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Contributor Role	Role Definition	Authors		
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Conceptualization	Ideas; formulation or evolution of overarching research goals and aims.		X	X
Data Curation	Management activities to annotate (produce metadata), scrub data and maintain research data (including software code, where it is necessary for interpreting the data itself) for initial use and later reuse.		X	
Formal Analysis	Application of statistical, mathematical, computational, or other formal techniques to analyze or synthesize study data.	X	X	
Funding Acquisition	Acquisition of the financial support for the project leading to this publication.		X	X

Investigation	Conducting a research and investigation process, specifically performing the experiments, or data/evidence collection.	X		
Methodology	Development or design of methodology; creation of models	X	X	
Project Administration	Management and coordination responsibility for the research activity planning and execution.	X	X	X
Resources	Provision of study materials, reagents, materials, patients, laboratory samples, animals, instrumentation, computing resources, or other analysis tools.	X	X	
Software	Programming, software development; designing computer programs; implementation of the computer code and supporting algorithms; testing of existing code components.	X	X	X
Supervision	Oversight and leadership responsibility for the research activity planning and execution, including mentorship external to the core team.			X
Validation	Verification, whether as a part of the activity or separate, of the overall replication/reproducibility of results/experiments and other research outputs.	X		
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Discussion Points:

1. Increasing awareness of human factors will allow students to graduate with the skills to improve patient safety and healthcare delivery.
2. We also note the significant lack of confidence of students in challenging authority – which is, when appropriate, the safest course of action in clinical care

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1 **ABSTRACT.**

2

3 **Introduction:** The importance of human factors (HF) has been highlighted recently by the General Medical
4 Council's decision to include it in their processes for evaluating fitness to practice. Medical school is a vital
5 stage for embedding concepts into medical practice, but little is known regarding the rigor and extent to which
6 HF is taught across UK medical schools.

7 **Methods:** An 8-question survey was designed and disseminated nationally using the Qualtrics platform.
8 Respondents were asked for their existing knowledge and perception of HF, education throughout medical
9 school and relevant demographic factors.

10 **Results:** The survey was completed by 304 medical students from 12 UK medical schools. 45.7% of
11 respondents had never heard of HF as a concept. 96.9% of respondents deemed the concept of HF as very
12 important to medicine and future clinical practice. Simulated scenarios, one-to-one and small group teaching
13 emerged as the most effective teaching methods, whilst many students agreed this teaching should take
14 place in the early stages of medical education. Communication and teamwork were perceived to be the most
15 important aspects of HF.

16 **Conclusion:** Findings reveal a lack of awareness regarding human factors (HF) among UK medical students.
17 New strategies are needed to ensure the doctors of tomorrow are equipped with the necessary tools to
18 implement and deliver safer, more effective patient care.

19

20 **Key Words:** Interprofessional education, Medical Student, Medical Education, Health Communication

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1 INTRODUCTION.

2

3 Human factors (HF) are defined by the International Ergonomics Association as “a scientific discipline
4 concerned with the understanding of interactions among humans and other elements of a system, and the
5 profession that applies theory, principles, data and methods to design in order to optimize human well-being
6 and overall system performance”.^(1,2) In the field of medicine, human factors or soft skills, are generally
7 understood to mean all the non-technical skills needed by doctors to perform efficiently in different clinical
8 scenarios ranging from routine practice to high-stress emergency settings, such as trauma and resuscitation.

9

10 The importance of human factors and the application of its underlying principles within medicine have been
11 recently emphasised by the General Medical Council’s decision to incorporate HF into their process for
12 evaluating fitness to practice in the United Kingdom(UK).⁽³⁾ In the light of events such as the case of Dr Bawa-
13 Garba⁽⁴⁻⁶⁾, or the failings at the Mid Staffordshire NHS Trust in 2014, the patient safety agenda has been
14 brought to the forefront of both public and professional interest. Much of this work has centred around the
15 number of “avoidable deaths” within the National Health Service and ways in which this figure can be reduced.
16 This data feeds into wider exploration of the impact of medical error – defined as “failure to execute an action
17 as intended” or “use of an inappropriate plan to achieve a stated outcome”.⁽⁷⁾ Data from the UK suggests that
18 up to 35,000 deaths each year occur due to medical error. ⁽⁷⁾ The cost of these errors to the UK has been
19 estimated at around £2 billion⁽⁸⁾, with an intangible emotional cost to patients and families.⁽⁹⁾ Data from
20 patients admitted to hospital also suggests that up to 10% may suffer some form of avoidable harm.⁽¹⁰⁾ From
21 an international perspective the six International Patient Safety Goals from the Joint Commission International
22 includes correct patient identification, improving effective communication, improving medication safety and
23 ensuring safe surgery.⁽¹¹⁾ HF can have a key impact on these four goals, and knowledge surrounding HF
24 supports healthcare professionals in a meeting these goals. The World Health Organization (WHO) produced
25 a Global Patient Safety Action Plan in 2021, which highlights HF as critical in producing a safe healthcare
26 system. Strategy 2.4 of this action plan includes recommendations for ensuring availability of training
27 programmes in HF, and that any patient safety accreditation requires training on HF.⁽¹²⁾

28

29 Whilst greater emphasis is placed upon the teaching of HF during post graduate training, there appears to be
30 wide variations in the rigour and formality of HF teaching in UK medical schools.⁽¹³⁾ The aim of this research is
31 to describe the awareness of HF in medical students in the UK, and establishing their perception of HF
32 teaching and confident in soft skills.

33

1 METHODS

2

3 A draft questionnaire was developed from an initial literature search using Pubmed (search terms with and/or
4 used: human factors, education, medical, questionnaire, medical student) highlighting existing work and was
5 then tested on a group of medical students (n=10) based at one district general hospital. Use of feedback
6 including the clarity of the questions, understanding of questions and answer terms used and perceived
7 relevance of questions from the pilot group allowed construction of a final 8-question survey (Appendix 1). The
8 survey was accessible online via the Qualtrics platform.

9

10 In 2016/2017 the GMC reported 39,185 medical students in the United Kingdom.⁽¹⁴⁾ Our aim was to recruit 1%
11 of this cohort to gain data representative of the population as a whole. The inclusion criteria was all students
12 currently studying at a UK medical school, including those on intercalation years. No exclusion criteria in
13 terms of demographic were used. Ethical approval was obtained from the Brighton and Sussex Medical
14 School Research and Governance Ethics Committee (RGEC Ethical Approval ER/BSM6909/1).

15

16 The survey was available online via a web-link which was distributed through contacting medical student
17 societies ("MedSoc") via e-mail. This contact outlined the aims of the study and provided a shareable web-link
18 to access the survey. A second phase followed up on the initial e-mail contact and contacted a selected range
19 of medical school administrative offices where no response was received in phase 1. The survey was
20 available online for 5 months.

21

22 Personal data were gathered as part of the questionnaire including gender, age and medical school attended.
23 Participants were required to provide informed consent to take part in the survey prior to commencing
24 questions. Students who completed the survey in its entirety could opt in for a prize draw. Participation in the
25 study was voluntary and data were treated in accordance with the Data Protection Act and GDPR (2018).^(14,15)
26 This work received £800 from Brighton and Sussex Medical School which funded the prize draw, the medical
27 school itself had no input in the study design, analysis of data or manuscript production. The data from
28 participants who did not complete the survey in full were removed prior to analysis.

29

30 Data were extracted from the Qualtrics software⁽¹⁷⁾, which allowed for separation of groups of participants
31 based on responses to specific demographic and HF related questions. Statistical analysis was undertaken on
32 SPSS using fishers exact test and chi squared with a 95% confidence interval.⁽¹⁸⁾ Results were accepted as
33 significant if the p value was <0.05. Categorical data were collected using a likert scale with not at all
34 confident, somewhat confident and very confident as options.

35

1 RESULTS.

2
3 Over the 5-month survey period 304 students from 13 medical schools consented and completed the survey
4 in full. Demographically, respondents were primarily aged between 19 and 24 (92.6%) with a range of 18 to 37
5 years, mean of 21. Gender of participants was weighted towards female (66.97%), with 32.4% male and
6 0.61% prefer not to say. Participants ranged from all years of medical school education. No link ($p>0.05$) was
7 identified between which medical school was attended and awareness of human factors, there was no
8 significant difference ($p>0.05$) between gender or age and awareness of human factors.

9
10 45.7% of participants stated that they were not aware of the term human factors from their training so-far.
11 Within this group ($n=148$), only 51.3% of students were familiar with related terms including “soft skills” and
12 “non-technical skills”. Of the 176 of students who were aware of HF 83.9% had gained experience in the first
13 three years of their degree. A statistically significant difference ($p<0.001$) was found between year of study
14 and awareness of HF. As participants progressed through medical school training a higher proportion were
15 aware of HF, only 24.7% of year 1 students were aware but 61% of third year and 80.9% of final years had
16 come across the term (Figure 1).

17
18 The questionnaire highlighted that a large proportion of students were extremely or somewhat confident in
19 communication and leadership skills but 50.5% were not at all confident in challenging authority. Table 1
20 outlines this information for all ten skills related to human factors. A chi squared analysis was conducted
21 comparing the confidence levels of students from different years in each of the ten skill areas, with statistically
22 significant differences found in confidence in leadership ($p<0.001$), communication ($p<0.05$), coping with
23 stress ($p<0.05$), coping with criticism ($p<0.001$) and situational awareness ($P<0.001$), with those in later years
24 of study expressing higher confidence levels. 48.1% stated they were more confident in soft skills/human
25 factors over technical skills (such as venepuncture or cannulation) with 30.9% equally confident in both areas.

26
27 A range of teaching methodologies for teaching human factors were reported. Most frequently were small
28 group based ($n=252$), lecture based ($n=219$) and simulation ($n=182$). The opinion of participants of which
29 teaching methodology was most effective was obtained. Simulated scenarios, small group and one-to-one
30 teaching were highlighted as perceived to be the best methods (Table 2)

31
32 Assessment of which direct skills related to human factors were being taught revealed some areas where
33 education may be lacking. Participants indicated coping with criticism (20.8%), challenging authority (32.7%),
34 leadership (34.4%) and task prioritisation (33.3%) were the least frequently taught skills. Most participants
35 received education in communication (91.8%) and teamwork (74.4%) skills.

36
37 Almost all (96.9%) medical students considered HF teaching in medical schools to be very (24.8%) or extremely
38 (72.1%) important. 55.4% believed that “pre-clinical” years (1 to 3) would be the most appropriate stage of
39 medical school for human factors teaching to occur. With 9 students selecting other and commenting that
40 teaching should occur throughout the curriculum. The perceived importance of certain HF skills over others was
41 explored. Students were asked to rank 10 human factors skills from one (most important) to ten (least important)

1 compared to each other. This question established that communication (90%) teamwork (47%) were ranked
2 highly as important skills (% who rated this skill rank 1 or 2). The lowest ranked aspects (% who rated this skill
3 rank 9 or 10) were challenging authority (69%), reporting error (37%) and coping with criticism (36%).
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1 DISCUSSION.

2
3 Our results show that HF is forming a part of the medical curriculum, with over 80% of final year students
4 aware of the concepts, but could potentially be featured more later on in undergraduate studies.⁽¹⁹⁾ In recent
5 years the House of Commons Health Committee produced a patient safety report (2009) highlighting a need
6 for integration of non-technical skills and HF training into the training of undergraduates.⁽¹⁰⁾ Similarly a multi-
7 professional patient safety curriculum guide from the WHO details the importance of HF in patient safety.⁽²⁰⁾
8 These both advocate increased training in HF for medical professionals and our appear to show progress has
9 been made but the significant percentage who were unaware shows further work is still required. Both in
10 improving awareness of HF as a term and in providing training earlier on in undergraduate training. This is
11 supported by 55.4% of participants responding that the pre-clinical years would be the best time to provide HF
12 education. Studies have shown favourable feedback to curriculum reform with an aim to providing more HF
13 training. With students reporting more confidence in communication, in overall patient interactions and in
14 breaking bad news.⁽²¹⁾ A survey targeted at NHS and military doctors in the UK identified that junior clinicians
15 were much more likely to have had training in HF, with 60% of senior doctors reported no HF training at all.⁽²²⁾
16 Further providing evidence of a movement towards HF educational provision.

17
18
19 Students showed high confidence levels in leadership (96.2%) and communication skills (92.6%) This data is
20 supported by participants specifically stating they received education in these areas of HF skills from their
21 respective institutions. A systematic review of 22 studies providing non-technical skills education found that
22 key featured themes were leadership, communication and teamwork.⁽²³⁾ A 2014 study explored medical
23 students' attitudes regarding leadership and management training and again similar areas were highlighted as
24 of importance.⁽²⁴⁾ The GMC's guidance regarding expected outcomes for graduates gives a range of HF
25 related skills as requirements for newly graduated doctors, including awareness of patient safety,
26 communication skills, leadership and team working, and multi-disciplinary work.⁽²⁵⁾ Considering the significant
27 non-technical requirements for new graduates limited assessment is undertaken regarding these skills on a
28 national basis.⁽²⁶⁾ In light of the requirement to provide this training it is positive that almost all undergraduate
29 students are receiving education in these specific areas and also have high confidence levels with these skills.
30 Exploring further we found 48.1% of students had more confidence in HF related skills over technical skills
31 and 30.9% stated equal confidence in both areas. We hypothesise this could be due to a perceived lesser
32 technical skill ability rather than specific confidence in HF related skills. There may also be an element of
33 more junior students feeling their technical skills to be more limited compared to HF.

34
35 Only 48.5% of students stated an element of confident in challenging authority, this is unsurprising when just
36 32.7% received any education on this topic, although 69% of students ranked challenging authoring as one of
37 the least important HF skills. The well-known case of Elaine Bromiley who died of cerebral damage after a
38 prolonged hypoxic episode pre-operatively highlighted multiple failures in HF within the team including poor
39 communication and a failure to challenge authority and valuable lessons were learned from this.⁽²⁷⁾
40 Challenging authority in the healthcare setting can be a difficult part of HF. A review of 31 studies discussed
41 that significant barriers were in place to speaking out. These included poor inter-professional skills, fear of

1 repercussions and perceived hierarchal gradients amongst professionals.⁽²⁸⁾ Methods do exist to improve
2 communication when challenging authority, including the use of incremental challenges or provocative words
3 (such as expressing concern, discomfort or that an action is unsafe).⁽²⁹⁾ We suggest further introduction of
4 education in this area of HF to the medial school curriculum would allow individuals to feel more able to
5 challenge authority if the need arose. Even relatively small interventions can be of significant effect, with four
6 1 hour simulation sessions with subsequent guided debriefs found to improve self-reported confidence in
7 correction of another healthcare provider.⁽³⁰⁾

8
9 The methodologies utilised most frequently for HF teaching were small group based, lectures and simulation.
10 The most effective of these were highlighted to be small group or simulation-based teaching. This is
11 supported by research into the effects of simulation-based training as a tool to develop non-technical skills.
12 93% of medical students found a mass casualty simulation useful in development of non-technical skills.⁽³¹⁾
13 Hagemann et al., (2017)⁽³²⁾ compared medical students undertaking simulation before and after exposure to
14 either a clinical or HF skills based seminar. After the seminar the HF group had a statistically significant
15 improvement in team-work and situational awareness, decrease in stress and better error handling. There
16 was no difference in clinical outcome in either group.

17
18 Further work shows a correlation exists between higher non-technical skills scores and clinical performance in
19 simulated scenarios in medical students.⁽³³⁾ This supports simulation with facilitated de-brief as a highly
20 effective method for delivery of HF training, evidenced by the increasing use of simulation in medical training
21 at all stages.⁽³⁴⁾

22
23 An understanding of human factors can be seen as a threshold concept within medical education.⁽³⁵⁾
24 Establishing this understanding allows for a shift in perspective in how individuals view and act in professional
25 interactions. A transformation is required from a clinical based viewpoint to a non-clinical to facilitate higher
26 quality educational experiences for the student and to allow for growth both as a professional individual and
27 as part of a multi-disciplinary team. For human factors to be fully utilised in practice students are required to
28 undertake higher levels of cognitive processing (evaluation and analysis), as detailed in Bloom's
29 Taxonomy.⁽³⁶⁾ Higher level thinking can allow for reflective practice to take place upon learning events and for
30 future practice to be influenced upon by experiential learning.

31
32 We do acknowledge a number of limitations of our study. Respondents were from 12 of the 33 UK medical
33 schools, we feel this number of high enough to be representative overall as curricula are designed to meet the
34 GMCs outcomes for graduates.⁽²⁵⁾ The methods of content and delivery of teaching may have variation
35 between schools. This is evidenced by Meats et al, (2009)⁽³⁷⁾ who showed variation in methods and content of
36 medical school curricula but did note the majority of schools had the same core topics. The limited numbers of
37 questionnaire participants from a few of the medical schools surveyed may provide a non-representative
38 sample of the HF teaching at that establishment but the overall opinion of these students regarding feelings
39 and beliefs around HF is still valid. The recruitment methodology may lead to participation bias with initial
40 reliance upon medical school societies to share the survey and limited response from administrators of

1 establishments. We feel the data obtained is broad enough in scope to allow for assessment of medical
2 students' opinions regarding HF and to guide future educational planning.

3
4 Further research from this survey could aim to explore the various teaching methodologies in more depth to
5 identify which is most effective and guide best educational practice. The survey can be expanded to explore
6 the beliefs of post-graduate medical professionals about HF. The introduction of novel training curricula for
7 postgraduate surgical training focusing on generic professional capabilities highlights that a clear need has
8 been identified for training in, and acknowledgment of, HF related skills in professional practice.^(35,36) The
9 increased focus on HF could allow for improvement in patient safety, patient care and in interdisciplinary
10 work.^(40,41)

11
12 The research findings highlight a number of areas where specific development of teaching in aspects of
13 human factors can be undertaken. Whilst individual curricular changes would be under the remit of the
14 medical school itself, we would advocate for improved awareness of human factors as a concept at an earlier
15 stage of medical education to allow for development of higher levels of thinking on the subject. We also note
16 the significant lack of confidence of students in challenging authority – which is, when appropriate, the safest
17 course of action in clinical care. Whilst further work to the nature of education and teaching in this specific
18 topic would need to be established we would advise this be an area of focus for educators. Students
19 highlighted which teaching methods they perceived to be most effective (simulation, small group and one-on-
20 one teaching) and this should be taken into account when planning educational delivery, although resource
21 and time allocation has to be balanced against meeting course aims and objectives.

22
23 Minimal literature exists regarding student perceptions of human factors teaching in UK medical schools. This
24 research establishes that there is some awareness of the term human factors, but the majority of students
25 believe it to be of significant importance as a part of their training. We have identified a number of areas within
26 HF where teaching is almost universally performed but some specific aspects of human factors were identified
27 as lacking. These areas could be focused on further to improve undergraduate education. The most effective
28 methodologies were perceived to be simulation and smaller group-based learning. The significance of these
29 results in assisting development of undergraduate curricula and would have an impact on medical education
30 methodology as a whole. Increasing awareness of human factors will allow students to graduate with the skills
31 to improve patient safety and healthcare delivery.

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1 SUMMARY - ACCELERATING TRANSLATION

2
3 **Title:** The Education of Medical Students in Human Factors – A National Survey.

4
5 Human factors (HF) are defined by the International Ergonomics Association as “a scientific discipline
6 concerned with the understanding of interactions among humans and other elements of a system, and the
7 profession that applies theory, principles, data and methods to design in order to optimize human well-being
8 and overall system performance”. In the field of medicine, human factors or soft skills, are generally understood
9 to mean all the non-technical skills needed by doctors to perform efficiently in different clinical scenarios ranging
10 from routine practice to high-stress emergency settings, such as trauma and resuscitation.

11
12 The aim of this research is to describe the awareness of HF in medical students in the UK, and establishing
13 their perception of HF teaching and confident in soft skills.

14
15 A draft questionnaire was developed and after refinement, the finalized survey was available online via a web-
16 link which was distributed through contacting medical student societies (“MedSoc”) via e-mail. This contact
17 outlined the aims of the study and provided a shareable web-link to access the survey. A second phase followed
18 up on the initial e-mail contact and contacted a selected range of medical school administrative offices where
19 no response was received in phase 1. The survey was available online for 5 months. Over the 5-month survey
20 period 304 students from 13 medical schools consented and completed the survey in full.

21
22 Headline results included the fact that 45.7% of participants stated that they were not aware of the term
23 human factors from their training so-far. The questionnaire highlighted that a large proportion of students were
24 extremely or somewhat confident in communication and leadership skills but 50.5% were not at all confident in
25 challenging authority. A range of teaching methodologies for teaching human factors were reported. Most
26 frequently were small group based (n=252), lecture based (n=219) and simulation (n=182). The opinion of
27 participants of which teaching methodology was most effective was obtained. Simulated scenarios, small
28 group and one-to-one teaching were highlighted as perceived to be the best methods.

29
30 Students were asked to rank 10 human factors skills from one (most important) to ten (least important)
31 compared to each other. This question established that communication (90%) teamwork (47%) were ranked
32 highly as important skills (% who rated this skill rank 1 or 2). The lowest ranked aspects (% who rated this skill
33 rank 9 or 10) were challenging authority (69%), reporting error (37%) and coping with criticism (36%).

34
35 An understanding of human factors can be seen as a threshold concept within medical education.

36 Establishing this understanding allows for a shift in perspective in how individuals view and act in professional
37 interactions. A transformation is required from a clinical based viewpoint to a non-clinical to facilitate higher
38 quality educational experiences for the student and to allow for growth both as a professional individual and
39 as part of a multi-disciplinary team. For human factors to be fully utilized in practice students are required to
40 undertake higher levels of cognitive processing (evaluation and analysis), as detailed in Bloom’s Taxonomy.

1 Higher level thinking can allow for reflective practice to take place upon learning events and for future practice
2 to be influenced upon by experiential learning.

3

4 This research establishes that there is some awareness of the term human factors, but the majority of
5 students believe it to be of significant importance as a part of their training. We have identified a number of
6 areas within HF where teaching is almost universally performed but some specific aspects of human factors
7 were identified as lacking. These areas could be focused on further to improve undergraduate education. The
8 most effective methodologies were perceived to be simulation and smaller group-based learning. The
9 significance of these results in assisting development of undergraduate curricula and would have an impact
10 on medical education methodology as a whole. Increasing awareness of human factors will allow students to
11 graduate with the skills to improve patient safety and healthcare delivery.

12

Accepted, in-press

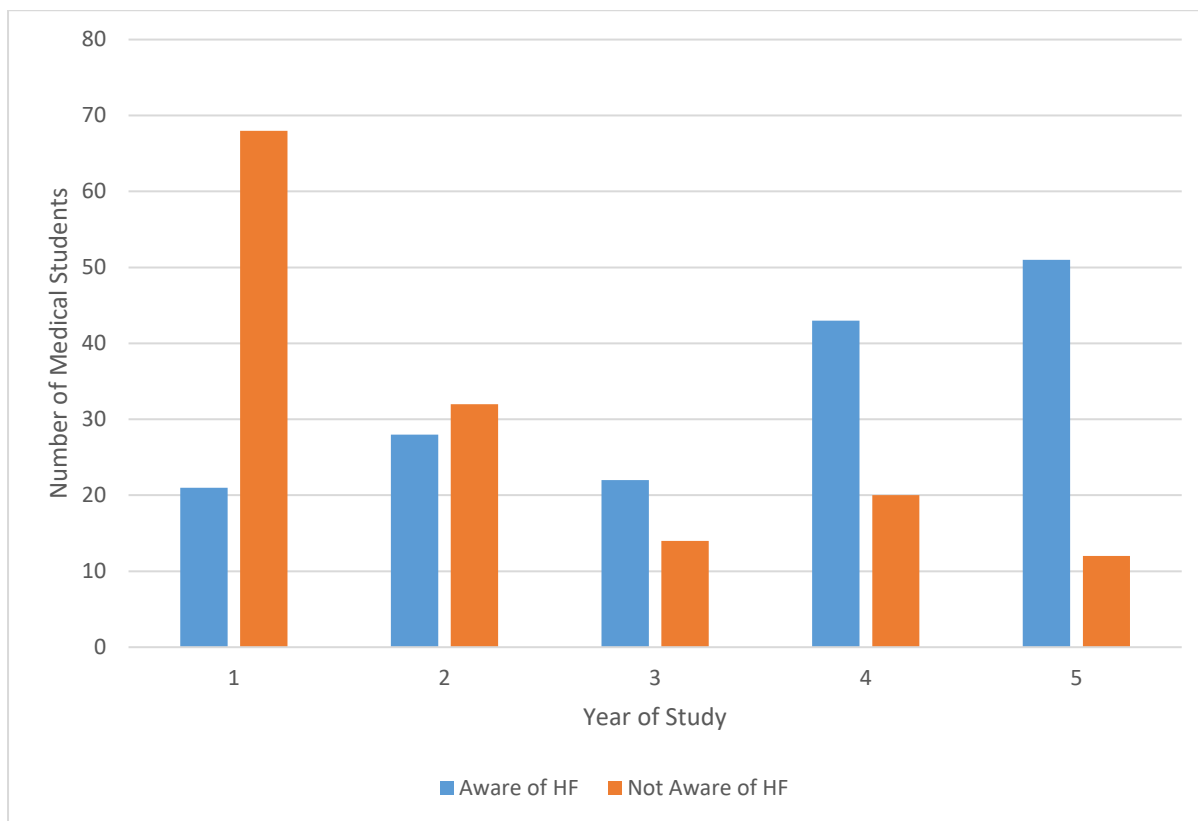
1 **FIGURES AND TABLES.**

2

3

4 **Figure 1.** The Number of Respondents in Each Year Group who were Either Aware or Unaware of Human
5 Factors as a Concept.

6



7

8

Accepted

1 **Table 1.** Reported Confidence Levels (%) of Participants in Various Human Factor Related Skills
2

		Confidence Levels of Participants (% of responses)		
		Not at all confident	Somewhat confident	Extremely confident
Human Factors related skill	Communication	1.7	47.8	50.5
	Leadership	14.2	57.1	28.7
	Teamwork	1.0	31.5	67.5
	Decision Making	12.5	70.6	16.9
	Coping with Stress	10.0	70.2	19.8
	Coping with Criticism	20.4	55.7	23.9
	Situational Awareness	14.2	55.4	30.4
	Task Prioritisation	10.4	60.5	29.1
	Reporting Errors	17.6	56.1	26.3
	Challenging Authority	50.5	40.8	8.7

3

4

1 **Table 2.** Participant's Beliefs Regarding which Teaching Methodologies are Most Effective for HF Education
2 and which Teaching Methodologies are Utilised in HF skills Teaching.

3

		Receiving this type of teaching (%)		Beliefs regarding effectiveness (% of respondents)		
		Yes	No	Not effective	Somewhat effective	Extremely effective
Type of teaching for HF skills	One to One Teaching	43.8	56.2	4.9	36.1	59.0
	Small Group Teaching	87.5	12.5	1.7	24.3	74.0
	Lecture	76.0	24.0	40.0	56.9	3.1
	Simulated Scenarios	63.2	36.8	0.7	22.2	77.1
	E-Learning	33.3	66.7	54.5	43.4	2.1

4