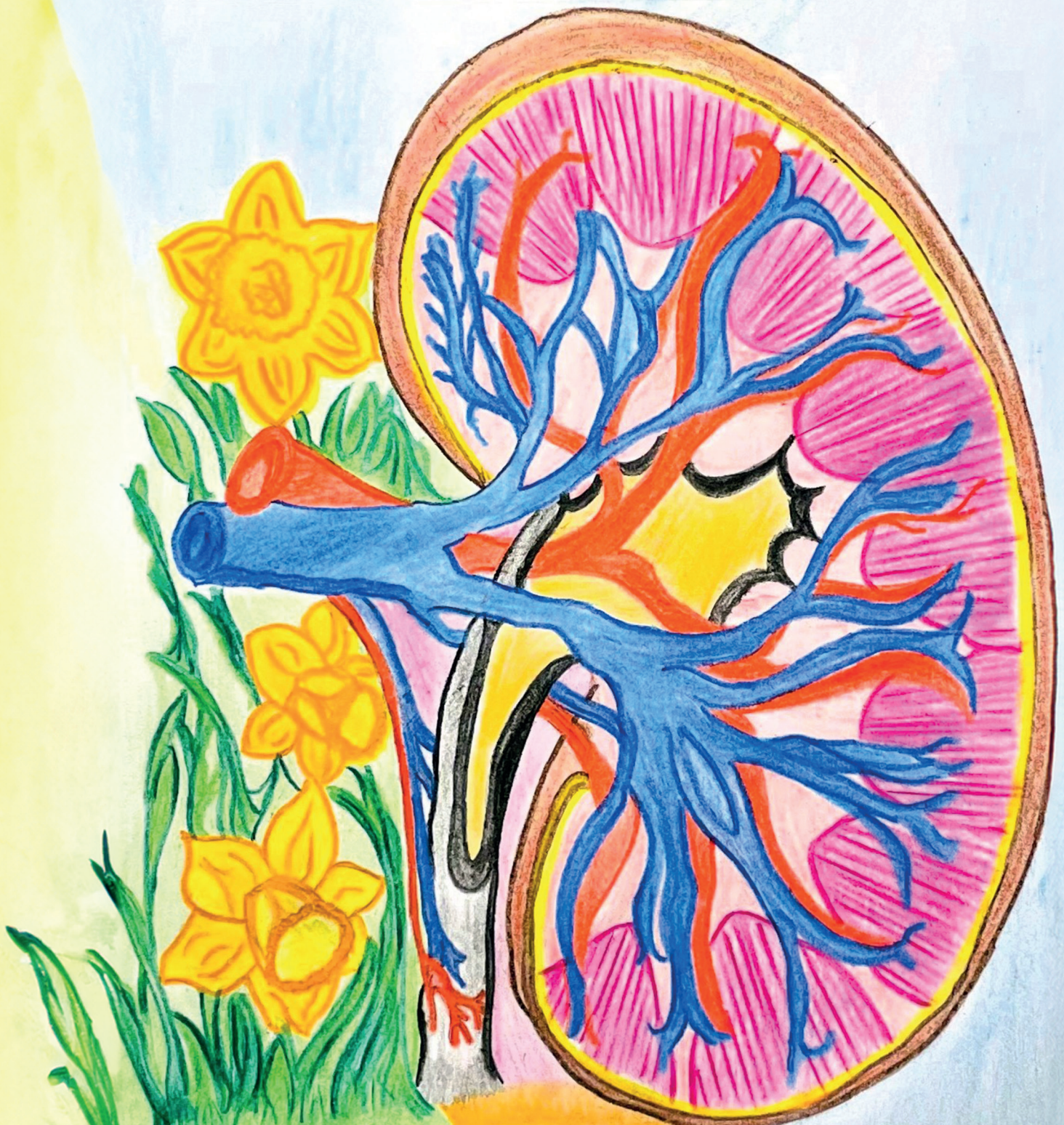


# inspire



Volume 8 | Number 1 | Autumn 2024

Student Health Sciences Research Journal



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# Hi! Welcome to the Autumn 2024 issue of the INSPIRE Student Health Sciences Research Journal.

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We hope you enjoy reading the INSPIRE Student Health Sciences Research Journal – the articles have been written and peer-reviewed by students throughout 2024. See all our past issues at [www.inspirestudentjournal.co.uk](http://www.inspirestudentjournal.co.uk). Find out more news, events, case studies and opportunities related to the INSPIRE programme at [gw4inspire.co.uk](http://gw4inspire.co.uk).

Best wishes,  
**INSPIRE Student Health Sciences  
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## Front Cover

Cover image  
by **Dilshan Jayakody**



"I'm a final-year student at the Peninsula Medical School. I created this art feature for World Kidney Day on 14 March. This was showcased at 'The Kidneys: Demystified' Conference, organised by the University of Plymouth and Kidney Research UK. My drawing vividly depicts the kidney's internal structure, drawing inspiration from kidney anatomy and blooming daffodils. I aimed to blend the complexity of human anatomy with nature's beauty, enhancing engagement and aesthetic appreciation in the study of



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## Efficacy of the sentinel cerebral protection system used during transcatheter aortic valve replacement

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### Abbreviations

*BHR PROTECT TAVI - British Heart Foundation Randomised Clinical Trial of Cerebral Embolic Protection in Transcatheter Aortic Valve Implantation*

*CEPD - Cerebral embolism protection device*

*CPS - Cerebral protection system*

*Fr - French units (used to measure the size of catheters and other medical devices)*

*SAVR - Surgical aortic valve replacement*

*TAVR - Transcatheter aortic valve replacement*

Transcatheter aortic valve replacement (TAVR) is a treatment of choice as it is less invasive compared to surgical aortic valve replacement (SAVR). A prosthetic valve is implanted in place of the calcified valve through any of these approaches: transfemoral, transcarotid, transapical or transaortic.<sup>1</sup> Transfemoral is the preferred approach in most cases. Ever since its first performance in 2002, TAVR has become common in practice. Despite its popularity, its long-term durability and the complications that follow this procedure remain in question. Major complications that follow TAVR include thromboembolism, paravalvular leakage, cerebrovascular events resulting in ischemic lesions or stroke, and neurocognitive impairment.<sup>2</sup> The catheter may mobilise a thrombus or a clot that may travel up to the brain. Interaction between the implanted valve and the calcified valve or paravalvular leakage due to a mispositioned valve may activate

the coagulation cascade and cause platelet aggregation forming a clot that might enter any cerebral artery and result in ischemia or stroke. Medications such as dual anticoagulant therapy i.e. aspirin indefinitely and any anticoagulant drug, such as clopidogrel for six months, are recommended to avoid clot and thrombus formation.<sup>3</sup> These concerns have led to the development of devices called cerebral embolism protection devices (CEPDs) which include filters and deflectors. These devices function mainly to filter any debris or embolus from the vessels that supply the brain and aim to collect any debris or clot traveling from the site of valve implantation towards the cerebral arteries. CEPDs are positioned at the origin of supra-aortic vessels in the aortic arch.<sup>4</sup>

The sentinel cerebral protection system (CPS) is the approved and most widely used CEPD in TAVR. It is a dual filter system with a proximal filter placed in the brachiocephalic trunk and a distal filter placed in the left common carotid artery. It is delivered through a 6 Fr delivery catheter through the radial artery (preferred) or the brachial artery over a 0.014" guide wire and placed before the TAVR system.<sup>5</sup> This placement of CPS usually takes less than 10 minutes in most individuals. It is removed through the catheter after the implantation of the prosthetic valve. This device aims to filter the blood entering the vessels that it covers and collect the debris entering the circulation. This device got approval for clinical use in 2017, and various improvements have been made to increase its safety and efficacy. The Sentinel CPS is the most studied CEPD. In a patient with normal

anatomy of vessels, this system is safe to use, with a study suggesting a procedural success rate of 85%.<sup>6</sup> The efficacy of the Sentinel CPS is controversial. Some old studies suggest this system is efficient in preventing ischemic lesions and stroke while also reducing the chances of dementia and neurocognitive impairment.<sup>7</sup> A decreased in-hospital mortality rate has also been suggested in various studies. Although, recent studies suggest that the Sentinel CPS has no major effect on reducing stroke or neurocognitive impairment.<sup>8</sup> At the time of publication, the BHF PROTECT TAVI trial, which began in 2020 and will conclude in 2026, is determining the impact of CEPDs on stroke rate.

The vascular anatomy also contributes to the effectiveness of the Sentinel CPS. Vascular tortuosity and variations in the anatomy of the aortic arch may contribute to the failure of Sentinel CPS administration. Complex anatomy of the aortic arch and supra-aortic vessels may make it difficult to administer the system via catheter to the designated vessels and may also increase the risk of atheroembolisation and vessel injury.

The Sentinel CPS filters three out of four arteries, the right and the left internal carotid arteries and the right vertebral artery, supplying to the brain. It fails to protect the left vertebral artery which is a major part of the posterior circulation of the brain, and the brain stem and cerebellum through the basilar artery. A left vertebral filter system called the Wirion filter can complement the Sentinel CPS to overcome this. The Wirion filter is directed towards the left vertebral artery from the radial artery over a 0.014" guidewire. The amount of debris collected in the Wirion filter is almost equal to the amount of debris collected in the Sentinel CPS, suggesting the importance of protection of the left vertebral artery for the prevention of neurocognitive impairment, ischemic lesions and stroke perioperatively.<sup>9</sup>

Despite the reduction in mortality, stroke continues to be a significant concern, as recent trials indicate a consistent stroke rate of 2% to 2.5% following TAVR.<sup>10</sup> An individualised evaluation may assist in determining its benefits for particular patients and populations. However, additional research is required to determine which patients can benefit from this device.

## Contribution statement

Khadija Azeem contributed to the conception, design, and drafting of the manuscript. Ahmad Akhtar contributed to the conception and revising of the manuscript. All authors have approved the final version of the manuscript for publication.

Khadija Azeem is the guarantor of this work.

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## Beyond the bedside, into the bloodstream: microplastics pollution and hospital waste management

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### Abbreviations

PPE – personal protective equipment

PVC – polyvinylchloride

### Introduction

Concerns about our planet's health have turned our attention to our use of plastic and how dependent we are on it. This mass attention is evidenced by the popularity of the recent Glasgow Climate Pact agreement and is reflected in the increased posts created about the United Nations Climate Conference (COP), which is the decision making body of the UNFCCC (United Nations Framework Convention on Climate Change).<sup>1</sup> Viral media has demonstrated the devastating effects of single-use plastics and general plastic overproduction on our environment. It has caused huge concern in how we dispose of plastic and what implications it can cause. Now all industries and service sectors, including healthcare, are being criticised. They protest for the need for mitigation of waste disposal and management in hospitals to be improved so that they can be more environmentally friendly.

Recent evidence has shown that 75% of all waste and debris in the ocean consists of plastic.<sup>2</sup> This undoubtedly has detrimental effects that can disrupt the careful balance of biological ecosystems and indirectly affect global human populations' health. Therefore, it is imperative that hospitals should consider plans to effectively manage plastic as 30% of all waste from hospitals consists of plastic.<sup>3</sup>

### Why plastics?

There are many variations of plastic used within the medical field with the most common being polyvinylchloride (PVC). PVC is flexible and inert to chemical reactions; therefore, its properties are essential in equipment such as face masks, bags for IV and infusion tubes.<sup>4</sup> It further demonstrates its suitability as a key material for healthcare as it is able to be sterilised via gamma radiation. This method has the highest certainty to cause sterility compared to other sterilisation options.<sup>5</sup> Therefore, it provides the highest guarantee to maintain patient safety through minimising the risk of infections. This is important as not all materials can be sterilised this way but fortunately plastics can.

### The complications

However, this method of sterilisation has its drawbacks and has the potential to cause harm in patients. Gamma radiation has been shown to change the structure of medical devices that consist of polymer<sup>5</sup> which includes PVC. This can cause unintended side effects of the equipment that can lead to malfunction or degradation of the product. Furthermore, PVC from hospitals and other plastics can be difficult to recycle due to the plastic being used in equipment that is in contact with potentially infectious substances.

With the way the plastics are used such as catheters or tubing inserted into humans, it causes it to be unsuitable for recycling. This is because of its exposure to human tissue, including blood.<sup>3</sup> The exposure makes recycling this plastic an issue of infection control and safety

of public health. Therefore, other methods are favoured instead such as landfill. The NHS long term plan has identified this and states that in 2016 to 2017, 15% of its wastes were sent into landfill,<sup>6</sup> which is a statistic it is hoping to reduce. Whilst landfill remains one option to dispose of plastic, incineration is also used in combination.

Incineration of plastics itself causes the release of toxic gases and, more specifically to PVC, can cause the release of halogens which contribute to climate change and reduced air quality.<sup>7</sup> The reduction in air quality may lead to respiratory diseases to population around the world and therefore would be inadvisable for healthcare systems to use this method. However, the incineration process is still used and leaves a residue called bottom ash. Bottom ashes are disposed of into landfill sites, where both burnt and unburnt plastics can leach into open water systems and introduce microplastics.<sup>8</sup>

Microplastics are defined as plastics consisting of polymer that have a diameter smaller than 5mm<sup>9</sup> and have been recorded to have been found in marine life. In areas of Brazil, 18% to 33% of catfish have been found with plastic debris within their system.<sup>7</sup> If consumed, microplastics can be introduced to the person leading to damage to most organ systems. More specifically, it damages blood vessels and causes atherosclerosis.<sup>9</sup> This may lead to increased cases of health problems such as higher blood pressure, and hence increases in the number of individuals visiting hospitals. Samples taken from across 15 patients have detected 9 different types of microplastics with the largest being 469µm.<sup>10</sup> Although not all heart samples showed plastics, the detection of these plastics highlights future health complications that healthcare systems will have to face. Therefore, it is in the hospitals' best interest to manage plastic waste effectively. This is not only due to the negative health effects of microplastics on global populations, but also their potential to increase the already overwhelming volume of patients needing to be seen.

## Reducing, reusing and repurposing

Recycling single-use plastics currently seem unfavourable for medical environments. However, other methods of plastic management have been seen to be effective. In the US, tonsillectomy packaging and equipment have been reduced from 40 disposable items to 28.<sup>11</sup> This demonstrates that plastic usage can be minimised without compromising patient safety, and removing 12 pieces of unnecessary packaging is significant across many surgeries. Not only is this method effective in waste management but it can also help a hospital's budget as the cost of tonsils packs was reduced by USD\$11.25.<sup>11</sup> This study should showcase the incentive for more studies to be conducted on other surgeries. There is the possibility to identify further unnecessary plastic which can help reduce spending and decrease contribution to landfills and incinerators.

Improving on how healthcare is delivered can also reduce the waste of equipment. Greener NHS has identified that in a hospital, 40% of cannulated patients did not require the use of the cannula for their treatment which led to an extra 24,000 kg CO<sub>2</sub> per year.<sup>12</sup> Not only has this impacted the environment and cost a portion of the budget, but it has also affected patient care. Cannulating a patient when not needed puts the individual through extra unnecessary pain and discomfort, which does not reflect a hospital's value of causing the least amount of harm to a patient. The solution would be to challenge this behaviour and raise awareness,<sup>12</sup> which is a method that requires little to no budgeting and focuses on teamwork and communication.

Another approach to manage plastic usage is swaying away from single-use plastics and prioritising reusability. An example is a switch from paper pulp trays to plastic. An observation has demonstrated in favour of plastic trays compared to paper pulp trays as they are more environmentally friendly. This change has an initial higher CO<sub>2</sub> emission to produce plastic trays, but in a larger time frame it proves to produce less CO<sub>2</sub> due to the constant incineration of the pulp trays compared to the plastic trays.<sup>13</sup> Another incentive is the monetary

benefits; an analysis states that only £10,500 would be needed to replace all paper pulp trays compared to £14,000 to constantly produce paper pulp trays.<sup>13</sup>

Due to plastic's wide range of properties, innovators have found ways to repurpose its attributes. An example would be from the COVID-19 pandemic which led to a large insurgency of personal protective equipment (PPE) waste, especially masks. The masks, instead of being disposed of, have been found to be useful in the production of concrete and can be processed to be incorporated into the mixture. It provides extra resistance to fires and can create more time before the concrete explodes from extreme heat.<sup>14</sup> Though the process of turning the masks into a suitable ingredient for concrete mixture may produce CO<sub>2</sub> emissions, it avoids the plastic from being dumped into landfills and incinerators.

## Conclusion

To conclude, this paper has identified both the positives and negatives of plastic. For example, how plastics can contribute to a destructive process that directly affects the environment, such as when they are disposed of in landfill sites or incinerated. It is also important to recognise the clear correlation between environmental health and human health. Through several methods of plastic disposal, it has an indirect effect on people's bodies. As hospitals' goals include reducing diseases, it is contradictory to perform actions that harm people's health.

On the other hand, plastic proves itself to be a key material for maintaining a sterile environment within healthcare settings, which maintains the important goal of patient safety. It is also difficult to deny the countless benefits plastic provides, especially when in certain cases it can help reduce our emissions through reducing paper waste, as plastic is reusable.

From the analysis of all information provided from the articles referenced, the issues identified do not lie within plastic as a material itself but rather in how plastic is managed. Hospitals require close monitoring of where their waste is disposed and to improve communication with waste removal services. Healthcare systems would also benefit from re-evaluating packaging in all levels of care, as when time and resources are allocated, significant improvements can be made. These not only benefit the environment but have been proven to provide monetary benefits. Reducing costs in one aspect means that funds can be redistributed to other sectors that desperately require funding.

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## Soren Gurung

Soren Gurung is a medical student at the University of Plymouth who is interested in tackling the negative environmental effects the healthcare industry can have. They take particular interest in what larger companies and smaller communities can do to help become more environmentally sustainable.

Other notable interests they have are in plastic surgery and the mechanism behind beauty standards within that industry. Soren currently plans to create further research behind this and the phenomenon of “euro-centricty”. They also have curiosity in dermatology, which he wishes to produce literature on in the future.

# The INSPIRE Podcast

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**Victoria Bak, host**  
Senior Editor



**Naabil Khan, guest**  
Founder for *Skin For All*





## Is diet modification an effective adjunct to use when treating mental illness?

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### Abstract

The aim of this article is to highlight that the modification of patients' diets could be used as tool to combat milder symptoms of mental illness, which have been shown to be less responsive to pharmaceutical treatments traditionally used. The article talks about the role of the gastrointestinal microbiota in this process and aims to explain how the food we consume interacts with these microbes, and the consequences these interactions have on mental wellbeing. The article is important because mental illness is a significant public health concern, and more holistic approaches to treating it could be beneficial.

### Abbreviations

*LPS* – lipopolysaccharide  
*PUFAs* – polyunsaturated fatty acids  
*SCFAs* – short chain fatty acids  
*WHO* – World Health Organization

### Introduction

The human gut microbiome is an emerging area for clinical research, with the importance of the flora in our gastrointestinal tracts and relation to mood only being recently acknowledged. Mental health illnesses are an important concern for public health, with approximately one billion people globally managing a mental health

condition in 2019. According to the World Health Organization (WHO), this number was exacerbated by the COVID-19 pandemic as rates of depression and anxiety rose by 25% throughout it.<sup>1</sup>

The type of diet and micronutrients consumed has consequences on mental wellbeing, which is defined as the ability to manage everyday stressors and to have a positive view of self.<sup>2</sup> These consequences are partially due to how the food eaten interacts with the gut microbiome. Although much of this research is still developing, it is suggested that these interactions can be utilised to treat illnesses like depression. However, current approaches to managing mental health conditions have little emphasis on diet with 74% of doctors in the UK giving nutritional advice less than once a month.<sup>3</sup> Additionally, the advised management for depression in adults contains little about diet, with the major focus for adult treatment involving medications and encouraging patients to attend talking therapies.<sup>4</sup>

Pharmaceutical approaches to treating depression are effective. A meta-analysis analysed the efficacy of 21 anti-depressants on depression and found all of them to have higher efficacies than the placebo.<sup>5</sup> However, anti-depressants are not as effective for all individuals, and they are arguably more useful for more severe presentations. For example, one study demonstrated that the efficacy for anti-depressants decreased as the extent of depressive symptoms became less severe.<sup>6</sup> Other sources have reported that approximately 40% of individuals noticed no improvement in their symptoms after taking an anti-depressant<sup>7</sup> and research has cited that around 30-40% of patients do not respond adequately to "pharmacological or psychological treatment".<sup>8</sup> Therefore, whilst anti-depressant use may

be effective for those with more severe depressive symptoms, other interventions may be needed to improve the health outcomes for those with milder presentations of the illness or for those who do not respond well to the management strategies currently provided. Clinicians could take a more holistic approach when treating less severe mental health illness and one such method could be by paying closer attention to patient diet.

## How are diet, the gut microbiome and mood linked?

Diet alters the type of bacteria present in our gut, which in turn influences the level of inflammation occurring there. One study analysed the effect of high polyphenol intake and consumption of a Mediterranean-like diet on the type of bacteria and compounds found in participants' faecal samples. Higher levels of certain species of bacteria, such as *F.prausnitzii*, were found in those who had a higher compliance to the Mediterranean diet.<sup>9</sup> In addition, higher levels of benzoic and 3-hydroxyphenylacetic acids were observed. These compounds are derived from microbial metabolism of the food we consume and are known to have anti-inflammatory properties. Although these results are less generalisable because the study primarily observed older individuals with an average age of 71.3 years, the paper still provides a base of evidence to show how diet influences the composition of the gut microbiome and how this composition influences gut inflammation.

Gut inflammation is a significant variable with regards to mood because it has been demonstrated that higher levels of inflammation is associated with experiencing depressive symptoms. For example, one study compared the levels of inflammatory biomarkers in individuals with major depressive disorders alongside healthy individuals.<sup>10</sup> Evidence of raised systemic inflammation was observed with those experiencing depressive symptoms alongside increased levels of lipopolysaccharide (LPS) binding protein. LPS is a structural component to the cell walls of certain types of bacteria to which the binding protein is synthesised by human cells as part of an immune response. Higher levels of LPS-binding protein are associated with increased gut epithelial damage and movement of gut microbes across the intestinal barrier. This suggests there is microbial involvement in the inflammatory process, which in turn affects mood. Secondly, long term inflammatory conditions are associated with low mood with sources citing that around 49% of patients with inflammatory bowel disease experience depressive symptoms.<sup>11</sup> Cross-sectional studies have also shown that an inflammation-inducing diet corresponds with a raised chance of experiencing depressive symptoms.<sup>12</sup> However, a limitation of all of these studies is that they do not provide evidence for a causal relationship between inflammation and depressive symptoms. In fact, other studies have demonstrated no correlation between diets thought to be pro-inflammatory and depressive symptoms.<sup>13</sup> Future studies should aim to develop an understanding on the mechanisms that link inflammation and low mood.

## Implementation of certain dietary patterns to alter mood

Despite the inconsistencies in the evidence relating diet and microbiome-mediated inflammation, changes in diet can be implemented to have beneficial effects on patients' mood, and evidence proposes that the microbiome plays a role in this process. One randomised controlled trial compared the impacts of two types of diet on individuals' self-reported depression scores and the composition of their intestinal microbiome.<sup>14</sup> One diet was classed as a low-fat diet and the other as an almond-based low-carbohydrate diet. Results showed that the almond-based diet was more beneficial to patients as it showed a greater significant decrease in participants' depression scores that was lower than average scores in the general population. The average score for individuals in the UK is between 51-53<sup>15</sup> and by the third month of the study, participants on the almond-

based diet had an average score of 42.07. The number of bacteria that secrete short chain fatty acids (SCFAs) was also significantly higher, and the secretion levels of GLP-1 were maintained to a significantly higher level than those on the low-fat diet. SCFAs decrease the permeability of the intestinal wall and hence reduce inflammation within the intestine,<sup>16</sup> and GLP-1 has been demonstrated to possess anti-anxiety and anti-depressant effects on rodents.<sup>17</sup>

Whilst this research seems promising, it has a few limitations. For example, the participants of the study all had a diagnosis of type 2 diabetes so results may differ in healthy individuals. Moreover, the participants were not diagnosed with clinical depression. Therefore, the results cannot be used to justify the prescription of these diets as a therapeutic for depression. However, as the forms used to assess depression scores were not disease specific the results can be applied more widely to the population, and they suggest that this diet could be used to improve the mental wellbeing of people in general. Furthermore, the proportion of each macronutrient in the almond-based diet are similar to that of the Mediterranean diet, and this dietary pattern has been suggested to also have positive effects on mood, although the evidence is conflicting. A greater intake of olive oil, fruits and legumes alongside a reduced consumption of red meat are characteristics of a Mediterranean diet.<sup>18</sup> Initially, a meta-analysis of cohort studies found no correlation between a Mediterranean diet and improved depressive symptoms.<sup>19</sup> However, when this same review analysed 9 cross-sectional studies, it revealed a significant beneficial relationship. The inconsistencies in the results of these studies emphasise the need for more and larger observational studies to determine the correlation between this type of diet and incidence of depression. The meta-analysis also highlights the importance of conducting consistent studies so that comparisons between them can be more easily made. For instance, the assessment of outcome (level of depression) differed between the studies ranging from use of anti-depressants, self-assessed questionnaires or interviews.

Whilst the literature is unclear on the efficacy of supplementing a Mediterranean diet as a treatment strategy for depressive episodes, there is strong evidence to suggest that it could be instead used as a prophylaxis for its development. One study demonstrated an inverse relationship between adherence to this diet and self-reported depression.<sup>20</sup> Another study also demonstrated that this dietary pattern was associated with less severe depression in a large cohort of women.<sup>21</sup> Therefore, it is suggested that a Mediterranean diet could be used to reduce both occurrence and severity of depression. This second study also highlighted a potential group who may benefit more from this diet as the protective effects were shown to increase alongside age. It is possible that clinicians could tailor advice to patients depending on their age to provide more personalised care in depression.

## Implementation of specific supplements to alter mood

Supplementation of specific micronutrients such as omega-3 polyunsaturated fatty acids (PUFAs) could be a way of treating depression. A meta-analysis that evaluated 13 randomised control trials found that consumption of this compound had a positive effect on depressive symptoms.<sup>22</sup> Additionally, a second meta-analysis found a "small but significant" positive impact on perinatal depression as a result of omega-3 PUFA consumption.<sup>23</sup> However, the results of this second study are not as generalisable as the previous one because the outcomes may not be the same for other types of depression. Moreover, neither of these studies provide explanations for the mechanisms behind these observations. However, it may be due to the anti-inflammatory properties of omega-3 PUFAs. Their anti-inflammatory properties have been explained in some studies as a consequence of their interactions with gut flora.<sup>24</sup>

Finally, intake of probiotics could aid in the treatment and prevention of depression. For example, a meta-analysis analysed a sample of 5 randomised control trials that evaluated the effect of probiotic

consumption on mood.<sup>25</sup> Interestingly, it found a significant decrease in depression scores was observed in both those with major depressive disorder and healthy subjects. This suggests that the intake of probiotics may be beneficial for preventing the development of depressive symptoms. Other randomised controlled trial have yielded similar results with a second randomised control trial showing the consumption of a probiotic yoghurt alongside a probiotic capsule improved the state of mental wellbeing in participants.<sup>26</sup> Despite providing significant evidence for the benefits of probiotics, these studies have a few notable limitations. For example, different depression rating scales and types of probiotics were used between the studies mentioned. Therefore, it is hard to draw completely reliable comparisons. Additionally, all of these studies have small sample sizes and are not carried out over long periods of time. Longer and larger randomised control trials with a baseline continuity in their methods are needed to progress this area of research further.

## Conclusion

The literature linking diet modification, the human microbiome and mood suggests that alterations to dietary patterns may have beneficial effects on depressive symptoms. However, the mechanisms underlying how diet, the microbiome and inflammation are connected remains unclear and more extensive randomised control trials are needed to clarify this relationship. There is stronger evidence to suggest that certain diets have preventative effects on mood as opposed to using dietary advice as a therapeutic. The therapeutic benefits are minimal and so should be used in conjunction with the current treatment methods already used, or for those who have 'milder' depression which is often treatment resistant. There are numerous documented risk factors for developing dysthymia such as low dietary intake and low socioeconomic status.<sup>27</sup> These are all potential future targets of research regarding the holistic treatment of depression.

This article only covers diet in regard to the holistic treatment of depression, where there are in fact numerous factors to consider. Exercise levels, sleep quality and even Mediterranean lifestyles<sup>28</sup> are all potential factors that can influence a person's mood. More research is needed to investigate the usefulness of adjusting these variables when trying to treat depression holistically. As mentioned previously, clinicians are hesitant to provide nutritional advice to patients. If advising alterations to diet in the treatment of depression is to become mainstream in clinical practice, future doctors need to feel confident at providing nutritional advice. Some proposed reasons for this hesitancy are the lack of teaching hours dedicated to nutrition in medical schools.<sup>29</sup> A proposed idea for effectively including more nutritional education into medical school curricula is by incorporating interprofessional learning activities<sup>30</sup> and altering the way fundamental biomedical concepts are taught.<sup>31</sup> Implementation of these methods could hopefully increase the confidence of doctors to provide nutritional advice, which could ultimately improve the outcomes of patients with depression.

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### Benjamin Craig

My name is Ben and I am a third-year medical student at Plymouth. I have had an interest in nutrition since starting medical school and was really pleased to be able to explore this in my first SSU. I hope you enjoy the rest of the articles in this journal and consider submitting one too!

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## The effect of sound healing by Tibetan singing bowls on human wellbeing

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### Abstract

This literature review explores the effect of sound healing by Tibetan singing bowls on human wellbeing. The methods of research include databases such as PubMed, GoogleScholar and OVID. This paper critically evaluates previous studies examining the effect of Tibetan singing bowls, as well as the theories behind the concept of sound healing. The paper concludes that sound healing is an area of complementary and alternative therapy that has been linked to beneficial effects on human health and well-being, especially in the reduction of anxiety and tension.

### Abbreviations

*FACIT* – Functional Assessment of Chronic Illness Therapy Scale  
*FACIT-SP* – Functional Assessment of Chronic Illness Therapy-Spiritual WellBeing Scale  
*HADS* – Hospital Anxiety and Depression Scale  
*PANAS* – Positive and Negative Affect Scale  
*POMS* – Profile of Mood States

### Introduction

The history of Tibetan singing bowls dates to the traditions of the Himalayan fire cults of the 5th century BC. The Tibetan singing bowl is a metal bell that is bowl shaped and is excited by striking with a mallet, which causes the bowl to vibrate and produce a melodious sound. The composition of the bowls varies by creator, but usually consist of bronze used in conjunction with copper, zinc, and iron.<sup>1</sup> The use of Tibetan singing bowls in medicine stems from Eastern

ceremonial and meditation practices.<sup>2</sup> As opposed to Western ideas, there is a belief that afflictions occur when the body is imbalanced, when there is disunity within oneself. The vibrations released by Tibetan singing bowls are believed to realign the body and mind.<sup>3</sup>

The International Journal of Healing and Caring describes sound healing as “the therapeutic application of sound frequencies to the body/mind of people with the intention of bringing them into a state of harmony and health”. There are different techniques of sound healing, including the use of sonorous instruments, such as the Tibetan singing bowl, voices and music.<sup>4</sup>

A study conducted by Dykxhoorn et al, who are affiliated with the Division of Psychiatry at University College London, estimated the temporal trends of common mental disorders (CMDs) including depression, anxiety, and stress between 2000–2019. The findings from this study estimate that the incidence of recorded CMD in the UK increased between 2000-2019.<sup>5</sup> Furthermore, a meta-analysis by the Department of Psychiatry from the University of New South Wales, found that, each year, nearly 20% of individuals meet the criteria for CMD and 25% during their lifetime. The findings from these studies emphasise the importance of further exploration into new management strategies, an example of which, is sound healing with Tibetan singing bowls.<sup>6</sup>

This short literature review explores the concept of sound healing as provided with Tibetan singing bowls, and the effect upon human wellbeing. In addition, this paper seeks to raise awareness about alternative therapies for conditions, such as stress and anxiety, in a population where these disorders are increasing in incidence.

## Methodology

This literature review focuses on studies published between 2015 to 2024 that evaluate the effect of Tibetan singing bowls upon health and wellbeing. To begin, databases such as PubMed, Google Scholar and OVID were examined for relevant publications. The following Medical Subject Terms (MeSH) terms were created and used in various combinations: 'Tibetan singing bowls', 'sound healing', 'sound bath' and 'mental health outcomes.' Only peer-reviewed journal articles published in English were included. Studies were excluded if they did not specifically measure 'sound baths' or 'sound meditation.' Studies were assessed using the Critical Appraisal Skills Programme (CASP) checklist, focusing on the design of the study, the strengths and limitations of the study, and the overall reliability of the analysis. There was limited literature available surrounding research into Tibetan singing bowls, which creates a limitation of the literature review itself.

## Discussion

### *Sound baths and sound meditations*

Tibetan singing bowls can be used in many settings, including personal or group meditations. Sessions involving singing bowls are often referred to as sound meditations or sound baths. Medical News Today describes a sound bath as "a meditative experience, immersing a person in sound. In most cases, the bath involves singing bowls, that create highly resonant, immersive music"<sup>7</sup> Bowls are either applied directly to the body or placed in proximity, to ensure a fully surrounded experience for the individual.<sup>8</sup> Various studies have been conducted, investigating the effects of Tibetan singing bowls during sound baths or sound meditation upon human wellbeing.

### *Previous studies of Tibetan singing bowls*

A study published in the European Journal of Integrative Medicine evaluated the effect of Tibetan singing bowls on metastatic cancer patients. Bidin et al underlined that it was a pilot study, specifically designed to evaluate the feasibility of a large-scale study. Consequently, the results were clinically insignificant; however, the researchers also undertook some qualitative research. Observations of the participants included profound relaxation and a reduction in anxiety, expressed both metaphorically and explicitly. Responses included phrases such as "I sensed a breeze that wiped out anxiety and pain"; "I felt that I could again trust in my self-defence ability"; "I had the perception of my body, and this helped me not be afraid."<sup>9</sup> These expressions convey a sense of increased wellbeing and mood, suggesting that the effect of Tibetan singing bowls on the mental health of cancer patients is an area for more in-depth research, with the potential to improve the wellbeing of these individuals.

Using qualitative data is a strength of this study design, as it decreases the response bias, allowing for individuals to respond in a more honest manner, using their own phrases to do so. In contrast, the pilot study design is more appropriate for an exploratory purpose, rather than an investigation into the statistical significance of the findings from the study. The relative success of the pilot study is promising, and it suggests that a more large-scale study would be beneficial to explore the clinical significance of Tibetan singing bowls for cancer patients.

Secondly, a study conducted by Panchal et al, published in the International Journal of Psychotherapy Practice and Research, explored the changes in mood and heart rate after a sound bath meditation. The changes in mood were measured via the Positive and Negative Affect Scale (PANAS) and the Profile of Mood States (POMS) survey (see **Appendix**). Psychologists Watson, Clark and Tellegen designed the PANAS scale as a self-report measure to assess an individual's positive and negative emotions, through a set of adjectives, offering a reflective way to gauge affective

states.<sup>10</sup> McNair, Lorr and Droppleman, the psychologists behind the design on the POMS scale, describe it as such: "Brief, easy to administer and score, the POMS is a set of 65 five-point adjective rating scales with a six oblique unipolar factor structure: tension-anxiety, depression-dejection, anger-hostility, fatigue, vigour, and confusion-bewilderment."<sup>11</sup> In 2012, the POMS-2 score was released. This updated version of the original POMS score provides more robust normative data, refined item wording, and offers both adult and youth versions, along with short and long forms for increased flexibility.<sup>12</sup> A potential limitation of the study by Panchal et al, is that it used the original POMS scale instead of the updated POMS 2 which may lead to outdated conclusions due to the lack of more recent normative data and refined measurement.

Upon critical analysis of the study, there are many strengths to the quality of the study design. It investigates the effects of Himalayan singing bowl meditation on mood and heart rate variability (HRV), two important psychological and physiological indicators of wellbeing. Combining mood assessment with HRV provides a holistic perspective, integrating both qualitative and quantitative data. Conversely, a weakness of the study is the lack of a control group. Therefore, there is a limited range of conclusions that can be drawn from the results. It is more difficult to directly attribute parameter changes to the sound meditation, without considering placebo effects.

Looking at the results of the study, all participants showed significant reductions in heart rate and improvement in mood post sound bath. This study demonstrates both a psychological and physiological response to a sound bath, of which the physiological response is particularly interesting.<sup>13</sup> Heart rate is slowed by the increased activity of the parasympathetic nervous system in conjunction with decreased activity of the sympathetic nervous system.<sup>14</sup> It could be concluded from this study that Tibetan singing bowls can influence the autonomic nervous system, promoting relaxation and bradycardia.

In addition, an observational study published in the Journal of Evidence-Based Complementary and Alternative Medicine investigated the effect of Tibetan singing bowl sound meditations on mood, tension and wellbeing. These variables were measured using the POMS, Hospital Anxiety and Depression Scale (HADS) and the Functional Assessment of Chronic Illness Therapy Scale (FACIT) surveys (see **Appendix**), and further analysed by age groups (see **Table 1**).

This use of these validated scales adds increased credibility to the self-reported data, which adds an objective dimension to a subjective data collection. In addition, the observational study design allows for direct comparison of the parameters, clearly indicating the effects of the intervention, in this case, the Tibetan singing bowl sound meditation.

The HADS self-report questionnaire is designed to assess anxiety and depression levels in patients. It includes 14 items, focusing on the emotional symptoms of anxiety and depression, avoiding the physical manifestations such as fatigue. Each item is scored on a sub-scale, with higher scores suggesting a more severe disorder.<sup>15</sup> The FACIT tool encompasses a collection of health-related quality of life questions, designed to assess the wellbeing of patients with chronic illnesses. It measures various domains such as physical, social, emotional, and functional wellbeing, along with disease-specific concerns.<sup>16</sup> Despite it being an informative questionnaire, it could be argued that the FACIT scale is only appropriate for chronic health conditions and their management, which could be a potential limitation to the interpretation of the results of the study.

Upon exploration of the results of the study conducted by Goldsby et al, a significant difference was found in all variables examined in response to the meditation, in particular the tension subscale, suggesting that the sound meditation increased feelings of relaxation

and peace, and decreased the prevalence of stress and agitation. Thus, it could be concluded from both studies that Tibetan singing bowls have a positive impact upon human wellbeing.<sup>17</sup> The reasons for the beneficial results of sound meditation are unclear, however, there are various theories attempting to explain their effect.

## Theories of sound healing

One theory proposes the concept of brain entrainment. Brain entrainment suggests that certain frequencies can alter and synchronise one's brainwaves via the mechanism of binaural beats.<sup>18</sup> Brainwaves are the oscillating electrical voltages in the brain, of which there are five characteristically recognised types: gamma (25 to 60 Hz), beta (13 to 25 Hz), alpha (8 to 13 Hz), theta (4 to 8 Hz), and delta (1 to 4 Hz).<sup>19</sup> Each type of brain wave is characterised by their frequency and is related to a state of mind. Higher frequencies, such as gamma waves, are associated with high levels of concentration, when the brain is active and busy. In contrast, lower frequencies including theta and delta waves, are associated with states of relaxation and sleep.<sup>20</sup> Beauchene et al, who are affiliated with the Virginia Polytechnic Institute and State University, describe binaural beats as a "phenomenon that occur within the brain when two different frequencies are presented separately to each ear, producing a brainwave whose frequency is equal to the difference of the two presented tones".<sup>21</sup> For example, if a frequency of 210 Hz is played through one earphone, and 200 Hz through the other, the brainwave that occurs is determined by the difference of the two frequencies, i.e. 10 Hz. Sound healers may manipulate this phenomenon, using instruments such as the Tibetan singing bowl to entrain the brain to produce theta waves, inducing a deep meditative and peaceful state of mind, encouraging clarity and relaxation.<sup>22</sup>

An alternative theory draws upon the hypothesis that the human body has its own energy field: a 'biofield'. Within a paper titled, "The scientific hypothesis of an "energy system" in the human body", published by The Journal of Traditional Chinese Medical Sciences, the idea is proposed that the human body includes both visible and invisible parts, with the invisible part relating to the thought of an energy system.<sup>23</sup> The concept of 'qi' is often referred to in Traditional Chinese medicine, which refers to energy of the body, the biofield. Miles and True propose that sound healing may interact with the body's energy field, causing vibrational attuning which relate to the observed beneficial effects, such as decreased stress and tension due to sound meditation.<sup>24, 25</sup>

## Conclusion

Sound healing is an area of alternative and complementary medicine with roots in Eastern traditional medicine, and is delivered in various forms, including the use of Tibetan singing bowls at sound baths and sound meditations.

Tibetan singing bowl therapy has been linked to beneficial effects on human health and wellbeing, especially in the reduction of anxiety and tension, and increased feelings of relaxation and peace. There is also evidence to suggest that sound baths can have a physiological effect on human health, particularly, influencing the autonomic nervous system. The reasoning behind sound healing is unclear with various theories proposed to explain these beneficial outcomes; further investigation into the biochemistry and physiology of Tibetan singing bowls would be of interest.

Current literature mostly assesses the use of Tibetan singing bowls in scenarios such as meditations and sound baths, generally areas of relaxation. Future research could explore the potential use of Tibetan singing bowls to decrease tension and improve mood in potentially stressful situations, such as the workplace or before exams. In addition, it would be interesting to research the united use of Tibetan singing bowls with mainstream treatment options, exploring the effect of a combined therapy on human health and well-being.

## Appendix

### FACIT:

Zeeshan Butt, Jin-shei Lai, Deepa Rao, Allen W. Heinemann, Alex Bill, David Cella. Measurement of fatigue in cancer, stroke, and HIV using the Functional Assessment of Chronic Illness Therapy — Fatigue (FACIT-F) scale, *Journal of Psychosomatic Research*, Volume 74, Issue 1, 2013, Pages 64-68.

<https://doi.org/10.1016/j.jpsychores.2012.10.011>

<https://www.facit.org/measures/facit-fatigue>

### PANAS:

Watson, D., Clark, L.A., Tellegen, A. (1988). Development and validation of brief measures of positive and negative affect: The PANAS scales. *Journal of Personality and Social Psychology*, (54), 1063-1070.

[http://homepages.se.edu/cvonbergen/files/2013/01/Development-and-Validation-of-Brief-Measures-of-Positive-and-Negative-Affect\\_The-PANAS-Scales.pdf](http://homepages.se.edu/cvonbergen/files/2013/01/Development-and-Validation-of-Brief-Measures-of-Positive-and-Negative-Affect_The-PANAS-Scales.pdf)

### HADS:

Anna F. Stern, The Hospital Anxiety and Depression Scale, *Occupational Medicine*, Volume 64, Issue 5, July 2014, Pages 393–394, <https://doi.org/10.1093/occmed/kqu024>

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### Serena Deekollu

Serena Deekollu is a third-year medical student at the University of Bristol, passionate about both conventional medicine and alternative health remedies. Serena is particularly interested in pursuing a career in surgery, working in a high-stakes environment using creativity and compassion to care for patients.

Serena is also excited about complementary therapies, and the integration of these into patient care, to promote better health outcomes. With a commitment to healing, Serena is dedicated to becoming a well-rounded healthcare professional, focusing on the core value of whole-person, patient-centred care.

Age Group (Years)	n	Premeditation		Postmeditation		Change	P	η
		Mean	SD	Mean	SD			
<b>Tension (POMS)</b>								
20-39	15	1.56	0.88	0.21	0.31	1.35	.000	.71
40-59	33	1.29	1.15	0.20	0.68	1.09	.000	.47
60-79	14	0.88	0.78	0.26	0.43	0.62	.038	.29
<b>Anxiety (HADS)</b>								
20-39	15	1.43	0.61	0.67	0.62	0.76	.000	.70
40-59	33	1.03	0.70	0.27	0.52	0.76	.000	.54
60-79	14	0.74	0.46	0.29	0.47	0.45	.019	.35
<b>Depressed mood (HADS)</b>								
20-39	15	0.63	0.37	0.48	0.32	0.15	.207	.11
40-59	33	0.66	0.66	0.38	0.39	0.27	.012	.18
60-79	14	0.55	0.43	0.35	0.32	0.20	.051	.26

**Table 1.** Mean change in tension, anxiety, and depressed mood by age from pre- meditation to post-meditation from the observational study by Goldsby et al.<sup>17</sup> Table reproduced, with thanks.



## The impact of BMI on surgical outcomes, a literature review

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### Abstract

The prevalence of being both underweight and overweight is increasing. It is critical that we understand how BMI contributes to human health and wellbeing. This literature review focusses on the impact BMI has on surgical outcomes and encompasses various procedures. The literature was reviewed from a variety of surgical journal publications over a period from 2008 to 2022.

Being underweight (BMI<18) carried increased risk of poor surgical outcomes, including mortality and morbidity. Numerous studies suggest that some degree of obesity (BMI>30) has a protective effect on mortality, giving rise to the 'obesity paradox', whilst others report the opposite effect. Despite this, the risk of significant morbidity increased as BMI increased.

Overall, BMI does have an impact on surgical outcomes, those who are underweight have an increased risk of mortality and morbidity. Those who are obese may carry lower risk of mortality, however, they have increased risk of significant morbidity.

### Abbreviations

*BMI – Body Mass Index*

### Introduction

Over the past 15 years the prevalence of those underweight (BMI<18), overweight (BMI>25 to BMI<30) and of obesity (BMI>30) has continued to increase.<sup>1</sup> This highlights the importance of

research into how BMI can impact on human health and wellbeing. The literature suggests that obesity can have a large impact on human health and the development of negative health outcomes such as hypertension, cardiovascular disease and diabetes mellitus.<sup>2</sup> However, this literature review focusses specifically on the impact BMI has on surgical outcomes and includes a variety of acute emergency surgeries as well as planned, elective surgeries. As the population ages and life expectancy increases, the number of surgical procedures an average person receives is also increasing. It is estimated that the average person will undergo approximately six major surgical procedures in an 85-year life.<sup>3</sup> Therefore, it should be a priority to understand how different lifestyle factors, such as BMI, can impact surgical outcomes, so that we can better optimise patient care in the perioperative period.

### Methods

A PubMed search was conducted to find relevant literature by searching for the keywords 'BMI' or 'body weight', and 'surgical/perioperative/operative outcomes' in the title or abstract. The search was further refined by excluding any literature containing 'bariatric surgery' as this is not accessible to patients of all BMI groups and makes it difficult to ascertain the impact BMI has in these cases. Literature was selected that explored the relationship between BMI and surgical outcomes directly, specifically mortality and morbidity, but also other long-term health implications resulting directly from surgery. The main exclusion criterium was if the literature was outside the scope of the review, this included literature that had a primary focus on factors outside of BMI and surgical outcomes or did not explore the impact of BMI at all. Literature focussed on surgery undertaken by a single demographic was also excluded.

## Results

A total of 26,580 people across the USA, China, Japan and Germany were included and various procedures were chosen. These procedures include vascular surgery (aneurysm, cerebrovascular, amputation), intra-abdominal cancer surgery, otolaryngology-head and neck surgery, laparoscopic hepatectomy, oncological microvascular head and neck reconstruction, hepatic resection, total gastrectomy, and emergency laparotomy for high-risk abdominal emergencies.

Across the four studies that included an underweight (BMI<18) category there was a unanimous increase in 30-day mortality compared to a normal control group. This increase varied from 31% for vascular surgical interventions to 500% in major intra-abdominal cancer operations after adjustment for confounding.<sup>4</sup> In addition to increased 30-day mortality in the postoperative period those in the underweight category were shown to be more likely to need unexpected further surgery ( $P \leq 0.05$ ), further increasing the risk of complications and mortality.<sup>2</sup> A study into the outcomes of patients following hepatic resection identified a link between low BMI and risk of stroke. Those who were underweight were at 10 times greater risk of stroke following the operation compared to the control group ( $P=0.014$ ).<sup>8</sup> In addition, the risk of morbidity in patients with low BMI was 25.4% greater following vascular surgery when compared to a control group. This arises from an increased risk of multiple complications, including a 70.8% increased risk of systemic infection, a 49.5% increased risk of respiratory complications and a 32.8% increased risk of renal complications.<sup>2</sup>

Literature exploring total gastrectomy,<sup>9</sup> hepatic resection<sup>8</sup> and several emergency abdominal surgical procedures<sup>10</sup> found that high BMI carried increased risk of mortality following surgery. For total gastrectomy for stage IV gastric carcinoma, individuals in the obese group had much lower chance of survival than those in the non-overweight group ( $P=0.045$ ). Mortality 2 years post operatively for the overweight group was approximately equal to mortality<sup>5</sup> years postoperatively in the non-overweight group.<sup>9</sup> The findings for hepatic resection and emergency abdominal surgery were similar, with an approximate 50% increased likelihood of mortality in hospital following surgery<sup>8,10</sup> ( $P=0.003$ ).<sup>10</sup> In contrast, studies into vascular surgery, head and neck surgery and laparoscopic hepatectomy all reported either no impact or reduction in risk of 30-day mortality in individuals with high BMI, when compared to a normal BMI control group.<sup>2,4,5,6,7</sup> In some cases this reduction could be as great as mortality being four times less likely in individuals who are obese when compared to a normal control group.<sup>5</sup> Despite compelling evidence that a high BMI could be protective for mortality, risk of significant morbidity was associated with an increasing BMI.<sup>2,4,5,8,9,10</sup> Numerous studies reported longer operative time and increased risk of perioperative complications in patients with high BMI when compared to a control group.<sup>7,9,10</sup> Complications included: greater blood loss during surgery,<sup>9,10</sup> increased risk of pneumonia or other infection,<sup>2,4,8</sup> needing to be reintubated following surgery<sup>5</sup> and liver or renal failure ( $P < 0.0001$ ).<sup>8,10</sup> Complications of this nature may go on to have a significant impact on an individual's health and wellbeing. Therefore, they should be considered alongside mortality when assessing an individual's suitability for a surgical procedure.

**Figure 1** compares the 30-day morbidity and mortality rates with BMI class. As BMI class increases so does morbidity. However, mortality tends to decrease outside of the obese III category.<sup>4</sup>

## Discussion

The impact of low BMI on surgical outcomes appears to be well-documented and widely agreed upon.<sup>2,4,5,8</sup> Across the literature that included an underweight (BMI<18) group there was a unanimous increase in mortality compared to a normal control group. In addition to this, the added stroke risk identified following hepatic resection<sup>8</sup> could result in significant disability and reduction in an individual's quality of life. This could then lead to poorer outcomes in the form of

reduced independence, inability to complete activities of daily living as well as an increased risk of premature death.

High BMI has been shown to have a largely negative impact on human health and wellbeing, but when it comes to surgical outcomes it is unclear what the impact of BMI truly is. Many studies suggest that a high BMI increases risk,<sup>8,9,10</sup> whilst others suggest that some degree of obesity has a protective effect on 30-day mortality, known as the 'obesity paradox'.<sup>2,4,5,6,7</sup> The 'obesity paradox' is the notion that obesity can reduce the risk of mortality and morbidity in the perioperative period, despite being a risk factor for many other poor health outcomes. This includes increased risk of cardiovascular disease, Type 2 diabetes, musculoskeletal disease such as osteoarthritis and cancer. It is not entirely clear where this protective effect arises from, although there has been a number of theories proposed. These include the idea that individuals with obesity are better nutritionally optimised, specifically relating to the levels of preoperative albumin.<sup>2</sup> Albumin has been shown to have an impact on mortality and morbidity, more specifically hypoalbuminemia is an independent predictor of increased mortality and morbidity following cardiac surgery.<sup>11,12</sup> A meta-analysis into the impact of preoperative serum albumin levels on mortality and morbidity following cardiac surgery evaluated 22,553 patients and found that hypoalbuminemia was associated with an increased risk of mortality of between 66% and 110%. Hypoalbuminemia was also associated with increased rates of complications including congestive heart failure, renal injury, infection, bleeding and atrial fibrillation.<sup>13</sup>

Other explanations include the idea that obese individuals generally have a greater lean body mass and peripheral body fat which could both be protective in the postoperative period. It is also suggested that the paradox could arise from a reduced inflammatory response to the trauma of surgery, or that there is a genetic confounding variable that increases the risk of having high BMI and reduces mortality following surgery.<sup>14</sup>

## Evaluation of literature

There are some limitations to this research, arising from both the literature used and the usefulness of this literature review in isolation. Most of the literature included in this review are retrospective, cohort studies which use data from medical records, introducing selection bias.<sup>5,7,8,9,10</sup> In addition, using medical records can be problematic as there is a risk that documentation is poor, and patient's outcomes were not recorded. It also makes adjusting for confounding more difficult as many potential confounders may not be documented in medical records. This makes proving that BMI is causal of a given surgical outcome challenging. In addition, many of the operations carried out throughout the studies are elective, non-essential procedures where those deemed to be at the highest risk would be excluded from the study group, giving rise to procedural bias.<sup>4,5,7</sup> Many of the studies are also impacted by confounding bias as they only examine the association of one variable with an outcome. For these studies it is possible that other variables such as chronic illness or genetics could play a role in explaining the proposed association.

One of the main limitations with the scope of this review is that surgical outcomes are only one dimension when assessing the overall success, health and wellbeing of a patient following surgery. It does not account for other medical complications, or the psychological and emotional impact surgery may have on a patient, this is especially true for individuals who may have reduced ability to function and complete activities of daily living.

**Table 1** shows all the literature used in this review and the potential biases and limitations identified.

## Implications for further research

Further research into post-operative outcomes, outside of surgery, including medical and psychological complications would be a

good next step. This would give a more holistic perspective on overall patient outcome. In addition to this, further research into the physiology that underpins the 'obesity paradox' could be clinically significant and may give rise to the idea of physiologically optimising patients of all BMI groups in the preoperative period.

## Conclusion

The impact of BMI on surgical outcomes has proven to be complex. The literature suggests that low BMI has strong evidence to support negative surgical outcomes, both morbidity and mortality. However, in patients with high BMI, whilst the risk of morbidity following surgery seems to mirror that of other disease, such as diabetes mellitus and cardiovascular disease, 30-day mortality unexpectedly appears to decrease as BMI increases. Many theories have been proposed to explain this phenomenon, yet it is clear more research is needed to understand why this occurs. Fully understanding this would prove very valuable to the surgical field and could improve surgical outcomes for many through physiologically optimising patients pre-operatively.

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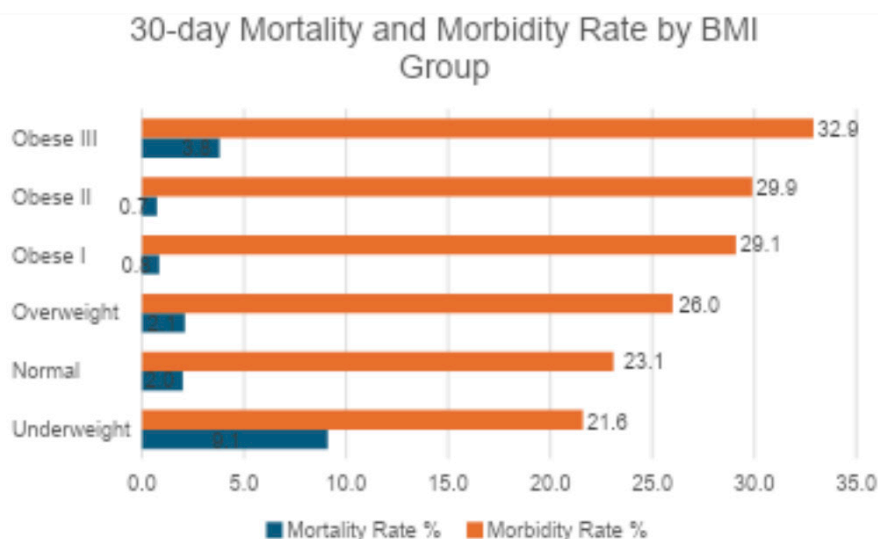
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## James Kelly

I am currently a second-year medical student at the University of Bristol and my primary interests are surgery and paediatrics. I have just completed a student selection component in paediatric orthopaedic surgery, where I was able to see the impact research can have on clinical practice. This has left me wanting to deepen my interest in this developing field, both throughout my degree and into my career as a doctor.



**Figure 1.** Comparing mortality and morbidity rate by BMI group, created using data from Mullen et al 2008<sup>4</sup>

NHS Digital. (n.d.). <i>Part 1: Age, time series and sex</i> . [1]	Davenport, D.L., Xenos, E.S., Hosokawa, P., Radford, J., Henderson, W.G. and Endleian, E.D. (2009). The influence of body mass index obesity status on vascular surgery 30-day morbidity and mortality. [2]	Lee, P.H.U. and Gawande, A.A. (2008). The number of surgical procedures in an American lifetime in 3 states [3]	Mullen, J.T., Davenport, D.L., Hutter, M.M., Hosokawa, P.W., Henderson, W.G., Khuri, S.F. and Moorman, D.W. (2008). Impact of Body Mass Index on Perioperative Outcomes in Patients Undergoing Major Intra-abdominal Cancer Surgery [4]	Crippen, M.M., Brady, J.S., Mozelka, A.M., Jean Anderson Eloy, Soly Baredes and Chan, R. (2018). Impact of Body Mass Index on Operative Outcomes in Head and Neck Free Flap Surgery [5]	Zhao, L., Wang, J., Kong, J., Zheng, X. and Yu, X. (2022). The impact of body mass index on short-term and long-term surgical outcomes of laparoscopic hepatectomy in liver carcinoma patients: a retrospective study [6]	Asaad, M., Yao, C., Praneeth Kambhampati, Mitchell, P., Liu, J., Lewis, C.M., Yu, P., Hanasono, M.M. and Chang, E.I. (2022). Impact of Body Mass Index on Surgical Outcomes in Oncologic Microvascular Head and Neck Reconstruction [7]	Mathur, A.K., Ghafari, A.A., Osborne, N.H., Pawlik, T.M., Campbell, D.A., Englesbe, M.J. and Welling, T.H. (2010). Body Mass Index and Adverse Perioperative Outcomes Following Hepatic Resection [8]	Daisuke Nobuoka, Naoto Gotohda, Kato, Y., Takahashi, S., Konishi, M. and Kinoshita, T. (2011). Influence of excess body weight on the surgical outcomes of total gastrectomy [9]	Kassahun, W.T., Mehdorn, M. and Babel, J. (2022). The impact of obesity on surgical outcomes in patients undergoing emergency laparotomy for high-risk abdominal emergencies. [10]	11.Engelman, D.T., Adams, D.H., Byrne, J.G., Ananki, S.F., Collins, J.J., Couper, G.S., Alamed, E.N., Rizzo, R.J. (1999). Impact of body mass index and albumin on morbidity and mortality after cardiac surgery [11]	Randell, Z., Martini, B., Hendrickson, N., Brodke, D., Spiker, R., Lawrence, B. and Spina, N. (2023). Hypoalbuminemia as a Predictor of Mortality, Disability, and Readmission in Patients Undergoing Spine Surgery [12]	Xu, R., Hao, M., Zhou, W., Liu, M., Wei, Y., Xu, J. and Zhang, W. (2023). Preoperative hypoalbuminemia in patients undergoing cardiac surgery: a meta-analysis [13]	Valentijn, T.M., Galal, W., Tjeertes, E.K.M., Hoeks, S.E., Verhagen, H.J. and Stolker, R.J. (2013). The obesity paradox in the surgical population. [14]	
<b>Literature</b>	Language bias Language bias, Confounding bias	None identified	Procedure bias, Language bias, Confounding bias	Selection bias, Procedure bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Confounding bias, Language bias	Language bias, Selection bias, Confounding bias	Language bias	Language bias, Confounding bias	
<b>Identified Biases</b>	Language bias	None identified	Procedure bias, Language bias, Confounding bias	Selection bias, Procedure bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Selection bias, Language bias, Confounding bias	Confounding bias, Language bias	Language bias, Selection bias, Confounding bias	Language bias	Language bias, Confounding bias	
<b>Other Limitations Identified</b>	Data is on school-aged children. Whilst the rising rate of obesity is consistent between children and adults, it may not be to the exact same extent.	Study based in the US and could be unrepresentative of other populations. The result is an estimate, not an exact number.	Data collected from large institutions, findings may not be generalisable to other institutions. Includes 5 different surgical procedures - the findings may not be representative of other procedures.	Data collected from a single centre - results could be affected by the surgeons' strategies.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded. Single institution experience - possible the literature could be unrepresentative of wider populations due to biases of individual practitioners.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded.	Study relies on one parameter to assess nutritional status and does not adjust for potential confounders, such as pre-existing chronic health condition.	Data obtained from medical records - risk of poor documentation and confounding variables may not be recorded.	No further limitations identified.	Data is largely collected from Western populations and could be unrepresentative of different patient populations.

Table 1 shows all the literature used in this review and the potential biases and limitations identified.

## Should probiotics be co-prescribed alongside antibiotics to mitigate gut microbiome disturbances?

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### Abbreviations

*AAD - Antibiotic-associated diarrhoea*

*NHS - National Health Service*

It is well known by now the altering effects certain antibiotics can have on our gut microbiome, with studies postulating long-term disruption being associated with diabetes, asthma and even obesity.<sup>1</sup> Any change in the microbiota, from a healthy pattern to one associated with disease is termed dysbiosis and has a wide range of studied causes, not just antibiotics. One of the first signs of early dysbiosis from antibiotic use is antibiotic-associated diarrhoea (AAD).<sup>2</sup> Despite this association, the current treatments include firstly stopping the antibiotics course early, possibly followed by more, secondary, antibiotics.<sup>3</sup> However, such an approach has increased antibiotic resistance radically, with the latter also being costly for the National Health Service (NHS).<sup>4</sup> With these pressing concerns in mind, along with the NHS' renewed interest in reducing antibiotic use, as seen in the NHS Long Term Plan, probiotics could be the future.<sup>5</sup> Probiotics, literally meaning 'positive bacteria' (for the gastrointestinal tract) are, on the surface, a simple idea of replacing the bacterial diversity lost due to antibiotics.<sup>11</sup> This article will explore evidence-based findings and the possible complications of these tablets to evaluate their future in prescriptions alongside antibiotics.

### The gut microbiome

The terms 'gut microbiota', 'microflora' or 'microbial phyla' all describe the community of microorganisms (majorly bacteria) that inhabit

the human gastrointestinal tract (gut), while the gut microbiome refers to this community and all their collective genomes.<sup>6</sup> With an approximated 100 trillion microbes in one gut microbiota, it is now considered to be the latest human organ under active research.<sup>7</sup> For the most part, the gut bacteria and their host work in a commensal manner, with these bacteria being vital for digestion, nutrient supply, barrier strength promotion and immune system regulation.<sup>8</sup> In return, they get a protective host environment. While this topic is still elusive in some areas, much research has been done into the effects of the disruption of this reservoir of life, particularly when caused by antibiotics.

### The gut microbiome and antibiotics

A systematic review of 31 articles confirmed the disturbances of antibiotics on our gut microbiome. The evidence shows that antibiotics (specifically those commonly prescribed in primary care in the UK) cause rapidly diminishing levels of bacterial diversity and changes in the abundance of certain bacteria.<sup>9</sup> These changes prevent the microbiome from carrying out its vital role, as well as allowing for 'bad' bacteria to increase in numbers. All the studies chosen had a low or unclear risk of bias, although it should be mentioned there was a concern about small sample sizes; however, this was not believed to have skewed the evidence or conclusion. The length of time taken for gut bacteria to recover to pre-antibiotic levels differed between studies, with most stating within a few weeks, but some suggesting longer term issues ongoing for two to six months after antibiotic cessation. This establishes the link between antibiotics and gut dysbiosis and brings to light the prolonged recovery of the gut

even after the antibiotics are stopped.

This proven dysbiosis secondary to antibiotics then goes on to cause AAD in a large majority of patients.<sup>2</sup> This is most common in response to antibiotics that act on anaerobes, namely aminopenicillins and cephalosporins. Between 5 and 30% of patients who take antibiotics will experience AAD either at the beginning or as late as two months after the end of treatment. This is thought to be due to a few reasons, including the new gut bacterial imbalances causing decreased short chain fatty acids absorption which subsequently results in osmotic diarrhoea.<sup>3</sup>

Currently, the control of mild cases of AAD is carried out by halting antibiotic use. This, however, raises questions of antibiotic resistance associated with the early stopping of the course without the patient having fully recovered.<sup>3,4</sup> Severe AAD events are further treated with antibiotics. Oral metronidazole is usually the first given, followed by oral vancomycin if the symptoms persist.<sup>3</sup> However, with the growing threat of antibiotic resistance and growing number of diseases resulting from dysbiosis, the World Health Organization has said that the world "urgently needs to change the way it prescribes and uses antibiotics".<sup>10</sup> Therefore, this author raises the question of whether the preventative pill of probiotics could be the answer.

## Probiotics

Probiotics are bacteria that positively influence the gastrointestinal microbiome. These can be found in certain foods or can be consumed in tablet form, the latter of which this article is focussing on. Probiotics are made from bacteria and/or yeast that naturally live inside of us, but are not to be confused with prebiotics, which are compounds that promote the growth of these beneficial microbes.<sup>11,12</sup> As a type of immunomodulating bacteria, probiotics can stimulate or suppress the immune system and may help the body combat cancer, infection or other diseases.<sup>13</sup> They have a much lower virulence compared to their more pathogenic gut microbiome counterparts. Many probiotics are presumed to have the ability to protect gut bacterial balance, thereby preventing the incidence of dysbiosis-related disease from antibiotics and its side effects. The history of probiotics is long, going back nearly 10,000 years, but only recently has it gained traction through new evidence-based medicine.<sup>13</sup>

Firstly, evidence has highlighted that probiotics act beneficially on our gut microbiome, specifically when taken in conjunction with antibiotics. A 2020 study was carried out into the efficacy of *Bacillus subtilis* and *Bacillus coagulans* probiotic, which exhibits characteristics of the *Bacillus* and *Lactobacillus* genera, on gut dysbiosis.<sup>14</sup> This was executed via an in vitro gut model, a mucosal simulator of the human intestinal microbial ecosystem. This study found that, in conditions of antibiotic-induced dysbiosis, probiotics could significantly reduce gut membrane barrier damage compared to when no probiotic was present. It is important to mention the study's limitations, such as the use of the model gut and a single healthy donor's gut microbiome, neither of which are representative to the general population. Therefore, more research should be done into this topic to look at the effects of probiotics in different microbiome environments.

Probiotics are thought to protect the gut during antibiotic intake, it is possible to see this by reviewing probiotics effectiveness in preventing AAD. The biggest limitation of these studies was the difference in probiotic strains used between them, and a review found that this impacts on whether a definitive conclusion can be drawn.<sup>15</sup> To understand the importance of probiotic type, a systematic review and meta-analysis reviewed all the standard medical databases up until 2018.<sup>16</sup> It specifically investigated the evidence-based efficacy of probiotics on a strain and disease individual probiotic level. It specifically investigated the evidence-based efficacy of probiotics on strains of bacteria and disease at an individual level across 249 trials and 22 different types of probiotics. Several of these had strong evidence for the prevention of AAD (*Saccharomyces boulardii*, a mixture of *Lactobacillus* strains and *Lactobacillus casei*) with others

showing positive evidence for additional diseases such as irritable bowel disease. Thus, highlighting that further research is needed to assess the impact of different probiotics on AAD and antibiotic-associated dysbiosis.

A systematic review and meta-analysis in 2020 looked into probiotic specificity further.<sup>17</sup> It evaluated existing evidence from 42 studies with 11,305 participants and found that the co-administration of probiotics with antibiotics reduces the risk of AAD in adults by 37%, with a relative risk of 0.63 (95% CI from 0.54 to 0.73,  $p < 0.00001$ ). This review investigated the best probiotic species used, finding that only a certain group seemed to be effective, namely *Lactobacillus* and *Bifidobacteria* genera. This addresses conflicting evidence and proves that selection of the probiotic strain is vital in its efficacy in reducing incidence of ADD. Therefore, these differences show that more research needs to be done into strains of probiotics, proving this topic is not as simple as 'any probiotic will do'.

## Antibiotic resistance from probiotics

This debate is complicated further by the possible link between probiotics and antibiotic-resistant genes. Probiotics, being live microbes, are not exempt from the naturally occurring antibiotic resistance.<sup>18</sup> Consequently, it could be possible for the horizontal transfer of these resistant genes. This can be shown with the genus *Lactobacillus* (a popular probiotic strain) belonging to the lactic acid group which is known for its possible vancomycin-resistant phenotype.<sup>19</sup>

With all evidence-based applications, there is an element of a risk-benefit analysis. For cases of severe ADD, oral metronidazole or vancomycin is prescribed, which further increases the risk of resistance. Therefore, although there is a chance of resistant gene transfer, the use of probiotics in addition to antibiotics is thought to reduce antibiotic resistance indirectly by preventing the need for secondary antibiotics to treat any side effects. Furthermore, the screening of gut microbes for antibiotic resistant genes before using them as probiotics is possible and should perhaps become strongly advised, if not enforced.<sup>18</sup> This implies that reducing the risk of antibiotic resistant bacteria with probiotics could be feasible, while achieving this with antibiotics is more challenging.

Despite the improvement in AAD in patients, it is important to consider the cost impacts that prescribing probiotics alongside antibiotics would have on our health service. As of May 2022, the prescribing of over-the-counter medicines by the NHS has changed, with prescriptions generally no longer being written for probiotics to reduce costs to the NHS.<sup>20</sup> Bringing back probiotic prescriptions would add this cost back onto the health service. However, this article raises the question of whether the benefits outweigh the costs. Probiotics could be the future in preventing antibiotic dysbiosis, thus reducing the frequency of secondary antibiotics required, as well as meaning patients are more likely to finish their antibiotic course. Therefore, probiotics should perhaps start being prescribed alongside all, or certain, antibiotics. By making them a prescribed drug, it could not only increase their popularity in the population, but also make them more readily available to those in lower socioeconomic areas. While it may raise costs for the NHS in the short term, it could save in the future due to fewer secondary antibiotics needed, as well as less antibiotic waste, and fewer ADD hospital admissions, perhaps also making this an economical choice.

## Conclusion

This article has briefly looked at the dysbiosis-causing effects antibiotics can have on the human gut microbiome, and subsequently the associated diarrhoea a large proportion of individuals suffer as the first sign of this dysbiosis. Although for most, these changes in bacteria are likely to return to pre-medication levels, for others this is not the case. With probiotics thought to lessen the impact of antibiotics on the healthy gut, future research should investigate the potential of

probiotics as a potential prescription alongside antibiotics. Moreover, their ability to reduce the unwanted side effects of AAD will mean more individuals will not be stopping their antibiotic course early, whether out of choice or following the instructions of a healthcare professional. This may help in the current war against antibiotic resistance, as well as increasing patient satisfaction. Furthermore, less frequent, or less severe AAD will mean fewer antibiotics for secondary infections will be required, again reducing the chances of resistance, as well as saving the NHS' valuable but limited resources. Despite this, probiotics are not ready for prescriptions just yet. This article raises the question of whether naturally sourced probiotics via food and drink could solve the above issues, while still providing the population with antibiotic protection. It is clear a lot more research needs to be invested into probiotics and the best strains of probiotics for each of our unique gut microbiomes. This may mean a more personalised approach to probiotic prescriptions, but in the new age of personalised medicine, all healthcare is moving in this direction anyway, so why not strive for an individualised wall of protection against antibiotics and other dysbiosis-causing events.<sup>21</sup>

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## Sophie Lawrence

Hi, I am Sophie, a third-year medical student at Peninsula. As well as submitting an article for the Inspire journal, I am also one of this year's journal editors. I initially got involved with INSPIRE through the research program, which eventually led me to do a summer project with the same lab. My current research interests include cancer endocrinology and the role of APP in the pathogenesis of Alzheimer's, breast and prostate cancer, as well as, of course, the gut microbiome. Outside of medical school, I love running and anything else outdoors, including walking my three cockapoos :)).

## The impact of cardiovascular exercise on human cognition

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### Abstract

Cardiovascular exercise has been long practised. The dawn of its popularity began in the 1960s when it was known as ‘aerobics’. Several studies have shown that cardiovascular exercise can increase levels of cognition in various subjects, both acutely and in the long term. Cognition was measured in terms of ‘learning success’, memory ability and attention, for example. Many individuals with existing neurodevelopmental disorders have had their symptoms alleviated by engaging in cardiovascular exercise. The brain’s neuroplasticity is a widely acknowledged contributor to our fluctuating cognitive function. Common issues encountered when reviewing these studies are their small sample sizes and lack of homogeneity.

### Abbreviations

ACC - anterior cingulate cortex  
 ADHD - attention deficit hyperactivity disorder  
 BDNF - brain-derived neurotrophic factor  
 CE - cardiovascular exercise  
 COPD - chronic obstructive pulmonary disease  
 CVD - cardiovascular disease  
 MRI - magnetic resonance imaging  
 ERP - event-related potential  
 ES - effect size  
 RCT - Randomised Controlled Trial  
 VEGF - vascular endothelial growth factor

### Introduction

Cardiovascular exercise (CE) has been long practised. The dawn of its

popularity began in the 1960s when it was known as ‘aerobics’. It was a term coined by Dr Kenneth H Cooper who pioneered this concept, with the intention of developing a system of exercise to prevent complications involving the coronary arteries.<sup>1,2</sup> Today, this term is commonly shortened to ‘cardio’, and exercises range from swimming and walking to dancing and marathon running.<sup>3,4</sup>

There exists a considerable body of research on the influence of CE on human cognitive function, in particular the physiological theories underlying this hypothesis. Much of this research includes seminal studies which have greatly contributed to our understanding of cognitive processing.<sup>5</sup> However, it is evident that an abundance of this research entails the effects of CE on memory alone, failing to discuss human cognition as a whole. Cognition is defined as the mental processes involved in gaining knowledge and comprehension and can include attention, learning and perception, as well as memory.<sup>6</sup> Thus, this brief literature review will critically analyse some of the theories regarding the physiological mechanisms that are elicited through CE, that may contribute to human cognition. It will subsequently focus on the most widely discussed of these mechanisms, neuroplasticity, in order to bring forth a greater understanding of the neurobiology underlying exercise-induced cognitive enhancement.

### Background

CE is physical activity that increases metabolic rate. Its name refers to the stresses placed on the cardiorespiratory system by these exercises, which involve consistent, dynamic movements.<sup>7</sup> Regular CE engagement can increase fitness and prevent the risk of/manage chronic conditions.<sup>8</sup> Middleton et al (2010) found that the risk of cognitive impairment was higher in women who remained inactive in their lifetime compared to those who later became active.<sup>9</sup>



Arousal theories have played an important role in research investigating the relationship between CE and cognition, such as the Yerkes-Dodson Model, which explains that an intermediate stress level optimises performance.<sup>10</sup>

## Methods

A literature review was deemed the most appropriate method for this field of study. Research into the effects of exercise on cognitive processing is extensive, and so a literature review would facilitate an overview of the main findings and debates regarding this subject area. Seminal studies were included as well as less notable research. Excluded were those related to strength training and other forms of exercise that do not significantly raise heart rate. The database primarily used to search for literature was Ovid MEDLINE. Keywords and terms frequently entered into the search engine were 'cardiovascular exercise', 'cognition', 'memory' and 'learning'.

## Discussion

The UK's ageing population highlights the importance of cheaper interventions to counteract age-related declines in cognitive function.<sup>11</sup> Kuhne et al (2023) investigated the correlation between CE and cognition, which they hypothesise is mediated by 'an altered immune response to exercise'. In their randomised controlled trial (RCT) participants engaged in either a bout of indoor cycling or stretching (control), immediately following an artificial vocabulary learning task. Blood samples were obtained to measure serum cytokine concentrations in both groups. 'Learning success' was measured by the number of correctly matched pseudoword-picture pairs.<sup>12</sup>

The results of this experiment, although conducive, may be of limited use in the attempts to corroborate a direct positive correlation between acute CE and cognition: The study showed no significant difference between the two groups for learning success. However, serum cytokine levels (IL-6) significantly increased in the CE group, and there was no such increase in the control group.

Nevertheless, the critical remark must be made that these results merely confirm that CE increases serum cytokine levels, not learning success. Kuhne et al conducted additional research that revealed CE-specific cytokines do, in fact, increase cognition.<sup>12</sup> However, this was not implicated in the RCT. By combining the results of the two studies it would be reasonable to infer that acute CE and enhanced cognitive function are positively correlated. However, doing so may be circuitous, and offers a post hoc justification for this relationship. A study with results establishing a direct relationship would be of greater use.

Two years earlier Kuhne et al conducted a study of a similar premise, this time investigating exercise-induced neurotrophic factors in lieu of the cytokines in the aforementioned study.<sup>13</sup> This study also failed to show a significant difference between the CE group and the control group in terms of memory ability, however a greater increase in brain-derived neurotrophic factor (BDNF) and vascular endothelial growth factor (VEGF) levels was observed in the CE group. BDNF and VEGF have been shown to increase memory consolidation in humans.<sup>14</sup> Although this poses the same notable criticism as the study above, it does shed light on another potential mechanism by which CE could impact cognition.

Neuroplasticity refers to the brain's ability to adapt in response to stimuli. Synaptic networks undergo growth and reorganisation in order to change their function. Such neural modifications can be prompted by both environmental and internal stimuli, such as brain injury and learning processes.<sup>15</sup> Recent research by Lehman et al (2020) suggests that the brain's neuroplasticity is a mediator of the association between CE and cognitive function - specifically, sustained attention. They prescribed the use of neuroimaging. They

discovered that two weeks of regular CE increases sustained visual attention, and that the left middle frontal gyrus of the brain increases its intrinsic connectivity to facilitate this.<sup>16</sup>

Results from Winneke et al (2019) agree with the above. They theorise that cognitive function following a bout of CE improves due to the activation of attentional control resources. In the CE condition, participants completed indoor cycling training whilst their event-related potential (ERP) data was measured. They found exercise produced a shorter P3 ERP peak latency compared to the resting state, indicating an increase in neural processing.<sup>17</sup> Although this study provided a small sample size of 11, the p value was <0.001, allowing the acknowledgement of the link between CE and augmented attentional control.

A meta-analysis conducted by Lambourne and Tomporowski in 2010 found that exercise-induced cognitive function improved by a mean effect size (ES) of 0.2, especially in tasks that involved rapid decision-making.<sup>18</sup> In agreement with these findings, Etnier et al (1999) concluded that chronic obstructive pulmonary disease (COPD), age, pulmonary ventilation and aerobic fitness are all useful predictors of cognitive function. They discussed that the impact of the latter may be due to an increase in cerebral oxygenation during exercise. They also conducted a meta-analysis presenting 852 effects of acute CE on cognition, showing a significant positive ES of 0.16.<sup>19</sup> However, Lambourne and Tomporowski criticised its methodology, stating that they failed to employ a process to address the small sample sizes used in their study.<sup>18</sup> Furthermore, many studies investigating cognition tend to use mundane artificial cognitive tasks lacking ecological validity.

A number of authors have recognised that CE can enhance cognition in individuals who have suffered from disease, as well as those currently living with neurodevelopmental disorders. Research has shown that CE can help alleviate symptoms in individuals with attention deficit hyperactivity disorder (ADHD), for example by increasing attention span.<sup>20</sup> Additionally, CE has been found to increase sensorimotor control (mediated by cognitive regions in the brain) in stroke survivors and older individuals with cardiovascular disease (CVD).<sup>21,22</sup> However, these studies fail to consider potential confounders such as sleep quality, which can be increased by CE and prevents cognitive impairment.<sup>23,24</sup> It could be that participants in the CE condition began to sleep better and so any prior cognitive deficits restored themselves.

It is apparent that over time, extensive literature has developed on the impact of CE on brain neuroplasticity; this appears to be the most widely discussed mechanism by which CE may increase cognition. The results of previous studies are in agreement with the aforementioned study by Lehman et al. (2020). They show CE has led to neural angiogenesis, synaptogenesis and increased hippocampal plasticity in both humans and animals, and produces exerkines that induce long-term synaptic potentiation-related pathways.<sup>25,26,27</sup> Others have shown that CE is related to decreased atrophy in the anterior cingulate cortex (ACC) and medial temporal lobe.<sup>28</sup> Nonetheless, the impact of the type of CE is seldom addressed in these studies. Müller et al (2017) found a greater increase in grey matter in the brains of participants in the dancing condition compared to those in the cycling condition, indicating the effects of some aerobic exercises may be more potent.<sup>29</sup>

## Conclusion

There is a plethora of CEs that people engage in to improve their fitness. Due to this large scope, it is an accessible way of minimising age-related declines in cognitive function.

Several studies report an increase in cognition through CE, although the potential mechanisms by which this takes place differs between studies. Some employed the use of blood sampling and others magnetic resonance imaging (MRI) scanning, for example. The most

commonly discussed theory was that the brain's neuroplasticity mediates an increase in cognition alongside CE.

Many studies in this field have small sample sizes and narrow age ranges. They also fail to consider potential confounding variables that may impact both CE and cognition and would therefore reduce their validity. As such, more research is needed that accounts for confounders and is accommodative of other populations, for example older people. Additionally, the cognitive tasks should be made less artificial, having greater real-life application. However, there are notable commonalities between studies that point toward future implementation of CE to enhance cognitive function.

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## Simisola Alexandra Solanke

Hi! I am a second-year medical student at the University of Bristol. I am particularly interested in gastroenterology and integrative medicine, and how alternative therapies can be used alongside conventional approaches in mainstream medical practice. I enjoy sports, cooking and reading.

## How can the UK healthcare system adapt to the increase of patients with autism spectrum disorder?

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### Abbreviations

*AASPIRE – Academic Autism Spectrum Partnership in Research and Education*<sup>7</sup>

*ASD – Autism Spectrum Disorder*

*GP – General Practitioner*

*NIH – National Institute of Mental Health*

### Abstract

As the number of people in the UK with an autistic spectrum disorder (ASD) diagnosis increases, there has become a more obvious gap in the healthcare system for how the service is set up to support these individuals. This article looks at statistics of autism diagnosis and the regularity of attendance to healthcare services with the view to providing coping strategies for the future. Whilst also looking at the effectiveness of the current studies and how they could be adapted to get better quality data in order to address this problem that is growing larger and potentially causing huge problems for patients. Results found that there can be more ways to improve the experience of healthcare for patients with ASD, including both in environmental factors and education/awareness from practitioners and the public.

### Introduction

Autism spectrum disorder (ASD) is a neurodevelopmental disorder affecting children and adults. Its common characteristics include challenges in social interaction and communication, and the inability

to alter routine or interests, which is often linked to repetitive behaviours.<sup>1</sup> There has been an increase in ASD prevalence worldwide over the past 20 years<sup>2</sup> and approximately 1 in 100 children are diagnosed with the condition globally.<sup>3</sup> Most notably in England, there is an increase in people with an open referral for suspected autism diagnosis. This has risen to 125,109 people in July 2022, an increase of 34% since October 2021.<sup>4</sup> This review article covers some research conducted in Western medical practice surrounding how patients with autism struggle to access healthcare services and investigates what can be done to combat these problems.

Escalation in autism diagnoses has led to an increase in the number of people with ASD using healthcare services. Due to this, limitations and barriers that prevent people with ASD from receiving the correct or best care have been brought to light.<sup>5</sup> The World Health Organization highlights the importance of equal healthcare access for the entire population. However, currently there are more unmet healthcare needs amongst those with autism.<sup>6</sup> Identifying barriers preventing people with ASD from having the same opportunities as those without should help the healthcare service adapt for autism.

### Methodology

To find the papers used in this article, PubMed was used for the initial search. The focus of the research stemmed from the key words: 'healthcare,' 'autism spectrum disorder' and 'barriers/inequalities'. Once the overarching systematic reviews were identified using these key words, the primary data from within these reviews was used to ensure the data was interpreted from the primary source article and

not as secondary data. Another specific filter was that only data from the last 20 years was used to provide the most relevant data where possible. This was achieved with the eldest paper originating from 2006 and most of the data used from 2020 or more recent. Lastly, the identification of the website by The Academic Autism Spectrum Partnership in Research and Education<sup>7</sup> and its links to the National Institute of Mental Health (NIH)<sup>8</sup> provided a bank of resources to search through, using the same specifics as within the PubMed application.

## Results

People with ASD are commonly using healthcare services for the comorbidities they have alongside their ASD.<sup>9</sup> Some of these comorbidities include epilepsy, gastrointestinal problems and type 1 diabetes. Individuals diagnosed with epilepsy or are an offspring/sibling of someone with epilepsy are more at risk of being diagnosed with ASD, especially if diagnosed in childhood.<sup>10</sup> Gastrointestinal problems include recurrent diarrhoea, constipation and food sensitivities, and a common presentation is increased challenging behaviour in children with ASD.<sup>11</sup> Type 1 diabetes and ASD have risen in prevalence. Due to the invasive way diabetes must be treated, it is more likely for those with ASD to have an adult manage their diabetes into adolescence.<sup>12</sup> If there are circumstances preventing ASD patients from effective treatment, their comorbidities might not be treated correctly, increasing the risk of poor health in their lifetime.

A study conducted in Canada investigated the type of healthcare service adults with ASD use and their satisfaction with the service.<sup>13</sup> Results identified that after family doctors (general practitioners, GPs), the next most used service was the dentists, followed by counsellors and psychiatrists. However, it was a small study of 40 adults and is therefore not representative of the general population. There was also bias towards mental health services, possibly due to the health of participants involved. Looking at both this study<sup>13</sup> and the analysis of physical health conditions<sup>9</sup> it can be derived that there is a need for the same range of services to be available to all patients regardless of an ASD diagnosis.

With these frequently visited clinical services in mind, two studies in the US investigated the barriers faced by adults with ASD compared to non-autistic adults and adults with other disabilities. The first study devised both long and short-form online surveys. It compiled 41 questions about barriers faced into nine overriding categories.<sup>14</sup> The category with the biggest difference between the three groups was sensory barriers. 26.7% of participants with ASD stated that sensory distractions, such as light, sounds and smells, disrupted communication, made examinations difficult or caused general discomfort compared to just 6.3% and 1% for other disabilities and no disability respectively.<sup>14</sup> This was also identified in an interview-style survey, as sensory triggers such as harsh lighting and reflective surfaces were flagged as an issue causing overstimulation and reduced ability to engage with the service.<sup>15</sup> A Swedish online study looked specifically into the sensory stimulation affecting adults with autism compared to those without.<sup>16</sup> Interestingly, the biggest issue were auditory stimulants such as echoes, TVs and ticking clocks. A lot of emphasis was put on these sounds causing stress or overwhelming feelings, something not addressed by non-autistic adults. Another major difference between the two groups of participants was that movements, odours or verbal output from other patients caused the feeling of unpredictability and stress for patients with ASD.<sup>16</sup>

Another issue discovered in the surveys was that participants felt like their clinician had no understanding of what autism was or how to treat them, which often made them feel like they did not want to disclose their autism for fear it would affect their care.<sup>15</sup> An online self-report study has been conducted and 304 GPs from across the UK took part.<sup>17</sup> Of the 91.4% of the GPs who stated that they had at least one patient with autism, 10.1% had more than 30, and 65.8% said that this number had increased since their career had started. Almost the same number of GPs had not received any autism training

in their primary degree or GP specialisation as those who had not received any further training since initial qualifications, which are 63.5% and 65.8%, respectively. 39.5% had not received any training about autism at all. The second part of the survey was 14 questions on self-efficacy. The average score was 4.8 out of a possible 10, and the prescription of medication was identified as the least confident aspect of care.<sup>17</sup> If the growing number of ASD patients in GP surgeries are affected by the lack of confidence from their GPs on aspects of treatment and management for their comorbidities, then there is a risk of a reduced likelihood that GPs will refer their patients to diagnostic assessments that recognise autism diagnoses.<sup>17</sup> In the future, the volume of GPs with the inability to recognise or refer patients could raise the number of individuals who have underlying autistic symptoms and do not disclose them to clinicians.

A contrasting study comparing experiences between adult with and without autism demonstrates that not all experiences of clinical services among the two groups are significantly different.<sup>18</sup> This online survey asked participants from both groups questions about their healthcare experience, use of healthcare, unmet medical needs and self-efficacy. Results showed no significant difference between their satisfaction on healthcare as the total score, using a 4-point Likert scale (for example, never, sometimes, usually or always), is only slightly lower for participants with ASD. Although they only produce ordinal data and are more at risk of bias, they are easier to be created for online use, which can maximise responses.<sup>19</sup> Despite the overall survey not producing huge discrepancies between the two groups' responses, one area of the questionnaire that did demonstrate a difference in participants with autism was the recorded lower self-efficacy in healthcare that these individuals have.<sup>18</sup> This could be what causes them to also identify a higher number of unmet healthcare needs within the ASD population in this study.<sup>18</sup>

To address these issues that result in reduced care and lack of confidence in healthcare, a 'toolkit' has been created in the US to try and overcome some of the barriers adults with autism face.<sup>20</sup> This was created as part of research conducted by a US association called AASPIRE (the Academic Autism Spectrum Partnership in Research and Education<sup>7</sup>). It is described as a collection of information to aid the quality and availability of healthcare for adults with autism and is accessible online. The study conducted to evaluate the content of the 'toolkit' concluded that it was easy to use, as 92.1% would recommend it to a friend and 94.9% would recommend to a healthcare practitioner. Having used the 'toolkit' alongside a clinical scenario, the number of barriers experienced almost halved compared to before, and both self-efficacy and patient-provider communication went up.<sup>20</sup> Despite the improvements that the 'toolkit' makes to the accessibility of healthcare services, the adults using it still must rely on technology, as the study was only conducted on those who are able to access the internet and it does not help to eliminate the physical experiences, such as sensory issues, when attending the service.

## Discussion

The surveys used to conduct these studies were conducted on small cohorts that do not necessarily represent the entire population of people with ASD. Most of the data used has come from studies in the US. Looking at studies since 2000, the median prevalence of autism in the US is 21.6/100,000 people, slightly higher than the median in Europe using studies since 1999 which is 18.8/100,000.<sup>3</sup> However, for all disabilities, the US, Europe and Western Pacific are all very similar statistically.<sup>3</sup> Even though the US has a higher median rate of ASD, the UK rate of ASD diagnosis is similar and the ASD population is increasing. This means that the UK can learn from the US studies to make better improvements.

What has demonstrated the elevated level of expertise the US studies in the ASD research field is the use of the AASPIRE 'toolkit' and website<sup>7</sup> in many of the studies. It is a revolutionary source of information for patients, carers and healthcare providers for research-based information on autism and the challenges it might cause for

patients and those in their network all in one place. The connection to the NIH and their research<sup>8</sup> could allow the UK to do something similar with their research to create our own version of the American ASD 'toolkit' in the future. However, with the limited studies on the subject currently in the UK this is still a futuristic idea rather than a realistic suggestion to come out of the research.

The other main limitation of the studies used in this article was that the minimum age of participants in the sources was 18, and the fact that children with autism also use healthcare is not considered. Data from US showed children diagnosed with autism have almost six times as many outpatient visits annually compared to non-autistic children, and when compared to children with other developmental disabilities, nearly twice as many.<sup>21</sup> Therefore, there is uncertainty as to whether the experiences and barriers identified by the participants in the studies would be relevant to children and young adults. Surveys, possibly using the Likert-style scale due to their ease of use, could be given to young adults and children with autism. Outcomes should be compared to the findings from adults to see if the changes that need to be made to the healthcare system are applicable to all ages. Differences in the data could also be used to ensure that there is equality in the availability of healthcare across age groups as well as disabilities.

The strengths of the article are that it has culminated data from around westernised medical services and has made a clear analysis of what need to change within healthcare for the treatment of patients with ASD to be more equal and comparable to those without the condition. What researchers can do next in the future is to look more specifically into each area of the issues outlined to make more specific suggestions. Therefore, secondary research could be carried out and followed up to allow for a less holistic comparison of the adaptability of healthcare for patients with ASD and those without, focusing on each identifiable limitation more acutely. Secondly, despite the applicability and relevance of the research in this article to the UK, there could be more emphasis on UK research to ensure that the data used is as relevant to the research question as possible.

The healthcare system is currently not well adapted to cope with the increased number of patients with ASD, especially when there is a huge variation in the diagnosis and presentation of ASD.<sup>22</sup> These studies have outlined that there is inequality in the delivery of healthcare to individuals with ASD and as a result, there is a risk that this could leave patients with unmet healthcare needs. Adaptations to education, environments and accessibility should be made to prevent people with ASD not attending healthcare services for their comorbidities, dental health and mental health. In the long term, this will hopefully prevent patients with ASD from living with undiagnosed comorbidities. If there is a continuation of unmet healthcare needs, there could be a risk to patients with ASD having longer stays in hospital, more emergency appointments and a decreased quality or length of life. More guidance and awareness of how variations of ASD present and the common characteristics that can cause people with autism difficulty engaging with healthcare should be made available to clinicians and the public. Simple measures such as being able to adopt non-verbal communication skills to come across as less patronising, or describing procedures slowly should be integrated into training to prevent clinicians coming across as judgemental.<sup>16</sup> Not only should this improve the confidence of individuals with ASD in healthcare, but it could allow clinicians the ability to gain more confidence in recognising ASD in their patients and making appropriate referrals.

Improvements to the environment around the growing proportion of patients with ASD will hopefully allow them to have a better experience with healthcare. Firstly, to help improve the education of the clinicians that will be in contact with patients with ASD, programmes should be made to promote the skills needed and to allow clinicians to understand the specific healthcare needs of individuals with ASD.<sup>23</sup> Alongside practitioner awareness, public awareness needs to be promoted. This will not only mediate the cause

of some ASD patients stress in healthcare environments but might also maximise the opportunity for early screening and therefore earlier access to healthcare.<sup>23</sup> Other physical barriers could be overcome by simple changes such as having individual chairs in waiting rooms so no one sits too close, additional time in consultations, or removing the risk of loud echoes or reflective surfaces.<sup>16</sup>

## Conclusion

The adaptability of healthcare is essential to providing people with ASD the confidence to use services and trust in clinicians. Reducing the barriers to accessing healthcare for patients with ASD imminently to cope with the rising number of autism diagnoses will help make healthcare better suited to the diverse patient population.

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### Rosie-Jane Widdowson

Hello! I am a third-year medical student at Plymouth University. This piece started life as an SSU on the topic of 'healthy variation, what is normal?' and 'the healthcare environment', but has developed into a review article on the topic of autism and healthcare, which is a topic close to my heart and never fails to spark new interest in me. I have enjoyed the writing and editing process and hope to continue writing in the future to support my interests which are currently paediatrics, plastic surgery, and neurology.

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## The pathology summer school: new paths and astonishing discoveries

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### What is the Royal College of Pathologists' summer school?

Once a year, in August, the Royal College of Pathologists in partnership with several sponsors host a free two day course for medical and biomedical students (King's College London Guy's Campus and the Royal College of Pathologists) in central London. This showcases the weird and wonderful opportunities a pathology career holds, ranging from sub-specialist consultant posts in neuropathology, to the biomedical scientists working in clinical biochemistry. As well as career talks walking through the practical aspects of what training and qualifications are required for a career in pathology, small group breakout sessions are run throughout both days to give a taste of the day-to-day problems one may encounter while working in this field.

In addition to formal teaching, the occasion is the perfect opportunity to meet with medical and biomedical students in all year groups from all over the UK, with plenty of coffee breaks and a dedicated BBQ for participants to get to know each other. Not only was this a fun respite from the academic sessions of the day, but it was also a great chance to find out what it is like to work and study in other parts of the UK. The staff and keynote speakers were equally approachable and friendly during breaks and throughout the day.

### What made me want to attend?

Despite being in my final year of medical school, I have had very minimal exposure to pathology as a specialty. If anything, the dry histology content didactically taught in the early years of medical school left me with a jaded view of the discipline. Overcoming my initial bias, I went into this event with an open mind after reading the glowing reviews from attendees of the previous years. To my surprise, I was met with exuberant consultants and scientists passionate about their contributions to the medical field who are content with the work life balance that this specialty provides. Their enthusiasm was infectious, and I could not help but share their excitement in recent and historic innovations in the field.

One particularly inspiring doctor at the pathology summer school was **Dr Matthew Clarke**, an NIHR Academic Clinical Lecturer and diagnostic neuropathology ST4 (with an interest in pediatric neuropathology and molecular pathology) based in London. Having initially studied BSc Zoology and spending time training in surgery before eventually entering pathology, it was fascinating to hear his perspective of what led him to where he is today. He was kind enough to answer a few questions for our journal:

### What sessions did you lead and what behind the scenes work to put the event together?

*I have been involved in the pathology summer school for about 9 years, along with my colleague Katie Allen, a histopathology trainee. In 2024, I led the pathology pots session and also gave a talk about the opportunities that are available in pathology training. The pots session allowed students to come and have a look in more detail at some of the incredible specimens that are in the Gordon Pathology Museum. We were able to talk through some of these different specimens and work out what the pathology or disease process might be, helping to relate it back to the patient and their potential experiences. The museum is an incredible resource for pathology education and it is a pleasure to be a part of these sessions each year. Before each session, I walk through the museum and find a selection of specimens to use – I always find new ones that I have not seen before that students might be interested in! I try and select a few of the more common pathologies, but also some of the rarities too which are always interesting to talk through.*

### What are a few of your proudest moments over the course of your career?

*Some of my proudest moments are the following; as part of my PhD project, with the help and tuition of an amazing research team at the ICR (headed by Professor Chris Jones) and our fantastic national and international collaborators, I helped to discover a new type of high-grade glioma (a very aggressive brain tumour with a dismal prognosis) that occurred in infants. I was able to show that it contained just a single*

molecular alteration (a translocation) and these were targetable with drugs. Infants with this tumour are now able to enter clinical trials and are surviving after being given treatment. The scientific paper we published led to the creation of a new chapter in the WHO Classification of CNS Tumours about this tumour. I am regularly contacted by families and clinicians from around the world providing positive updates about their patients/child – I am so proud to have been part of an amazing research team that was able to make a difference for these children and help to lead this work through the completion of my PhD. Also, throughout my career, I have held several representative roles including being Chair of the Royal College of Pathologists Trainees' Advisory Committee, a BDIAP Trainee Councillor, Editor of ACP news, and also the Chair of the Academy of Medical Royal Colleges, Trainee Doctors' Group. I have been very proud to represent trainees in these different roles, and lead projects within the committees that have helped to bring a positive impact on training. I have worked with an amazing set of colleagues who helped with these.

**Does your zoology degree play into your day-to-day work as a consultant?**

My degree in Zoology was hugely beneficial; it provided me with a solid foundation of knowledge in comparative anatomy and physiology. We covered a lot about human-based anatomy and physiology too, which has been very useful throughout my entire career. Having an appreciation of the biology of other animals is very important in medicine; there are many diseases which can affect multiple species, and also many different zoonotic infections which can jump from one species to another. As well as being immensely interesting, and something I continue to study outside of my daily work, from my perspective, it is important to have an awareness of what is also happening in the natural world. Climate change is an example, and something which is going to have a huge impact on the spectrum of different diseases, and therefore the cases we may encounter as pathologists.

**Could you briefly summarise your journey into medicine and where you are today?**

I completed a BSc degree in Zoology at the University of Liverpool before deciding that I wanted to do medicine. I didn't get a place at medical school at the first attempt so I took a year out, got some more work experience and worked at a playgroup, and then finally got a place at Keele Medical School in 2005. After graduating in 2010, I chose to stay at the hospital where I trained for my foundation jobs. I had been heading for a career in surgery, but a 4-month post in histopathology during my FY2 year changed my perspective. I still applied for core surgical training, and successfully got a place in London. However, I could not forget about pathology! I completed my MRCS examinations but then changed career paths to join histopathology. After 2.5 years of training, I spent 6 months at Institute of Cancer Research learning about molecular pathology. This led to the completion of a 4-year PhD in the molecular pathology of infant gliomas. After this, I decided to switch training programmes to diagnostic neuropathology (a subspecialty of cellular pathology). I currently work as an NIHR Clinical Lecturer in a split role between clinical work and research. I am based at the National Hospital for Neurology & Neurosurgery (UCLH) for my clinical training and at the Institute of Cancer Research (as part of the Glioma Team, headed by Professor Chris Jones) for my research work. I am aiming to specialise in paediatric neuropathology and molecular pathology, and having recently completed my final FRCPath examinations, I am exploring the opportunities to become a consultant!

**What do you wish was taught in medical schools about pathology/histology?**

It is very sad that very little pathology is being taught in medical schools with each new iteration of the curriculum. Understanding the different mechanisms of disease is fundamentally important to help doctors understand how a disease is impacting a patient, and to be able to explain to a patient what is happening to them and how it can be treated. It is also very interesting to be able to see what different diseases

look like and the effects on different organs and tissues. Understanding what normal tissues look like under the microscope is important to be able to recognise when something might be abnormal. Integrating pathology as part of case-based teaching (just as it is integral to almost every patient that comes into a hospital) is a really engaging way of understanding the basics of pathology, and is important across all years of medical school, not just the early few. It is also important to teach medical students how important it is to provide the clinical information about the patient's signs, symptoms, past medical history etc. on the pathology request forms; this can make a huge difference to the diagnosis we provide, and so without it, it can have a huge impact on the patient. Without pathology being taught to medical students, future doctors will not have an appreciation of how important this is.

**What are some examples of flexibility in this field?**

There is a lot of flexibility in pathology, both within and post-training. There is flexibility to work less than full time, and explore different elements of a medical career including teaching and research. There are opportunities to be able to take time out of training and visit different labs or get some research experience – you could even do a PhD like I did! When you complete your training, there is flexibility to be able to shape the consultant or specialty job that best suits you, including thinking about the particular subspecialties you want to work in, how much clinical or research time you want to have, potential leadership and management roles, training responsibilities, and also where in the country you may want to work – there are plenty of job opportunities available for all!



Photo of Dr Clarke kindly provided by himself.

**Overall experience**

As this is a highly oversubscribed event, I recommend applying as soon as possible, but if you do not have the chance to attend, the Royal College of Pathologists website showcases plenty of free resources open to students, including webinars. It is also well worth approaching your local microbiology, haematology histology or immunology department for some hands-on experience too.

Whether you are already set on reading forensic pathology or scared of a histology textbook, I would highly recommend this summer school to any medical or biomedical student who has an open mind to pathology; you will not regret it!

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**Eva Ruiz-Daum**

My name is Eva and I am a fifth-year medical student at the University of Exeter. I have loved spending these past few months meeting with scientists and consultants with incredible insights into the world of health from their research and career paths. Although I am open minded to all specialities, I am especially passionate about internal medicine. My hobbies outside of medicine include drawing, classical guitar, learning languages and swimming.



## Learn 2 Innovate in-person event – April 2024

### Eunice Pak

Year 5, Medicine and Learn 2 Innovate cohort 3 student innovator, Cardiff University

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What does it take to innovate? We are here to tell you that it does not take a Steve Jobs or Mark Zuckerberg to make an impact....

The Learn 2 Innovate 2023–24 Programme is a cross-university collaborative event where students of healthcare, business and technology-related courses from the GW4 universities – Bristol, Cardiff, Exeter, Plymouth – get together to attend a series of virtual workshops on key themes of innovation, led by leaders in the field. These themes span from introduction to innovation: ideation, creation and business strategies through to patents, protection and pitch deck gruellings. A personal favourite of mine was a workshop on Innovation in Surgery from Mr Asit Arora and Mr Saahil Mehta discussing their innovative business practices in robotic surgery and breast surgery, respectively.



### Learn2Innovate Cohort 3 finally getting to gather in person for the first time since workshop 1 began in December 2023

After a series of eight virtual workshops from December 2023, on the 26 April 2024, the cohort got together in the sbarc|spark building in Cardiff University for a much looked-forward in-person highlight of the year. Seven groups of 27 like-minded student innovators got together after a few months of hard work, dedication and inspiration, to witness their efforts come into fruition by showcasing their unique ideas to the rest of the cohort in the form of a pitch deck competition. All eyes on the prize: £1000 funding to transform their idea into reality – only if the panel of judges are impressed!

### Welcome talks and judging

Before the pitches, student innovators were welcomed with coffee and welsh cakes, and a morning of inspirational talks from innovators in health. Dr Alexander Coombs and Connor Wood, Programme Director and Lead, respectively, opened the event by showcasing the student innovators Learn 2 Innovate Journey with highlights of all the workshops completed. The first two talks delivered by Professor Ian Weeks and Professor Rachel Errington captured the imagination of the audience through the impact one can have on healthcare through research and innovation. Professor Ian Weeks provided insight into his research into the replacement of radioactive isotopes using chemiluminescent (light-emitting) molecules. An idea that eventually became the basis for a spin-out company, with its technology now being used worldwide. Professor Rachel Errington discussed how research into Mr Kipling cakes led to developing novel

fluorescent probes and tools for cell-based assays. Similarly, Rachel created a spin out company from her discoveries called Biostatus, a company where she holds the role of Director. The last two talks were from clinical innovators. Dr Fiona Brennan, a consultant anaesthetist and intrapreneur, discussed the importance of planetary health and her role in reducing waste in the operating room. Lastly, Dr Dafydd Loughran, Concentric CEO and entrepreneur, delivered a captivating heartfelt talk on his innovation journey including the difficulties of not fitting the stereotypical CEO/Co-Founder mold that is assumed in media.



### Judging panel consisting of Maxine, Rachel and Barbara listening to an afternoon of well-delivered pitches

The panel of judges consisted of Maxine Birmingham, CEO of thinkingaroundcorners, Professor Rachel Errington, interim head of the Cardiff University School of Medicine, and Barbara Coles, project manager of Clinical Innovation Hub Manager at Cardiff University. Teams were judged on the following domains: 1. Market Validation: the problem and its size; 2. Product Proposition and Design; 3. Business Model: how would revenue be created, 4. Traction: whether expertise in the field have responded to the needs and appeal of the product; 5. Team: what makes your team suitable and how so over others; 6. Presentation in the pitch deck; and last but not least 7. Prototype: whether the prototype can be classified as a minimal viable product (MVP). The panel of judges, apart from having to listen intently to the pitches, had to challenge the groups by posing stimulating questions at the end – not an easy feat from the other end of the table!

### Pitch decks



The series of pitch deck presentations kicked off with the DSA team trying to tackle an emerging healthcare burden that is costing the NHS an estimated £70 million per year, contributing to doctors' burnout-discharge summaries. The group aimed to create the Discharge Summary Assistant - an automation tool that uses Large Language Models (LLM) to generate text-based discharge summaries in a mere 60 seconds; there is also a visual timeline feature which represents the patient's hospital journey and important touchpoints.

**Interview with Macca,  
CEO of Discharge Summary Assistant**

**What did you enjoy most from the programme?**

*It has been an incredible experience – I enjoyed the programme and it enhanced my expertise in technology and applying it to real life scenarios.*

*Our weekly meetings were charismatic, I loved building the incredible piece of software and the MVP, and I am looking forward to, as a team, taking it to a next level.*

**Which was your favourite online workshop from the programme?**

*I enjoyed the last event (Leadership and Entrepreneurship) where a founder (Sina Yamani, an entrepreneur in the FinTech space founding Yoello) came in to talk about his experience, it was inspirational and motivational.*

The third group was Bolytica, which aimed to minimise errors and improve efficiency in radiological imaging system by creating a multi-model AI approach that enabled image analysis of radiographic scans and detailed written reports to be generated, guiding clinicians on their decision-making process.



**Interview with Rajib from team Bolytica**

**Did the programme make you more motivated to become a medical innovator in the future?**

*It was a good and exciting programme which helped to supplement my medical studies and enabled me to see what flaws there are existing within the medical system. It was also very inspirational to hear about other people's journeys in healthcare innovation.*



Synapse is an idea pitched by the second group of student innovators. They believed that current systems are not sufficient and convenient enough to link up students with professors and other stakeholders within universities and research communities. They aimed to create a centralised platform which uses algorithms to bring everything into a single "synapse" network, creating cross-institutional collaborations. Synapse aims to facilitate students thorough an automated workspace setup, for example to match their dissertation or research work targets to potential supervising academics.

**Interview with Synapse**

**How did you come about this idea to begin with?**

*It started off as an idea whilst working with consultants and other student groups in Bristol – we found that there was no easy access to other student groups, clinicians, industry and company members when we wanted to approach them, so we wanted to set up a dialogue and bridge the gap for everyone in the industry through Synapse, by creating a cross disciplinary collaboration.*



**Interview with Veronica from team  
Postnatal Readmission Tool**

**Say someone presents with risk factors, how long would it take the system to identify it and how soon after will she be called to visit the doctor?**

*We haven't done any testing and we don't have the details about how long it will take to identify anyone with a complication, however, women will be able to add their pain scores and track their symptoms, and clinicians will be able to monitor it before each visit once the baby is born. This will help to support clinician's judgement on what is the best course of action.*

The Ockenden Report highlighted that maternity services in some areas of the country have been treated as a Cinderella service for years, and maternal deaths can be as high as 52% from 1–41 days post birth. Traditionally, those of black ethnic origin, younger or older

age groups and women living in deprivation are at higher risk of being admitted postnatally. That is what the Postnatal Readmission Tool hopes to tackle – it hopes to assess risks and identify mothers who are at higher risk of developing complications post birth and following discharge. It provides a risk assessment and symptoms tracker tool to identify a woman’s risk factors of readmission post-discharge. Clinicians will use this information to help with decision-making on the best course of action before each mother’s visit in the post-natal period (eg wait, observe, admit, act on certain symptoms). Community midwives can also monitor the interface and identify those at risk early, so things can be actioned quickly.

Ever wondered how diabetics count their calories? You would have thought there would be a more tech savvy way of doing so in the 21st century than literally adding up calories from food labels – here is how Diabecon comes to the rescue! Invented by a healthcare professional whose girlfriend is a type 1 diabetic, Diabecon helps to accurately carbs count. Working like a weigh scale, it syncs with its unique mobile app through closed loop voice systems. You simply have to tell the device what food is placed on, and it will do its job by weighing how heavy it is and calculating the amount of carbohydrate it consists. This saves patients time and effort to carb count every single meal of the day, preventing from burnout, and more importantly, complications like hypoglycaemia and diabetic ketoacidosis.



**Interview with Joe from team Diabecon**

**What did you find most helpful from the programme?**

*It was good working with people from different courses and unis, as well as with our mentor as she was very helpful and gave very good advice about the MVP.*

**Type 1 diabetics are usually quite young, how do you ensure that children can handle the device, under supervision from their parents?**

*Our device is very user friendly and uses a closed loop system syncing with their mobile phones, only simple language is required to communicate with the device.*



Bring in another discharge summary assistant! Perhaps this highly unmet need in the healthcare environment which is causing disruption through discharge delays is recognised widely - that’s why Summit hopes to come to the market. Summit is another discharge summary automation tool that helps alleviate clinicians’ time in handling administrative tasks, allowing them more time to conduct clinical diagnoses and patient interactions. Summit also provides text translations into different languages, and has a separate report generated to the GP, bridging the communication gap between primary and secondary healthcare.

**Interview with Harris from team Summit**

**How do you see the market of discharge summary automation in the future? It seems to be a buzzing theme at the moment as an easy-win solution to help clinicians, save time and costs.**

*Yes, it is definitely a big market with good potential. The fact that there are 2 groups undertaking the same project highlights the need for it to be addressed as a matter of urgency.*

Ever encountered a time where you have unfortunately missed your long-scheduled hospital clinic because of clashes with other commitments? DNAs (Did Not Attends) are a costly problem in the NHS; an estimated £290 million of NHS funds has been wasted due to people not attending their appointment slots. Health Sync aims to tackle this issue by bridging the communication barrier between GPs and hospital doctors by creating a platform where, for example, a patient requires to be referred for radiology scans in the hospital; during the GP appointment, the patient can state when he is free for an appointment, the radiologist on hospital site can then use the same platform to accept or decline, and at the same time, view health records and assessment reports from GP. This way, the transparency and efficiency of information provision between the two parties are greatly improved and can hopefully act to minimise the costly DNAs.



**Interview with Saaketh from team Health Sync**

**Do you think that Do Not Attends are a neglected issue in the NHS, and are you aware of any current systems put in place to tackle the underlying causes?**

*We believe that DNAs are a significant issue within the NHS. They not only contribute to delays in care but also wasted resources and increased costs. We identified several reasons including transportation difficulties, patients having other priorities, and a lack of understanding of the inefficiencies created by missing appointments. Current systems in place to mitigate the issues include SMS or email reminders introduced by certain trusts to alert patients of upcoming appointments. Some clinics are also implementing more flexible booking systems that improve accessibility and give patients more freedom. However, further steps might be required to fully address the many causes of DNAs.*

## Awards and closing

After an enlightening afternoon, student innovators were given a short comfort break to mingle and socialise with their like-minded peers, whilst awaiting the judges to make difficult decisions...

As someone who has been part of this student innovation journey, it definitely feels surreal to see our efforts pay off after the afternoon's intense pitch presentations. I would like to take this opportunity to congratulate all groups for their enthusiasm and for their hard work to come into fruition. I have no doubt that regardless of who wins, it has been a rewarding journey for all, and for some, it is just the starting point for something bigger and better in the near future.

It took the judges a while to come to decide, however, it seems that the two groups pitching for discharge summaries have swayed their hearts unanimously, persuading them to believe in the impact of bringing this issue to the table and the public's eye. It came down to the presentation style for which the Discharge Summary Assistant surmounted over Summit – lending themselves to be entitled “Winners” and “Runner-ups” of Cohort 3 of Learn 2 Innovate, respectively. Special mention was also given to the “Postnatal Readmission Tool”. The winning team would be given a generous funding of £1000 to bring their idea to reality, and an opportunity to pitch their project to the next level of panelists at the Cardiff University Clinical Innovation Hub.

coming to an end, but in fact it is only the beginning for us, and more importantly, for YOU, budding innovators of the future.

*Photos credit: Ieuan Miles*

*Thanks also to Alexander Coombs*

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**All smiles for the two teams pitching on discharge summaries – the Discharge Summary Assistant was awarded First Prize and Summit closely came second**

So, what does it take to innovate? As a proud member of the winning team, I would say a key spice to the recipe of success is, if anything, do not limit yourself to a box with four sides. Being able to think out of the box, being observant and receptive to little things in life would be a great start for those who would like to follow our journey. Formulating opinion of what you think require improvement in the environment around you, and brainstorming how these can be done – bit by bit, efforts will accumulate and be sufficient to last an impact of a lifetime. Our time in Learn 2 Innovate 2023–24 might be

# Connie Hardwick, Academic Clinical Fellow at the University of Bristol

## Deepa Sharda

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**"It's nice to do the zigzag: a pathway into dental specialty training"**

***Going into dental specialty training can seem overwhelming; hence I met up with Miss Connie Hardwick (BDS), who shared her route with me. The aim of sharing Connie's journey is to reassure those of you considering specialty training, that there is not just one pathway into your chosen dental specialty, you do not have to decide what you want to do with your career straight after Dental Foundation Training (DFT); it is a journey to be enjoyed.***

**As a DFT, you've had such little experience in the world of dentistry. Do we need to be making big decisions of specialty training and applying to DCT so early on or, could that place be reserved for somebody that has maybe been a General Dental Practitioner (GDP) for x number of years and understanding what we love? Therefore, what was your inspiration for applying for Dental Core Training (DCT)?**

"We worked in a hospital when we were students, and I really enjoyed that team element, but I also really enjoyed working in practise. So, I thought I'm going to apply for DCT and see what happens. I enjoyed paediatric dentistry; Bristol had a position, and I thought if I get this role, I will go for it. Even if I want to go back to practise, I'm not going to lose the skills but develop new ones. I'm still doing dentistry and I'm in a place I really enjoy."

**As a fifth-year dental student, I have often heard: "If you are thinking of specialising, make sure you get involved with**

**extracurricular at university, do your MFDS (Member of the Faculty of Dental Surgery) as soon as possible, apply for DCT straight after DFT etc." However, DCT is intense, it is competitive, you might not have figured out what you truly enjoy at this stage and who knows what all this stuff really means so early in your dentistry career?**

"Starting the Bristol DCT job was a massive eye opener because I was with people who knew what they wanted to do. I didn't yet know. I just thought I'll explore options, and it was a bit of an eye opener because some people had completed exams, started writing publications, completed audits and presentations. This was a real opportunity for me to develop my CV and how can I improve if I decide the hospital pathway or the practice route."

**How did you decide to go onto DCT2?**

"My biggest tip is, don't ever say no to an opportunity, always explore every avenue. I'm one of those people that would rather apply for something and not get it, than close the door on an opportunity."

"I really enjoyed DCT1, more than I anticipated so the natural step was applying for DCT2, I also knew how the process worked and was in the hospital mindset. I still hadn't closed off the idea of going into practise again. DCT 2 in oral and maxillofacial surgery (OMFS) was really enjoyable, but it was hard in a different sense. You are working in a medical world as a dentist. Working in Accident and Emergency (A&E), working long night shifts, working 36 plus hours on a weekend with potentially no stops, and working in A&E where patients come in with the police or have been in nasty road traffic incidents. This role created a huge development in me personally. It sounds very cliched if I had not done my OMFS year, I would not be the person I am now. I think it gives you such good training and good grounding."

"If you had asked me as I started my DFT, there's absolutely no way I would have thought I would have been embarking on that route."

**A concern from myself and other students is how do I stand out on my CV? How do I get into research?**

"I was never particularly academic at university, I worked really hard to pass my exams, but I was never top of the year. I didn't get involved with research outside of the timetable. [During DCT1] I had some interesting cases and I was able to do a poster presentation at an international conference; it was at this point I realised there are different elements to dentistry: you can travel and meet other clinicians and learn from international colleagues. I later joined the paediatric specialty trainee research group called CONNECT after attending a talk at the national paediatric conference. Opportunities came out of it, I became involved in doing a national research project and completed qualitative interviews. The group has members interested in research, some completing PhDs, others doing MSc and other members involved in teaching. Everyone learns from each other and attends courses. It is a fantastic opportunity. Now I am combining my clinical career in paediatric dentistry and an academic

career, and I couldn't be happier. This however would not have been possible without support and guidance from my academic and educational supervisors".

**This summary of Connie's dental career to date wasn't as smooth as it sounds, sometimes you have knockbacks.** "It is demoralising when you think you're working really hard and you're ticking all the boxes but maybe not progressing as fast as you would like. However, keep going, keep taking opportunities that interest you and your career will develop."

**From Connie's perspective, here are the advantages and disadvantages to taking the longer/specialty route:**

## Advantages

- You are pushed out of your comfort zone
- Endless learning
- Meet lots of different people
- Acquire new skills
- Research projects
- Become a well-rounded clinician
- Opportunities

## Disadvantages

- It takes time
- Have to re-apply for DCT every year and then for specialty roles and academic roles
- May have to relocate
- Hospital jobs take longer to 'lay down roots'

## Conclusion

**I would like to reiterate that these events have taken place over a course of seven years. Connie is now one year into specialty training as an Academic Clinical Fellow in Paediatric Dentistry which will be three to five years of clinical training, plus time completing her academic pursuits. Within this, she plans to pursue an NIHR doctoral research fellowship. Many of us dentists are perfectionists, we like to plan, however, Connie is a great example to emphasise that your career is not a linear path. She did not plan any of this and by taking opportunities, it happened organically. Unfortunately, the fear of failure can prevent us from taking these leaps of faith. Hence, a key piece of advice from Connie is to "never turn down an opportunity".**

"If you imagine the London Underground map, it's all massively interlinked and you can take a little diversion" but "the most important thing is enjoying the journey, It's nice to do the zigzag."

**Hence the theme of this article: it's NOT a straightforward path, it's a "zig zag", do whatever best suits you, take opportunities and see where the journey takes you.**

*Photo kindly provided by Connie Hardwick*

## Dr Roger Highfield, Science Director, Science Museum, London

Eunice Pak

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On 12 June 2024, I was fortunate enough to meet Dr Roger Highfield, Science Director of the Science Museum in London, for an in-person interview regarding his early career in research and later moving on to science journalism and authorship. He has a rich experience with promotional engagement activities as the Science Director of the Science Museum, and also has written 10 popular books in recent years. With his rich wealth of knowledge and experience in the scientific academia field, I thought he would be the best person to pass on his words of wisdom and advice to prospective students who might be interested in venturing into this career field. I first met Roger in the New Scientist Live event 2023 held in Excel, London where he was conducting a talk on the concept of digital twins and its application in the medical research field, based on his new book, *Virtual You*. I found this concept extremely enlightening and innovative, and so I thought I would explore it and open your eyes to this exciting new concept through this interview.

**Can you briefly introduce yourself and your scientific background – including your education in university and careers thereafter – can you share some experience about your education and work, and perhaps some anecdotes?**

I undertook my doctorate in Chemistry at Oxford, where I conducted experiments on bouncing neutrons off soap bubbles. A lot of my downtime in university was spent undertaking student journalism posts. Upon the end of my doctorate, there were not that many jobs out there in science, due to Margaret Thatcher's government reducing funding for scientific research during the early 1980s. As part

of her broader economic policies, which focused on reducing public spending and promoting free-market reforms, there were cuts to various areas of government funding. There were few opportunities available in academia. As I enjoyed getting involved with student journalism in university, I was encouraged by my supervisor at university to apply for a journalistic career, and I started out working for Pulse and freelancing for the *Economist* and the *Guardian*.

An interesting story to share occurred on 28 April 1986. I was working for the journal *Nuclear Engineering International* and visiting a nuclear power plant in Forsmark, in Sweden, just before the Swedes were to open a new nuclear repository under the sea. All of a sudden, the plant's radiation alarms went off – they all thought there was a leak on site – and we were confined in the canteen. However, following analysis of the radionuclides, it was found that the source was likely a Soviet graphite moderated nuclear reactor, the RMBK 1000.

The Swedish pressured the Soviet Union to provide an explanation. Under this pressure, the Soviet state news agency TASS issued a brief statement acknowledging an accident at Chernobyl, but it downplayed the severity. Sweden demanded for more transparency from the Soviet Union, which was echoed by other European nations. It was not until later that the true extent of the Chernobyl disaster was officially declared to have occurred at the Chernobyl Nuclear Power Plant in Ukraine, publicly acknowledged by the Soviet Union, and full details of the event and leakage were finally revealed. This happened to be the same time when the *Telegraph* was looking for a new science and technology correspondent – I, as the first British journalist to witness the Chernobyl disaster, was invited to take on the new position and I started in September 1986. I worked for the *Telegraph* on Fleet Street, which was then well known for its exhaustive news coverage, before moving later to Canary Wharf and then Victoria, for a total of 22 years. My work as a journalist was diverse, ranging from science news and features, to editing special supplements and the science page, organising science writing and photography competitions, parties, mass engagement experiments and more. I later became the editor of the *New Scientist* journal, having worked there from 2008–2011. Following then, since December 2011, I have been working in the Science Museum here in London where I was first appointed as the Director of External Affairs where I was in charge of Press and Marketing before becoming the Science Director, which is my current position. I hold responsibility across a group of four additional museums under the Science Museum Group apart from the Science Museum London, including the Science and Industry Museum in Manchester; the National Railway Museum in York; the Locomotion railway museum in Durham; and the National Science and Media Museum, Bradford. I help colleagues develop exhibitions, galleries and events, making sure the scientific content is both suitable for a target audience and accurate too. The aim is to explain things to a very broad audience group which range in age, academic backgrounds, and life experiences. For example, we had to explain Stephen Hawking's work on black holes – and his discovery that they glow – in simple terms in an animation aimed at museum visitors, which range from families with young children to adults.

**What are your special interests in science? Out of all the written works you've produced, what aspects excite you most, can you name a few?**



I'm into many aspects of science, ranging from cosmology and the Apollo Moon programme to gene therapy. One of my favourite topics is reproductive medicine, as there is so much to offer on that field – apart from the hot topics of cloning and IVF, there are multiple spin-out technologies, involving mitochondrial donation, cloning, pre-implantation genetic diagnosis, stem cell research etc. And with so many people now benefitting from IVF technology – about 10 million people on the planet – it has so much potential for the future. I wrote two books on that area – *The Dance of Life and After Dolly*. My other books *The Science of Harry Potter* and *The Physics of Christmas* explore the exciting quirky aspects of science that most people don't know about. I am a science generalist but particularly like subjects that are quirky or with mysterious twists and turns!

**The books that you have written seem very interesting – can you tell us a bit more about these and perhaps some interesting facts from these books which people might not know about? (For your reference, these books are: *The Private Lives of Albert Einstein*, *Can Reindeer Fly?* *The Science of Christmas*, *The Science of Harry Potter: How Magic Really Works*, *After Dolly: The Uses and Misuses of Human Cloning* – very interesting titles!)**

The book about Albert Einstein, *The Private Lives of Albert Einstein*, was the first Einstein biography that incorporated letters from his younger years, which painted an image of Einstein as a handsome, funny and charismatic figure in his 20s–30s. The Einstein Papers Project was a key information source. We also conducted interviews, not least with Evelyn Einstein, Albert Einstein's granddaughter, who gave us access to the love letters that Einstein wrote to Mileva Marić, his ex-wife.

**Gasps: Wow, that's so cool.**

I was amazed by the number of scientists – a hundred something – who were happy to help me with the my book *The Science of Harry Potter: How Magic Really Works*. It got really popular and was published in lots of foreign editions, featured in several literature festivals/Festival of Ideas. The first half of book discusses on some magical 'muggle' topics, such as how to make an invisibility cloak, how does flu powder work, how do potions work. The second half of the book explains magic in a rational and scientific way – it is about the human brain, superstition and how the brain can mislead us via visual illusions, and why things appear to be magical to us.

**How do you actually make an invisibility cloak then?**

Today, you can probably use metamaterials to make an invisibility cloak; metamaterials are artificially engineered materials with unique structures that can control electromagnetic waves. You can create an invisibility cloak by manipulating light, making it flow around an object – in theory at least!

Another interesting story to share involves my encounter with Dolly the sheep. She was a big character and my impressions of her was that she was a prima donna diva. She eventually passed away by catching an infection that triggered lung tumours, which was commonplace for sheep. There were also discussions about if the cloning process had caused her to die young but I am not convinced by this.

**I saw that you are a fellow of the Academy of Medical Sciences (FMedSci), and a member of the UKRI- Medical Research Council. What area of medical sciences are you most involved in?**

I have not got a medical background but am on the council of the Medical Research Council (MRC). As a kind of 'trustee' of the organisation, I take part in meetings four times a year to discuss big issues. As the medical council is spending £800–900 million pounds on medical research, it is important that the public understands how their tax money is being spent (eg on COVID research). We discuss all kinds of issues, from the way research is managed to key research areas to ethics and how to present and communicate research in a way that is relevant to the public, even involving the public in setting the research agenda.



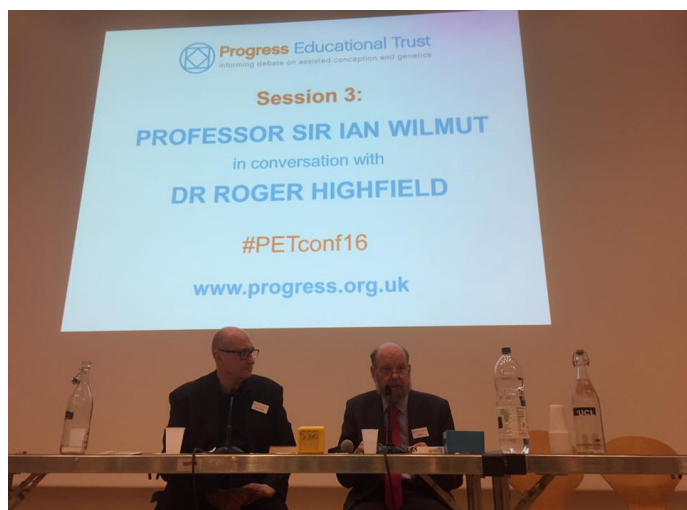
**About your recent book *Virtual You* (which I got a signed copy of) can you share with us and readers about the digital twin concept and how the idea first came about?**

Glad to hear you have a copy of *Virtual You*, which is the third book I have coauthored with Peter Coveney of UCL! In a hand-waving way, *Virtual You* follows on from themes we explored in our two previous books, from the power of theory to complexity and computer simulation. This time, however, we focus on Peter's research and how to fix the shortcomings of the current 'one size fits all medicine', which is based on past data gathered on people of different genetic makeups and in different circumstances to you, so it often does not work and sometimes produces harmful side effects. That is if it works at all, of course. Look at the years and billions wasted on drug development. Moreover, those who are biologically female, or from minority ethnic groups, have been relatively neglected by medical research over past decades so that, if you train an AI on current medical data, for example, it will be biased in favour of white, male medicine. Unlike AI trained on population data, digital twins offer the prospect of truly personalised medicine.

Just as a weather model that runs in a powerful computer can produce forecasts of flood, droughts and storms, so these digital twins can produce 'healthcasts' of how the body will respond to a disease or a treatment, whether drug, implant or surgery. The amount of data and the sophistication of the model depends on whether you are modelling the whole body, an organ or a molecular subsystem, and what questions you ask of it: to use an analogy, if you goal is to navigate around London then a high-resolution satellite image of the city is helpful but nowhere near as practical as a simple tube map. Digital twins are special examples of computer models which



are updated in real time with data from the body – the constant interaction between the virtual and real you produce a virtuous circle in which the model is honed by reality to produce ever better healthcasts and so on.



We list many examples in *Virtual You* where simulations are already producing reliable forecasts of biological reality. We cover a vast number of computer models and digital twins, from simulating bacteria and cancers to screening heart drugs and planning epilepsy surgery. *Virtual You* simulations are based on actual understandings of human biology, unlike AI, which blindly seeks correlations. That is good news in two ways: if your model predicts how a heart beats in novel circumstances, then you know it works, and how. If its predictions are wrong, then you know you need new chemistry and physics, and a model, supported by experiments, is the best way to explore these possibilities. Perhaps the easiest way to express how much progress has been made is to say that regulators, such as the FDA, now accept simulations, and a plethora of commercial companies are working in this domain. This effort is now shifting out of the laboratory into the company and clinic.

As one dramatic example, accurate digital twins of the human heart already exist – bioengineer Dr Jazmín Aguado Sierra of the Barcelona Supercomputing Center created a twin of her own heart, based on the Alya Red heart model and her own data, which is now beating in the Science Museum, London. (more here: <https://www.sciencemuseum.org.uk/about-us/press-office/first-engineer-model-their-own-heart-reveals-simulation-science-museum>). And there are already companies that offer digital twin technology, such as Twinomics (acute myeloid leukaemia) and ELEMBio, along with others that use this approach in medical device design and implementation, such as ANSYS and Dassault Systèmes.

**What do you think is the biggest medical breakthrough/innovation in this era of Artificial Intelligence and Big Data?**

We see Big Data and AI as complementing digital twin efforts and of all the AI out there, I am most impressed by AlphaFold, which has the ability to predict protein structures, and was not surprised it earned a Nobel Prize. This could prove important to biology and medicine, from developing vaccines and drugs to diagnostics. Many other challenges, like finding ways to break down industrial waste, are also tied to understanding proteins, notably enzymes, which are proteins that can accelerate chemical reactions. However, Peter Coveney and I are concerned that AI should be made more scientific (and we have just written an editorial for a journal about this) and that people do not see a blend of AI and Big Data as a replacement for theory and understanding, the subject of another piece we wrote together.

**What does the “One Health” concept mean to you?**

It is not a term I use very much, I must confess, though I do appreciate the importance of integrating knowledge about individuals with that

about the environment. Here, I am sure digital twin research can help. As a practical first step, however, I do think we need to join up the parallel UN COP (Conference of the Parties) processes to avert dangerous climate change and ecosystem destruction: ecosystem collapse and climate change are two sides of the same coin.

**What are some of the key skills you’d like to share for students aspiring to go into academia- what can they do during their time at university to enhance their skill set?**

Just remember that university is much more than a course and a degree. You make friends for life as a student and you can try all sorts of other things, from amateur dramatics to sport, music and more. When I comes to my own experience, I studied chemistry but ended up in journalism because of my experiences on student radio and on the university paper. Bottom line: being a student is not just about enhancing your skill set – it is also about having fun with a view to seeing if a passion could turn into something more serious!



**Can you share some tips about scientific journal editorial work mainly for students with scientific or medical background who would like to pursue such roles? Will it be difficult to balance time if you’re not a full-time editor – especially those who need to balance clinical work?**

Communicating clearly is a really useful skill for lots of professions – if you can’t write clearly, you’re not thinking clearly, as Bill Bryson once told me. And it makes your life a lot easier when it comes to winning grants, impressing your peers or wowing VIP visitors and ministers. Try to get some experience at university doing student radio, blogs, podcasts, videos, magazines or whatever, so you can demonstrate some real interest in editorial work. Ditto work experience and attachments. When I was the Science Editor of the *Daily Telegraph*, I would get a lot of job applications for correspondent jobs I advertised but found that, when I excluded all the people with no experience of any kind, the longlist shrank by more than 90 per cent. Rolling up your sleeves and having a go at editorial work sends out a strong message that you are keen. And, of course, you learn a huge amount along the way.

*Photos kindly provided by Roger Highfield*

## From dentistry to medical entrepreneurship: Dr Periwinkle Kaur, Director of ESU Medical Solutions

### Dilshan Jayakody

Year 5, Medicine, University of Plymouth

Email: jayakody.a.jayakody-3@students.plymouth.ac.uk



"Hi everyone! I'm Periwinkle Kaur, you can call me Peri. Dentist by profession, I now lead ESU Medical Solutions, a company specialising in medical and veterinary equipment and surgical supplies.

"If I am not in my office, you can find me playing lawn tennis or exploring some great locations and countryside farms. We're fortunate to be in the beautiful Southwest, and I enjoy long drives through Devon and Somerset, visiting charming local villages, sampling fresh produce, and of course appreciating the local cider!

"I am the Co-founder and Director of ESU Medical; we are based in Taunton, Somerset and have successfully achieved global reach.

"My company is dedicated to serving private hospitals, veterinary practices and universities across Somerset and the rest of the UK and the world including six continents. We pride ourselves on being an independent company that offers an 'all-in-one' solution for hospitals, clinics and independent practices, no matter the make or model of the surgical devices."

**What inspired you to transition from a practising dentist to leading a business that supplies surgical equipment and hospital materials?**

"During my journey through dental school in India, I developed a deep fascination with the technology and functionality of medical and surgical equipment, alongside my studies in dental and medical subjects. While I initially pursued dentistry, this interest, along with

my interest in healthcare management, persisted and grew stronger over time. What ultimately inspired me to transition from practising dentistry to leading a business that supplies surgical equipment and hospital supplies was my passion for making a meaningful impact in healthcare. I saw an opportunity to enhance the tools and equipment that healthcare professionals depend on daily, aiming to elevate the standard of care. The challenge of running a business and the opportunity to innovate within the industry were irresistibly exciting to me."

**Can you share some key challenges and opportunities you faced during this career shift?**

"Transitioning from dentistry to leading a business in medical devices and surgical equipment presented several challenges and opportunities. Key challenges included adapting to a new industry with different regulatory requirements and learning curves in marketing, product development, and supply chain management. However, these challenges also brought opportunities to innovate and improve existing practices, in terms of product range and supply chain. An opportunity I still very much enjoy is building relationships with suppliers and healthcare professionals, which continues to provide invaluable insights and collaborations that fuel our growth and impact as a business!"

**Skills and knowledge:**

**How did your background in dentistry prepare you for the business side of medical supplies?**

"My background in dentistry provided a strong foundation for transitioning to the business side of medical supplies. As a dentist, I developed a keen eye for detail, precision and quality—traits that are crucial when evaluating medical and surgical equipment. My clinical experience gave me a deep understanding of the practical needs and challenges faced by healthcare professionals, enabling me to search for, select and help develop products that truly meet their demands. Dentistry honed my skills in patient communication, time management and other transferrable skills, all of which have been invaluable in managing and growing the business."

**What additional skills did you have to develop to succeed in this new role?**

"A key step I took towards achieving my goals was pursuing a Master's degree at the University of Northampton and likewise doing market research. I learned about consumer behaviour, supply chain management and key industry stakeholders, which I later implemented specifically in the healthcare industry. These skills have been crucial in navigating the complexities of this new role and driving the company's success. I also completed CMI (Chartered Management Institute) accreditation to assure my outgoing skills are polished well."

## Business insights:

### What are some current trends in the medical and veterinary equipment supply industry that you find particularly exciting or concerning?

"One exciting trend in the medical and veterinary equipment supply industry is the rise of telemedicine and remote monitoring technologies, which are enhancing patient care and accessibility. Additionally, advancements in AI and machine learning are improving diagnostic tools and treatment options. However, a concerning trend is the increasing prevalence of supply chain disruptions, which can affect the timely delivery of essential equipment. I believe that balancing innovation with reliability in supply chains is crucial for the industry's future."

### Can you describe the process of developing and bringing a new product to market?

"Well, this is an area that I wish to pursue further as the business grows. Bringing a new product to market involves several key steps. First, we conduct thorough market research to identify needs and gaps. Next, we work on product design and development. Within the medical industry, key players such as Styrker, Karl Storz, Ethicon and Medtronic predominantly to ensure that their products meet the regulatory standards. I work with R&D teams and the team completes the prototyping and engages in rigorous testing following which we gather feedback from healthcare professionals, our customers. Once refined, we feedback to our suppliers who will then proceed with manufacturing, followed by marketing and distribution – which I personally oversee. Continuous monitoring and support post-launch ensure the product meets expectations and can be improved over time. An example is our very own ESU adapters."

## Business operations and customer relations:

### How do you maintain relationships with veterinary and equine centres, and hospitals globally?

"Maintaining relationships with veterinary and equine centres and hospitals globally involves consistent communication, offering professional development support and fostering partnerships. I keep them engaged with regular updates, workshops and personalised support. Collaborating on research, as well as leveraging technology for telemedicine, strengthens our connections. Participating in industry events and providing customised solutions further enhance these relationships. I enjoy attending conferences and trade shows like FIME in the States, Arab Health in UAE and BVA in the UK. I also prioritise regular feedback and maintain high standards of quality to ensure ongoing improvement and satisfaction. I established a remote consultancy programme as part of the company during the pandemic, which remains active. This programme was designed to enable surgeons to offer immediate solutions wherever possible for elective surgery equipment issues. Additionally, I conduct on-site visits across the UK and EU to provide training, equipment setup and servicing."

### Can you share any anecdotes about how your products have made a significant difference in a clinical setting?

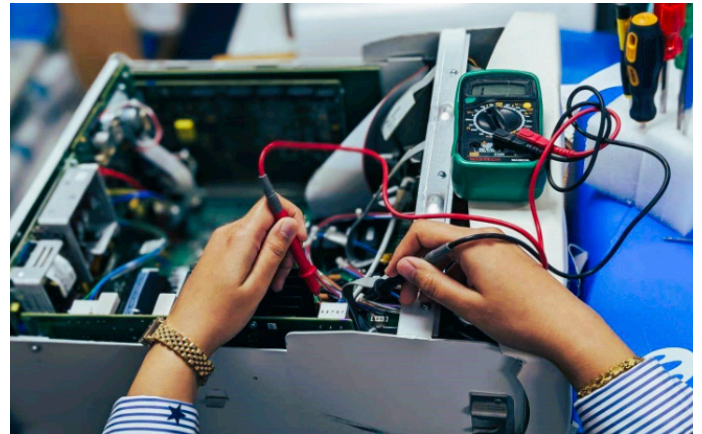


"ESU Medical's efforts/contribution in medical aid to Ukraine: My company has been actively contributing to medical aid efforts in Ukraine by providing surgical supplies, accessories and equipment through a channel network. We ensured movement of goods when none of the logistical companies delivered goods to Ukraine. We streamlined and coordinated donations of medical and surgical items to support frontline healthcare workers and facilities. I, along with one of my colleagues who is from Ukraine, worked indirectly with a team of doctors at district hospital to supply surgical equipment they needed by God's grace and will. Though our efforts are small, they are ongoing, and we hope to improve care for those affected by the crisis."

## Challenges and opportunities/innovation and technology:

### How has the global market for medical supplies changed in the past decade and where do you see it heading?

"Looking ahead, I see the market continuing to evolve with a greater focus on sustainability and eco-friendly products. The integration of artificial intelligence and machine learning into medical devices will likely become more prevalent, enhancing diagnostics and treatment options. Additionally, as the world recovers from recent supply chain disruptions -due to various reasons, there will be a push towards more resilient and localised supply chains to ensure the reliable availability of critical medical supplies."



## Advice for students:

### What advice would you give to students in medical, dental and veterinary fields who are interested in entrepreneurship?

"For students in medical, dental and veterinary fields interested in entrepreneurship, my advice is to first trust themselves and keep faith in the Almighty, following which one should gain a deep understanding of field through hands-on experience. Identify gaps and unmet needs in the industry, and don't be afraid to approach people and discuss ideas which can pave a path to innovation. Continuously educate yourself on business fundamentals, network with industry professionals, and seek mentorship. Embrace challenges as learning opportunities, stay adaptable, and remain passionate about improving patient care through your entrepreneurial endeavours. Lose anything but confidence to do something."

### What skills or experiences should they focus on to prepare for a potential career in the business side of healthcare?

"To excel in healthcare business, students should focus on 'what to do and how to do' without ignoring the emotional intelligence. Clinical experience, curiosity to know about different things alongside the education in healthcare management, finance, marketing and supply chain logistics help one become confident. Attending conferences and trade shows to explore the market establishes strong network and makes one aware of the regulatory compliance. Nevertheless, stay updated on healthcare technology, and hone problem-solving

abilities. This blend of skills will set you up for success. There will always be someone who will not trust your abilities, never let that person be you."

**Future goals:**

**What are your long-term goals for your business and how do you plan to achieve them?**

"My long-term goals are to make a greater impact in the overall healthcare industry which includes medical and veterinary to bridge the gap within this sector that exists in many parts of the world. I envision establishing partnerships with industry leaders and suppliers, and expanding our product range and services for our customers including veterinary industry, which is often deprived of technical support. Nevertheless, I intend to involve professionals and new talent to work on creative projects that could lead to continuous product innovations.

"My aim is to make healthcare more accessible and more affordable for every living by providing innovative products and solutions and through partnership with organisations."

**Would you ever consider returning to dental practise and clinical work?**

"My focus and passion are now fully dedicated to growing and innovating the medical, dental and veterinary industry therefore I will not consider practising dentistry, rather I would like to work closely with dentists and other healthcare professionals. I found my calling in the medical device industry, so I am inclined to enhancing the product range in the sector including dentistry."

**Leadership and management:**

**How would you describe your leadership style and how has it evolved over time?**

"I portray myself as a Transformational Leader as I believe I have emotional intelligence and resourcefulness. I've got a great team behind me, so leadership has been relatively smooth. I naturally tend to follow the collaborative and adaptive leadership style. Initially, I focused on leading by example and providing clear direction as Co-founder. Over time, I've evolved to prioritise empowering my team, fostering open communication and encouraging brainstorming of ideas for growth. This approach has helped build a strong, motivated team and adapt to new challenges effectively."

**Personal insights concluding thoughts/remarks:**

"I personally believe that one should follow his/her passion so every day's work does not feel like a job and one should feel grateful to the Almighty for each new day."

**What do you find most rewarding about your current role compared to practising dentistry?**

"The most rewarding aspect of my current role is the ability to drive broader impact through innovation in medical and veterinary equipment. Unlike practising dentistry, where the impact is often limited to individual patients, my current role allows me to influence and improve the tools and services used by healthcare professionals on a larger scale. Seeing how our solutions enhance patient care and streamline operations across the industry is incredibly fulfilling."

"I'd like to extend a big thank you to the Inspire Student Health Sciences Research Journal for the opportunity to be interviewed. Special thanks to Dilshan for the engaging discussion about my transition from dentistry and my journey with ESU Medical. I hope my experiences are both helpful and inspiring to your readers. Wishing you all the best in your future careers, and I encourage you to explore opportunities beyond traditional fields like medicine, dentistry, or

veterinary science—consider the exciting realm of business! Feel free to reach out if you'd like to know more."

[www.esumedical.co.uk](http://www.esumedical.co.uk)

Photos kindly provided by Dr Kaur.

# Senior Editors, Autumn 2024

## Hajer Al-Shakarchi

*Year 4, Dentistry, Cardiff University*

Hello, I am Hajer going into fourth year of dentistry at Cardiff University! Within dentistry, my interests comprise maxillofacial surgery and cosmetic dentistry. As an inquisitive student with a passion for lifelong learning, I saw INSPIRE as a great opportunity to gain some insight into research and editing. I am eager to learn from other people and to contribute my expertise in editing when reading other students' papers. Outside of dental school, I enjoy going on walks and I also run a social media page to document my journey as a dental student and the progress I make.



## Umaima Arif

*Year 5, Medicine, Cardiff University*

Hi! I am a final year medical student with a heavy passion for research, writing and travel. My current clinical interests include internal medicine and oncology as well as global health and humanitarian medicine. Most recently, I have been interested in the role of immunotherapy and biologic therapy for gynecological cancers, which has been the focus of my recent SSCs and my current elective in Canada. Because research publication and writing has always been a particular passion of mine, I deeply appreciate being part of the editor team for the INSPIRE Student Journal, as it enables me to encourage other students' research interests as well as spread the word regarding new prospects and versatile developments in different fields - something I believe to be the core of one's medical career. Outside of the journal, I try to further my experience through peer-reviewing, leading research in the Refugee Health Society, and teaching for Cardiff Muslim Medics. I hope that further experience will enable me to grow into a well-rounded, conscientious practitioner who is open to learning more about the world and my colleagues' impressive works.



## Victoria Bak

*Year 2, Medicine, University of Exeter*

I am currently a second-year medical student and my interest in research began in my previous degree where I studied Medical Sciences at the University of Exeter. I enjoy learning about a various number of topics including neuroscience, women's health, dermatology and preventative medicine. Being an editor for the INSPIRE journal has reinforced my desire to pursue a medical career in both a clinical and academic setting. Learning how the journal is assembled from behind the scenes as well as reading the written pieces has been interesting. Outside of my studies, I enjoy going to the gym, reading, playing the piano and travelling.



This edition of the journal, shows a broad range of scientific highlights. I hope you find these contributions both insightful, like we have, and appreciate that such research will ultimately underlie how clinical practice will exist in the near and far future. Enjoy the read!

## Dilshan Jayakody

*Year 5, Medicine, University of Plymouth (On to Intercalation - Master's in Cardiovascular Research, King's College London)*

My journey in medicine is driven by my passion for addressing health disparities and inequalities, and I'm deeply involved in several research projects aimed at improving healthcare outcomes for our vulnerable



populations. I am also passionate about quality improvement projects in planetary health and sustainability. My research interests led me to discover INSPIRE, and I feel honoured to be part of a likeminded editorial team.

In the future I aspire to become a surgeon, with interests in trauma surgery and cardiothoracic surgery. In my free time, I love cycling and mountain biking, enjoying the thrill of navigating challenging terrains. I also really enjoy watching sports, whether it is live or down at the pub with friends!

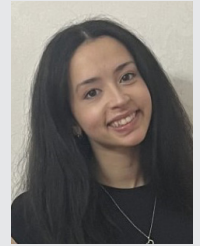
My experience working with INSPIRE has been incredibly enriching. I've gained valuable skills in copy-editing, social media management, and interview/podcast. I've thoroughly enjoyed every aspect of handling submissions from our talented peers across the GW4 and around the world.

I hope readers find as much joy in reading this issue of INSPIRE as we did in creating it!

## Tayha Jupe

*Year 4, Medicine, University of Bristol*

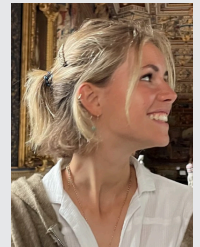
Hello, I am Tayha, a fourth-year medical student at the University of Bristol. During my intercalation, my interest in research grew, leading me to join INSPIRE as an editor. I've thoroughly enjoyed gaining insights into the publication process and understanding the journey a paper undergoes from submission to acceptance. My interests include dermatology, plastic surgery, women's health, microbiology, and pharmacology, making this role a perfect opportunity to explore these fields further. Outside of my studies, I enjoy reading and playing badminton. INSPIRE is an excellent platform for students to engage with research, and I encourage everyone to explore its content. Research is vital to advancing all areas of medicine, especially as we move towards a more sustainable and evidence-based healthcare system.



## Sophie Lawrence

*Year 3, Medicine, University of Plymouth*

Hello, I am Sophie, a third-year medical student at Peninsula. I initially got involved with INSPIRE through the research program, which eventually led me to do a summer project with the same lab. My current research interests include cancer endocrinology and the role of APP in the pathogenesis of Alzheimer's, breast and prostate cancer. I have enjoyed my time as the editor for the INSPIRE journal and have found it fascinating to read the research papers from various universities and explore new and innovative research. Outside of medical school, I love running and anything else outdoors, including walking my three cockapoos.



## Alvin Leung

*Year 4, Medicine, University of Bristol*

Hi! I am a fourth-year medic from the University of Bristol. My main clinical and research interests are dermatology and venereology, and I am also passionate about tackling inequalities in healthcare. It has been a pleasure working as an editor for the INSPIRE Student Journal, perusing through the innovative literature that we have received, as well as delving into topics that are less familiar to me previously. In my spare time I enjoy travelling, strolling in art galleries and a nice cup of coffee.



# Senior Editors, Autumn 2024

## Mafa Mohlala

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*Year 2, Dentistry, University of Plymouth*

I am a second-year dental student at the University of Plymouth. I became engaged with academic research during my previous degree, Medical Pharmacology, in which I was able to contribute to research as part of my dissertation. This curiosity and intrigue did not leave me and when the opportunity arose, I decided to take on the role of editor as part of the INSPIRE student journal. I have thoroughly enjoyed the process of learning about the behind-the-scenes processes of academic writing from submission to acceptance. My current academic interests include oral medicine and maxillofacial surgery. In my spare time I enjoy Muay Thai (Thai kickboxing) and playing football.



## Eunice Pak

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*Year 5, Medicine, Cardiff University*

Hello! I am Eunice, a final year medical student at Cardiff University aspiring to be a clinical academic. Within medicine, I like the fields of internal medicine and children's health. I have previously undertaken research work in clinical pharmacology and paediatrics, having presented in several international conferences. Being an editor for the INSPIRE journal has enabled me to understand the process behind publications, working with an excellent team of editors and reviewers to produce the manuscript in your hands. I also enjoy teaching, opening my eyes to new medical innovations and reading about, or even producing, works on medical humanities- including art, music, literature and history. In my spare time I enjoy hiking, watching tennis, listening to music, singing, playing board games and maintaining my blogs.



## Sasha Scott

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*Year 3, Medicine, University of Exeter*

Hi, I am a third-year medical student at the University of Exeter. I am currently interested in psychiatry and anaesthetics, but hope that my upcoming placement years will provide me with a bit more clarity about which area I would like to specialise in! Outside of medicine, I love to read, dance, draw and get outdoors. I've really enjoyed being an editor for the INSPIRE student journal, as it has been fascinating to see the behind-the-scenes of the publishing process in research. I have loved reading all the work that has been sent in, and hope you enjoy our new issue as much as we have creating it!



## Eva Ruiz-Daum

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*Year 5, BMBS, University of Exeter*

My name is Eva and I am a fifth-year medical student at the University of Exeter. I have loved spending my time as a student journalist meeting with scientists and consultants with incredible insights into the world of health, both from their research and career paths. I was lucky to also begin to develop skills in copy-editing and appraising incoming submissions. Although I am open minded to all specialities I am especially passionate about internal medicine. My hobbies outside of medicine include drawing, classical guitar, learning languages and swimming, and I am hoping to take up surfing during my placement in Cornwall this year.

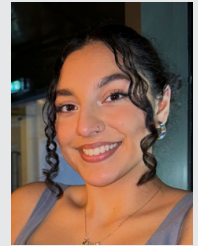


## Deepa Sharda

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*Year 5, Dentistry, University of Bristol*

Hello! My name is Deepa and I am a 5th year dental student at the University of Bristol. Unlike most dental students, I studied A-Level English Literature and have always had a love for writing and the world of academia. Teaching and education is definitely my passion, for 2 years I voluntarily worked with students with English as a second language; I now work with the University of Bristol as a Widening Participation tutor, encouraging students from less advantaged backgrounds to study health sciences/ dentistry. I resonate with these students and hence feel joy in giving back. I love to share my enthusiasm and passion for dentistry with the younger generation and hope to do this through the INSPIRE journal too. I am so grateful to be a part of the INSPIRE scheme, helping to spread fantastic research, educate others and learn many things myself!



# Advisory board, Autumn 2024

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*Cardiff University*

Nell Marquess,  
*University of Exeter*

Mimi Mostefai  
*University of Exeter*

Phoebe Sussmann  
*University of Bristol*

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## List of referees, Autumn 2024

Aisha Elahi,  
*University of Plymouth*

Anoushka Agarwal,  
*University of Bristol*

Eguono Oneyibo,  
*Cardiff University*

Fawn Lavina Hunkins-Beckford,  
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# The INSPIRE scheme is coordinated by the Academy of Medical Sciences and supported by the Wellcome Trust

## University of Bristol



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[www.bristol.ac.uk/vet-school/research/inspire](http://www.bristol.ac.uk/vet-school/research/inspire)  
[www.bristol.ac.uk/dental/courses/undergraduate/inspire](http://www.bristol.ac.uk/dental/courses/undergraduate/inspire)

Bristol Medical School Co-Leads: Dr Anu Goenka, Senior Clinical Lecturer in Paediatric Infectious Diseases and Immunology; Dr Becky Foster, Associate Professor in Microvascular Medicine.  
Bristol Veterinary School Lead: Dr Alex Tasker, Senior Lecturer in One Health Trusted Research Environment  
Bristol Dental School Leads: Dr Mark Gormley, Consultant Senior Lecturer and Mr Alexander Gormley, Clinical Research Fellow



## Cardiff University

[www.cures.cardiff.ac.uk/inspire](http://www.cures.cardiff.ac.uk/inspire)

Cardiff School of Medicine Co-Leads: Dr William Davies, Reader (Basic Science), Dr Emma Tallantyre, Clinical Reader  
Cardiff School of Dentistry Lead: Dr Heather Lundbeck, Clinical Lecturer in Paediatric Dentistry



## University of Exeter

[www.exeter.ac.uk/faculties/hls/studying/catp/doctors/inspire](http://www.exeter.ac.uk/faculties/hls/studying/catp/doctors/inspire)

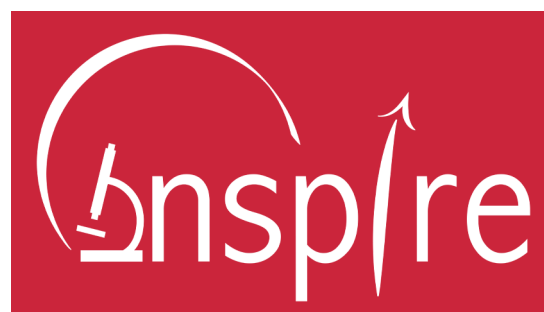
Lead: Dr Jane Smith, Senior Lecturer, Faculty of Health and Life Sciences



## University of Plymouth Peninsula School of Medicine and Dentistry

[www.plymouth.ac.uk/about-us/university-structure/faculties/health/inspire](http://www.plymouth.ac.uk/about-us/university-structure/faculties/health/inspire)

Leads: David Parkinson, Professor of Neuroscience;  
Vehid Salih, Associate Professor in Oral & Dental Health Research,  
Dr Alex Cresswell-Boyes, Lecturer in Oral Sciences



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