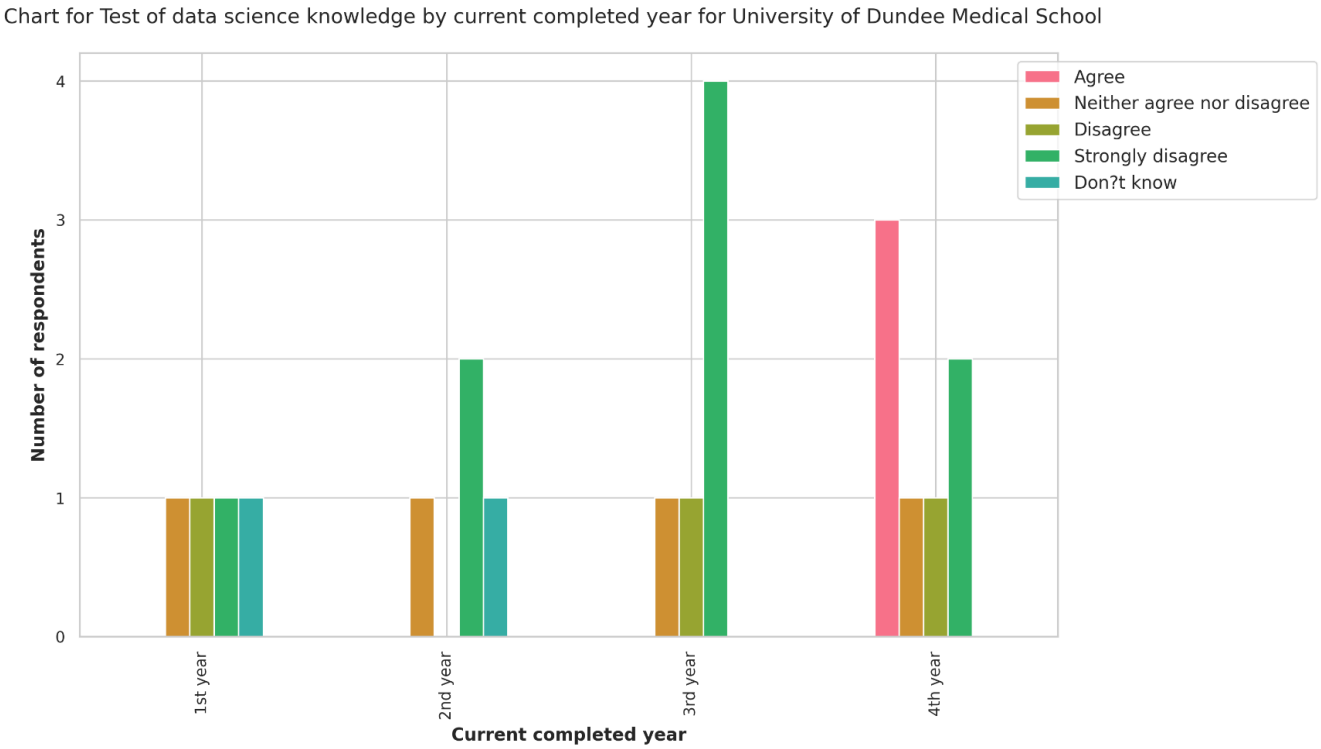

Fig. 16 Chart for test of data science knowledge by current completed year for University of Dundee Medical School

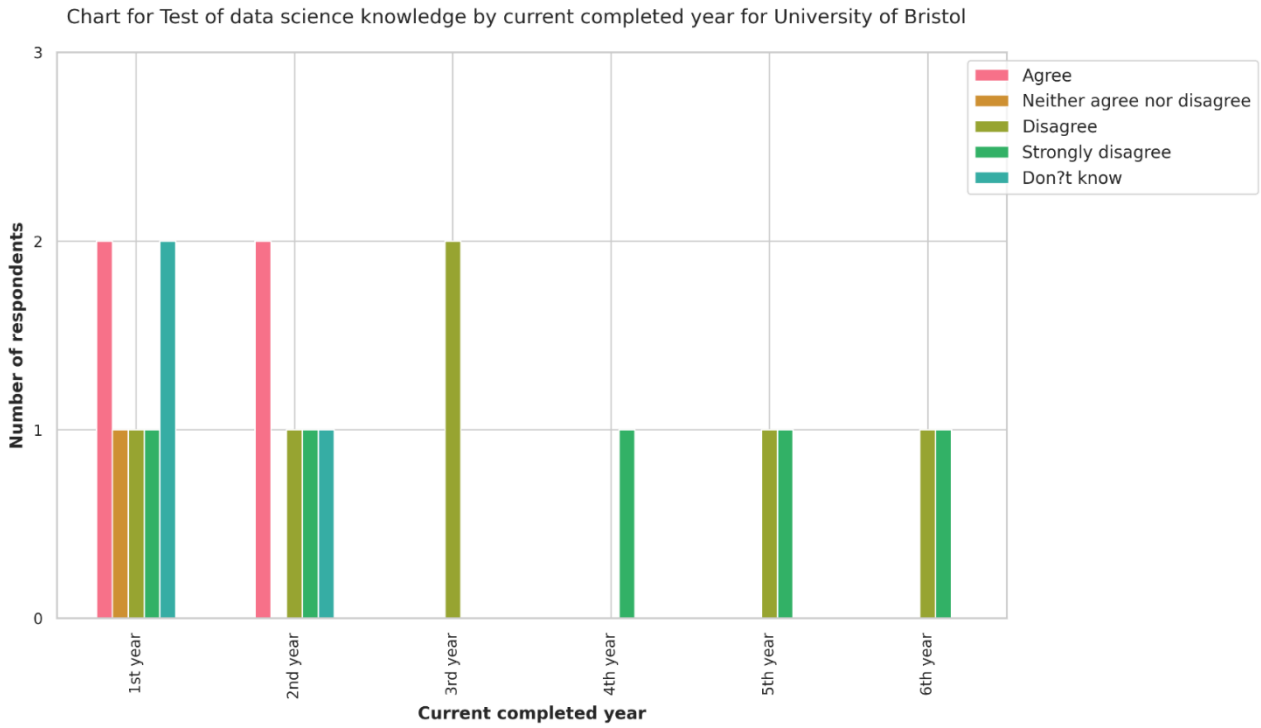

Fig. 17 Chart for test of data science knowledge by current completed year for University of Bristol

Staff Survey Results

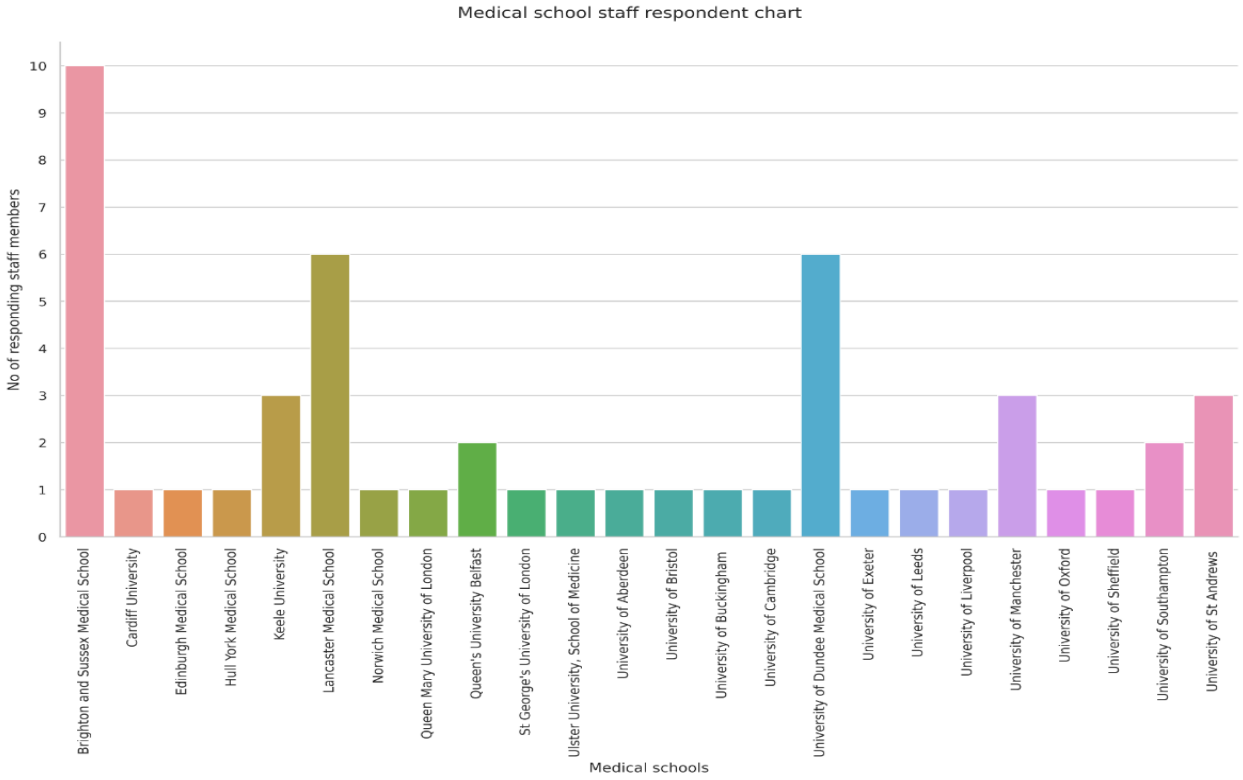

Fig. 18 Staff survey response distribution across schools

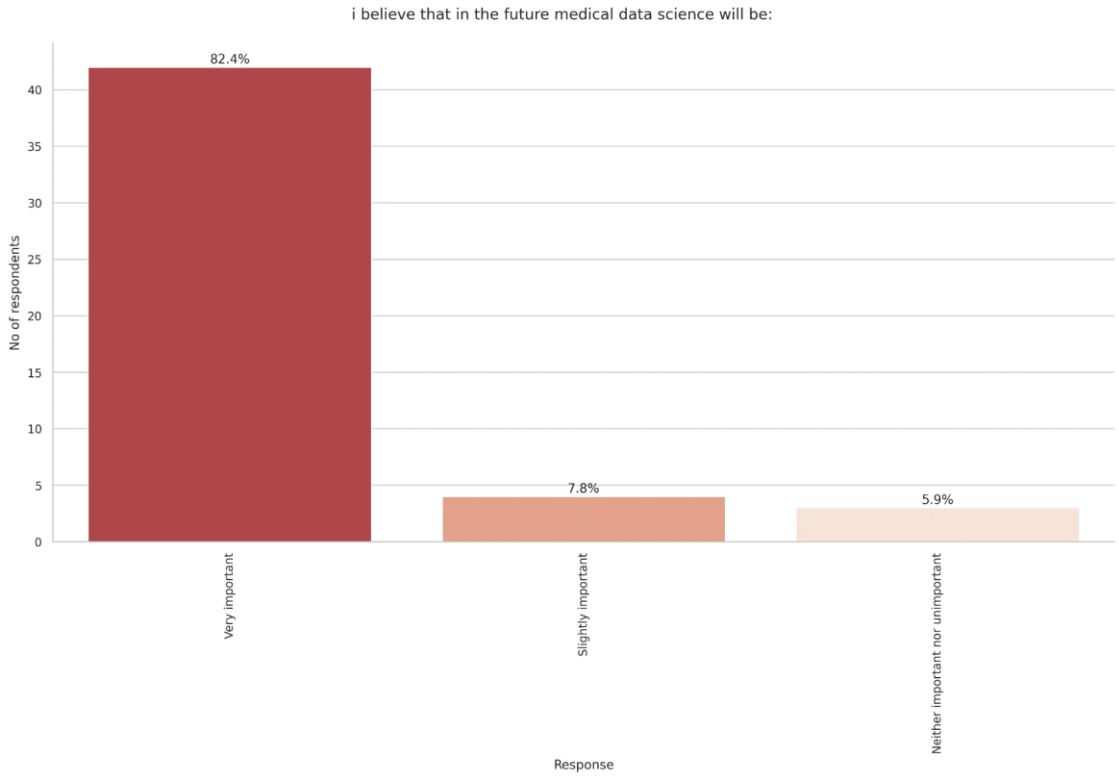

Fig. 19 I believe that in the future medical data science will be

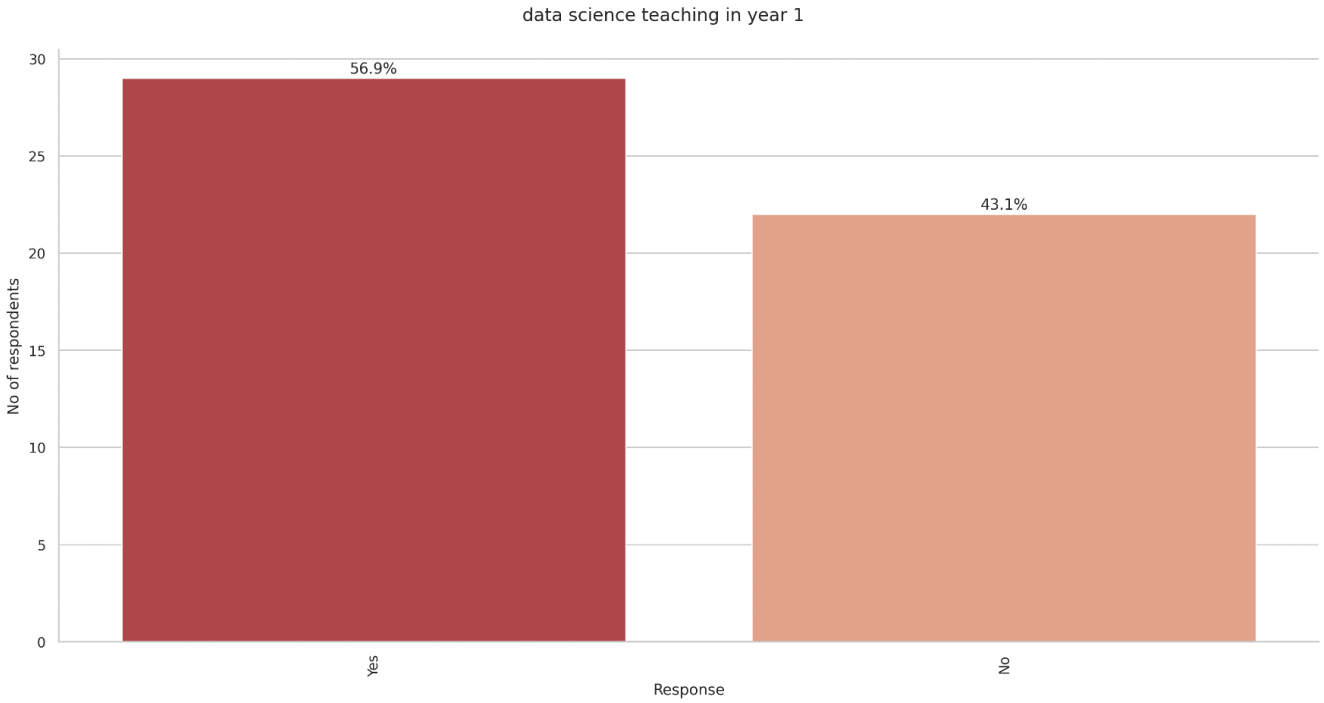

Fig. 20 Data science teaching in year 1

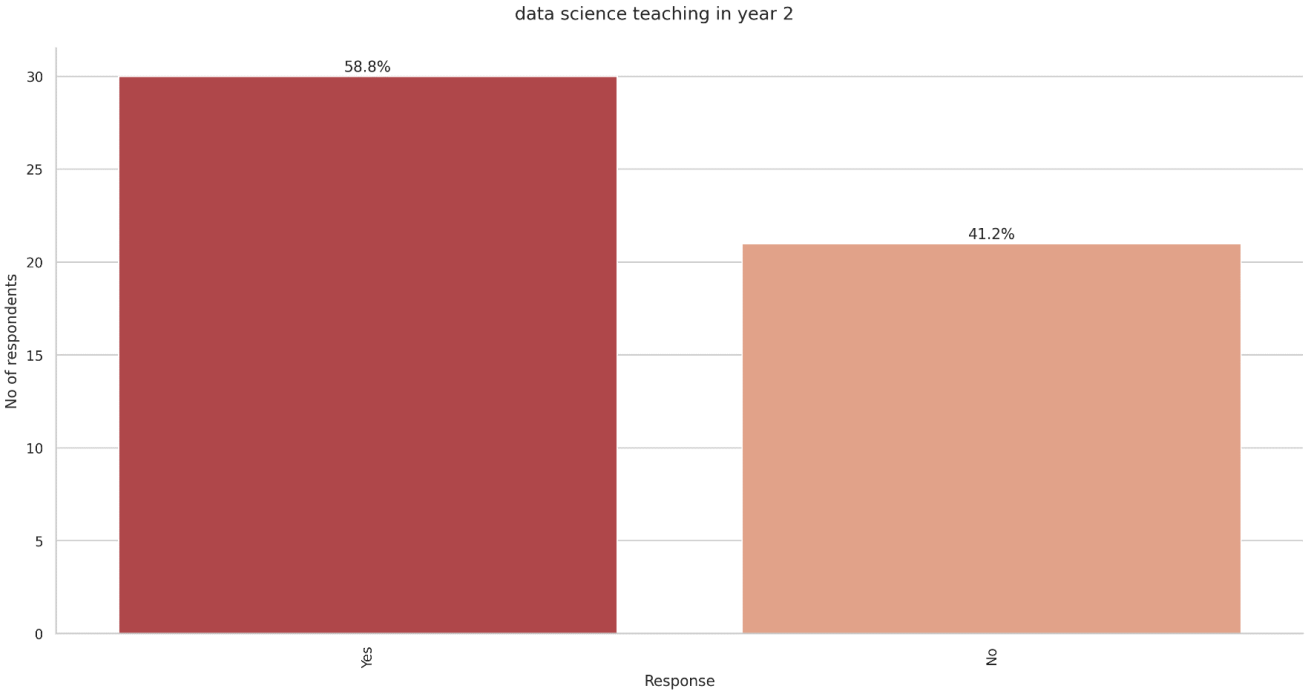

Fig. 21 Data science teaching in year 2

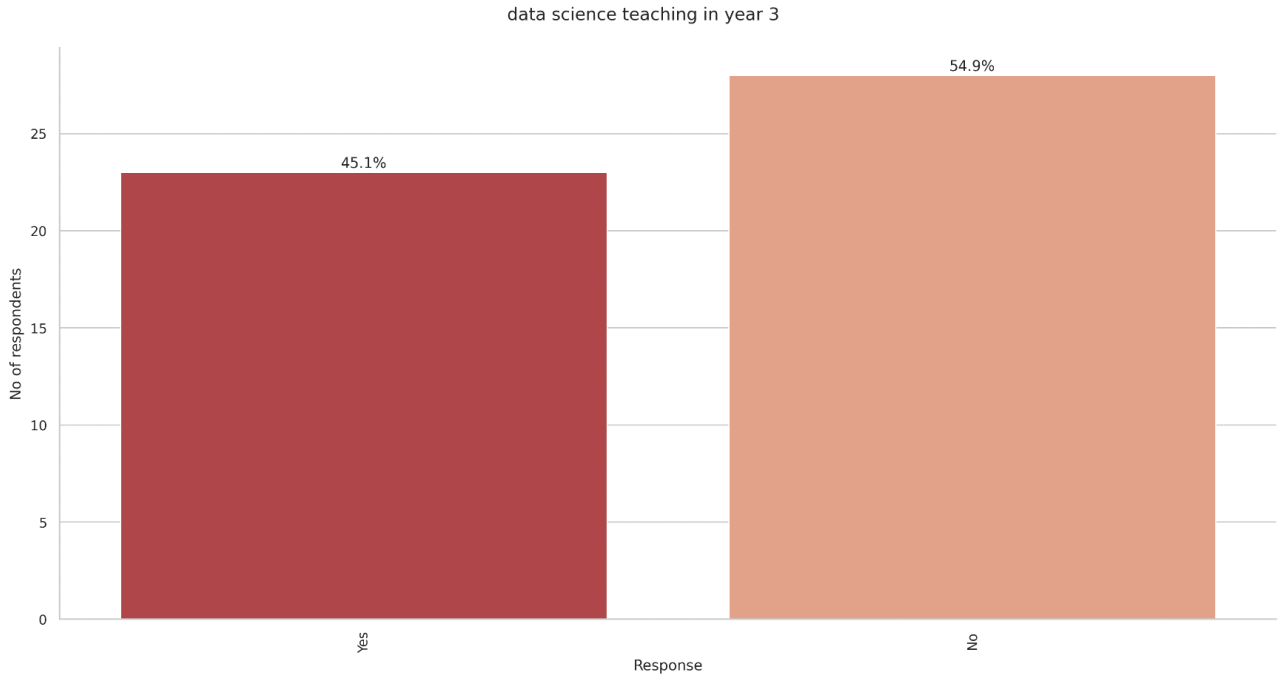

Fig. 22 Data science teaching in year 3

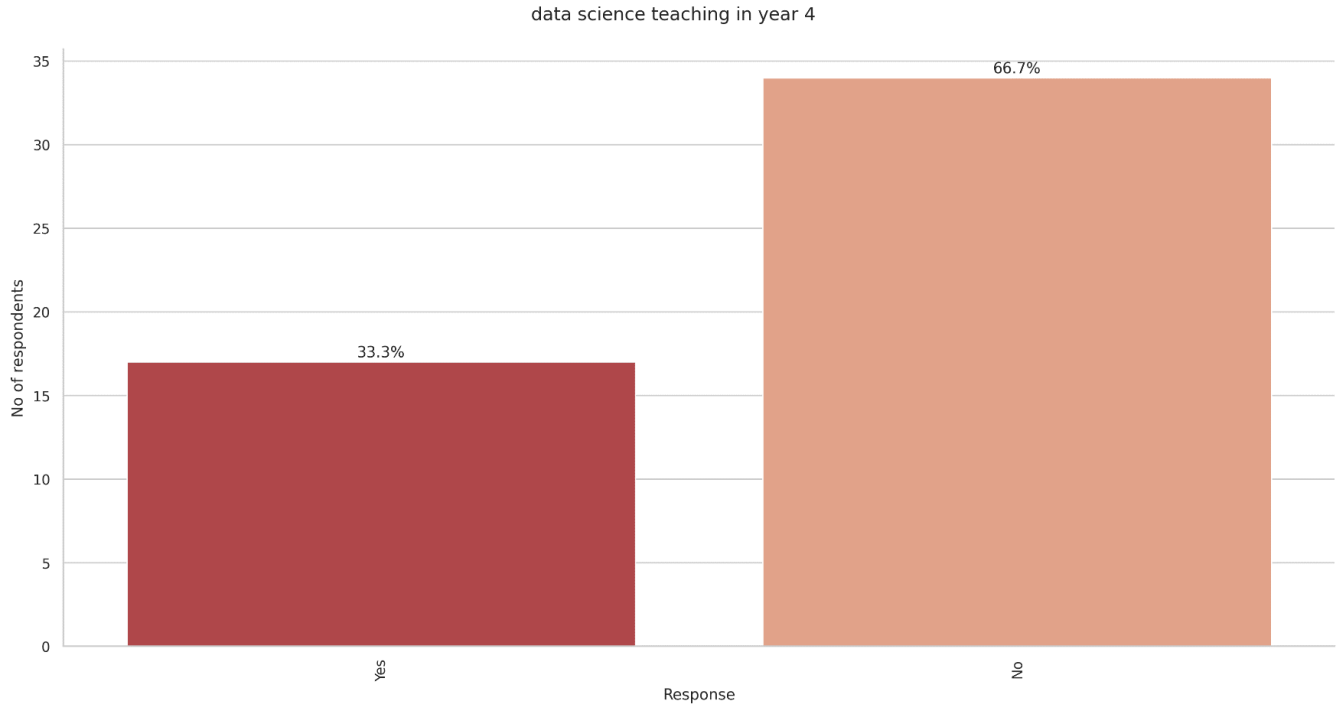

Fig. 23 Data science teaching in year 4

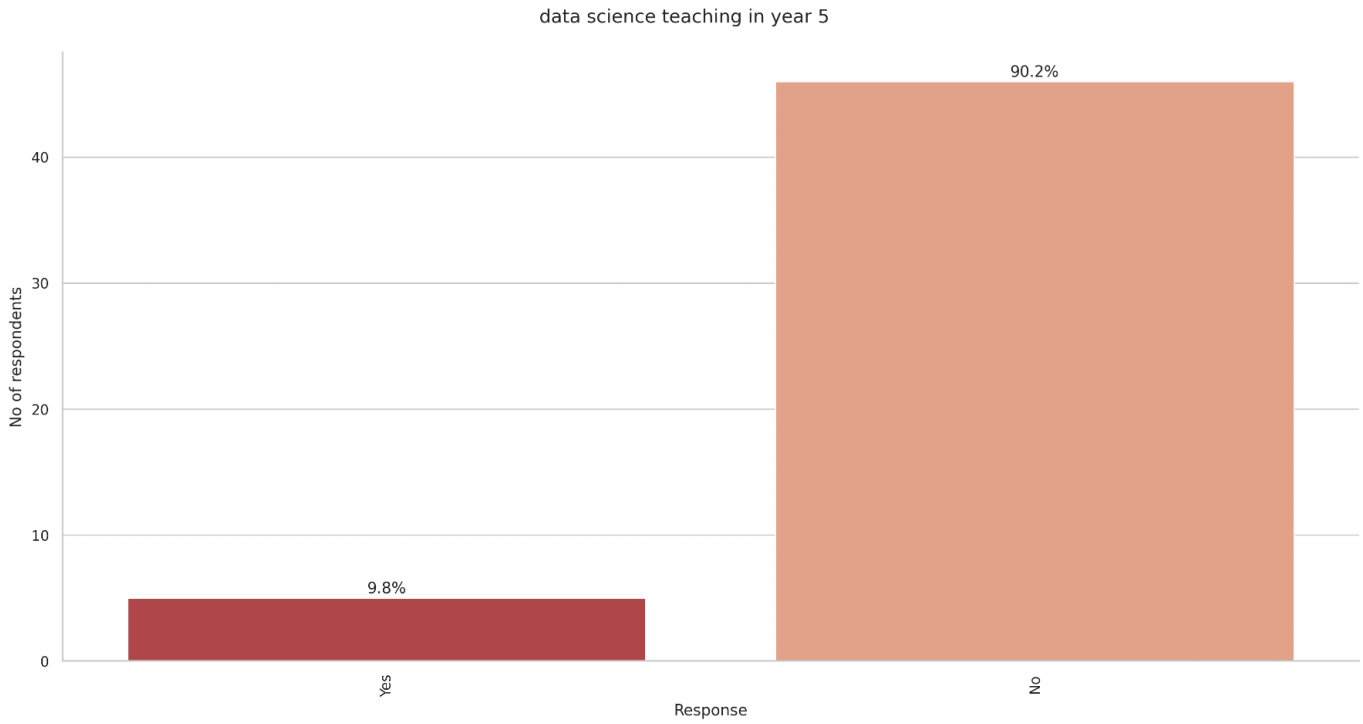

Fig. 24 Data science teaching in year 5

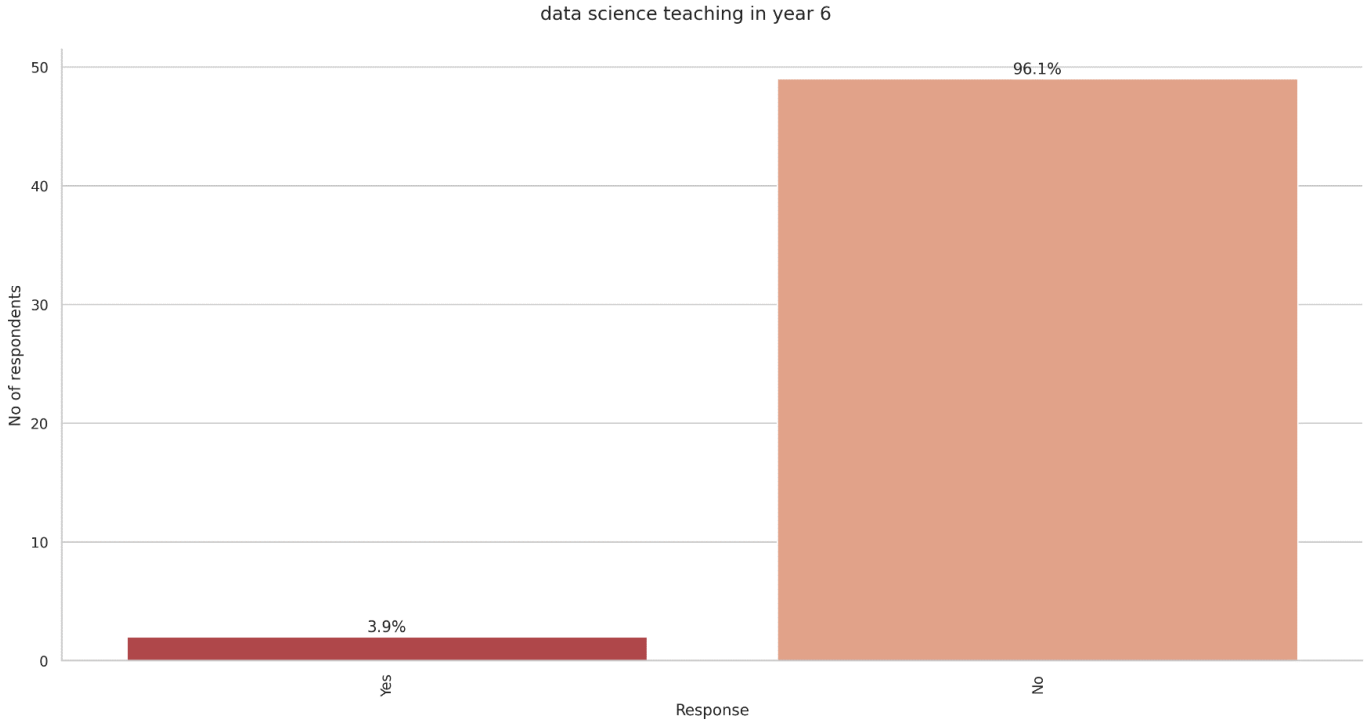

Fig. 25 Data science teaching in year 6

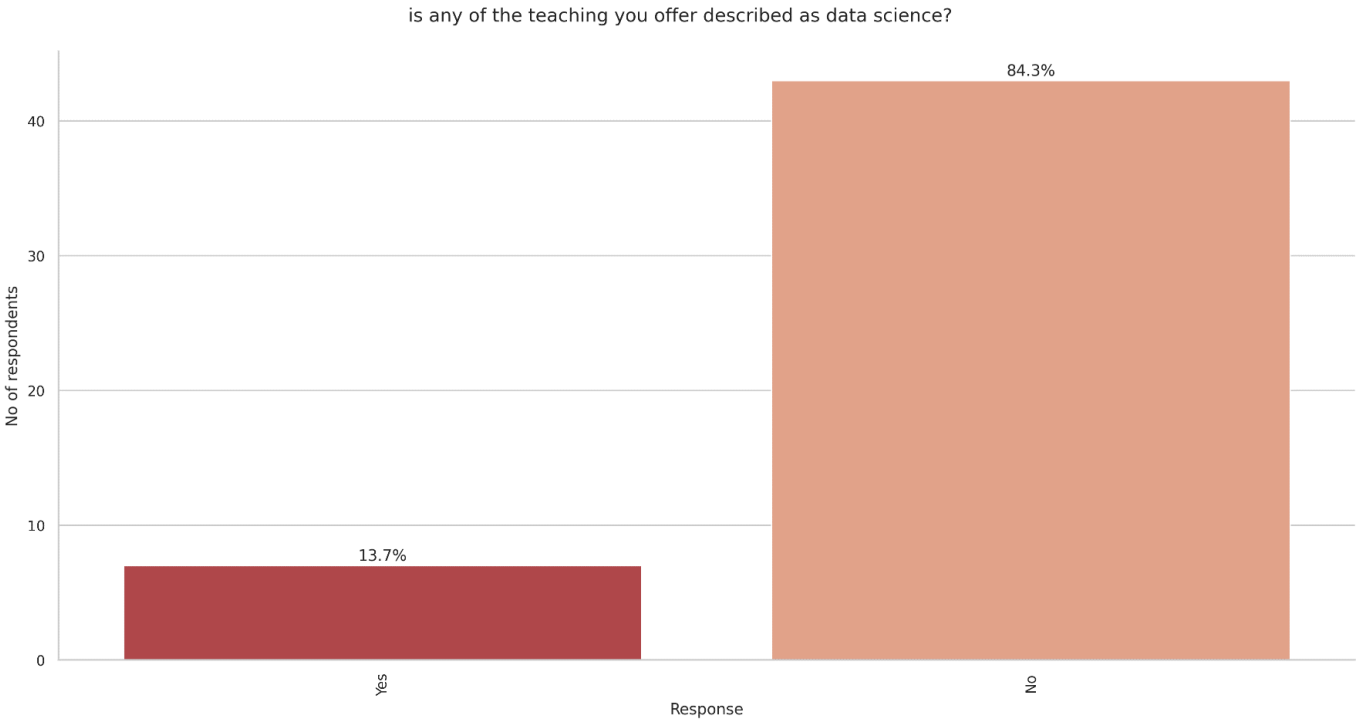

Fig. 26 Is any of the teaching you offer described as data science?

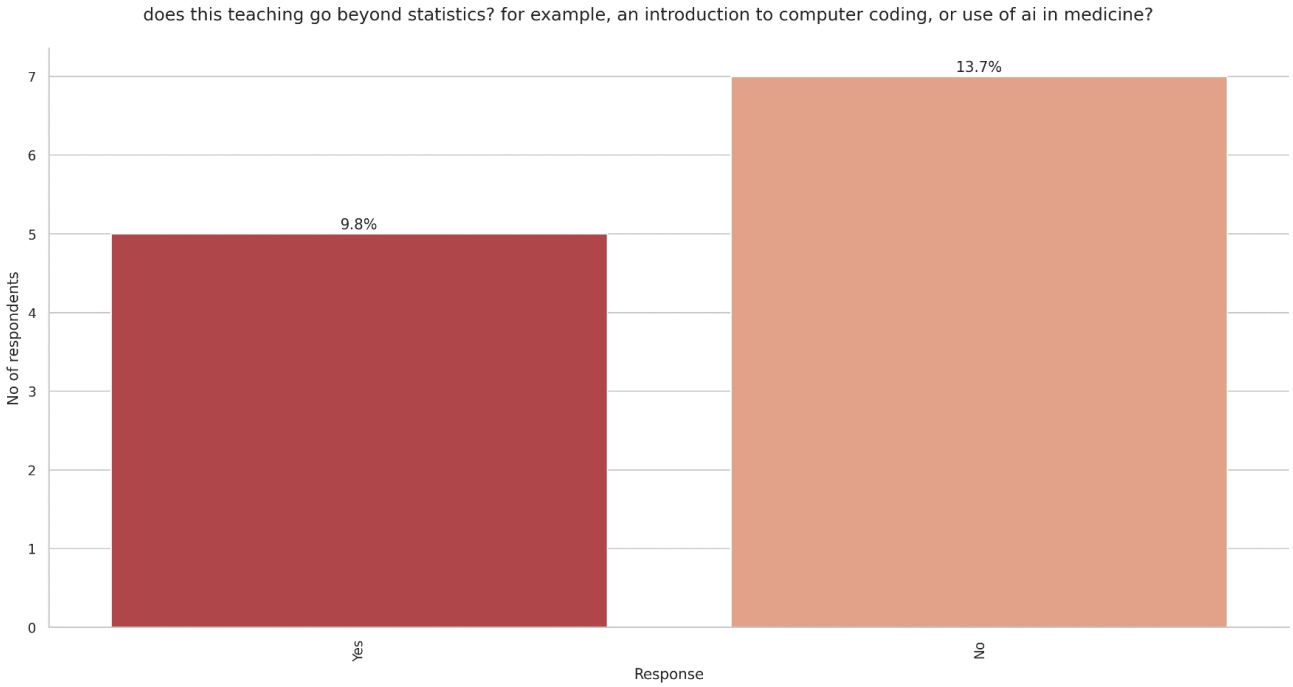

Fig. 27a If yes, does this teaching go beyond statistics? For example, an introduction to computer coding, or use of AI in medicine? (Overall percentage)

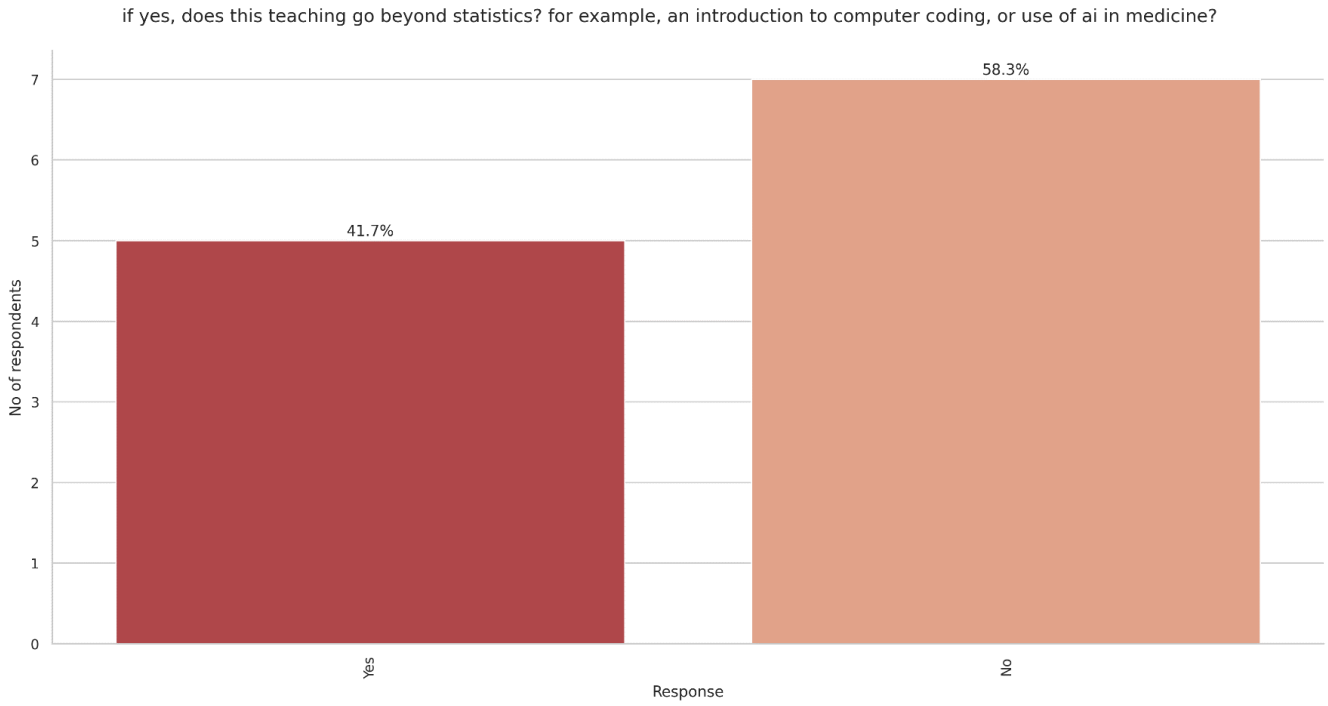

Fig. 27b If yes, does this teaching go beyond statistics? For example, an introduction to computer coding, or use of AI in medicine? (Specific percentage)

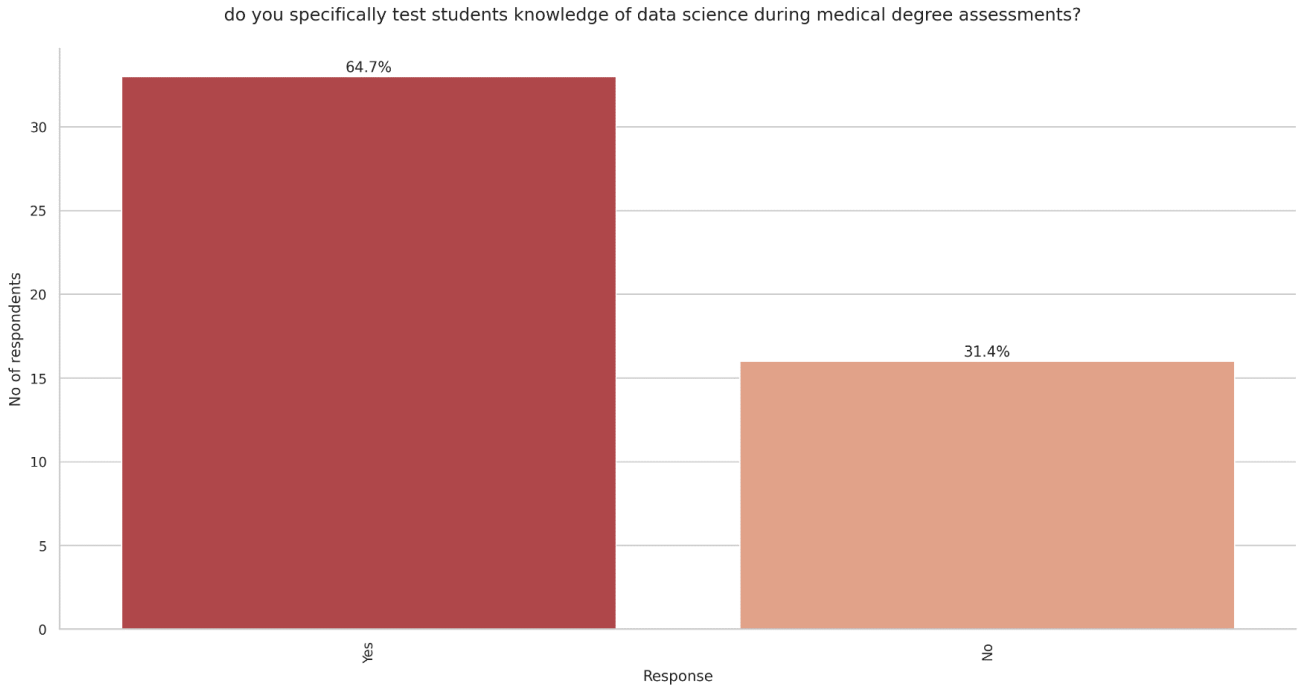

Fig. 28 Do you specifically test students' knowledge of data science during medical degree assessments?

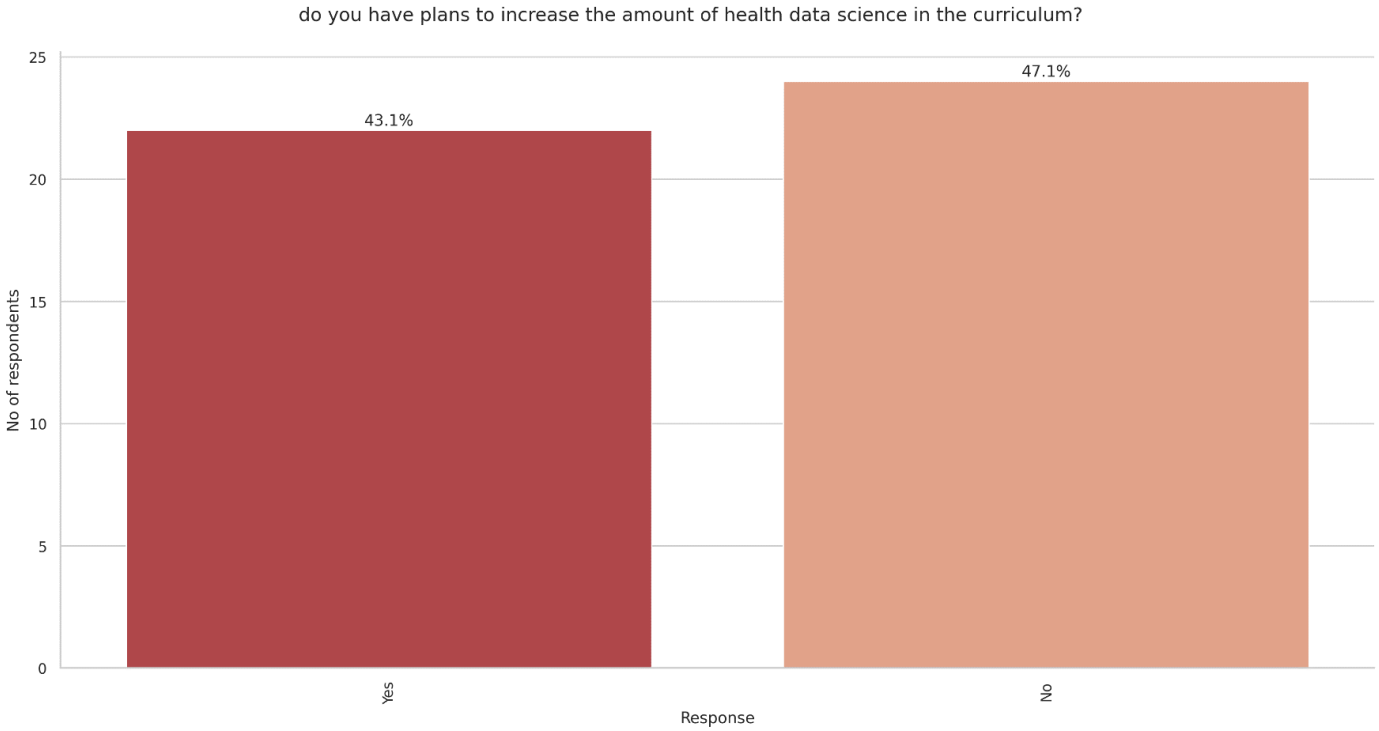

Fig. 29 Do you have plans to increase the amount of health data science in the curriculum?

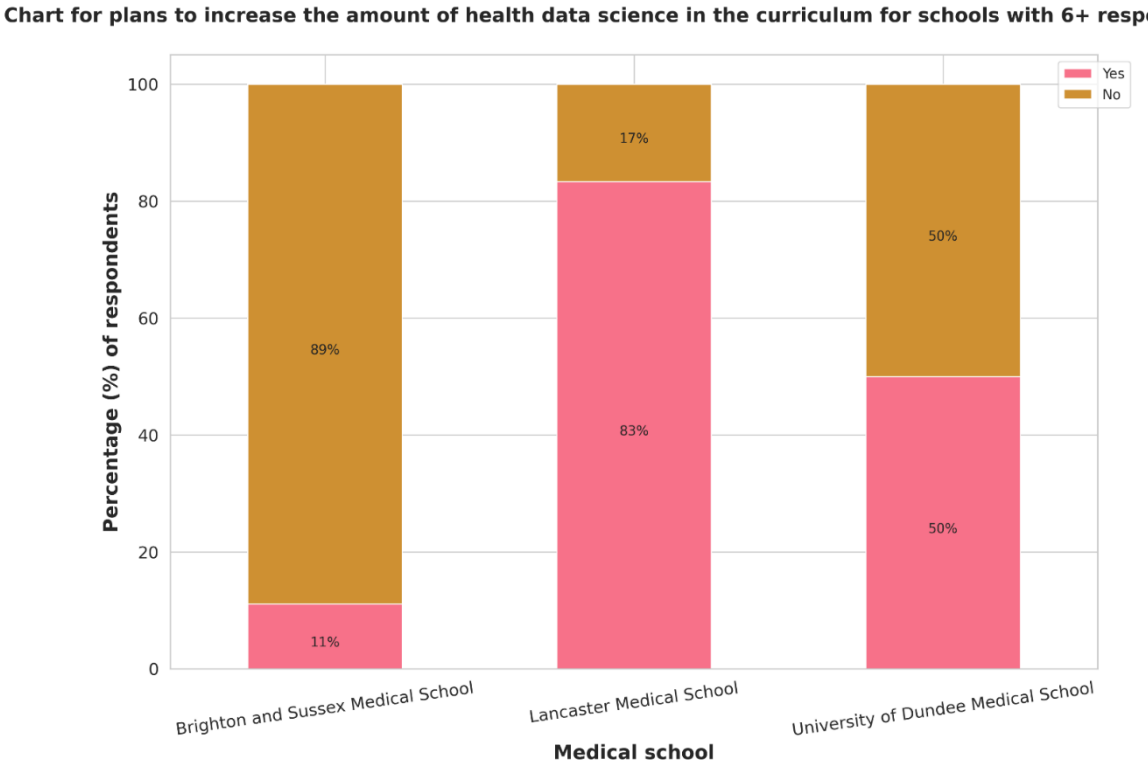

Fig. 30 Chart for plans to increase data science training in schools with 6 or more respondents

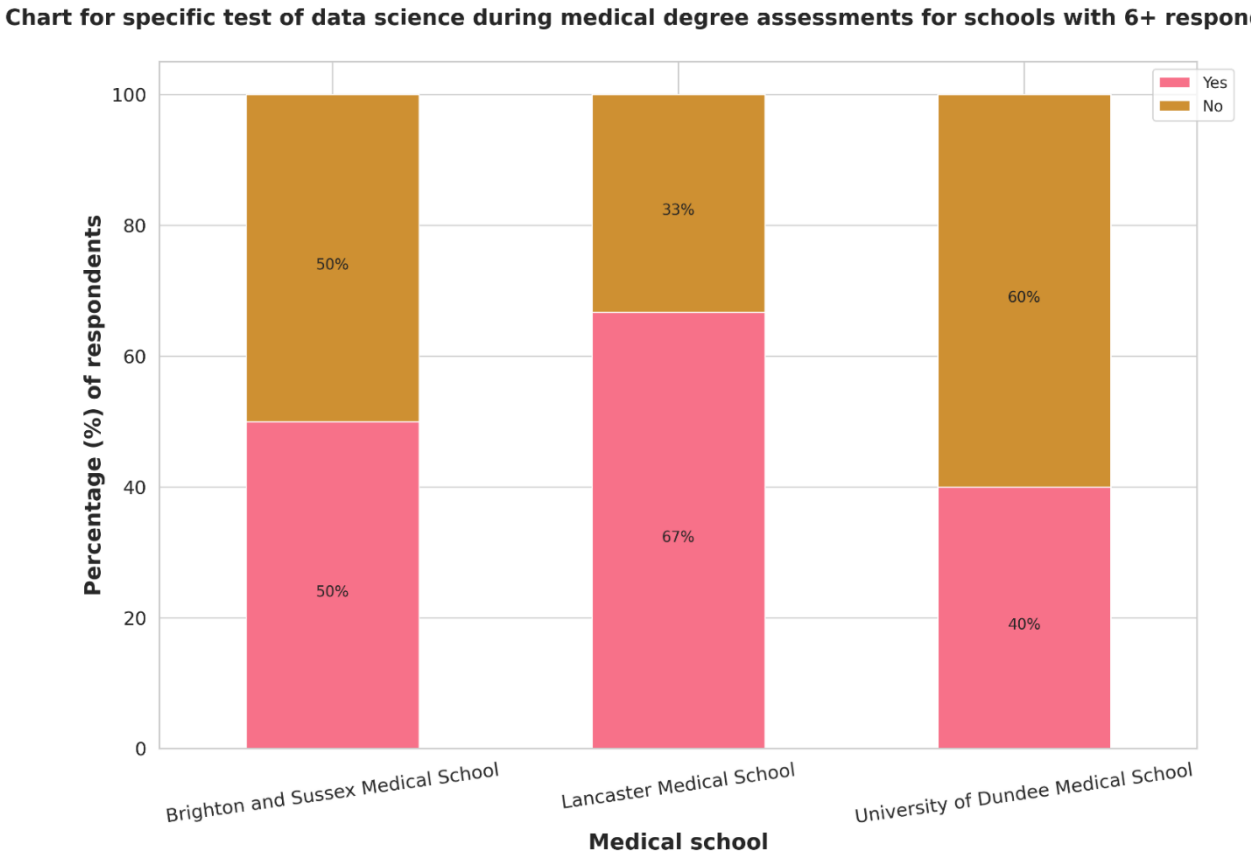

Fig. 31 Chart for test of data science training in schools with 6 or more respondents

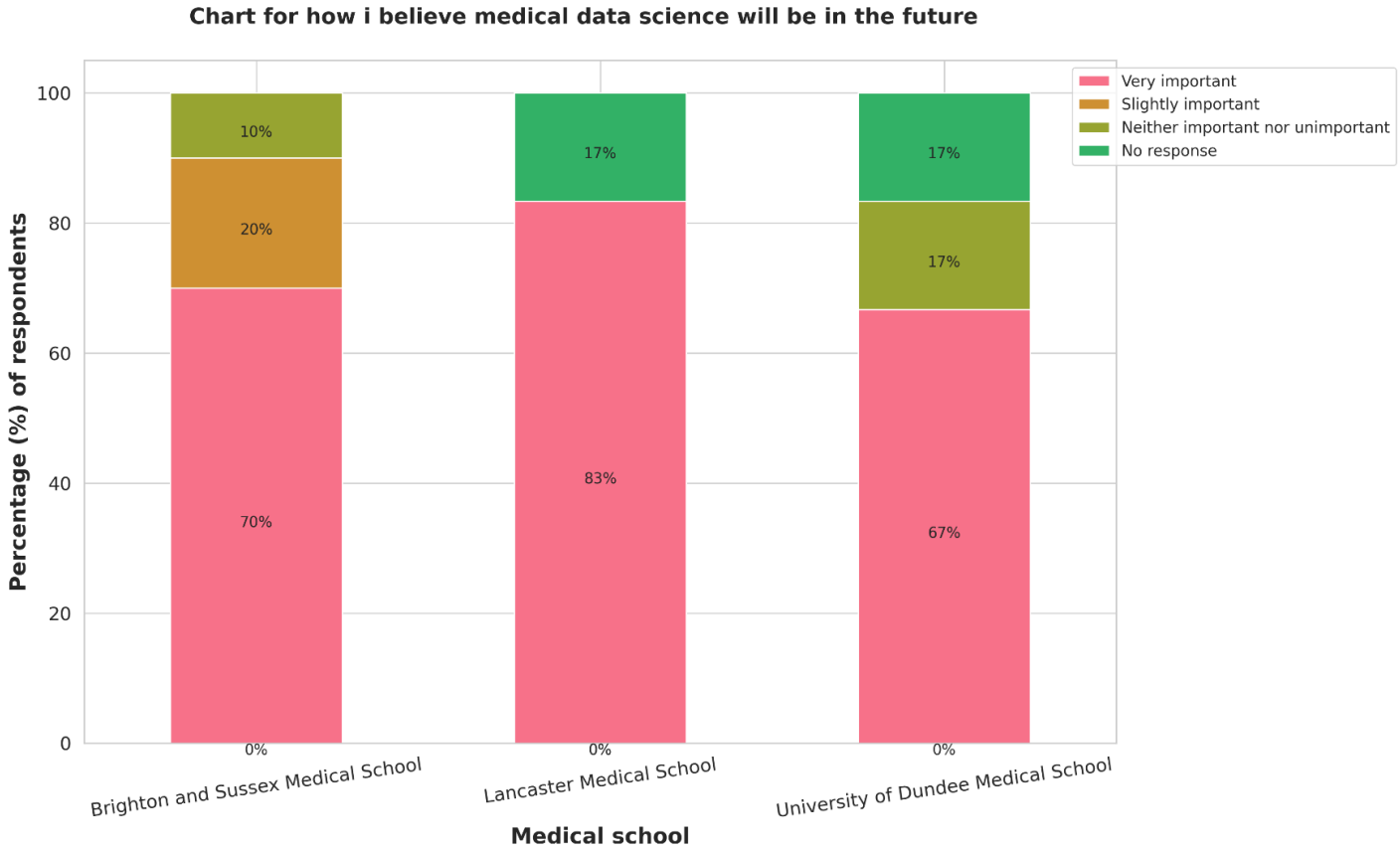

Fig. 32 Chart for “I believe that in the future medical data science will be:” in schools with 6 or more respondents

Discussion

Student Survey Discussion

175 responses were received across 19 unique medical schools. Students were queried regarding the extent of data science present in their curriculum and were also queried about their personal perception of the importance of data science and its elements. This was in a bid to gather evidence on the level of data science being taught to medical students across the United Kingdom.

The majority of the respondents were of the opinion that the level of data science in the curriculum was much less than needed as the survey responses highlighted the awareness of the respondents to the growing importance of data science. When asked what the level of data science training provided within their medical degree was, 42.3 per cent suggested that it was much less than needed and 23.4 per cent considered it slightly too little with only 11 per cent convinced that the right amount of data science is being taught (fig. 5).

Subsequent questions probed into individual elements of data science to understand the level of teaching of these elements that were represented in the curriculum from the students' perspective. The result agrees with the initial observations (fig. 5) that not a lot of data science is being taught to medical students. However, Clinical trials and Statistical testing and plotting data had a significant representation in the curriculum with 60 per cent of responding students stating they received training on each of them (appendix 2). In contrast, elements that inclined more with core data science are still largely unexplored in the curriculum with 83 per cent of respondents indicating they have not received any training on using statistics software e.g. SPSS, Excel, STATA, R, Python etc. Similarly, 95.4 per cent, 98.3 per cent and 88 per cent of the respondents indicated that they have not received any training in Basic Computer programming e.g. in R or Python, Artificial Intelligence / Machine Learning, Big Data Analytics / Real World Evidence respectively (appendix 2).

In comparison to the respondents perception of the influence and importance of data science elements in how they will practice medicine in the future, it was observed that although not a lot of data science is present in the curriculum at the moment, students are aware of the growing importance of data science and the digitalisation in healthcare as majority indicated that these elements of data science will either be slightly important or very important in how they will practice medicine. 86.3 per cent of the total respondents suggest that artificial intelligence will be slightly important or very important in how they will practice medicine (appendix 1). 60.6 per cent, 89.1 per cent, 90.9 per cent, 86.3 per cent, 65.2 per cent of respondents considered Virtual Reality, Big data analytics, Precision Medicine, Wearable technology, and The Internet of Things respectively to either be slightly important or very important in how they will practice medicine (appendix 1).

These, in combination with the 65.7 per cent of respondents that were of the opinion that the level of data science being taught to them was either slightly too little or much less than needed (fig. 5), against the observed low level of teachings/trainings in individual digital skills like use of statistics software (appendix 2) highlights the significant gap between the expectations of medical students in terms of data science and what they are currently being taught.

School-by-School Analysis

On a more specific note, upon analysis of a few schools with more than 15 respondents each, interesting patterns were uncovered. In University of Leeds and University of Bristol, 5 per cent of the respondents considered the amount of data science being taught to be much more than needed (fig. 6). Another 21 per cent in University of Leeds thought the amount of data science being taught was a little too much (fig. 6). 16 per cent in University of Leeds considered the amount of data science being taught to be the right amount. A further 21 per cent in the University of Leeds were of the opinion that the data science being taught was much less than needed (fig. 6). This is significantly low compared to other schools that met the set threshold. University of Bristol, University of Dundee and University of Oxford all presented with 53 per cent, 43 per cent and 50 per cent of respondents respectively suggesting that the level of data science training on their courses were much less than needed (fig. 6). University of Bristol and University of Oxford had 15 per cent and 22 per cent of their respective respondents suggesting that the amount of data science being taught was the right amount (fig. 6). Regardless, it is clearly represented that students across these universities would like to take on more data science in their curriculums considering their opinion that the data science being taught was less than needed.

Similarly, when students were asked if they were specifically tested on data science, students from University of Leeds had the highest agreement rate with 43 per cent of respondents either strongly agreeing or just agreeing compared to the 28 per cent of respondents from University of Oxford (fig. 7). In University of Bristol and University of Dundee, 21 per cent and 14 per cent of respondents agreed that they were specifically tested on data science respectively (fig. 7).

From the observed data, University of Leeds appears to be offering more data science in their curriculum compared to the other universities.

Course-type Analysis

Across the different course types offered by universities in the UK, there are different patterns in the perception of students enrolled in these different course types. Of the 99 respondents enrolled on the 5-year course, only 5 per cent considered the amount of data science being taught to be much more than needed with 6 per cent thinking it was slightly too much. 12 per cent thought it was the right amount, 19 per cent thought it was slightly too little and 39 per cent thought it was much less than needed (fig. 8).

Amongst students enrolled on the 5-years plus intercalation course type, 46 per cent considered the amount of data science being taught to be much less than needed, and 34 per cent saying it was slightly too little (fig. 8). This highlights the higher demand for data science training amongst students enrolled in the 5-year plus intercalation program. Similarly, amongst students enrolled on the 4-years course type, 47 per cent considered the amount of data science being taught to be much less than needed, and 27 per cent saying it was slightly too little (fig. 8). Only one respondent was enrolled on the 5-year plus science foundation course type which is not enough data to analyse the trends in the course type.

When asked if they were specifically tested on data science, a similar percentage ranging between 22 per cent to 24 per cent of respondents agreed that they were tested in data science across the course types with the exception of the 5-year plus science foundation as there was only one respondent in that category (fig. 9). This suggests that across all course types, there is a consistency in how data science is being tested in the curriculum.

Intra-school Analysis

Level of Data Science Training

This survey highlighted the differences between the opinions and perspective of students in the same class in the same school, despite being subjected to the same learning conditions under the guide of the same learning outcomes.

Schools with at least 15 responding students were filtered and analysed, revealing that despite being taught the same thing, students might have different perceptions and understanding of what is being taught (fig. 10 – 13).

Seven responding students that just completed the first year at University of Bristol (fig. 10), gave four different answers regarding the level of training received on data science ranging from two participants suggesting the level of data science being taught was the right amount, two participants said slightly too little, one participant said it was much less than needed with another two not being sure what they think. This highlights the underlying but important factor of students' understanding of the curriculum as these are largely subjective. A similar pattern ensued across all selected Universities, that is University of Oxford, University of Leeds and University of Dundee (fig. 11 – 13).

Notably, the three responding students in the second year of University of Oxford (fig. 13) all registered the same opinion of the level of data science being taught to them as they all considered it the right amount.

Level of Data Science Testing

Similar to the patterns and trends observed in the perception of students within the same class and in the same school about the level of data science they are being taught, there was a noticeable disparity between the responses of students when asked “To what extent to you agree or disagree with the following statement: My university will specifically test my knowledge of data science during my medical degree assessments?”.

Students reported differing opinions on their level of agreement on if they have been specifically tested on data science, which raises a point of concern as to whether students truly understand what data science is and if they could identify elements of data science in their tests and in the curriculum, giving the contrasting nature of responses within the same class. It is unclear if the objectives were truly understood by the students.

Although these questions are raised, it is important to note and consider the varying levels of attention paid by students in class because this can be influenced by a variety of factors on an individual basis, as students tend to have different experiences and also report different accounts of the same event, as highlighted in this survey.

Two students in the 3rd year at University of Bristol (fig. 17) disagreed with the question, suggesting that they were not specifically tested on data science. Although not statistically significant as just two students responded from that class, that was the only instance of uniformity in response from students in the same class and in the same school when asked if they were tested on data science. Classes with just one respondent were not considered in this notation.

A visual representation of the extent of contradiction of opinions of students on if they are specifically tested on data science is represented in fig. 14 - fig. 17.

Staff Survey Discussion

A total of 51 responses were recorded from the staff survey which thinly spread across 21 unique medical schools (fig. 18). Brighton and Sussex Medical School had the most representation with 10 responses, closely followed by Lancaster medical school and University of Dundee Medical School with 6 respondents each.

When queried, majority of the medical school staff members that participated in this survey believed that data science will be very important in the future with 82.4 per cent of the respondents suggesting that it will be very important and a further 7.8 per cent suggesting that it will be slightly important (fig. 19). This follows a similar trend of perception observed in the students' survey, highlighting the confidence within both responding groups that data science will play a major role in medicine in the future.

Since the perceived importance of data science in medicine has been established amongst the responding staff members of medical schools, further query into the amount of data science currently being taught to medical students was analysed. An interesting trend was observed as the amount of data science taught to medical students generally dropped as the years progressed, with the exception of the 2nd year (fig. 21), where more data science was taught compared to the 1st year (fig. 20). 56.9 per cent of the responding staff members said they/ their medical school taught data science in the 1st year, 58.8 per cent, 45.1 per cent, 33.3 per cent, 9.8 per cent, 3.9 per cent in the 2nd year, 3rd year, 4th year, 5th year and the 6th year respectively (fig. 20 – fig. 25). It will appear that less of data science is included in the latter part of the medical school curriculum, it is unclear whether this is to focus more on clinical requirements of the medical curriculum, but this seems to be a consistent trend across medical schools that have respondents in this survey.

When asked if any of the teaching they offered was described as data science, 84.3 per cent suggested that was not the case as only 13.7 per cent said "yes" (fig. 26). This amounts to 7

respondents out of the 51 total respondents. Surprisingly, when asked “If the answer to question 5 (the previous question) is yes, does this teaching go beyond statistics? For example, an introduction to computer coding, or use of AI in medicine?” 12 responses were received as opposed to the initial 7 “yes” responses received, highlighting the need for validation of the survey questions on the appropriate platform. Regardless, of the 12 responses received, 5 responded positively to the question suggesting that indeed, the teaching of data science offered went beyond statistics. This amounts to 41.7 per cent (fig. 27b) of the 12 specifically responding participants, and 9.8 per cent (fig. 27a) of the total respondents. This suggests that majority of the medical schools do not teach data science beyond statistics.

This is further evidenced by the query into the presence of learning objectives for individual elements of data science in the curriculum. 84.3 per cent (appendix 3) indicated that there are learning objectives for clinical trials in the curriculum. Similarly, 86.3 per cent (appendix 3) indicated that statistical testing and plotting data learning objectives are present in the curriculum. In contrast, only 27.5 per cent, 37.3 per cent, 7.8 per cent and 2.0 per cent (appendix 3) suggested that they had learning objectives for “Using statistics software e.g. SPSS, STATA, Excel, R, Python etc”, “Big data analytics/ real world evidence”, “Basic computer programming e.g. in R or python”, and “Artificial Intelligence / Machine Learning” respectively in the curriculum. This further solidifies the position that data science is often not thought beyond statistics in medical school which is in consonance with the observations made in the students’ survey analysis where core elements of data science like machine learning and computer programming were not heavily represented in the curriculum.

When asked if they specifically test students’ knowledge of data science during medical degree assessments, 64.7 per cent (fig. 28) of the respondents suggested that they test students’ knowledge in data science. The high rate of awareness of the importance of data science in medicine, particularly in the future reflects in the attempts of staff members to test medical

students in data science, though, not as much in the training offered to students in data science as core elements of data science are still not undertaken and only 43 per cent (fig. 29) of the respondents suggesting that they had plans to increase the amount of data science in the curriculum. It should be noted that the extent of the testing of data science accommodated in the curriculum was not established in this survey.

Inter-School and Intra-School Analysis

A threshold of six respondents was set for schools that participated in this survey to get some insight into the unique patterns in individual schools. Brighton and Sussex Medical School (10 respondents), University of Dundee Medical School (6 respondents), and Lancaster University (6 respondents) are the medical schools that met the set threshold.

Test of Knowledge of Data Science

In Brighton and Sussex Medical School, 50 per cent of responding staff members suggested that they specifically test students for knowledge of data science with the other 50 per cent saying otherwise in what was an even split (fig. 31). This could be due to differing understandings of the curriculum, or a specific and limited knowledge of the section of the curriculum that relates to each responding staff member, nevertheless, there is an inconsistency in the level of testing of students' knowledge in data science. This was similar in University of Dundee Medical School where 40 per cent of respondents suggested that they test students for the knowledge of data science. This was also the case in Lancaster University, where 67 per cent of respondents suggested that they test students for the knowledge of data science (fig. 31).

Importance of Data Science in the Future

Across all three filtered schools, there was a high rate of perception of importance of data science in the future, similar to the overall perception of the general respondents. Brighton

and Sussex Medical School returned 70 per cent rate of “Very important” and 20 per cent rate of “Slightly important” with 10 per cent being indifferent (fig. 32). In Lancaster University and University of Dundee Medical School, 83 per cent and 67 per cent indicated respectively that it will be very important (fig. 32).

Plans to Increase Data Science Training

There are no concrete plans to increase the level of data science training in Brighton and Sussex Medical School as 89 per cent of respondents suggested that there were no such plans (fig. 30). In contrast, 83 per cent of respondents from Lancaster suggest there are plans to increase the level of data science training they provide (fig. 30). In University of Dundee Medical School, it was an even split of 50 per cent each with one half suggesting there are plans to increase data science training, while the other half said otherwise (fig. 30).

Limitations

Student Survey

A major limitation to this study is the response rate across the medical schools in the UK. Only 175 respondents across 19 schools with some schools having as high as 21 respondents while some only had 1. This means that there was not enough data to triangulate this survey on a school-by-school basis and there is a potential risk of underrepresentation for certain schools and overrepresentation for some schools which could introduce bias.

Noteworthily, students in the same school and in the same class appeared to have different perceptions of the level of data science elements in their curriculum as highlighted in the discussion.

Staff Survey

Similar to the student survey, there is a shortage in data points as the survey turnout was low with 51 respondents further spread thin through 21 responding medical schools. This made it difficult to statistically back the findings of this survey and puts this analysis at risk of bias through over-representation and under-representation.

Secondly, a survey question that was directly tied to the response of another question in the survey received an unexpected number of responses, limiting the accuracy of the relationship between both questions as respondents who didn't select the prerequisite option proceeded to answer the subsequent question.

Recommendations

Considering the current trends in health care and the surge in applicability of data science alongside the potentials it holds in improving health care, it is considered desirable for health professionals to possess relevant data skills to maximise this said potential. With the apparent levels of current data training available to medical students, it is unlikely that the relevant skills will be obtained. It is therefore recommended that more data science training be included in the medical school curriculum across the United Kingdom.

Upon observations of the inconsistencies in the perceptions levels of data science training and testing across different universities, it is recommended that a central learning outcome for data science be developed within the confines of the medical school curriculum that offers a consistent level of data science training to students across different universities while still retaining the flexibility within each school.

In addition, considering the already cumbersome workload and the tight schedules that currently exist in the medical school curriculum, it is recommended that data science learning can be explored outside of the confines of the medical school curriculums through bootcamps or prerecorded data science lessons with digital learning environment, made available to students with keen interest in data science to explore and engage in self-directed learning. This is particularly recommended as students have shown significant interest in data science based on the outcome of this survey as highlighted in the results and discussion sections. Students are also aware of the significant benefits attached to being proficient in data science domain for medical professionals. This will suggest that if this keen interest of students in data science is leveraged upon, it is likely that students will engage in well-paced self-learning courses that complements the existing medical school's curriculum.

Furthermore, Seeing the varying opinions and interpretations of the curriculum by staff members in the same medical school, a joint ownership and understanding of the learning objectives is recommended for a consistent approach to learning.

Albeit consistent with the findings of the student survey to a significant extent, more effort is required to improve the consistency of the learning objectives across medical schools in the United Kingdom.

Lastly, further research on these surveys is encouraged to further validate or contest the findings of these surveys and analyses.

References

Gehring, S., & Eulenfeld, R. (2018). German medical informatics initiative: unlocking data for research and health care. *Methods of information in medicine*, *57*(S 01), e46-e49.

Goodman, J., Gorman, L., & Herrick, D. (2010). Health information technology: Benefits and problems. *National Center for Policy Analysis, Washington*, 1-23.

Gutiérrez-Aguado, A., Curioso, W. H., Machicao, J. C., & Eguia, H. (2023). Strengthening capacities of multidisciplinary professionals to apply data science in public health: Experience of an international graduate diploma program in Peru. *International Journal of Medical Informatics*, *169*, 104913. https://doi.org/https://doi.org/10.1016/j.ijmedinf.2022.104913

Mehta, N., & Pandit, A. (2018). Concurrence of big data analytics and healthcare: A systematic review. *International Journal of Medical Informatics*, *114*, 57-65. https://doi.org/https://doi.org/10.1016/j.ijmedinf.2018.03.013

Mijwil, M. M., Faieq, A. K., & Al-Mistarehi, A.-H. (2022). The Significance of Digitalisation and Artificial Intelligence in The Healthcare Sector: A Review. *Significance*, *10*(3).

Park, S. H., Do, K.-H., Kim, S., Park, J. H., & Lim, Y.-S. (2019). What should medical students know about artificial intelligence in medicine? *Journal of educational evaluation for health professions*, *16*.

Raghupathi, W., & Raghupathi, V. (2014). Big data analytics in healthcare: promise and potential. *Health Information Science and Systems*, *2*(1), 3. https://doi.org/10.1186/2047-2501-2-3

Reddy, P., & Sharma, B. (2016). Digitalisation: the future of health care. *Journal of business Management*, *11*.

Wang, Y., Kung, L., & Byrd, T. A. (2018). Big data analytics: Understanding its capabilities and potential benefits for healthcare organizations. *Technological Forecasting and Social Change*, *126*, 3-13. https://doi.org/https://doi.org/10.1016/j.techfore.2015.12.019

Appendix

Appendix 1 (Importance)

On a scale of very important to not important at all, how would you rate the following in terms of how influential they will be on changing the way medicine is practiced within your career?

Artificial Intelligence

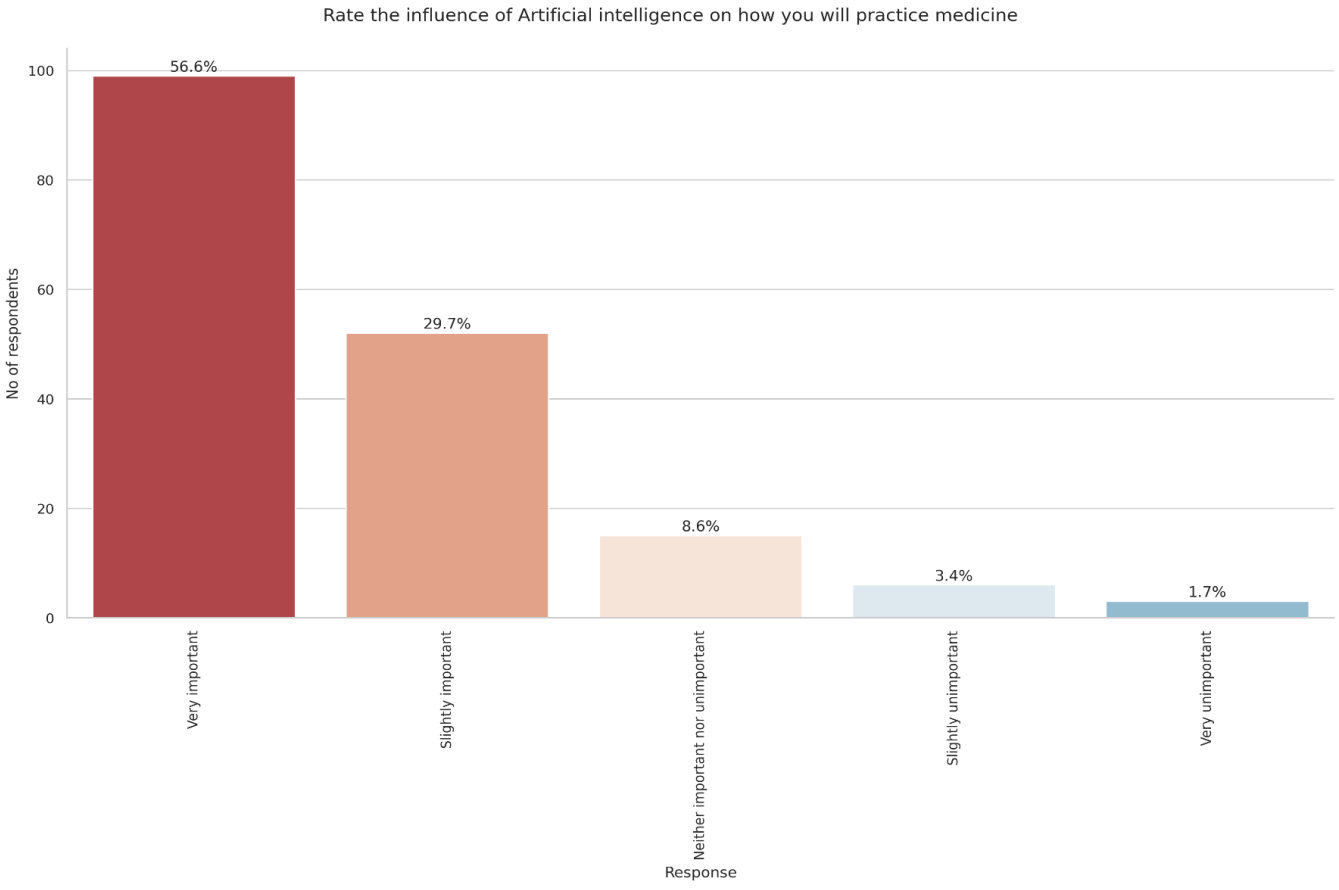

Fig. 33 Influence of artificial intelligence on how you will practice medicine

Virtual Reality

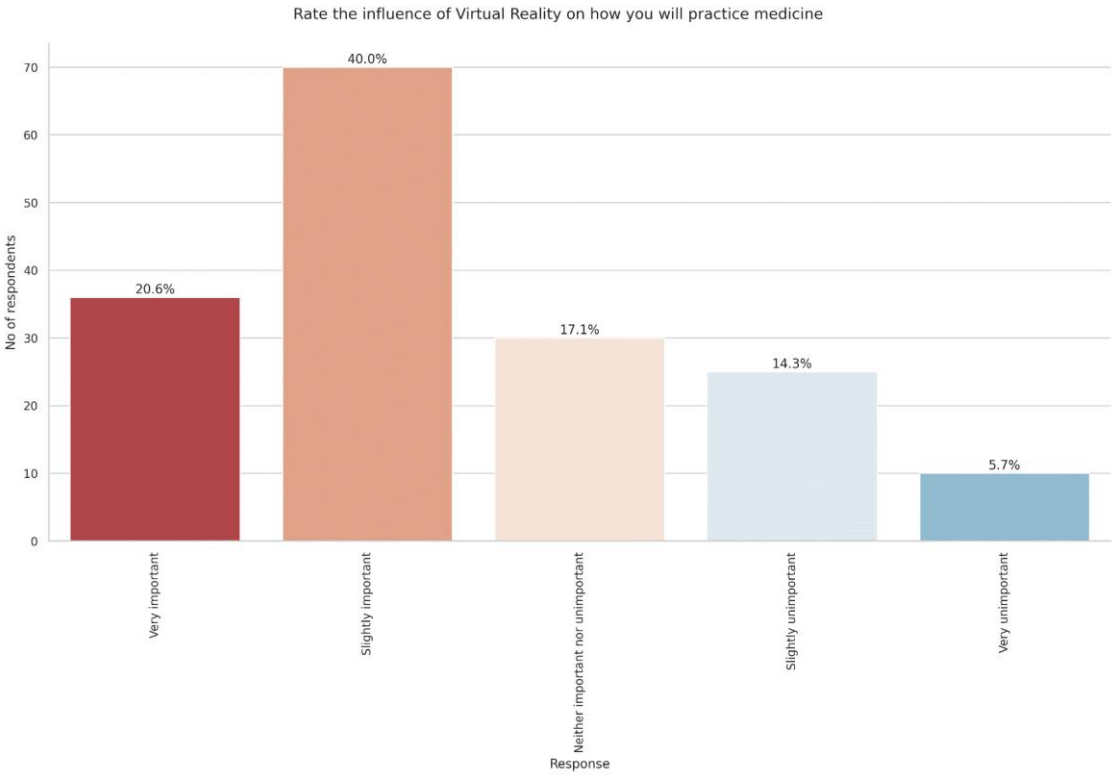

Fig. 34 Influence of virtual reality on how you will practice medicine

Big Data Analytics

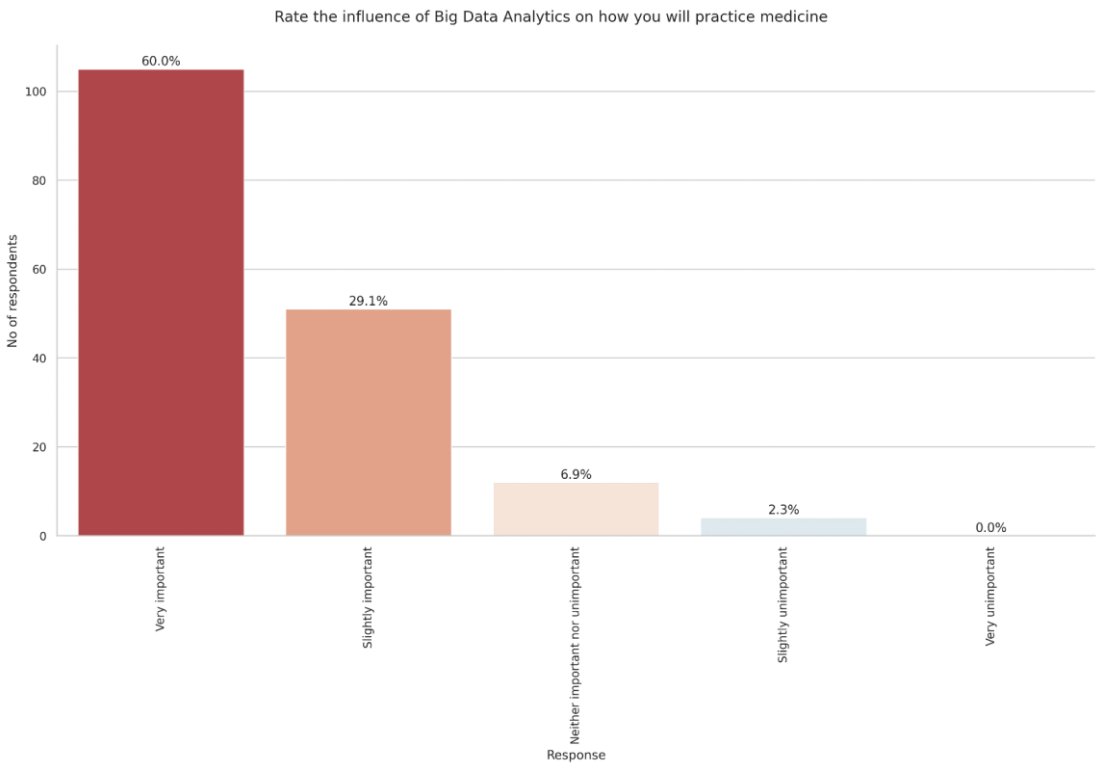

Fig. 35 Influence of big data analytics on how you will practice medicine

Precision Medicine

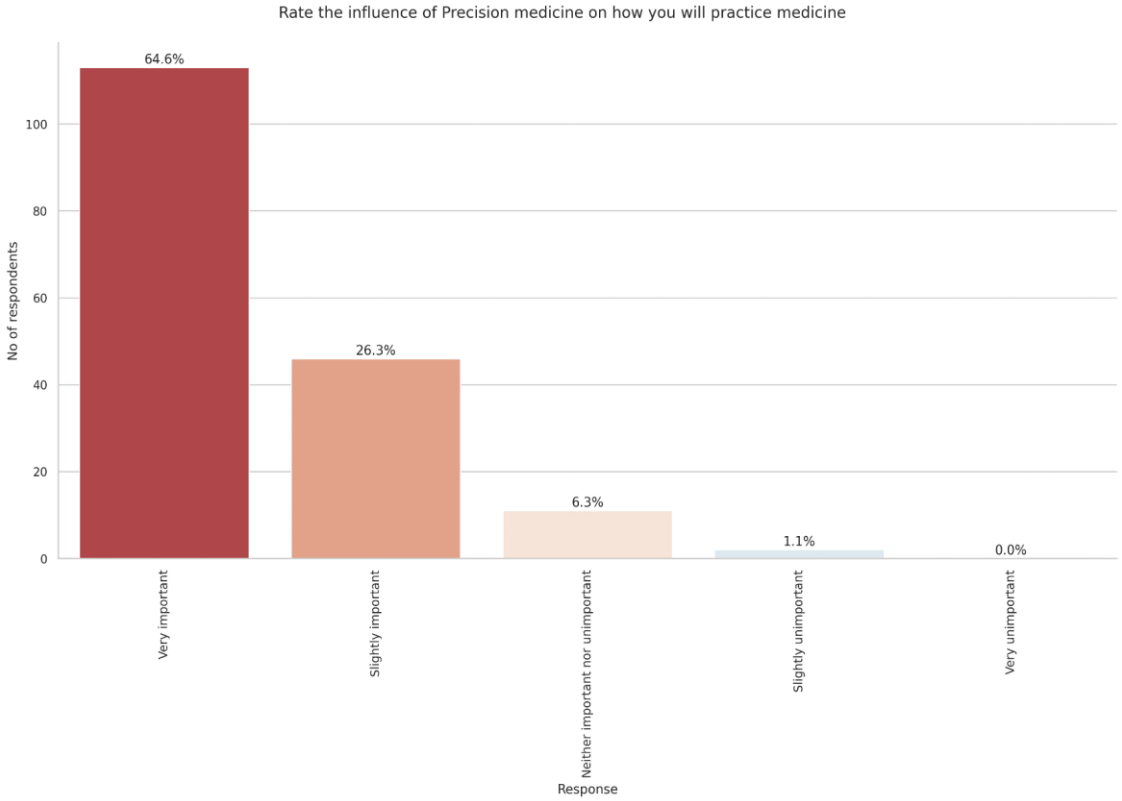

Fig. 36 Influence of precision medicine on how you will practice medicine

Wearable Technology

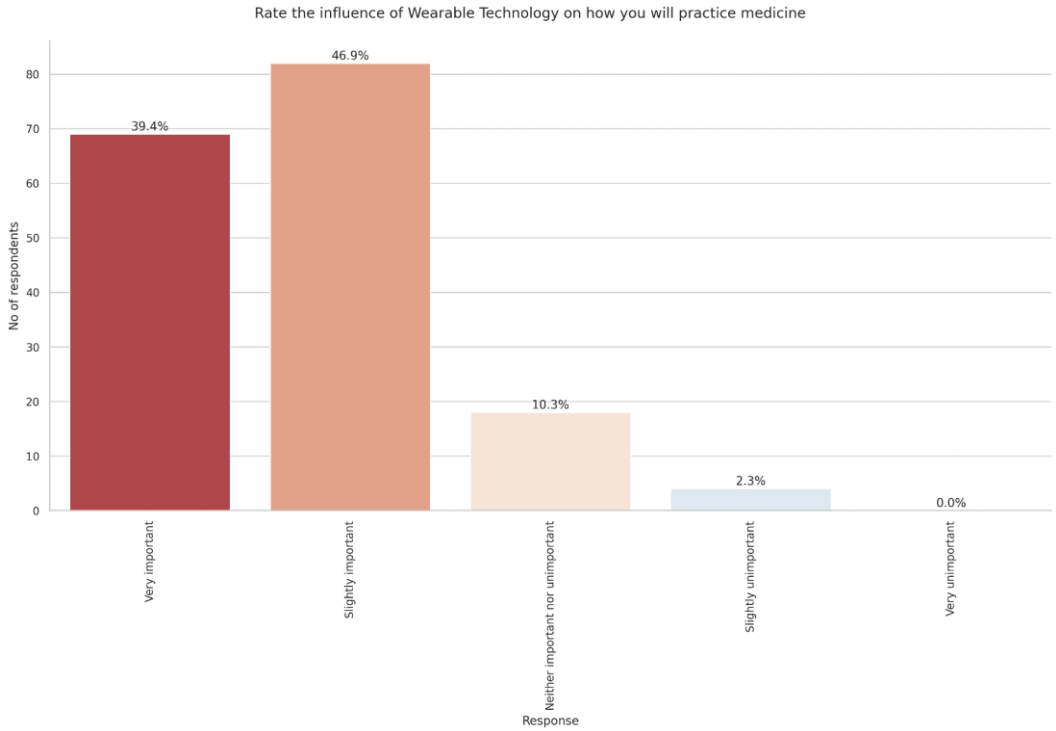

Fig. 37 Influence of wearable technology on how you will practice medicine

The Internet of Things

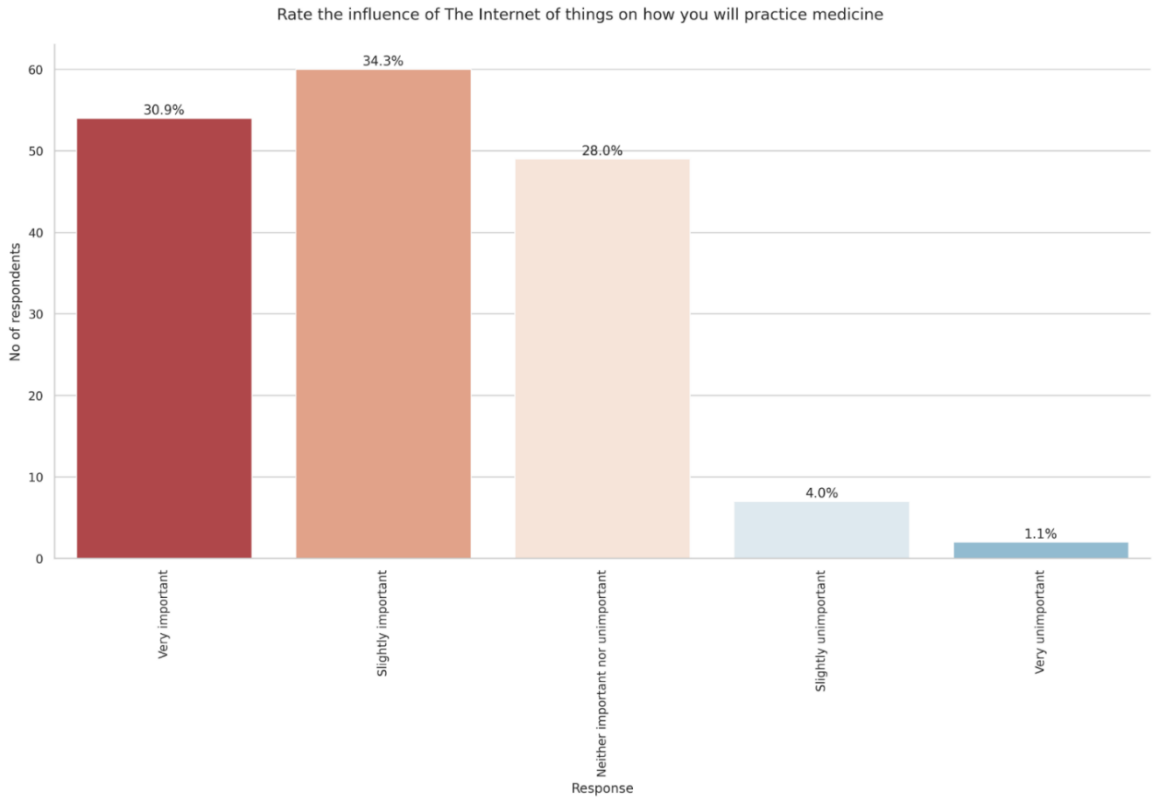

Fig. 38 Influence of the internet of things on how you will practice medicine

Appendix 2 (Training)

During your time at medical school which of the following have you received training on:

Clinical Trials

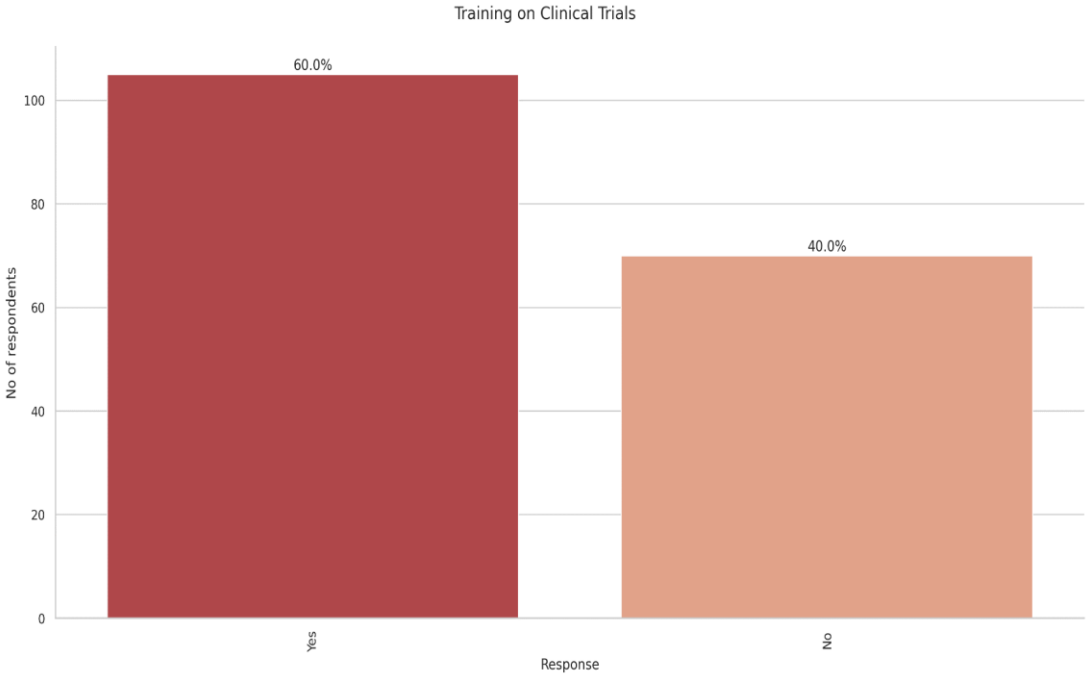

Fig. 39 Training on clinical trials

Statistical testing and plotting data

Fig. 40 Training on Statistical testing and plotting data

Using statistics software e.g. SPSS, Excel, STATA, R, Python etc

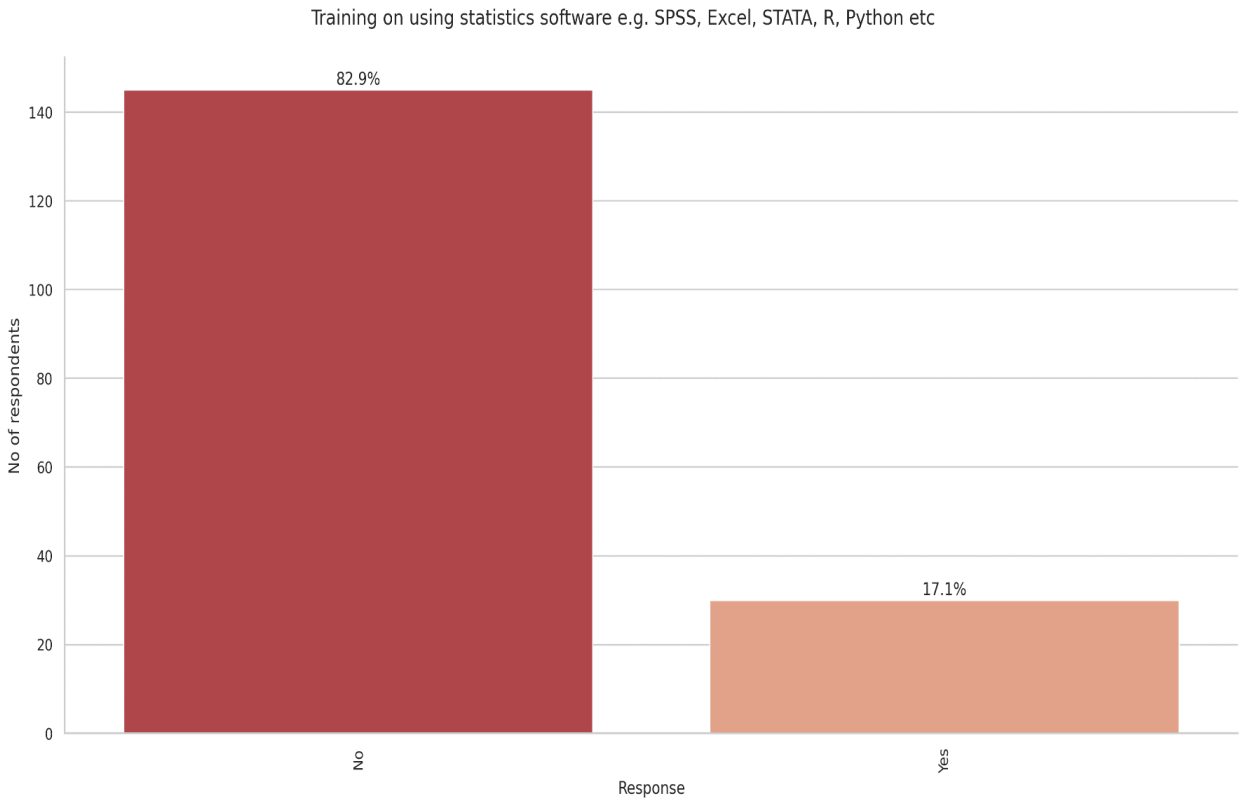

Fig. 41 Training on using statistics software e.g. SPSS, Excel, STATA, R, Python etc

Basic Computer programming e.g. in R or Python

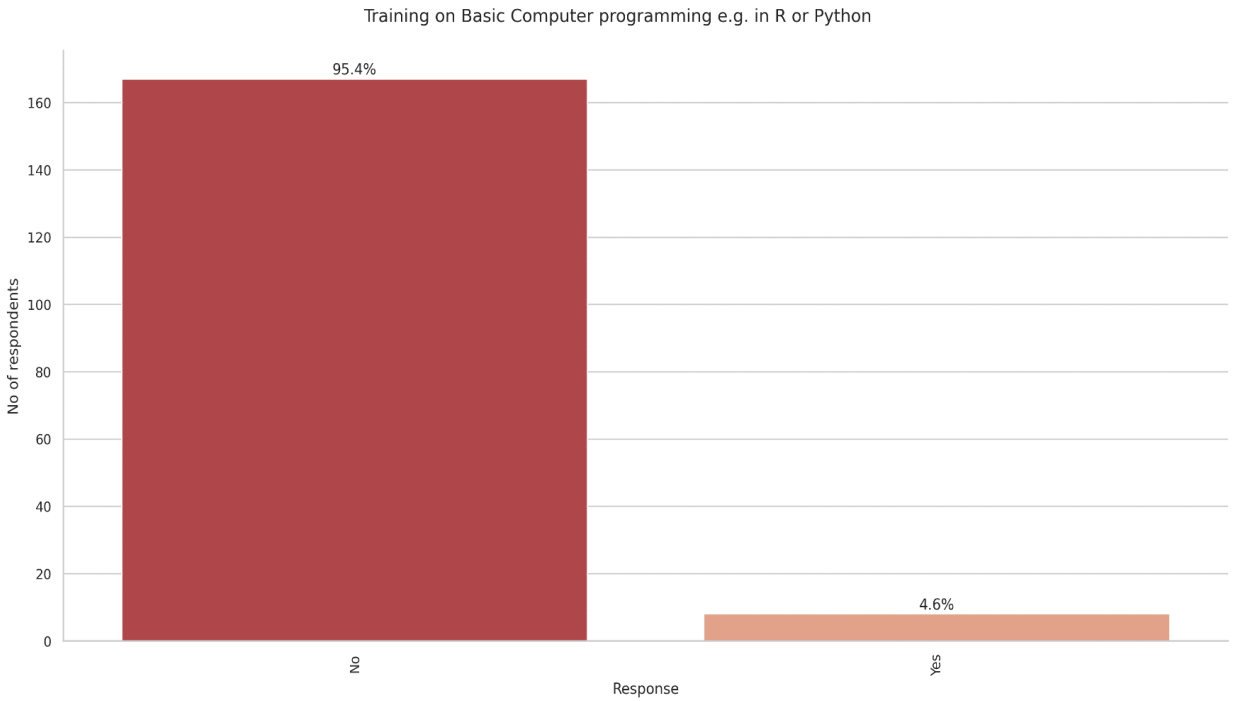

Fig. 42 Training on basic Computer programming e.g. in R or Python

Artificial Intelligence / Machine Learning

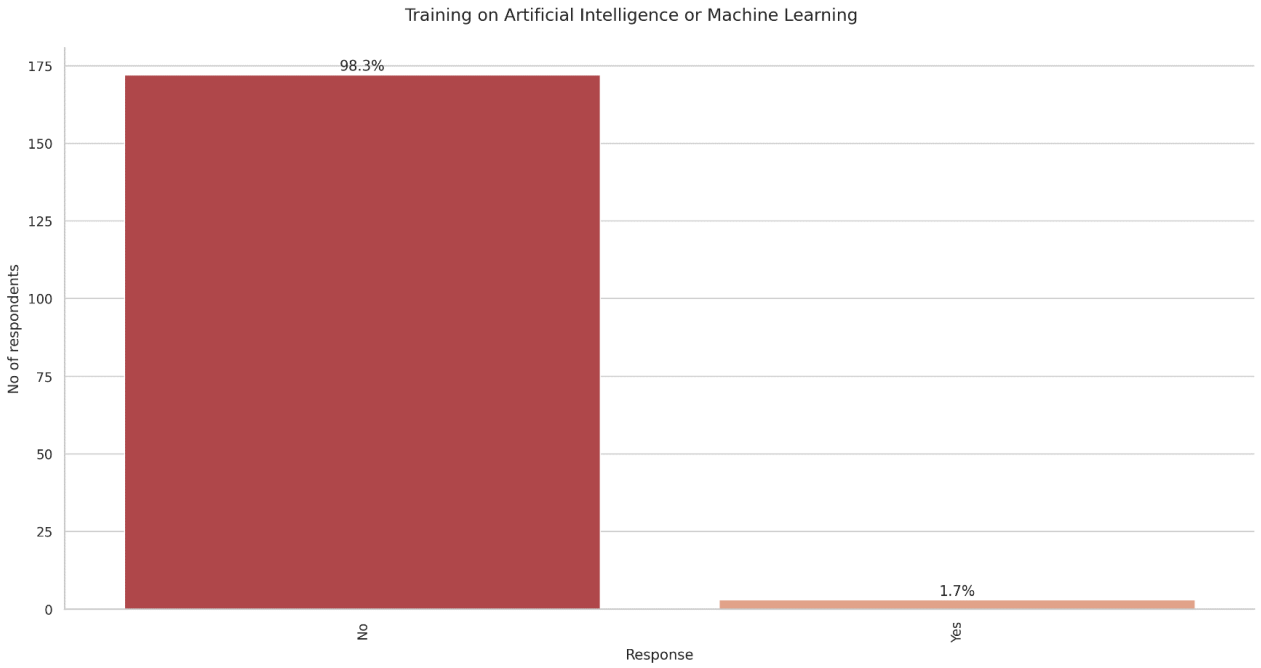

Fig. 43 Training on Artificial Intelligence / Machine Learning

Big Data Analytics / Real World Evidence

Fig. 44 Training on big Data Analytics / Real World Evidence

Appendix 3 (Staff Learning Objectives)

Clinical Trials

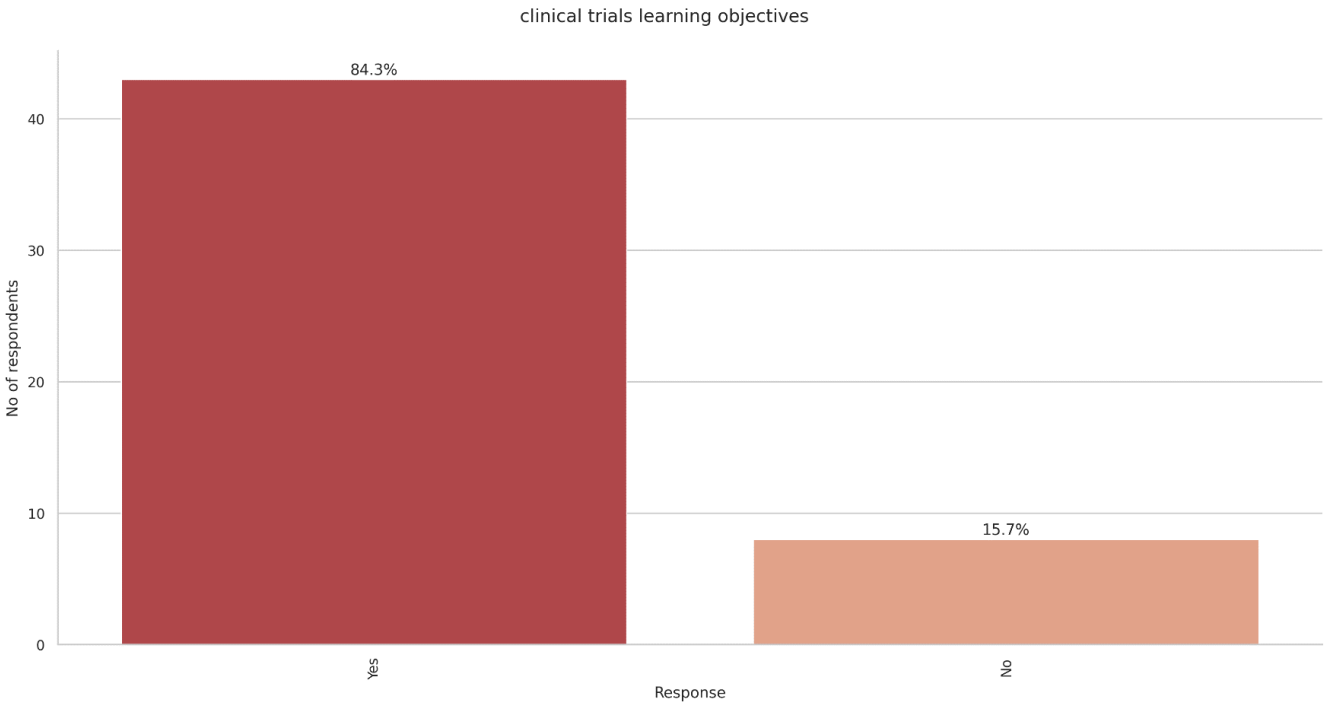

Fig. 45 Clinical Trials learning objectives

Big Data Analytics/ Real World Evidence

Fig. 46 Big Data Analytics/ Real World Evidence learning objectives

Basic Computer programming e.g. in R or python

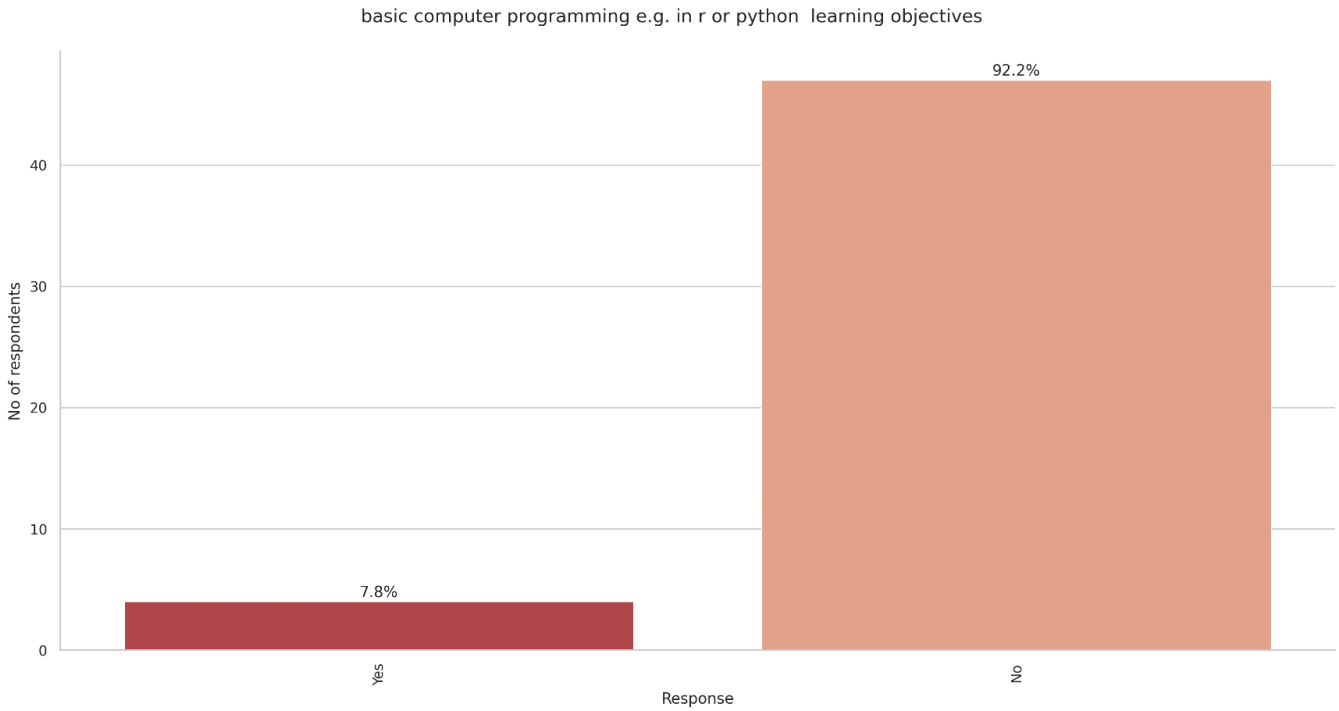

Fig. 47 Basic Computer programming e.g. in R or python learning objectives

Artificial Intelligence / Machine Learning

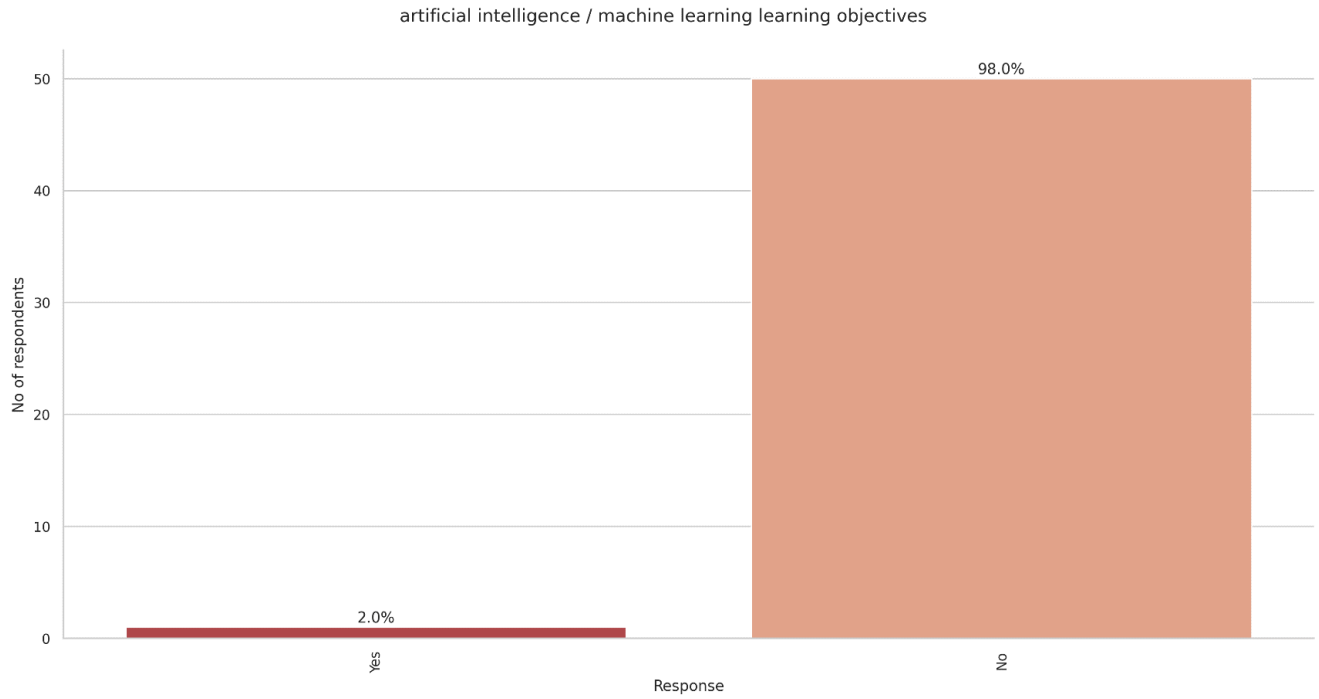

Fig. 48 Artificial Intelligence / Machine Learning learning objectives

Using statistics software e.g. SPSS, STATA, Excel, R, Python etc

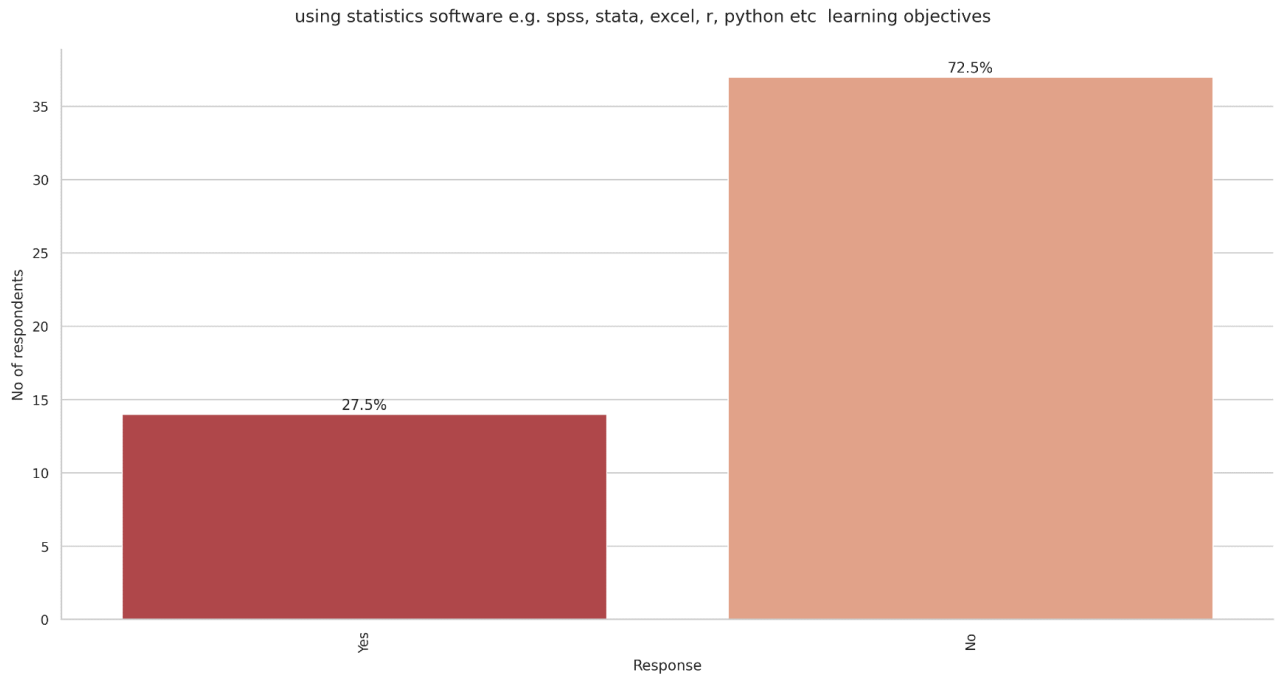

Fig. 49 Using statistics software e.g. SPSS, STATA, Excel, R, Python etc learning objectives

Statistical testing and plotting data

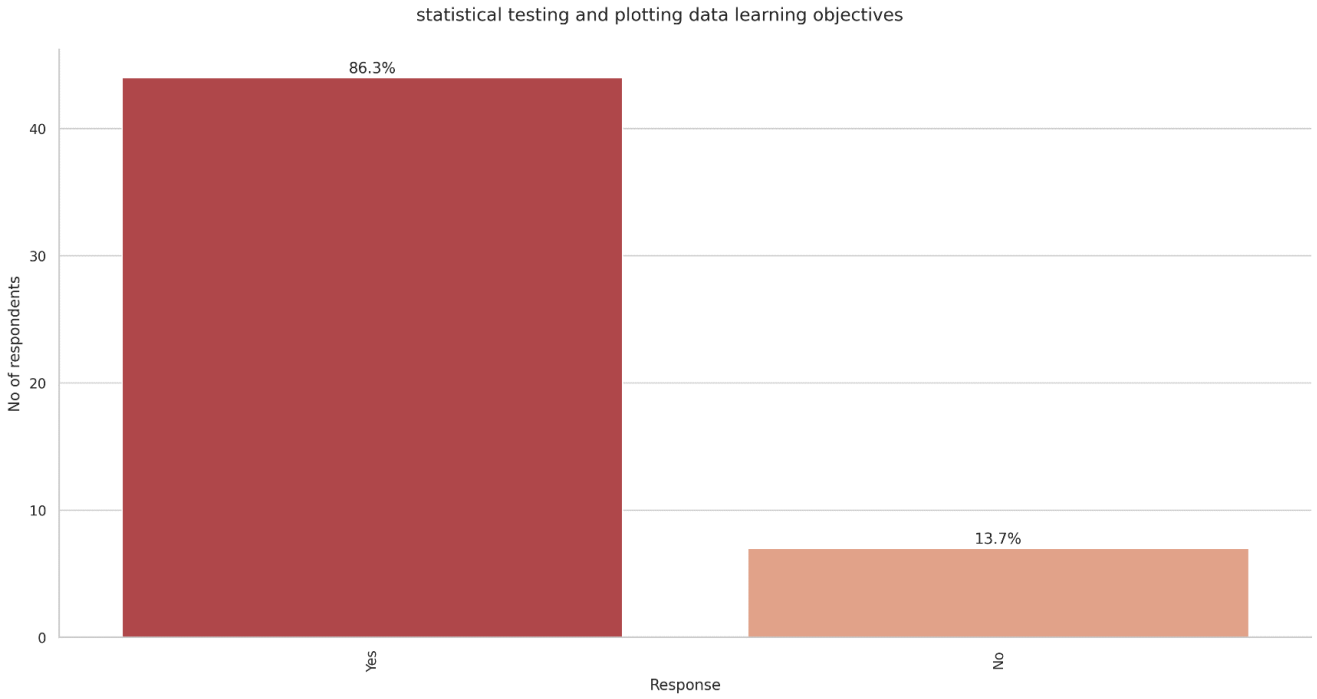

Fig. 50 Statistical testing and plotting data learning objectives