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Welcome to the Autumn 2022 issue of the INSPIRE Journal: created by students for students

Hello readers! It is with great pride we bring to you the Autumn 2022 edition of the INSPIRE Student Health Sciences Research Journal (ISHSRJ). We have endeavoured to continue the excellent work previous editors have done with the journal. This issue, like the rest, is written, peer reviewed and edited by students, making this journal a true reflection of student capability in the field of research.

INSPIRE provides a platform for students to experience research first hand, from taster days to funded Summer Studentship Research Projects. The ISHSRJ is a collaborative effort between the Universities of Bristol, Cardiff, Exeter and Plymouth. This issue continues to promote the work students have completed in effort to support INSPIRE's overall aim, to provide students with the opportunity to experience research and consider this in their chosen career path Moreover, the ISHSRJ provides students with the opportunity to experience the publication process first hand, as well as volunteer as a peer reviewer. This is an excellent way to discover new research and projects produced by students, whilst strengthening your CV. We strongly encourage all students reading this journal who feel inspired to engage in research to participate in what the INSPIRE scheme has to offer.

Despite the current economic and environmental uncertainty, the scientific community continues to thrive. The ability for global collaboration within the scientific community has been highlighted during the COVID-19 pandemic and continues to remain strong in the face of new threats, such as the 2022 monkeypox outbreak. We are proud of the INSPIRE Student Journal's role in galvanising the next generation of academic clinicians that will propel our understanding of healthcare and science forward.

We hope you enjoy reading this issue. It has been a pleasure to read the incredible work students have produced. As the new academic year begins, we hope this issue will encourage new and returning students to participate in the journal and the wider research community and ultimately consider research as an important aspect of their future career. We welcome you to email us with new suggestions, comments and feedback at inspirestudentjournal@gmail.com.

Best wishes,

INSPIRE Student Health Sciences Research Journal Senior Editors

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FRONT COVER
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Opinion

COVID-19: should we really be surprised?

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Abstract

The article discusses causes of zoonotic disease such as COVID-19, with an emphasis on deforestation as a cause. Climate change and ecology is of growing importance, especially relating to human and animal health. The growing incidence and variation of zoonotic diseases highlights the need to explore this relationship further to gain understanding of the cause. This paper aims to describe some of the reasons why human health is dependent on successful ecosystems and how disease transmission may increase due to deforestation, as well as providing potential preventative methods.

Abbreviations

COVID-19 - Coronavirus disease
SARS - Severe Acute Respiratory Syndrome
MERS - Middle East Respiratory Syndrome

In December 2019, a new infectious disease spread through the city of Wuhan, China, before quickly spreading around the world, infecting almost every country and causing a worldwide pandemic. The causative agent was found to be Beta coronavirus which is genetically related to SARS-CoV and other bat-borne SARS viruses.[1] Diseases that are transferred from animals to humans are referred to as zoonotic diseases. These types of zoonotic diseases, such as Ebola, SARS and MERS,[2] have been increasing rapidly over the past decade due to human activities[3] which push people closer to animals, thus increasing the risk of contracting such diseases.

Understanding why rates of these diseases have been increasing is vital in order to prevent future outbreaks. A major cause for the SARS-CoV-2 outbreak is increased exposure to wild animals. The virus has a similar structure to that of bat and Malayan pangolin coronaviruses, yet strains sampled from these animals lack polybasic cleavage sites, structural components that enable the SARS-CoV-2 strain[4] to produce illness in humans. This difference in structure may suggest that the strain causing the pandemic stemmed from elsewhere, however, it is more likely that natural selection occurred within animal populations to produce these changes, before the virus was transferred to the human population. This highlights the need to understand the mechanisms of spread of zoonotic diseases and the factors that increase human exposure to wildlife. Alternatively, the virus may have developed genetic changes through transmission between humans after zoonotic transfer. This hypothesis suggests that the initial coronavirus from bats and pangolins may not have produced the disease symptoms, implying exposure to animals will not always produce illness. However, the root of the disease is still of animal origin, highlighting the need to reduce human exposure to animal pathogens.

A major cause of increased exposure to zoonotic disease is deforestation, mainly occurring in tropical climates for land to be used for agriculture, palm oil and timber. Many studies draw strong correlations between forest loss and disease such as Ebola outbreaks in Africa since 1976 and Dengue in South East Asia,[5] suggesting that continuation of deforestation would expose people to new diseases. In fact, 60% of emerging infectious diseases are shown to be zoonotic,[6] which emphasises the danger from forest removal. This link to deforestation could be explained by the 'dilution effect':[7] a higher biodiversity in an ecosystem effectively 'dilutes' the risk of transmission of diseases due to varied susceptibility to infection from a higher number of species. Activities which reduce biodiversity, such as deforestation, increase risk of zoonotic diseases as disease-carrying animals are able to reproduce with less competition, creating a greater likelihood of transmission to the human population. Additionally, there are positive correlations between deforestation and increases in vector-borne diseases, namely, malaria.[8] Deforestation allows accumulation of water and thus new areas for mosquitoes to breed, leading to higher populations and risk for disease to spread thereby threatening millions of people. In combination with increasing temperatures, this could mean mosquitoes may be able to survive and infect people in areas which were cooler prior to climate change.[9] In this way, there is a greater risk of, not only new diseases, but also transmission of current diseases. Hence, it is unsurprising another zoonotic outbreak occurred given the increasing rates of deforestation and increased exposure to wild animals.

It is difficult to identify a direct relationship between deforestation and the COVID-19 outbreak. Wuhan markets displayed a vast range of wildlife, already potentially carrying a multitude of diseases. Animals were kept in non-hygienic conditions,[10] providing zoonotic pathogens room to flourish. This offers an alternative cause for the outbreak: poor control of the species and the conditions in which they were sold. However, in China, the value of bushmeat remains high, giving poachers reason to continue capturing wild species to supply markets. This element of poaching sheds light on the relationship between deforestation and the pandemic. For example, one effect of deforestation is a reduction in habitats, which increases interactions between animals and humans thus giving poachers access to more wildlife and previously inaccessible parts of the landscape.

A suggested approach to tackle problems of zoonotic diseases is to adopt the 'One Health' approach:[11] a concept that relates human health, animal health and the health of the ecosystem. It ensures specialists from multiple disciplines work together at local, national and global levels to achieve the best healthcare outcomes. This can be exemplified by sharing resources between medical and veterinary sectors, therefore enabling greater understanding of zoonotic disease and methods for prevention. Reforestation has been found to reduce the risk of Hantavirus in Brazil[12] and may act as a plausible method to reduce risk from zoonoses in other tropical areas, potentially through the 'dilution' effect.

Overall, it is unsurprising another disease outbreak has taken place. Human activities have pushed people and animals closer together, reduced competition for disease and created an environment that facilitates disease transmission. Accepting that human and animal health depend on a healthy ecosystem, and constructing a framework to ensure the ecosystem is protected, are vital to ensure future risk is minimised. If human activities continue with little consideration for the environment, it can be assumed pandemics will continue to occur, threatening the lives of millions.

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Aisha Elahi

My name is Aisha Elahi, I'm a medical student at Plymouth University. My current research interests include the possible therapeutic effects of different food groups on neurological disorders and the impact planetary changes will have on our health.

Opinion

Disguised eugenics: scrutinising the involvement of Nazi doctors in the "Euthanasia" program

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Abstract

In former times, the eugenics movement had gained a great deal of traction in many parts of the world – especially in Europe – owing to its claim of improving human nature by controlled mating. Propelled by fascist propaganda and misplaced beliefs in eugenical principles, the "Euthanasia" program in Nazi Germany commenced with the intention to eliminate perceived biological threats and preserve the purity of the gene pool. Popular support from doctors had amplified this movement into what is remembered as one of the most devastating crimes against humanity – systematised mass murder. Although we can now acknowledge the reductionistic theory of the movement, without much deliberation, it becomes difficult to stop history from repeating itself. This article aims to explore the power dynamic in Nazi Society – among the leaders, the doctors, and the public – and analyse the consequences of the abuse of medicine as a political tool and as a means for social control.

Introduction

On 1 September 1939, Germany's dictator Adolf Hitler signed a decree authorising certain physicians across the country to grant "merciful death" upon the incurably ill.[1] Stemming from the Nazi party policy of racial hygiene, the so-called "Euthanasia" program (enclosed in quotation marks due to its use as a camouflage term) aimed to prevent the unfit -mentally, physically, behaviourally- from propagating and "corrupting" the Germanic gene pool. The Doctors' Trials, first of a series of thirteen trials conducted in Nuremberg, Germany, after the end of the Second World War explores the records of the defendants: 20 of whom were doctors with charges related to murder.[1] An analysis of the accounts from the Trials shines light on the doctors' part in the tragic "Euthanasia" program, and the convoluted power they possessed in orchestrating social change during the Nazi era.

The eugenic motive

The need to conquer in the Nazi worldview comes from two social pillars – race and space.[2] Its notion that humanity is divided into different racial groups that must compete for survival, is parallel to ideas from Social Darwinism, which lays the foundation for eugenics. Hitler believed in the popularised theory of eugenics, which surmised that controlled selective breeding could improve humanity. This supplemented the unfounded Nazi belief in the existence of an "Aryan" race – the master race destined to rule over all other races.[3,4] With the racial hygiene policy crediting physique, intellect, and ability as hereditary, public health authorities bought into the movement to "euthanise" the "dysgenic" people and preserve the integrity of the nation. The enlistment of physicians as a means to fulfil political agenda eventually catapulted the fascist crusade to its ultimate extreme – mass murder.

In an excerpt from the Nuremberg Trials, a witness accounts that the "Euthanasia" movement began with physicians aiming to ensure

social welfare and racial supremacy by eliminating perceived biological enemies.[1] Questionnaires filled out about psychiatric unit inmates (often schizophrenics and epileptics) were sent to a clandestine jury of psychiatrists, that decided quite arbitrarily who would be murdered.[5] Initially sentencing ill patients to carbon monoxide gas chambers, now experts in medical killing, doctors used techniques like starvation and deadly drug administration. With doctors and the government reigning over the future gene pool of the population, what started as riddance of disabled people, transpired into doctors actively exterminating Jews, Gypsies, and other minorities.[5] By 1945, over 275,000 people were killed including babies and children,[6] but this was not even close to the end of the tyranny. With strong antisemitic notions prevailing in the country from centuries prior, the effectiveness of this program appears to have also laid the groundwork for one of history's most destructive catastrophes – the Holocaust.[5]

The power gambit

Looking back at the atrocities committed by the Nazi Doctors, no amount of justification could excuse the abuse of medical practice. Some defendants in the testimony rationalised that they were not killing by their own authority, but simply obeying the laws of the State.[1] Interestingly, German medicine placed a lot of emphasis on valuing conformity to authority during the Nazi reign,[7] branding doctors with a sense of duty and the need for order. The paternalistic attitude donned by the physicians seems to be the consequence of similar authoritarian outlooks in the society, seeping into the practice of medicine and conforming it to the Nazi ideals. With the fear of treason and their propensity to be patriots, little resistance was provided to the horrors propagated by the Nazi regime.[8]

But if Nazi ideology had controlled the practice of medicine in society, is the crime not on the hands of the doctors? The power dynamic in Nazi society was clearly laid out – with the government directing medical society and the doctors determining who was valuable enough to remain in society. In a setting with no legal regulations present for breaking their Hippocratic oath to "Do No Harm," doctors had the ability to play God while still being puppets in the Nazi regime. But it was clear that it was the patients who faced the brunt of the deal – especially those belonging to the "inferior" races.[9] In the realm of Nazi medicine, a physician's role was amplified as an authoritative figure extending their healing powers to "fix" radical social issues. By promoting the racial status quo and its medicalisation, doctors overlooked that their duties were not based on the social priorities of the State and disregarded the ethical pillars of beneficence and non-maleficence. The oppression of patients of minority races on unrightful grounds with no regard to human dignity elucidates what it meant to be in their place during that era – powerless in what happens to them.

Piecing together the present

George Santayana once wrote, "Those who cannot remember the past are condemned to repeat it."[10] This stands true to the practice of medicine across centuries as we sometimes have considered science from previous generations to be the absolute truth, discrediting how dynamically the field changes with new observations, discoveries and shifting perspectives in society. Although eugenics is now classified as a pseudoscience with no scientific validity,[11] it can be argued that attitudes promoting the value of some sections of society, alluding to eugenics, persist today. Racism is still one of the biggest issues to be tackled in today's society – even in the medical sphere[12] – so we cannot live under the façade that all it takes are a few guidelines to tackle discrimination.

Moreover, euthanasia remains a contested topic till date, even if its current form as a method to relieve a patient's suffering by painlessly ending their life holds no semblance to the treacherous Nazi practice.[13] With families finding it difficult to make decisions on behalf of the severely ill and traces of concepts like "life without value" still persevering, society's stance on euthanasia as an acceptable practice remains divisive.

Conclusion

Nazi medicine raised questions about whether bureaucratised practice of medicine can be productive in a society. It is not. Ethical relativism suggests that we cannot judge the past with morality of today's standards, but there is no doubt that Nazi medicine was one of the darkest chapters in medical history. While Hitler excused the "Euthanasia" program from a utilitarian standpoint,[8] in recent times it becomes evident that a shared decision-making approach for treatment with doctors and patients collaborating ensures the best outcomes[14] and upholds patient autonomy. As future healthcare professionals with great medical power, we must accept our responsibility in delivering good medical practice by learning from the past and promoting equal treatment for all.

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Rishika Segireddy

Hi, I'm Rishika. I was born in India and lived in Dubai before I moved to Plymouth to study medicine. Currently, my academic interest lies in the brain and all of its eccentricities. I love reading books and watching movies and feeling guilty about doing too much of that.

News

The relationship between COVID-19 and periodontitis

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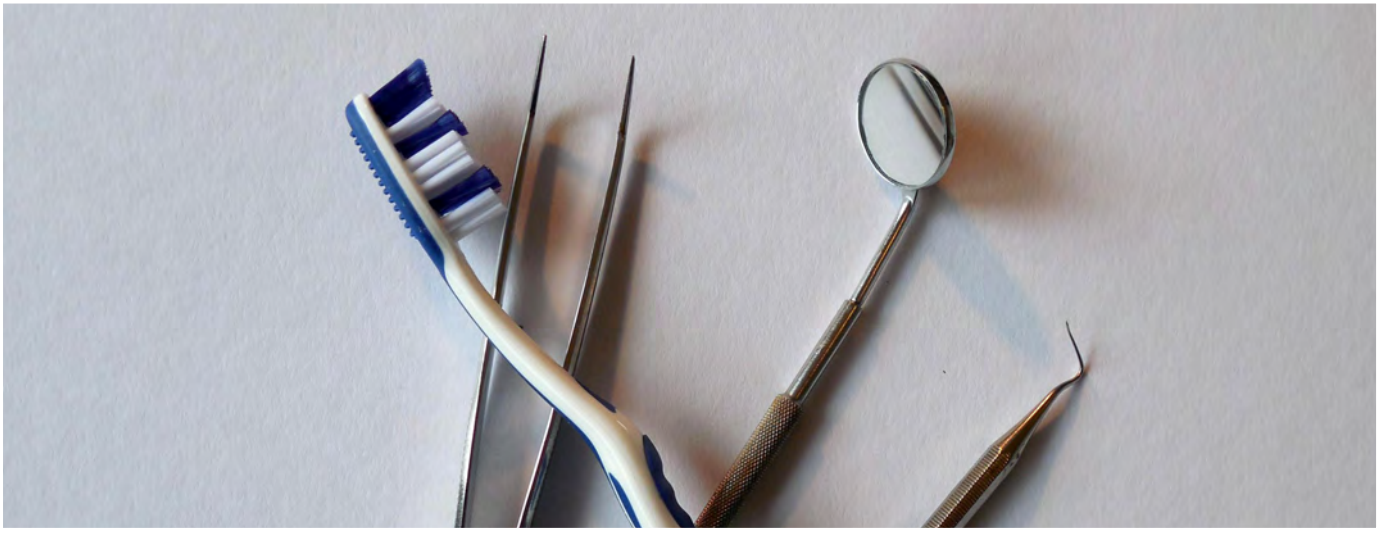

Abstract

The subject of this news article is to summarise the current literature highlighting the novel relationship between periodontal disease and COVID-19. The aims of this news article are to outline possible associations between COVID-19 and periodontal disease, offering explanations of potential pathophysiological mechanisms and identifying common comorbidities between them. The association is significant due to the high prevalence of both diseases in the adult population. This news article also reviews whether a periodontal disease status serves as a useful risk indicator for COVID-19 severity. This in turn stipulates the importance of maintaining the health of individuals suffering from conditions with predispositions to both diseases.

Abbreviations

IL-6 - Interleukin-6

Introduction

Periodontitis is the chronic inflammation and graded destruction of the tissues surrounding and supporting the teeth, such as the periodontal ligament and alveolar bone. This is caused by unfavourable changes in the oral microbiome, resulting in dysbiosis, often associated with poor oral hygiene. Severe periodontal disease has been recorded as the 11th most prevalent condition in the world by the Global Burden of Disease Study (2016).[1] However, it can be largely stabilised and prevented by effective oral hygiene methods.[2] A variety of comorbidities are seen with periodontal disease, including but not limited to diabetes mellitus, cardiovascular disease, hypertension, obesity and ageing. Interestingly, these same factors have been linked with the progression and severity of COVID-19.[3]

The pathogenesis of COVID-19 results from the replication and release of the SARS-CoV-2 virus in lung cells, which elicits an inflammatory host response. Current evidence suggests that periodontitis may worsen the symptoms of COVID-19.[3]

> *It is possible that bacterial imbalances in the mouth and excessive proinflammatory proteins produced in response to periodontal disease can increase the risk of life-threatening respiratory conditions.[3]*

This article reviews the connection between COVID-19 and periodontitis, their shared comorbidities and possible biological mechanisms. The reader must acknowledge the limitations of this article, considering the novel topic and lack of available current literature.

Mutual morbidities

Diabetes mellitus has shown to be an important predictor of severe COVID-19 illness. This is evidenced by individuals with diabetes displaying higher CT scores, indicating more severe illness in COVID-19.[3] Interestingly, diabetes is also linked with periodontitis and a bidirectional relationship is seen.[4] Hyperglycaemia has shown to reduce function of neutrophils, increase levels of cytokines and therefore impair healing responses to bacterial challenges faced in periodontitis.[5] Similarly, those with periodontitis have an increased risk of developing insulin resistance and poor glycaemic control.[6]

Cardiovascular disease and hypertension have been identified as potential risk factors for increasing COVID-19 complications.

Hypertension is the most common comorbidity among individuals with COVID-19, however, the reason for this is unclear.[7] Cardiovascular disease and hypertension are also both implicated in periodontitis. The biological mechanisms are multifactorial.

> *Several hypotheses include dissemination of inflammatory markers into the bloodstream from the periodontal lesion, disequilibrium of lipid marker levels and exacerbated immune responses and systemic inflammation.[3,8]*

Obesity has a significant relationship with COVID-19, increasing the risk of severe complications and death.[9] Obesity is associated with an impaired immune response, vitamin D deficiency, chronic inflammation and reduced ventilation associated with abdominal obesity.[10] Similarly, obesity has been shown to increase the risk of developing periodontitis.[3,11,12] Many researchers believe the chronic inflammatory state induced in obesity implicates the development of periodontitis.[9,11,12] This biological mechanism is evidenced by the presence of inflammatory cytokines, tumour necrosis factor-α and interleukin-6 (IL-6), in both obesity and periodontitis.[11]

Ageing is a significant risk factor for both periodontitis and severe COVID-19 illness. People over 65 are the highest risk group for severe COVID-19 illness.[13] Similarly, this age group presents a high prevalence of periodontitis.[14] This is mainly due to the progressive nature of the disease with advancing age.[15] Additionally, ageing is associated with reduced manual dexterity, affecting toothbrushing, and polypharmacy, leading to dry mouth. These both increase the risk of periodontal disease.[14]

These mutual morbidities between COVID-19 and periodontitis highlight an interesting relationship. Perhaps providing scope for further research that may benefit our understanding of COVID-19.

Pathophysiological mechanisms

Periodontal bacteria in the lungs Numerous mechanisms suggest a direct link between periodontal disease exacerbating respiratory infections including COVID-19. Individuals with periodontitis exhibit a plethora of bacterial colonies, notably, Fusobacterium nucleatum, Prevotella intermedia and Porphyromonas gingivalis species. Multiple theories hypothesise how the microaspiration of the high loads of bacteria from the oral cavity contribute to the immunologic homeostasis of the respiratory tract.

> *These secretions modify and adhere to the lung epithelium. This in turn facilitates or exacerbates further infection by respiratory pathogens.[16]*

Immunopathogenesis of periodontitis and COVID-19 Periodontitis elicits the release of pro-inflammatory mediators, predominantly IL-6, that increases systemic inflammation and triggers a local inflammatory response in the lungs. Resultantly, the lung's capacity of capillary blood gas exchange and oxygen diffusion is diminished, which reduces the individual's airflow.[17]

The increase in IL-6 levels has been shown to predict the severity of COVID-19 in patients. A three-month study concluded that individual's with the highest IL-6 levels are predictive for respiratory complications and the need for mechanical ventilation, with a 22 times greater risk of respiratory failure.[18] This link warrants the investigation of whether the exaggerated synthesis of IL-6 levels can act as a biomarker, with the clinical benefit of predicting COVID-19 severity.

Thus, the direct and summative effect of periodontal disease on individuals with COVID-19 has been successfully proposed, as well the need for further research to corroborate this association and analyse the risk in mild to severe disease forms.[19]

Conclusion

In line with the current literature, this article summarises the novel relationship between poor oral health, systemic transmission of oral bacteria and the synergistic effect of comorbidities and their association with COVID-19. It is pivotal to maintain the health of individuals suffering from conditions with predispositions to both COVID-19 and periodontitis. This article highlights the importance of regular oral hygiene measures and professional dental visits.

Contribution statement The two authors provided substantial contributions to the conception of the work. Both drafting the review and revising it critically for important intellectual content. Both authors gave a final approval of the review before submission to Inspire. Gabrielle Thompson is the guarantor of this work.

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Gabrielle Thompson*

Gabrielle Thompson is a general dentist working in a mixed NHS and private practice in North East London. She graduated from the University of Bristol Dental School in July 2021. Gabrielle has always had a keen interest in orthodontics and hopes to purse specialty training in the next few years. She enjoys the clinical and academic side of dentistry, completing various research projects and publications whilst continuing her clinical roles. When she is not working in general practice, she enjoys her different volunteer roles combating loneliness in the elderly and projects abroad aiding education and oral hygiene in developing countries.

Nidhi Parmar*

Nidhi Parmar recently graduated from the University of Bristol and is a general dentist, with an interest in prosthodontics. She currently practises in North West London. Nidhi is committed to further education with a love for learning through conferences, postgraduate level courses and study days. She is actively involved in research, publishing in national and international journals. She is a full member of the British Association of Cosmetic Dentistry, the Faculty of General Dental Practitioners and the British Society of Prosthodontics.

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Education & Teaching

Emergency and rural medicine: from Argentina to Peru

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My eight-week elective began in Peru with a volunteering expedition with the Vine Trust, an international development charity.[1] The Amazon Hope Medical Programme is one of its core projects, which since 2002 has provided a ship-based primary healthcare service to isolated communities in river basins in the Loreto region (**Figure 1**). For a fortnight, two other medical students and I worked alongside the ship's permanent Peruvian multidisciplinary team, closely collaborating with the medical lead, midwife, dentists, nurses and psychologists.

Figure 1. The Forth Hope moored outside a village in Loreto, Peru.

Each day I would wake to the ship powering up to navigate towards a new community, where we would often find a small crowd of people gathered to watch our arrival. The waiting room would soon fill with patients, who were triaged on arrival to direct them to the appropriate service, and clinic would begin. All the villages had something in common: how far away they were from a hospital. A trip to access secondary care in the nearest city could take several days of travel, primarily by boat.

Before starting clinic in the mornings, it was fantastic to be able to disembark to explore the riverside villages enclosed by jungle. On these walks, we met the residents of the community, spotted birds and animals (who knew that vultures are everywhere in the Amazon?), and a rich variety of flora, from pineapple plants to cacao trees. This glimpse into where the people we attended to lived, the physically demanding work done by many, and the role of the river in daily life, helped us to better understand factors contributing to many medical conditions. A typical day was busy, with patients ranging from small infants to elderly adults. We would start seeing patients from just after nine o'clock and usually finish by mid-afternoon, occasionally visiting two communities in one day. Evenings were spent relaxing with the team or venturing into the villages to look for nocturnal wildlife, in the darkness alive with the buzzing and chirping of insects.

My colleagues from Cardiff and I worked as a team, with the lead doctor close by to provide advice where necessary (**Figure 2**). Consultations were entirely in Spanish, which was an invaluable opportunity to develop my medical vocabulary, which I had spent a little bit of time working on before the trip.

> *Taking histories and explaining diagnoses and treatments to patients, combined with interpreting for my peers, was a demanding but satisfying task.*

However, you can volunteer even if you do not speak any Spanish at all: as stated on the Vine Trust's website, there is an interpreter on the ship, who doubles as a brilliant guide. He would normally be present throughout consultations to translate for volunteers, but

was satisfied that this was not necessary in our case. Furthermore, dental students, among other healthcare professions, are also able to volunteer; dentistry makes up a significant proportion of the ship's workload.

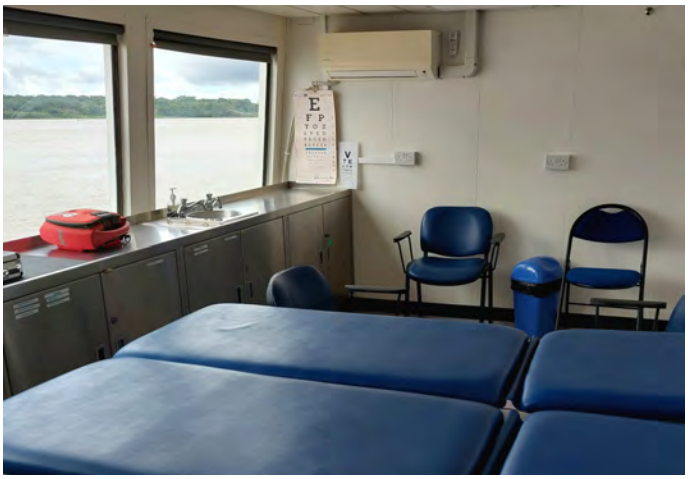

Figure 2. A floating medical clinic.

Patients presented with a variety of complaints, some of the most frequent being diarrhoea, blurred vision, headaches, cough, rashes and back pain. Often an entire family would pile into the room, with concerns relating to five different children being relayed all at once by a parent or grandparent. Multi-tasking and teamwork were necessary to ensure that each patient's problems were investigated and treated. One challenge was managing patient and parent expectations; mothers frequently asked for "vitamins" or an "injection" for their children. Children diagnosed with anaemia were prescribed ferrous sulphate, but we would need to explain that we could not offer the vitamins requested. The health perception of injections being the optimal type of treatment was prevalent, and one day an infant only several months old came to the ship with a large gluteal abscess thought to have originated from an intramuscular injection.

> *For me, the most memorable patient was a young woman who came in with stomach troubles, in whom we noticed several red flags. It was very rewarding to develop the rapport needed for her to disclose that she was experiencing domestic violence, and directly send her to the psychologist on the ship for psychological support and information on how to report her partner.*

Emergency medicine in Argentina

After two weeks sailing along tributaries of the Amazon, I travelled to Buenos Aires for a month in the emergency department (ED) of a large teaching hospital. This was a very different experience; I spent most of my time shadowing the residents (junior doctors) as they clerked and reviewed patients. Rather than the doctors, nurses would do almost all the bloods and cannulas, which are normally daily tasks for medical students in the UK! My hands-on experience was thus limited to taking some histories, examining patients, and assisting the doctors with requesting investigations. It was interesting to see the challenges faced by our EDs, such as exit block and crowding, mirrored in this new setting. There were many differences in the healthcare system as a whole: I was based at a university hospital, somewhere in-between the public and private system. If a patient did not have a certain type of insurance, they could still receive urgent medical treatment, but for interventions such as surgery they would need to attend a different hospital. In addition to variations in the choices of drug treatments, the cultural differences were remarkable; doctors would routinely greet patients with a fist bump! Coffee in break times was replaced with "mate", the national drink of Argentina drunk from a gourd and often shared among a group. Outside placement, I would spend hours exploring diverse neighbourhoods with impressive architecture, beautiful parks and busy markets. The Argentinian ritual of afternoon tea quickly became a daily habit, often involving medialunas (glazed, fresh-baked croissants).

> *Nights in "the city that never sleeps" would only truly begin close to midnight, with dance halls full of people dancing tango and salsa until dawn.*

Elective planning advice

> *Start thinking about what you might like to do for your elective as early as you can!*

It can take several months to organise a placement over email, and some projects only accept a few students at a time. It is a good idea to reach out to different places in case some do not respond. If you are interested in a particular specialty, then you may be able to find helpful contacts through national societies dedicated to the specialty; this was how I organised my hospital placement. Funding is also a key consideration; look for any bursaries that may be relevant to you or your proposed project. In addition to providing a list of bursaries you can apply for, your university may enable you to access the Turing Scheme, which can significantly help with the cost of such a long trip.

If you have never been to South America, and have thought about an elective there, I would highly recommend it! Argentina and Peru are two very different, beautiful countries with rich cultures, friendly people, and lots of great food. This is not to mention the stunning natural sights; while in Peru I had the once-in-a-lifetime experience of travelling to Machu Picchu. Likewise, the views from the Forth Hope were spectacular, and practicing medicine on the Amazon was a unique experience that I will remember for the rest of my career.

Figure 3. Sailing through the jungle.

Acknowledgements

I would like to thank the Vine Trust team for their support and enthusiasm both before and during the expedition, and the Division of Emergencies at Hospital de Clínicas José de San Martín for an excellent placement. If you have any questions or are interested in doing something similar, do not hesitate to get in touch.

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Genevieve Lawrence

Genevieve Lawrence recently graduated from Cardiff University and is working as a Foundation Year 1 doctor in the South Thames deanery. She completed an intercalated BSc in Emergency, Prehospital and Immediate Care after the fourth year of medical school, after volunteering as a community first responder with the Welsh Ambulance Service. Genevieve's interests lie in acute medical specialties, including emergency medicine and intensive care medicine. She has presented her research on medication safety incidents in the emergency setting at national and international conferences and is keen to get involved in further research and teaching as a foundation doctor.

Review

Does circadian autophagy have a protective or degenerative role in neurodegenerative disease?

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Abstract

Introduction
Dementia is a non-curable, terminal neurodegenerative disease that affects 50 million people globally, posing a burden to patients and their families.[1] Autophagy, the process of clearing cellular debris, is a possible contributor to dementia.[2] This literature review explores the homeostatic role of autophagy in sleep and its implications in neurodegeneration.

Methods
The primary research was conducted through the NCBI platform (PubMed Central) to obtain the latest original research papers and reviews from the last 10 years. Records were identified based on whether they contained the phrases "dementia", "autophagy" and "sleep". Fifteen records were identified and short-listed based on their title and abstract. Studies were only taken forward if they focused on the neuronal mechanisms, genetic, and hormonal pathways of dementia and autophagy. Eleven studies were included in the final review.

Results
Studies demonstrate that autophagy has a neurodegenerative role in the setting of chronic sleep fragmentation (CSF) and vascular occlusion. The upregulation of certain molecular pathways leads to the accelerated formation of autophagolysosome vesicles and the accumulation of abnormal protein aggregates. In Parkinson's Disease (PD), autophagy is protective because it is contained within the microglia of neurons. A possible link exists between autophagy and circadian rhythms, which is influenced by modafinil and melatonin.

Conclusion
There is conflicting evidence on the role of autophagy as a possible contributor to neurodegenerative disease. Further research is needed to definitively conclude the relationship between autophagy, sleep and neurogenerative disease, and whether these autophagy regulatory pathways can be targeted as treatment modalities for the same.

Abbreviations

Aβ – Amyloid βeta
AD - Alzheimer's disease
APP - Amyloid precursor protein
ATG - Autophagy Related Genes
CSF – Chronic Sleep Fragmentation
ER – Endoplasmic Reticulum
LPS – lipopolysaccharide
MPTP - 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine
PD – Parkinson's Disease

Introduction

The main features of dementia are impairment of memory and cognition, which are associated with ageing. The pathogenesis of the disease begins years before it clinically manifests. This is attributed to the accumulation of cellular debris overtime, ultimately leading to neuronal injury and degeneration.[3] In healthy individuals, this cellular debris is cleared by a catabolic process known as autophagy. It involves the lysosomal degradation of misfolded proteins and damaged organelles through the formation of an

autophagolysosome.[2] Under physiological conditions, a basal level of autophagy occurs to maintain the homeostasis of neurons by clearing cellular debris. This prevails during sleep, under the influence of melatonin.[4] Under pathological conditions, the accumulation of abnormal protein aggregates and neurotoxins induces excess autophagy, which can lead to endoplasmic reticulum (ER) stress and mitochondrial damage. Multiple proteins and hormones, including melatonin, play a protective role against neurodegeneration by regulating this process.[4] A disruption in autophagy pathways has been implicated in many neurodegenerative diseases. This review explores the pathways of autophagy that are induced during sleep, and both their neuroprotective and neurodegenerative role in the pathogenesis of neurodegenerative disease.

Method

A primary search of full-text articles was conducted on PubMed to determine the final chosen publications for the review, as detailed in the adjunct below (**Figure 1**).

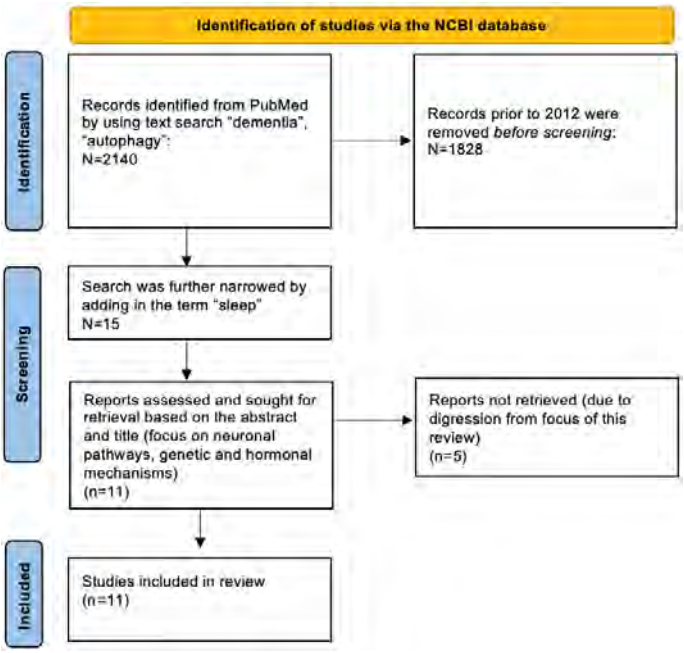

Figure 1. Flow diagram for the selection of studies for this review.

Discussion and results

Autophagy in chronic sleep fragmentation (CSF)

CSF impairs memory function due to a pathogenic process like that seen in Alzheimer's disease (AD). AD is the most common type of neurodegenerative disease, and is characterised by memory loss, spatial learning disability and behavioural changes in advanced disease.[5] A study applied a CSF model in wild-type mice with no genetic predisposition to dementia. After two months, investigations revealed significant cognitive impairment in mice with β-amyloid accumulation in the cortex and hippocampus.[5] This can be attributed to an imbalance between the formation and clearance of β-amyloid protein (autophagolysosome pathway dysfunction). In normal conditions, β-amyloid is cleared by internalisation of Amyloid precursor protein (APP) into the cell via early and late endosomes (detected by the protein markers Rab5 and Rab7, respectively). It is degraded into β-amyloid by APP secretase, which fuses with lysosomes for degradation. CSF dysregulates this pathway and leads to the accumulation of abnormal vesicles within the cell. Western blot and immunofluorescent staining, lab techniques used to detect proteins in tissue samples, indicated enhanced expression of Rab5 and Rab7 in the brain of wild-type mice after CSF. Additionally, Lamp 1 and LC3B (lysosome and autophagosome markers respectively), and Beclin 1 and UVRAG (autophagy positive regulators) were also detected (**Figure 2**). The presence of autophagy proteins in the setting of CSF indicates accelerated formation of autophagolysosome vesicles. As a result, an imbalance between the formation and degradation of β-amyloid occurs, ultimately leading to intracellular β-amyloid being released into the extracellular space to form A β plaques.[5]

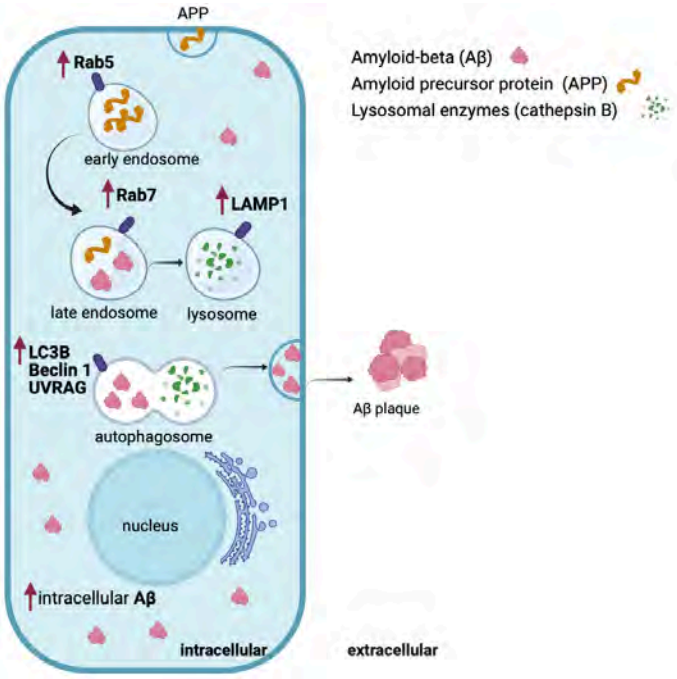

Figure 2. Accumulation of AB extracellularly due to the acceleration of autophagosome formation.

Autophagy and vascular occlusion

This theory is supported by another study exploring the role of Beclin 1 and cathepsin B (lysosomal enzyme) in vascular dementia (VaD). VaD is characterised by problems with reasoning, planning and judgement due to impaired blood flow to the brain.[6] The Pulsinelli four-vessel occlusion method was used to mimic vascular dementia in rats, by occluding the vertebral arteries whilst controlling the collateral circulation to the brain.[7] This induced ischemia in different cerebral regions, with the hippocampus being the most sensitive. The Morris water maze, a navigation test, was used to assess performance in learning and memory. The results indicated that vascular dementia induces expression of Beclin 1 and cathepsin B, increasing autophagy and decreasing performance on the Morris water maze. In a subset of subjects, wortmannin (an autophagy inhibitor) was administered. Less neuronal injury and higher performance on the Morris water maze was reported in this group.[8] Although vascular dementia due to hypoxic damage to neuronal tissue is different to the proteinopathic damage seen in other forms of neurodegenerative disease, the implication of autophagy is this process indicates the complexity of the process.

The effect of modafinil on autophagy

A similar effect is seen in with the administration of modafinil, a wakefulness promoting agent. A study found accumulated Nissl bodies, the equivalent of endoplasmic reticulum in neurons, and aggravated apoptosis in hippocampal neurons of sleep deprived mice. These changes were due to a decrease in the Bcl2/Bax ratio, which leads to the release of apoptogenic molecules from the mitochondria.[9] On administration of modafinil, excessive autophagy was attenuated in vitro and in vivo, restoring spatial memory in these mice. Modafinil phosphorylates the PI3K/Akt mTOR/P70S6K signal pathway (**Figure 3**), and suppresses the expression of L3B, Beclin-1, and P62. This alleviates the neuronal apoptosis that occurs when the formation of autophagolysosome vesicles exceed the lysosome's degenerative capacity.[10]

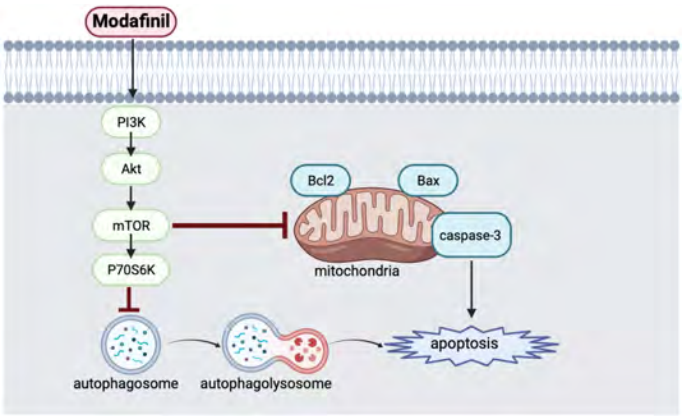

Figure 3. The effect of modafinil on the PI3K/Akt mTOR/P70S6K signal pathway.

Autophagy and Parkinson's disease (PD)

PD is a progressive neurodegenerative disorder which leads to bradykinesia, rigidity, and tremor.[11] Its pathogenesis is unclear but mainly involves a compromise in mitophagy, the process of removing defective mitochondria, and the aggregation of α-synuclein protein leading to loss of dopaminergic neurons.[12] In opposition, autophagy has been shown to have neuroprotective effects in PD and other forms of neurodegenerative disorders involving the accumulation of α-synuclein such as Lewy body dementia.

The clearing of α-synuclein aggregates in mice injected with the human form of this protein is done by microglia and is mediated by the TLR4-NK-κB-p62 pathway (**Figure 4**). Immunostaining indicated an intracellular increase in p62 levels, an autophagy receptor, but unaltered LC3 intracellular levels. The LC3 was localised within microglia containing α-synuclein. This suggests that autophagy was restricted and selective to α-synuclein rather than globally upregulated within the brain. The binding of the p62 receptor to ubiquitin-linked α-synuclein protein likely mediates the process.[13] In doing so, neurotoxicity by α-synuclein is prevented.

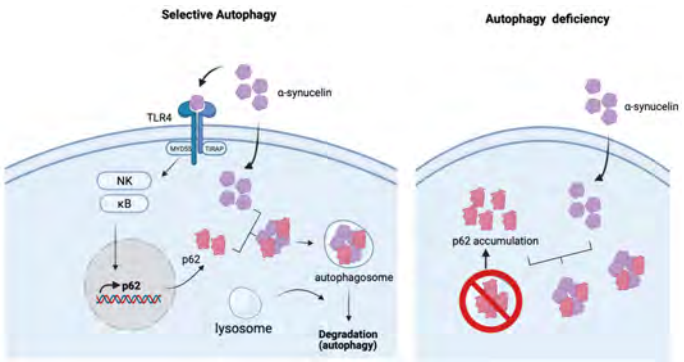

Figure 4: α-synuclein selective autophagy vs autophagy deficien y.

The effect of melatonin and circadian rhythms on autophagy

The role of p62 and LC3 is further explored in a study looking at excessive autophagy in the hippocampus of sleep-deprived mice. Sleep deprivation modulated the expression of glutamate receptors and affected hippocampal synaptic plasticity, reducing the performance of sleep-deprived mice in a Y maze test. On Western blot analysis, the expression of p62 was downregulated in the hippocampus of sleep-deprived mice. Meanwhile, the number of autophagic vacuoles observed under transmission electron microscopy increased, and the expression of Beclin-1 and LC3 proteins was upregulated.

Melatonin, a sleep-promoting hormone produced in response to darkness, is an important regulator of our circadian rhythms (24-hour internal clocks).[15] Lack of melatonin could be a possible contributor to neuroinflammation, as seen in mice who underwent lipopolysaccharide (LPS) treatment. LPS treatment causes neuroinflammation, inducing depressive like behaviours and cognitive impairment. This is due to increased levels of cytokines and NF-κB phosphorylation, causing dysregulation of Autophagy Related Genes (ATG).[16] These effects are modulated through the expression of the FOXO3a transcription factor. FOXO3a promotes autophagy by upregulating FOXO1, increasing activity in the PI3K-AKT1 pathway responsible for neuronal apoptosis.[17] When melatonin was administered to the LPS treated rats, cognitive impairment and depression were improved. These anti-depressive effects and cognitive enhancement were modulated through an increase in FOXO3a signalling pathway, upregulating the expression of ATG genes. The exact mechanisms of how melatonin interacts with the FOXO3a transcription factor remains unclear.[16]

Additionally, melatonin can also exert its neuroprotective effect through autophagy inhibition. An experimental animal model of PD was induced by 1-methyl-4-phenyl-1,2,3,6-tetrahydropyridine (MPTP). MPTP damages dopaminergic neurons by upregulating autophagy through CDK5. These changes were salvaged by the administration of melatonin which led to the knockdown of CDK5. This reduced autophagy-related dopaminergic neuron loss and dyskinesia symptoms in the PD animal model.[18]

Further evidence suggests that autophagy is regulated in a rhythmic pattern, similar to the 24-hour internal clock in humans. This is termed "circadian autophagy". A number of circadian transcriptional regulators upregulate the expression of autophagy genes. One of which is the C/EBPβ transcription factor. In cultured cells, C/EBPβ directly binds to the promoter regions of the ATG genes and activates their transcription.[19] This indicates a possible relationship between circadian rhythms and autophagy.

Limitations

The papers reviewed provide strong evidence for multiple molecular pathways in autophagy and neurodegenerative disease, but some limitations involving the methodology exist. Despite the use of navigation models and maze tests such as the Morris water maze and the Y maze test, it is difficult to quantify cognitive function and depressive symptoms in the study subjects. Furthermore, the significance of using mice in some studies and rats in others is unclear, and it is uncertain whether underlying differences in the neuroanatomy of each species influenced the results.

Environmental triggers and psychological factors such as educational background and underlying mental illness also heavily influence the development of neurodegenerative disease in humans. Despite attempting to control baseline cognition at a neuronal level in the subjects studied via the use of agents such as LPS and MPTP, it is nearly impossible to account for these individual differences in humans. This impacts the ability to translate findings directly to the human population.

Conclusion

The link between autophagy and neurodegenerative disease has demonstrated that autophagy acts as a protective mechanism against neurodegeneration, whilst creating a damage pathway that can lead to programmed cell death. The transcriptional regulation of this catabolic process in a diurnal manner is heavily influenced by circadian rhythms and melatonin. Whether sleep is protective against neurodegeneration is controversial. This is due to the conflicting evidence on the protective roles of stimulants and wakefulness-promoting agents against neuronal apoptosis. Further research is needed to definitively conclude the subtle interplay between autophagy, sleep and neurodegeneration, and whether

these autophagy regulatory pathways can be targeted to treat neurodegenerative disease.

Acknowledgements

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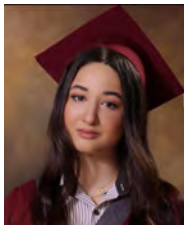

Zaina Aloul

I am currently a 4th year medical student at Cardiff University. The cellular pathways involved in neurodegeneration are a fast-growing field in neurology. Understanding how these pathways go array in disease can enable us to translate that knowledge into real-life solutions that help everyday people suffering from neurodegenerative diseases. This is why I chose this topic as part of my year 2 SSC project at Cardiff. I hope to contribute more to this field throughout my medical career and look forward to the exciting discoveries yet to be made in the future!

Review

The use of artificial i telligence in dental and maxillofacial radiology

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Abstract

The use of artificial intelligence in our everyday life is becoming more and more prevalent, from movie recommendations on Netflix to auto-correct features on our mobile phones. The field of medicine and dentistry can apply artificial intelligence to stay up to date with technological advancements and use them to increase the efficiency of practice. Although artificial intelligence is not widely used yet, it has great potential when used in combination with dental radiographs in the field of dentistry and maxillofacial surgery. Radiographs can act as a dataset for machine learning algorithms and enable artificial technology to carry out tasks such as diagnosing disease and treatment planning. Uses of artificial technology being investigated in dental research include dental charting, diagnosing caries, cysts and tumours, and treatment planning orthognathic and orthodontic cases.

Abbreviations

AI - Artificial intelligence
ANN - Artificial neural networks
CAD/CAM - Computer-Aided Design/ Computer-Aided Manufacturing
CBCT - Cone-beam computed tomography
CNN - Convolution neural network

Introduction

Artificial Intelligence (AI) is where technology learns to mimic aspects of cognitive behaviour, such as critical thinking, problem solving and learning. AI has already been utilised in the field of dentistry to detect and diagnose dentoalveolar pathologies, such as dental caries, periodontitis, periapical lesions and oral cysts. Research studies have also used AI to detect maxillary sinus perforations, oral cancers and lymph node metastasis.[1] Digital dental radiographs and intra oral scanning images collated by Computer-Aided Design/Computer-Aided Manufacturing (CAD/CAM) technology can act as datasets for AI. Computers can learn to recognise anatomical landmarks and key features of pathological conditions using these datasets and complex algorithms.[2] Radiographs are an essential component of constructing risk assessments, diagnosis and treatment planning. Access, knowledge, and training surrounding cone- beam computed tomography (CBCT) has also improved in recent years.[3] The combination of using accurate 3D imaging with AI has the potential to offer high quality diagnostic value with increased ease. This review will explore the current and future use of AI in dental and maxillofacial radiology as well as clinical barriers to the application of AI technology.

Artificial i telligence

AI can be defined using a hierarchy of intelligence as defined by Bostrom.[4] Artificial narrow intelligence is where technology is used to recognise patterns and solve classification based tasks. The next level up is defined as artificial general intelligence, which is comparable to total human cognitive ability. The final stage is artificial super intelligence, where cognitive ability would be beyond that of human capability.[4] The full potential of what AI can achieve is still being explored, with current research aiming to create AI that complements and co-operates with human intelligence.

Advancements in AI have been largely attributed to machine learning, which allows technology to use algorithms and datasets to learn and predict outcomes.[5] Deep learning is a sub-branch of machine learning that involves a process by which technology can learn a hierarchy of algorithms, as demonstrated by **Figure 1**.[6] This forms layers of algorithms stacked on top of each other to form a

complex deep network.[7] Deep learning improves on the principles of machine learning as it allows technology to solve more complex problems where the dataset is unstructured or interconnected. Artificial neural networks (ANN) are employed in deep learning. These networks have an input, an output, and several hidden layers that are not pre-defined. A convolution neural network (CNN) is a computer vision algorithm that performs image recognition and classification. CNN can automatically extract features and distinguish patterns from images.[8] CNN is the most widely used deep learning architecture utilised in dentistry due to its image detection abilities.[9] CNN consists of a hybrid neural network with an initial convolutional layer which identifies simple features such as edges, lines and textures. This information is then passed onto the subsequent layers within the neural network to detect more complex features and form an image.[7] CNN has reported high accuracy in detecting and diagnosing anatomical landmarks and dental pathology.[10]

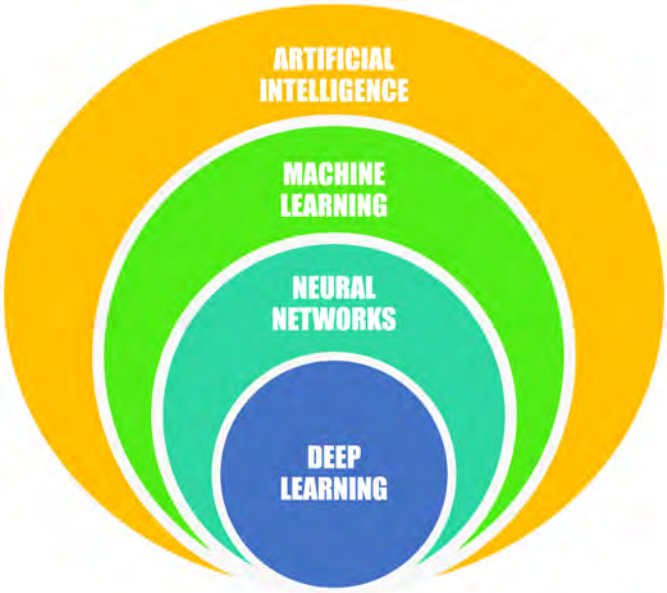

Figure 1. The various aspects of artificial intelligence. Reprinted from Khanagar et al (2021)[6], by Elsevier.

Application of artificial intelligence in dental and maxillofacial radiology

Dental charting

Studies have shown that AI in combination with dental radiographs can used to complete digital tooth charting. Tooth detection can be carried out using pixel-level segmentation methods, whilst tooth charting is based on the extraction of features such as width/height teeth ratio or crown size.[11] Tuzoff et al[11] investigated the use of CNNs in detecting and numbering teeth using panoramic radiographs, as shown by **Figure 2**. A dataset containing 1352 panoramic radiographs of the adult dentition was used to train the AI system. A separate group of 222 panoramic radiographs were assessed using the AI system to evaluate its performance, the outcome was then compared to tooth classification carried out by clinical radiology experts. They found that a CNN system achieved a similar sensitivity and specificity for tooth detection and classification as radiology experts. Lin et al[12] utilised an AI support-vector machine and dental bitewing radiographs for tooth classification. For tooth numbering, they combined an algorithm that detects missing teeth and a simplified alignment sequence to allow them to assign a number to each tooth. They reported that their AI system had an overall accuracy of 95% for classification, and 98% for numbering.[12] This demonstrates that AI systems can have high accuracy when it comes to dental charting, comparable to that carried out by clinicians. This could be used to aid dental practitioners during examinations with minor amendments if necessary. The advent of automatic dental charting would help to streamline dental appointments thereby increasing efficiency.

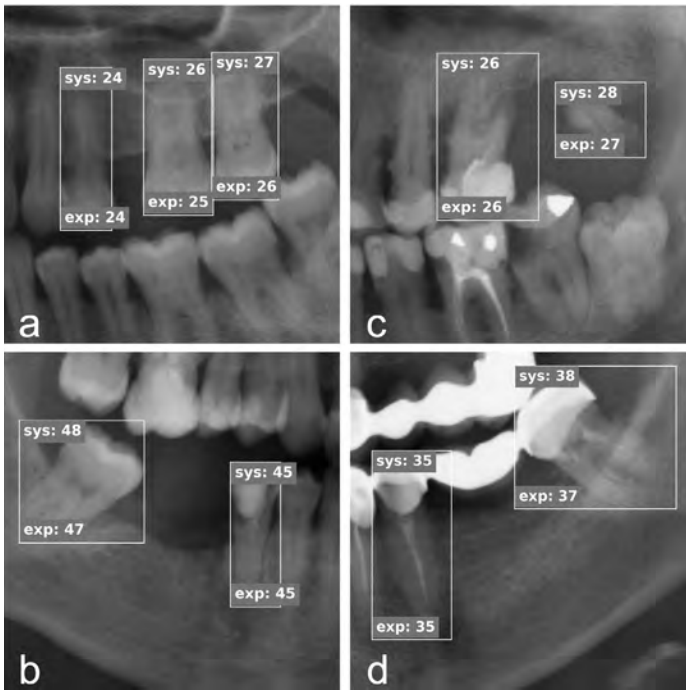

Figure 2. Tooth numbering errors produced by experts, the AI system classifi ation result is at the top (sys) and the expert classifi ation is given at the bottom (exp). Reprinted from Tuzoff et al (2019)[11], by BIR Publications.

Dental caries

Dental caries affects around 35% of the global population and evidence shows that over 20% of non-carious lesions are incorrectly diagnosed as caries.[13,14] Normally, a clinical examination, bitewing radiographs and a caries risk assessment are used to form a caries diagnosis. The presence of dark shadowing can indicate caries on an intra-oral radiograph. However, shadows can also be due to artefacts such as radiographic burnout, overlapping structures, or differences in contrast between restorative materials and tooth tissue. AI has shown to have the ability to diagnose caries with a high degree of accuracy, which may help to combat the irregularities in caries diagnosis between clinicians. Lee et al[13] used a pretrained CNN network to analyse 3000 periapical radiographs for dental caries. The diagnostic accuracy for carious premolar and molar models was 89% and 88%, respectively. Similarly, Ali et al[15] found that AI systems were able to distinguish between carious and non-carious teeth with a high degree of accuracy. An ANN system was used to detect and classify dental caries in dental radiographs. They reported that the diagnostic accuracy for carious teeth was 96%, comparatively the diagnostic accuracy for non-carious teeth was 98%.[15] If caries is diagnosed, the tooth often enters the restorative cycle to arrest the disease progression. This can affect the overall prognosis of the tooth as it can risk pulpal vitality.[16] Therefore, if AI can be used to supplement caries diagnosis, it may help to prevent unnecessary treatment.

Oral diseases

AI has also been used in dental research to detect and classify oral tumours and cysts, as shown by **Figure 3**. Poedjiastoeti et al[17] investigated the use of CNN to detect ameloblastomas and odontogenic keratocysts from dental panoramic radiographs. Differentiation between oral cysts and tumours using 2D radiographic imaging is complex, as they have similar characteristics. A 16-layer CNN model was trained by the researchers and 100 radiographic images were analysed to assess its diagnostic accuracy. They found that the CNN system had a similar sensitivity, specificity, and diagnostic accuracy compared to oral and maxillofacial specialists. The most significant difference was the diagnostic time; the CNN system took 38 seconds whereas the oral and maxillofacial specialists

took 23 minutes. The increased efficiency of CNNs could have a dramatic impact on healthcare and may help to reduce the stress and work load that healthcare professionals face. Mikulka et al[18] compared six different AI systems used to classify jawbone cysts. Dental panoramic radiographs were assessed using the various AI classification systems, the diagnostic accuracy was compared against diagnoses made by medical experts. They found that the Naive Bayes system produced the highest diagnostic accuracy of 88.9% for follicular cysts, whereas Decision Tree and neural network systems produced the highest diagnostic accuracy of 88.9% for radicular cysts. This demonstrates that a range of AI systems can be used to distinguish between oral tumours and cysts to a relatively high degree of accuracy.[18] These studies demonstrate the potential of AI in detecting oral tumours and cysts. This technology can act as an aid for general dental practitioners who may have limited experience or confidence in diagnosing oral tumours and cysts. This could reduce the number of referrals and provide patients with a quicker diagnosis. Early detection and treatment are especially valuable where you have potentially malignant tumours.[19]

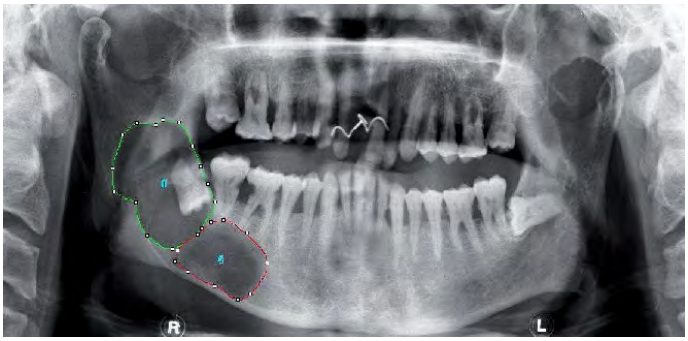

Figure 3. Semi-automatic segmentation by an AI system allowing two areas in the posterior mandible to be marked simultaneously. Reprinted from Mikulka et al (2013)[18], by Radioengineering Journal.

Orthodontics

Within orthodontics, AI has been used to aid decision making and treatment planning by determining the need for orthodontics, extractions and orthognathic surgery. Cephalometric radiographs are important for diagnosing and treatment planning in orthodontics. A systematic review found that several studies that investigated the ability of CNN systems to identify cephalometric landmarks produced similar results to analysis by specialists.[20] Decision making regarding orthodontic extractions is complex and specialist opinion may vary based on a clinician's experience. Teeth can be extracted to alleviate crowding, correct anterior posterior inter-arch discrepancies, and correct crossbites. Xie et al[21] evaluated the ability of AI systems to predict whether orthodontic extractions were required. A variety of indices were used to screen cephalometric radiographs of 180 patient cases. This information was used to train an ANN system to predict whether patients with a malocclusion between 11 and 15 years old required extractions. They found the ANN system predicted whether extraction or non-extraction was required with 80% accuracy.

> *These studies show great potential for AI in carrying out more complex decision-making tasks, previously only possible with human cognition. However, AI should not take precedence over orthodontic opinion and decisions made by AI need to be reviewed by orthodontic specialists.*

The introduction of orthodontic therapists in 2007 in the UK has led to changes to the structure of the orthodontic team.[22] Looking ahead AI systems may be useful in providing a second opinion for less experienced orthodontists and orthodontic therapists.[20]

Challenges and limitations

AI technology may have the potential to increase efficiency, improve diagnostic accuracy and reduce workload for dental professionals. However, there are barriers and limitations facing AI research and AI application in dentistry. AI employs machine learning algorithms used to train computers and digital software to detect, diagnose and treatment plan in dentistry. Machine learning requires a large sample of data so that the computer can be trained. These can be provided in the form of digital radiographs.[23] Digital radiographs need to be readily accessible as digitalising film radiographs is too time consuming.[1] Additionally, It may be difficult to obtain large samples of patient data due to issues regarding consent and confidentiality. There is also the challenge of storing large amounts of data. AI utilising cloud-based storage systems is one option being explored to accommodate extensive collections of data.[24] There tends to be smaller datasets in dentistry compared to medicine when programming AI systems. Transfer learning is a model that is being used to overcome this issue, this is where AI systems can be trained using similar images to perform a different task. For instance, to detect caries on a dental radiograph, the AI system can be initially trained to detect disease from chest radiographs; the knowledge gained from analysing the chest x-rays can then be applied to a different but related scenario such as detecting caries from a dental radiograph.[25] The amount of data is shown to be positively corelated with the performance of machine learning algorithms, therefore datasets are vital to the optimum functioning of AI systems.[23]

Whilst the use of AI is becoming more common in day-to-day life, the use of AI in a medical or dental setting may make clinicians and patients feel uneasy. A qualitative study discussing the implementation of AI in dental practices in Germany found that dentists were worried that they could become too reliant on AI systems over time and that AI systems may influence their own clinical judgement. Both patients and dentists also had fears that AI systems may make incorrect therapeutic decisions.[1] Whilst clinicians also make mistakes, due to machine learning, an incorrectly functioning algorithm can potentially cause harm to many patients.[23] Dentists should be mindful that reports produced by AI systems will not protect them from liability and failure to diagnose or treatment plan appropriately. Therefore, dentists still need to take responsibility when interpreting and analysing radiographs.[26] Patients have also expressed positive attitudes towards practices using AI technology, describing it as "innovative" and that it also demonstrates that the practice is up-to-date with current developments.[1] This highlights the needs for increased education regarding how AI systems operate with extensive training on managing AI systems and identifying when they malfunction.

Randomised blinded clinical trials are required to prove the efficacy and accuracy of AI systems.[26] Currently there are largely in-vitro studies investigating the use of AI in dentistry, therefore the clinical application of the results from these studies needs to be evaluated. The expense of purchasing, installing, and maintaining AI technology also needs to be assessed against the benefits of AI. Studies regarding AI use in dentistry often vary due to the use of different AI systems, datasets, and performance indicators. This makes comparison between different studies difficult or inappropriate in certain instances. There is a need for more standardisation so that definitive conclusions can be drawn surrounding the use of AI systems in dentistry.[23]

Conclusion

The transition of AI from a concept dramatised in science-fiction films to realistic everyday technology that is changing the way we live our lives has been pivotal. The field of dental and maxillofacial radiology

has been significant in enabling the application of AI in dentistry. Developments in AI technology such as machine learning, transfer learning and CNNs have expanded the capabilities of technology. AI can be used to diagnose disease, make complex management decisions and treatment plan. However, there are limitations to what AI technology can achieve. The advent of AI does not negate dental professionals from their professional responsibilities to ensure optimum standards of patient communication and care are delivered. AI may be used to detect, diagnose and treatment plan but dental care professionals are influential in encouraging behavioural change in patients, and providing holistic individualised care which cannot be provided by standardised machines. Advancements in technology that have the potential to improve patient and staff satisfaction by improving efficiency should be encouraged, in addition to further high-quality research assessing the full benefit that AI technology can provide within dentistry.

Contribution statement The author has made substantial contributions to the conception or design of the work, drafted the work, and gave final approval of the version to be included in Inspire.

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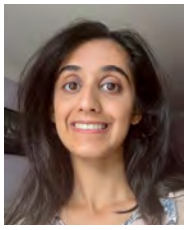

Yasmin Aziz

I am a final year dental student at Cardiff University and will be completing my dental foundation training in Sussex. My special interests include restorative dentistry and oral surgery. Dentistry has progressed from a profession solely responsible for treating disease to one that is increasing concerned about aesthetics. As a result of this shift, I have become interested in the range of tooth whitening technologies available and the mechanism by which they whiten teeth. I am also interested in the influence of artificial intelligence on the field of oral maxillofacial radiology and its potential future uses in healthcare.

Review

Something in the way: How underrepresentation of trauma & orthopaedics in undergraduate curricula impacts the development of understanding and interest in musculoskeletal medicine

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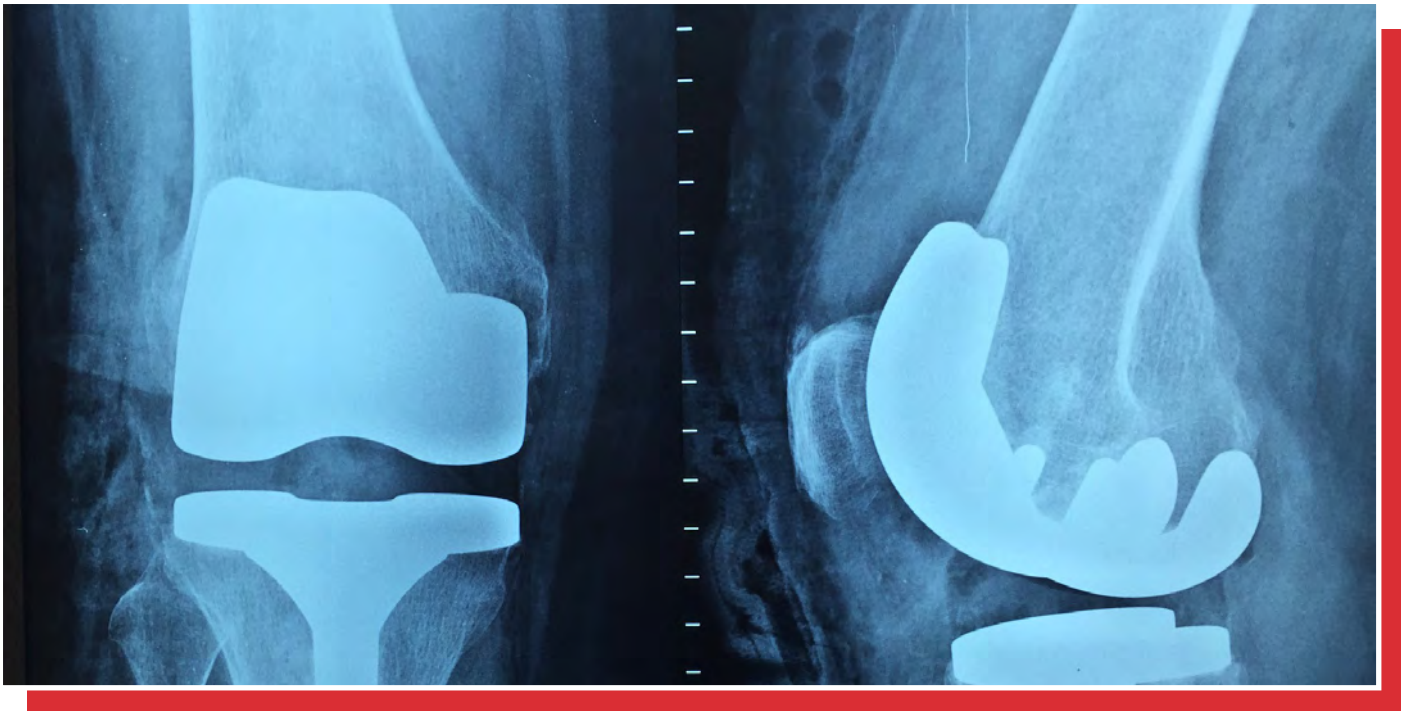

Abstract

Musculoskeletal (MSK) pathologies constitute a significant disease burden within our patient population. Many of these pathologies fall under the umbrella of trauma & orthopaedics (T&O). Medical school graduates should be confident and competent in their approach to identifying/managing these patients; therefore, their curriculum should reflect this requirement. A significant proportion of graduates do not display sufficient proficiency in MSK medicine which impacts our health service's ability to provide care for patients affected by MSK disease. This article explores how underrepresentation of T&O within undergraduate curricula is a contributing factor to this knowledge deficit. Furthermore, this article explores how underrepresentation may be contributing to a lack of gender diversity within the field of T&O. It is important that medical schools recognise the influence their curricula have on the development of specialty interest and strive to ensure a fair learning environment. In summary, this article discusses why it is important to have T&O exposure in undergraduate curricula with regards to ensuring graduates are well prepared to manage the burden of MSK disease and students are adequately exposed to experiences which will stimulate interest in MSK medicine.

Abbreviations

GP – General practitioner
MSK – Musculoskeletal
OSCE – Objective Structured Clinical Exam
T&O – Trauma & orthopaedics

Introduction

Musculoskeletal (MSK) disorders are the most common cause of repeat general practitioner (GP) appointments and constitute one in eight of all GP consultations that lead to a diagnosis.[1,2] Osteoarthritis is the most common joint disease in the world and it is estimated that almost 9 million people in the UK aged over 45 have sought treatment for it.[3] Therefore, orthopaedic knowledge is important for all medical professionals and for the majority this will be required in daily practice. Evidence suggests medical students' ideas, beliefs and interests in trauma & orthopaedics (T&O) mainly stem from experiences in medical school.[4–9] However, almost 20% of final year students have not experienced a single placement in orthopaedics,

and those who have spent on average only 2.5 weeks.[4,5] Given the large prevalence of MSK disorders, how does the undergraduate barrier of limited exposure affect students' interest and understanding of T&O medicine?

Methodology

To identify appropriate articles focusing on UK medical students' MSK knowledge, a search was conducted using PubMed with the following search terms: "UK", "medical student", and "musculoskeletal knowledge", yielding 43 results. An advanced search was conducted with the original search terms using the following parameters: Title: 'musculoskeletal' OR 'knowledge' OR 'medical', Filter: English language AND publication dates between 2002/1/1 and 2022/7/1 AND human species.

The advanced search yielded 22 results. Articles were then manually screened and those which discussed (or at least involved) UK medical students' or trainees' knowledge, understanding, opinion, or performance in MSK or orthopaedic medicine were further considered (n= 12). Studies based on or involving Irish medical students and trainees were then also excluded, resulting in a total of seven studies which met the inclusion criteria. These are outlined in **Table 1**.

Results and discussion

Impact 1: knowledge

Despite MSK disorders being one of the most common presenting complaints in modern day practice, they are woefully underrepresented in undergraduate curricula.[4–9] Subsequently, students may lack confidence and expertise in T&O, which may impact their interest in the speciality and motivation to develop knowledge of MSK medicine. Although lack of exposure impacts both those wanting to pursue a career in T&O and those who do not, evidence suggests students pursuing non-orthopaedic careers are disproportionately affected.[5–8,10–12] Almost 80% of graduates intending on pursuing non-orthopaedic specialities are deficient in their knowledge and understanding of the basics within MSK medicine.[10–12] Could this be due to lack of exposure or lack of interest? Graduates who have had greater undergraduate exposure or undertaken an elective or course involving MSK medicine during their undergraduate training showed much greater competence and understanding of T&O.[5,10–13] Even students who intended on pursuing a career in T&O showed greater competence with greater exposure during undergraduate study.[11] This suggests that limited undergraduate exposure, and not an absence of interest in T&O medicine, is the genesis of deficiency in MSK knowledge. Therefore, even if medical schools are unwilling to increase T&O placements, the promotion of related super-curricular activities such as courses and electives can help overcome this deficit and increase interest and understanding of T&O medicine.

From a global perspective it is clear there are deficiencies in knowledge and understanding of MSK medicine which may be attributed to limited exposure. However, to what extent does this affect UK medical students? Of the seven studies identified with the aforementioned search criteria, five displayed evidence of MSK knowledge deficiency in UK medical students (**Table 1**). Al-Nammari et al used the Freedman and Bernstein MSK cognitive examination tool to assess 210 recently graduated medical students.[5] The Freedman and Bernstein assessment is the most widely used tool for evaluation of orthopaedic knowledge and was originally validated in the US.[12] Only 21% of students passed this assessment despite 40% considering themselves competent in MSK medicine.[5] This corroborates data from non-UK studies which show low competence using the Freedman and Bernstein assessment tool.[10] Conversely, despite being widely used, it is not yet clear whether poor performance with the Freedman and Bernstein assessment tool is predictive of poor clinical performance. Therefore, it is difficult to extrapolate the deficiencies identified by the Freedman and Bernstein assessment tool to clinical practice and hence conclude what impact this will have on patient care. Modern, validated assessment tools such as the MSK30 which place greater emphasis on clinical relevance have been developed but are not yet widely used. A novel MSK Objective Structured Clinical Exam (OSCE) used by Stansfield et al identified significant deficiencies in examination skills needed to diagnose common MSK disorders in graduating UK medical students.[14] This may indicate that deficiencies identified by the Freedman and Bernstein assessment tool do carry over into clinical practice. However, this study involved US medical students and so it is difficult to conclude if these findings are shared among the UK population. More UK based studies looking at clinical performance in MSK medicine are required.

Since there are deficiencies with the Freedman and Bernstein assessment tool, what results do alternate methodologies yield? Of the remaining six studies selected for this review, three used a questionnaire format, two used computerised assessments and one involved annotation of a diagram to assess MSK knowledge.[4,15–19] Of the survey-based studies all showed deficiencies.[4,15,16]

Of the questionnaires, two involved self-rated competence with the major criticism of this methodology being that it may not be indicative of true competence in MSK medicine (as highlighted above by the discrepancy in student's self-rated competence and actual competence in Al-Nammari et al's study).[4,5,15] Despite this criticism, Atrey et al formally assessed knowledge in essential T&O topics alongside self-rated confidence in T&O before and after an education programme and noted there was a correlation between improved knowledge post-programme and self-rated confidence.[16] This suggests that low self-rated confidence may be linked to low competence in MSK medicine. However, overall the literature shows conflicting data on the relationship between improved self-rated confidence and increased MSK knowledge so further research is required to provide a definitive answer to this question.[13,16,20]

Of the two studies that utilised computerised assessments, both suggested knowledge of MSK medicine is adequate in undergraduate education.[17,18] One looked at knowledge in MSK medicine as compared to neurology and cardiovascular medicine and the other directly assessed knowledge from first to final year of medical school using a standardised progress test.[17,18] Both showed adequate knowledge of MSK medicine in their respective populations but it must be noted that both studies involved medical students from only one University so difficult to ascertain whether the results are a representation of this University's curriculum or the UK medical student population as a whole. Given that there are few studies which corroborate these findings, it would be difficult to conclude with certainty that undergraduate curriculums are adequately preparing medical students in the field of MSK medicine in the UK.

Spielmann et al used a basic test to assess MSK knowledge involving labelling of the carpal bones on a diagram.[19] This is a crude methodology in comparison to previous studies but provides an objective, though narrow, view of MSK knowledge in medical students and postgraduates. Only 30% of participants were able to correctly label all eight carpal bones and most medical students identified fewer than five.[19] This suggests that anatomical knowledge is poor within the medical student population. The sample size of this study was small, however, involving only 50 participants. These results have been replicated with a population of 111 medical students but it must be noted that they were from Irish medical schools.[21] As an example of the importance of MSK knowledge, in particular the anatomy of carpal bones, scaphoid fractures are a common presentation within clinical practice and the identification of this boat-shaped structure is important for all clinicians, not just MSK practitioners. The annual incidence of scaphoid fractures in the UK is estimated to be between 12.4 and 29 per 100,000 making it the most frequently fractured carpal bone.[22] Hand/wrist injuries are one of the most frequently misdiagnosed conditions and failure to identify scaphoid fractures can predispose patients to chronic

hand/thumb pain, early onset osteoarthritis and need for invasive surgery.[23] In view of the evidence currently available within the UK population, MSK knowledge is inadequate within medical students, but further research is required to inform what revisions are required within undergraduate curricula.

Impact 2: gender diversity

In the UK, over 50% of medical students are female yet they often account for less than 15% of orthopaedic surgeons, making orthopaedics the least gender diverse surgical specialty.[7,9,24–27] Although female representation is increasing, it still lags behind other specialities.[9,24–26] Diversifying the orthopaedic field and widening interest in T&O is important not only for the speciality itself also but for the aforementioned high prevalence of MSK disorders.[26]

Research suggests that increased exposure to orthopaedic content during undergraduate study is positively associated with the number of female applicants for orthopaedic surgery.[7,8,9,29] Furthermore, although there is a positive influence from increased exposure regardless of gender, the influence is much more pronounced in female students.[7] This is further supported by evidence suggesting males are more likely to develop their interest in T&O prior to clinical rotations, in contrast to females who are more influenced by their clinical experiences.[9] This discrepancy can be explained by role modelling being an important factor in the development of interest in career speciality, especially with regards to encouraging female interest as almost 70% of female graduates highlight lack of strong mentorship in medical school as a factor for not choosing orthopaedics as a career.[7,8,27,29–31] Therefore, one could surmise that increasing undergraduate exposure to T&O may increase interest in both MSK medicine and T&O as a career for both male and female students. Female students are more likely to benefit from greater exposure during clinical years and this may help diversify T&O homogenous population by stimulating career interest.

Conversely, there is data to show that extensive orthopaedic exposure does not exert significant influence in the development of interest in T&O.[29,32] Although early exposure to MSK medicine is acknowledged to be influential for female students, intrinsic factors such as work–life balance and physicality may be more influential in determining interest in T&O.[29,32] Subsequently increasing orthopaedic exposure alone may not be sufficient.[29,32] However, only 27% of the cohort sampled reported moderate to extensive orthopaedic exposure as part of their undergraduate curriculum, and although this did not influence their interest in the specialty, it is difficult to conclude the impact lack of exposure had on the remaining 73% of students.[32] The majority of research in the field supports the idea that increasing undergraduate exposure to T&O has a positive impact, and the evidence as a whole is in favour of increasing orthopaedic exposure as a means to encourage greater female interest. However, to further maximise interest it is important that attention be paid to mentorship, and in particular same-sex mentorship, as this has been shown to be influential in stimulating female interest.[7,8,27,29–31]

Conclusion

Undergraduate curricula do not reflect the current disease burden of MSK disorders in clinical practice by providing limited exposure to T&O. Lack of undergraduate exposure to T&O has significant bearing on MSK knowledge deficiencies in medical students and graduates and may be a contributing factor to female underrepresentation in orthopaedic surgery. Clinical exposure to T&O is essential in stimulating career interest in addition to developing proficiency in MSK medicine as a component of medical practice. I suggest greater emphasis be placed on:

1. Increasing undergraduate exposure via clinical placements
2. Encouraging electives/courses involving MSK medicine
3. Increasing mentorship for both male and female medical students

These three points benefit all medical students by increasing competence, confidence and understanding of MSK medicine. This is likely to be of significance in all fields given MSK pathologies high prevalence in our population.

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Sam Ghaznavi

My name is Sam and I am currently a 5th year medical student at peninsula medical school. I am interested in trauma and orthopaedics, in particular arthroplastics and regenerative medicine, as well as medical education. I intend to pursue a career in orthopaedics in the future.

Table 1

Study	Methodology	Results	Conclusions	Comments
Malik-Tabassum et al[4]	Survey of 414 final year medical students attending a 1-day T&O course. Measured outcomes included duration and perceived quality of T&O teaching as well as students self-rated competence.	37.4% of students described their training as "poor" with 19.3% not having experienced a single T&O placement. Self-rated competence was low in all basic T&O skills.	Inadequate undergraduate training and exposure to T&O with students having low confidence in basic skills.	Strengths: • Good sample size with students from a wide range of UK medical schools.[13] • Survey involved scenarios which are akin to real practice in comparison to other methods which may not translate well to actual practice. Weaknesses: • The data relies heavily on a student's subjective interpretation of their skills and competence within T&O which may not correlate with objective measures. • The very nature of the event may be a confounding variable with students who lack competence in T&O feeling potentially more obligated to attend in comparison to those who are more confident in their abilities. Therefore, the data may not be representative of the entire student population.
Al-Nammari et al[5]	210 recently graduated medical students assessed using the Freedman and Bernstein MSK cognitive examination tool.	44 (21%) of students passed the assessment.	Inadequate competence in MSK medicine in graduates.	Strengths: • Uses the Freedman and Bernstein MSK cognitive examination tool which is a validated tool with a predetermined cut-off. • Good sample size with graduates from a wide range of UK medical schools. Weaknesses: • Although the Freedman and Bernstein MSK cognitive examination tool is a validated tool, its contextual relevance is debatable with no data currently available on the correlation between competence as assessed by the Freedman and Bernstein test and patient outcomes.
Jandial et al[15]	Anonymous questionnaire assessing self-rated confidence in paediatric MSK assessment was completed by 346 trainee doctors.	Paediatric MSK assessment was ranked as the least confident system in comparison to other bodily systems. Majority answered "no" or "some" (21% and 53% respectively) with regards to confidence in paediatric MSK assessment. In contrast most responded "confident" for cardiovascular, respiratory, and abdominal systems.	Poor undergraduate training in paediatric MSK medicine.	Strengths: • Large sample size involving a wide range of different UK medical school graduates. • Includes trainees in a wide range of specialties (including orthopaedics). Weaknesses: • Self-rated confidence is not a reliable indicator of MSK knowledge. • Respondents were qualified from 23 different medical schools, nine of which were not UK based. It is not clear how many of the respondents were UK graduates and if there was any discrepancy between UK and non-UK graduates.

Atrey et al[16]	A questionnaire was devised and completed by 95 candidates including foundation year 1 and recently graduated medical students before and after an education programme.	Prior to the education programme: • 35% of F1's trained at a district general hospital • 54% of F1's trained at a teaching hospital • 45% of the medical students attained the pass mark. Also, only 42% felt confident in being an on-call orthopaedic doctor. All these metrics improved following the education programme.	Evidence of MSK knowledge deficiencies and low confidence in orthopaedic clinical practice in F1 doctors.	Strengths: • Population includes both recently graduated and working F1 doctors which is helpful in assessing the effectiveness of foundation training in developing MSK knowledge. Furthermore, the sample size includes different hospital types which can help further assess discrepancies in knowledge/learning. • The study focused on practical, case-based scenarios akin to what junior doctors are likely to face in day-to-day orthopaedic practice. Therefore, it is more likely that the responses mirror clinical competence compared to other forms of assessment which do not relate as well to clinical practice. Weaknesses: • The population size is limited and includes graduates from a limited number of medical schools. • The testing process was validated by consultant orthopaedic surgeons and not by professional examiners/educators. It is therefore difficult to ascertain the validity of the questions used to assess knowledge.
Basu et al[17]	Computer-based assessment covering core topics set at pre-registration house officer level in MSK medicine, cardiovascular medicine and neurology completed by 74 final year students at Sheffield Medical School.	A one-way analysis of variance revealed no significant difference in performance between the three fields.	MSK knowledge is equivalent to that of other disciplines despite less emphasis in the curriculum.	Strengths: • Topics used for the assessment were derived from guidelines by well-established sources e.g. EULAR. • The questions were set at a reasonable standard for the students involved and the average item difficulty between systems was equitable. Weaknesses: • The sample size is limited and only includes Sheffield medical students. • The assessment only included 24 questions per system and so may not be representative of medical students MSK knowledge as a whole.

Basu et al[18]	136 students from all years of study at Sheffield university completed a 40 multiple-choice progress test standardised by six MSK practitioners using a modified Angoff procedure.	Mean scores of students increased between first and final year from 41% to 84% and all final year participants score above the predicted standard.	Adequate competence in MSK medicine in final year students.	Strengths: • Involves medical students from all years of study which can help discern MSK knowledge progression. • Good sample size. Weaknesses: • The progress test they used is not a validated assessment tool. It uses Angoff/modified Angoff procedure. which does not use exam data to quantify a standard and is reliant on subjective interpretation by the MSK practitioners thereby negatively impacting the studies reliability and representativeness. • All participants were from Sheffield university and so may not accurately depict MSK knowledge of all UK medical students.
Spielmann et al[19]	Participants (25 medical students, 15 pre-registration house officers and 10 senior house officers) were given five minutes to label all eight of the carpal bones on a diagram.	Only 15 participants (30%) were able to correctly label all eight carpal bones. The majority of medical students (68%) identified less than five.	Inadequate undergraduate teaching in MSK anatomy. However, these deficiencies may resolve during postgraduate training.	Strengths: • The inclusion of participants at different levels of training enables us to view postgraduate training has on MSK knowledge. • The method used is an objective measure of anatomical knowledge. Weaknesses: • The sample size is small and only includes 25 medical students from Edinburgh medical school. • Although the method is objective, it is a limited representation of MSK knowledge and so cannot be generalised to the subject as a whole.

Review

I left my heart in low Earth orbit: a review of cardiopulmonary resuscitation in space

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Abstract

Introduction
To gain an understanding of the current state of CPR in microgravity with a focus on chest compressions in the event of a sudden cardiac arrest onboard.

Methods
An Ovid Medline search was conducted: 17 articles were found; 12 were excluded; six additional articles were found in the references of the remaining five articles, bringing the total number of articles included to 11. These were then critically analysed.

Results
No CPR method currently reaches the European Resuscitation Council (ERC) guidelines. The Handstand (HS) method appears to be the strongest. Evetts-Russomano (ER) is the second strongest method. Automatic chest compression device (ACCD) performed consistently well.

Conclusion
CPR appears to be far more difficult in microgravity. Inconsistencies in research methodology do not help. The ER method should be used as a first contact method and the HS method should be used once the casualty is restrained. An ACCD should be considered as part of the medical equipment. Further research is needed, directly comparing all positions under the same conditions.

Abbreviations

ACCD – Automatic chest compression device
AED – Automated external defibrillator
AHA – American Heart Association
BLS – Basic life support
CM – Cologne method
CMRS – Crew medical restraint system
CP – Compression product
CPR – Cardiopulmonary resuscitation
ER – Evetts-Russomano method
ERC – European Resuscitation Council
ESAM-SMG – European Society for Aerospace Medicine Space Medicine Group
HS – Handstand method
ISS - International Space Station
RBH – Reverse bear hug method
SCA – Sudden cardiac arrest
SHM – Schmitz-Hinkelbein method
SM – Waist straddling manoeuvre
STD – Standard side straddle method

Introduction

Microgravity or 'weightlessness' describes the lack of gravitational pull experienced by spacecraft in orbit. While technically still in the Earth's gravitational field and therefore falling, the spacecraft's forward velocity allows it to continuously miss the Earth, creating a state of zero gravity.[1]

Space tourism is a growing industry, already offering orbital tourism to wealthy clientele. Orbital flights such as those offered by SpaceX's Crew Dragon spacecraft could reach altitudes of 400 km and involve a stay of up to eight days aboard the International Space Station (ISS) and two days travel, exposing passengers to microgravity for more than a week.[2] Luxury hotels, such as the Aurora station, will host stays of up to 12 days, 320 km above the Earth.[3] Such exposures to microgravity may have profound effects on the cardiac physiology of crew and passengers whose cardiovascular systems have developed under terrestrial gravity for millions of years.

The observed changes in astronauts post-spaceflight, and subjects in earth-based mimics of microgravity, can be explained by the fluid shift from the legs towards the head due to loss of the pressure

difference between the upper and lower portions of the body created by gravity.[4] This cephalad fluid shift is interpreted as a fluid-volume overload by low pressure baroreceptors in the vena cava. This induces a reduction in plasma volume and circulating red blood cell mass. Such changes ultimately lead to relaxation of the cardiovascular system. This relaxation manifests in changes such as reduced heart rate, reduced mean arterial blood pressure and atrophy of the cardiac muscle.[5]

Despite these physiological changes, there has yet to have been an incident requiring cardiopulmonary resuscitation (CPR) or the manifestation of underlying cardiovascular disease in spaceflight. However, an isolated episode of ventricular tachycardia was observed in one astronaut during their second month aboard the Mir space-station.[6] This episode, while asymptomatic, signified that the occurrence of serious cardiac dysrhythmias remains a possibility in microgravity.

The lack of observed pathology in space exploration so far is likely to have been biased by the extremely healthy population that make up astronauts, who had to pass rigorous health checks and fitness protocols. The wealthy space tourist, on the other hand, may lack this level of cardiovascular fitness and may be at higher risk of cardiovascular pathology upon entering the microgravity environment.[6,7] The chance of sudden cardiac arrest (SCA) is always present, even in young healthy individuals, under normal conditions.[8]

For this reason, institutions such as the European Astronaut Centre Cologne and the European Society of Aerospace Medicine have worked towards developing a CPR algorithm for space.

The aim of this review is to understand how prepared the field of space medicine is to manage an event, such as an SCA during spaceflight, with basic life support (BLS). A specific focus has been placed on chest compressions. Other features of SCA response, such as ventilation and drug administration, were beyond the scope of this review.

Methods

A keyword search was conducted on OVID Medline for articles with the terms "Microgravity" AND "Resuscitation" in their titles/abstracts. This produced 17 results. Articles not written in English were excluded to avoid any misinterpretation of content. Articles were then read in depth and 12 were excluded due to either not being related to the subject matter (e.g. assessing airway management rather than chest compressions), being preliminary studies of chest compression techniques (which are evaluated better in more recent studies) or for solely using older CPR guidelines such as American Heart Association (AHA) 2000 guidelines (which make comparisons with more recent studies difficult). Six additional articles were found through exploring the references and citations of the relevant studies to bring the total number of articles included to 11.

Results

It would be impossible to carry out CPR in the same fashion as usual due to no gravitational pull holding the casualty in place. Chest compressions, without prior anchoring, would cause the casualty and rescuer to move apart and prevent anything close to lifesaving CPR.[9] The variety of different CPR techniques developed for microgravity take this into account, either through the rescuer directly anchoring themselves to the casualty, or through restraint together on the crew medical restrain system (CMRS), which is a foldable stretcher/examination table.[9] Currently, seven CPR positions have been developed for microgravity:

1. Standard side straddle (STD) method: This technique much resembles the position used for terrestrial CPR, apart from the fact that the casualty and rescuer are both restrained to the CMRS.
2. Waist straddling manoeuvre (SM): The rescuer performs compressions from on top of the patient, placing their knees either side of the patient's legs. Both rescuer and casualty are fastened together on the CMRS.
3. Reverse bear hug (RBH) method: This technique is an adaptation of the Heimlich manoeuvre where both arms perform compressions on the chest of the casualty.
4. The handstand (HS) method: With this method, the casualty is above the rescuer with their back against a solid surface. The rescuer places their feet on the opposite surface, with both hands above their head on the patient's sternum, and flexes and extends their legs to perform compressions. The patient can be free floating or restrained to the CMRS. **(Figure 1)**

5. The Evetts-Russomano (ER) method: The rescuer must place themselves on top of the casualty, with their left leg over the casualty's right shoulder and their right leg over the left side of the casualty's torso, locking their ankles around the casualty's back to create a base to perform compressions against. This position does not require the CMRS. **(Figure 2)**

6. The Schmitz-Hinkelbein (SHM) method: The casualty is positioned lying across the rescuer's knees. Chest compressions are performed similar to the STD method. **(Figure 3)**

7. The Cologne method (CM): Similar to SHM, but one arm is used to stabilise the patient while the other performs compressions via the elbow. **(Figure 4)**

On Earth, adequate chest compressions are determined by guidelines, such as those published by the ERC. CPR should aim to have a rate of 100-120 compressions per minute and a depth between 50-60 mm.[10] Braunecker et al[11] demonstrated in their systematic review that four of the five initial techniques could reach an adequate compression rate in microgravity. RBH was the only technique which could not (94.7 ± 5.4 /min). With regards to compression depth, HS achieved the greatest depth (44.9 ± 3.3 mm), then the RBH and ER techniques (39.8 ± 6.3 mm and 35.6 ± 6.7 mm, respectively). The conventional terrestrial techniques of SM and STD performed the worst (30.7 ± 11.9 mm and 19.8 ± 11.2 mm, respectively).

Braunecker et al[11] used compression product (CP), calculated by multiplying the compression depth by the rate, as a surrogate measure for the cardiac output from CPR. The CPs for the five given techniques were then compared against the minimum CP required for each guideline. All CPR methods achieved a CP above the minimum required by their respective guidelines (some studies used the AHA 2000 guidelines or the ERC 2010 guidelines which required minimum compression products of 4000 and 5000 mm/min, respectively). HS had the highest compression product (69.3% above minimum CP), with ER second (33.0% above minimum CP). The CP produced by SM was judged as satisfactory according to the authors (29.7%), while RBH and STD were both described as not achieving a sufficient CP (15.2% and 4.3%).

Schmitz et al[12] evaluated the two novel methods of CPR, SHM and CM in an underwater mimic of the microgravity environment. Both techniques achieved compression rates within ERC guidelines (111.1 ± 6.3/min and 102 ± 8.3/min, respectively). Instead of measuring compression depth directly, the authors reported the proportion of chest compressions that were performed at sufficient depth (65 ± 23% and 28 ± 27%, respectively).

Another CPR method under microgravity may be performed mechanically through an automatic chest compression device (ACCD). In a parabolic flight study, Forti et al[13] achieved a compression depth of 49.9 ± 0.7 mm and a compression rate of 101 ± 0.5/min with the ACCD. Both these parameters meet the ERC guidelines.

Discussion

Many challenges exist in developing a clear BLS algorithm for space. Firstly, the identification of someone that is having a cardiac arrest. The characteristic noisy fall that alerts bystanders to someone having an arrest on Earth cannot take place in microgravity. Cardiac arrest detection would be hindered further by the background noise in a spacecraft and obstructed view of passengers from the compartmented layout of most spacecraft.[9]

Automated external defibrillator (AED) deployment, although equally important under microgravity and on Earth, can only be used on a casualty restrained to the CMRS. This is due to the risk of accidental shock of other crew members or damage to the fuselage.[14]

Microgravity-induced physiological changes could also result in CPR becoming a more physically taxing process. These changes include quicker onset of fatigue, reduced skeletal muscle mass and altered muscle metabolism.[15–17] CPR may only be effective for short periods of time before the rescuer would become too exhausted to produce effective chest compressions.

Inconsistencies in CPR method assessment also contribute to the lack of clarity. Some studies used parabolic flight, in which microgravity can only be simulated for approximately 20 seconds.[11] The increased fatigability of certain CPR techniques may not present in this narrow window.[9] Others used underwater CPR. This method may have advantages, such as allowing measurement of CPR parameters for longer periods, but could be a less accurate mimic of microgravity due to water resistance and the continual existence of terrestrial gravity.[12]

It is also unclear what features make a good CPR technique. Technically no method reaches the ERC guidelines for both rate (100-120/min) and depth (50-60 mm). Braunecker et al[11] tried to compensate for this by using the surrogate measure of CP. CP had many limitations as, according to the author's own calculations, all five assessed CPR techniques reached a CP above the minimum required by their respective guidelines, yet only some techniques were described as being satisfactory without clarification of the cut-off points for a strong or weak CP. Additionally, CP ignores the individual importance of compression rate and depth being within guidelines. A poor compression depth and a fast compression rate (both of these harmful to the survival of the casualty) might produce a high CP, masking the poor utility of a technique in real-life scenarios.[10]

In terms of both depth and rate, HS appears to be the strongest CPR method. Additionally, the usage of leg muscles for generating compressions would mean that CPR could be carried out consistently for longer. However, this method does not allow transport of the rescuer and casualty to the CMRS (where medical equipment would be stored) without the interruption of compressions.

On the other hand, the ER and RBH methods do allow transportation. Although, perhaps not as strong a technique as HS, the ER method still produces a strong compression depth and rate, while the RBH method could not produce a sufficient compression rate. For these reasons, the European Society for Aerospace Medicine Space Medicine Group (ESAM-SMG) recommended the usage of ER as a first contact CPR technique, allowing a second rescuer to transport the rescuer and casualty to the CMRS without chest compression interruption. Once secured to the CMRS, ESAM-SMG recommends switching to HS, if the dimensions of the spacecraft allow.[14] However, it must be noted that the ESAM-SMG guidelines were written before the SHM and CM techniques were developed. While the CM technique appeared weak in the underwater study, the SHM technique needs to be compared against ER in order to determine which is the superior first contact CPR technique.[12]

The decrease in CPR sustainability, due to microgravity-induced physiological changes, could be overcome by the deployment of an ACCD when the casualty is secured to the CMRS, as these devices do not tire. The usage of an ACCD was 'weakly' recommended by the ESAM-SMG's guidelines due to the lack of evidence in microgravity when the guidelines were written.[14] However, Forti et al[13] demonstrated in their parabolic flight study that ACCD could consistently produce high quality compressions. In addition to this, there were no pauses or missed compressions, another issue that may be prevalent when CPR is performed by humans and may result in reduced CPR quality.[10] This was highlighted by the multiple periods of no-flow time (no chest compressions for >2 seconds) during the underwater study of SHM and CM.[12] ACCDs do have limitations, such as the evidence that they may delay time to first chest compressions and AED deployment.[18] For this reason, a standard operating procedure would need to be developed for the implementation of the ACCD and AED for treating an SCA on the CMRS.[9] ACCD presents additional logistical challenges. In spaceflight, weight is a key factor for deciding what to include in the medical equipment, the added load of 3.5–8.0 kg of an ACCD may not be justifiable.

Further studies need to compare all seven current CPR positions, under conditions close to microgravity, for longer periods than offered by parabolic flight in order to demonstrate the sustainability of the different CPR techniques (as well as their rate and depth). Such a study could perhaps be achieved with a body suspension device which allows different conditions of gravity, including microgravity, to be applied to the rescuer for extended periods of time.[9]

This article, while achieving its primary aim of evaluating chest compression technique in space, does not take into account other aspects of the BLS response, such as ventilation. In addition, while CPR in space is still a relatively unexplored research area and, thus, does not have much literature behind it, a more comprehensive literature

search could have been carried out through using other databases as well as using synonyms for keywords. However, it is unlikely that a different conclusion would have been reached. Additionally, while this review aimed to standardise the studies evaluated in terms of the guidelines for which CPR is performed, some of the data included in the CP study had been from studies where CPR was performed under AHA 2000 guidelines, which required a lower compression depth and rate.

Conclusion

The growth of space tourism means more people will be subjected to microgravity-induced stress on their cardiovascular system increasing the likelihood of an onboard SCA. If such an event were to occur, it remains unclear whether the current available CPR methods may be effective. Current evidence suggests use of the ER method upon first response. After restraint to the CMRS, the rescuer should switch to the HS method and apply the AED. An ACCD should seriously be considered as a component of the onboard medical equipment, in case of having to perform CPR for extended periods. More research should be conducted in order to clearly demonstrate which CPR methods would work best in the microgravity environment.

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Figures

Figure 1. Handstand (HS) method being performed on a mannequin aboard the International Space Station (ISS) in 2002. (Image from NASA)

Figure 2. Evetts-Russomano (ER) MicroG CPR technique being performed on a mannequin during parabolic flig t (ESA 2000). With thanks to Professor Thais Russomano for providing the image for this article

Figure 3. Schmitz-Hinkelbein method (SHM), (reprinted with permission ©MedizinFotoKöln)

Figure 4. Cologne method (CM), (reprinted with permission ©MedizinFotoKöln)

Tobias Leach

I have just finished my 2nd year of Medicine at the University of Bristol. Space has always been a passion of mine. I have combined this interest in space with medicine through a student choice project in my 1st year on the physiological changes observed in humans in microgravity; and this INSPIRE article with a focus on how resuscitation is impacted by microgravity. I look forward to seeing where I can pursue my interest in space and physiology in the next stage of my medical career.

Research article

The transmission of SARS-CoV-2 from mother to child – anxieties versus reality: a systematic review and discussion

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Abstract

Introduction
Increasing levels of anxiety have been observed among pregnant women surrounding vertical transmission of SARS-CoV-2 and the subsequent effects on the fetus. Therefore, the primary aim of the review is to summarise the available literature suggesting vertical transmission of SARS-CoV-2 with the secondary aim being the outcomes of neonates infected with SARS-CoV-2.

Methods
A MedLine search was conducted, 415 articles were screened based on title and abstract, 26 articles were assessed for eligibility and eight articles were critically analysed.

Results
The eight articles included a collective total of 988 confirmed SARS-CoV-2 positive women and 822 neonates, who were tested for infection. Twenty-four neonates had a positive SARS-CoV-2 test after birth and therefore the rate of vertical transmission is approximately 2.55%. 75% of articles did not observe an increase in neonatal morbidity.

Conclusion
The risk of vertical transmission is negligible and adverse outcomes in infected neonates are rarely seen. Maternal SARS-CoV-2 infection has been linked to preterm delivery. Antibodies may be transferred transplacental or via breastmilk.

Abbreviations

ACE2 - Angiotensin-converting enzyme receptor 2
CMV - Cytomegalovirus
HSV - Herpes simplex virus
NICU - Neonatal intensive care unit
PCR testing - Polymerase chain reaction testing
SARS-CoV-2 - Severe acute respiratory syndrome coronavirus 2
UKOSS - United Kingdom Obstetric Surveillance System
Viral RNA - Viral ribonucleic acid

Introduction

504 million cases of novel coronavirus (COVID-19) have been confirmed worldwide since the discovery of the virus in China in December 2019.[1] The severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is an enveloped, RNA positive virus. The Spike (S) protein, which assembles the viral envelope, assists with viral entry to host cells and replication. SARS-CoV-2 is transmitted by person-to-person contact via respiratory droplets, direct contact and airborne particles and the virus enters the respiratory tract cells using the angiotensin-converting enzyme receptor 2 (ACE2).[2] The most common symptoms of this virus include dyspnoea, continuous cough, pyrexia and myalgia, with approximately 5% of patients developing acute respiratory distress syndrome and becoming critically unwell.[3]

Vertical transmission involves virus RNA crossing the placental barrier and entering fetal circulation. Transplacental transmission of viruses such as cytomegalovirus virus (CMV) has been recorded; CMV may impede placental perfusion and cytotrophoblast invasion.[4] The transmission rate of CMV is approximately 30%.[5] Herpes simplex virus can be transmitted in utero (5%), during delivery (85%) or postnatally (10%) via direct contact with an orolabial lesion.[6] Vertical transmission of SARS-CoV-2 is controversial, however, the ACE2 receptor is expressed on the human placenta, ovary, uterus and vagina and therefore, a theoretical possibility of mother-to-child transmission exists.[7]

Pregnancy has been shown to cause a more severe respiratory disease in patients infected with SARS-CoV-2. Pre-eclampsia and perinatal death have been associated with maternal COVID-19 infection, with the most adverse pregnancy outcome being preterm birth and fetal growth restriction due to microemboli at the fetomaternal exchange interface.[8] Additionally, the immunocompromised status during pregnancy may increase the susceptibility of pregnant women to COVID-19 infection.[9]

Personal informal discussions with pregnant women reveal high levels of anxiety regarding the potential for in utero transmission of the virus. Due to the potential adverse outcomes of SARS-CoV-2 for neonates, understanding the role of vertical transmission during pregnancy is imperative. Therefore, the primary aim of this literature review is to assess and summarise the current available evidence, enabling a conclusion to be drawn regarding the role of vertical transmission of SARS-CoV-2 from mother to neonate. The secondary aim of this project is to understand the neonatal outcomes of infants born to mothers infected with SARS-CoV-2.

Methods

To investigate the risk of vertical transmission from infected mothers to their child and the subsequent neonatal outcomes, a search for published articles was conducted electronically using Medline. An advanced search was run using subject heading searching which was then supplemented with text-word searching. The three main themes included in the search were 'SARS-CoV-2', 'viral transmission' and 'mother-to-child'; search terms relevant to these themes were included and a full list of search terms can be viewed in **Appendix 1**. Initially, 415 articles were found, and articles were screened based on their title and abstract. Articles were considered if they included vertical transmission as their primary aim whilst articles were not included if the research trial was incomplete or if the article consisted of secondary data, such as systematic reviews. The inclusion and exclusion criteria are summarised in the PRISMA diagram (**Figure 1**). 26 full text articles were assessed for eligibility and subsequently reduced to eight articles which were critically analysed.

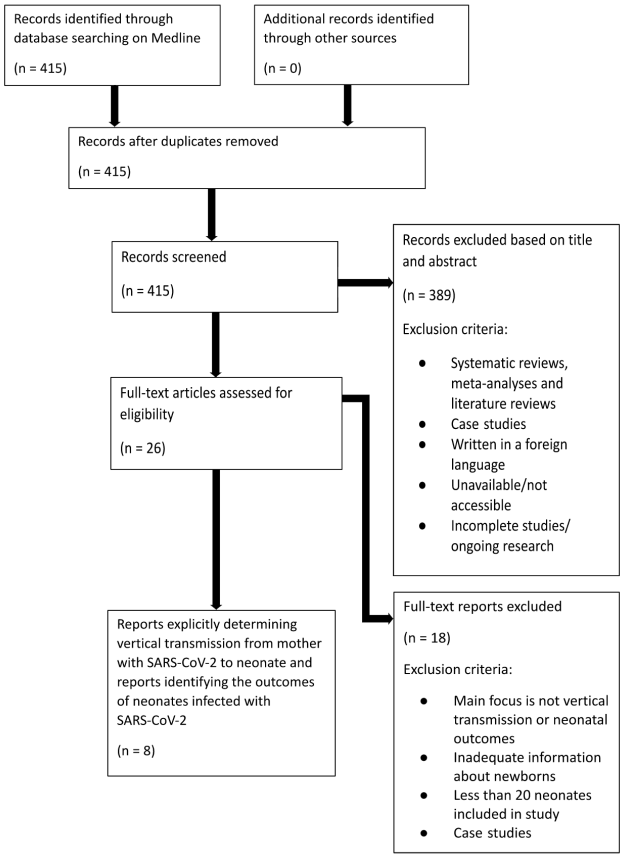

Figure 1. PRISMA diagram summarising exclusion criteria for article selection.

Results

The eight articles have been summarised in **Table 1**, where the presence of vertical transmission and neonatal outcome has been assessed. Fifty per cent of the articles noted the presence of vertical transmission. A retrospective study by Halici-Ozturk et al investigated the potential for vertical transmission in early pregnancy by analysing placental biopsies and samples from abortion material. 210 women with an early pregnancy loss were included in the study and 24 women were positive for COVID-19. There was no evidence of SARS-CoV-2 in any samples taken.[10]

Zhang et al completed a large prospective study in New York involving 142 neonates born to SARS-CoV-2 positive mothers, and of the 138 tested for COVID-19 via a nasopharyngeal swab, one neonate tested positive. This neonate was delivered via Caesarean section and the infection was likely due to vertical transmission. Two more neonates tested positive after seven days, this infection was likely acquired at home. Therefore, this study demonstrated a vertical transmission rate of 0.72%. All three neonates were asymptomatic. This study also investigated the placental histopathology and found no pathologies when compared with placentas from non-infected mothers.[11]

Similarly, Di Guardo et al took cord blood, amniotic fluid and placental samples from 145 pregnant women with SARS-CoV-2 in Italy during a retrospective analysis. Seven of 145 (5%) neonates tested positive for SARS-CoV-2 on PCR testing. Di Guardo also found that there was a higher percentage of term birth compared to preterm birth (62% vs 38%). There were 10 neonatal deaths in total (6%), two of which tested positive for SARS-CoV-2 after death.[12]

A large retrospective cohort analysis in New York by Dumitriu et al supports the previously mentioned studies by Zhang et al and Di Guardo et al. One hundred and one neonates born to 100 COVID-19 positive mothers were testing during this study using nasopharyngeal swabs. Two neonates (2%) had positive results, one born via vaginal delivery and the other via Caesarean; both were asymptomatic. All neonates born to COVID-positive mothers remained well at follow-up appointments.[13]

Contrasting with previously mentioned studies, a retrospective cohort analysis in Jamaica by Moreno et al tested 21 neonates born to 19 mothers who were infected with SARS-CoV-2. Samples were taken using nasopharyngeal swabs 24 hours after birth; these were negative in 100% of neonates and there was a 0% rate of vertical transmission. Unlike in previously mentioned studies, where there was no increase in neonatal morbidity, 61.9% of neonates in this study were admitted to NICU. The most common cause of NICU admission was prematurity. No mechanical ventilation, sepsis or neonatal mortality were observed. Preterm labour occurs in eight out of 21 (38.1%) births and seven (33.3%) neonates had a low birthweight.[14]

Furthermore, Yan et al had similar findings to Moreno et al. This study involved 116 COVID-19 positive women in a retrospective cohort study in China. Sixty-five women were laboratory confirmed COVID-19 cases and 51 were clinically diagnosed. Ninety-nine out of 116 infected women delivered and 86 out of 100 (86%) neonates were tested for SARS-CoV-2 using pharyngeal swab; the results were 100% negative; the vertical transmission rate was 0%. Amniotic fluid and cord blood was also taken from 10 neonates and the samples were 100% negative for COVID-19. No viral nucleic acid was detected in vaginal secretions and breast milk samples. Of the births observed, 21.2% were preterm, 6.1% before 37 weeks. Forty-seven out of 100 (47%) neonates received further treatment in NICU and there was one neonatal death.[15]

A prospective study by Liu et al based in China involved 48 pregnant women: 15 confirmed cases of COVID-19, 17 suspected cases and 16 women without COVID-19. Neonates were separated from mother after birth and samples from amniotic fluid, placental swab, gastric lavage fluid, neonatal serum, throat swab and faeces were tested

using PCR. All 48 neonates (100%) had a negative PCR swab, no neonates showed COVID-19 symptoms and there were no differences found between samples taken from the neonates born to infected mothers and those born to mothers negative for COVID-19. The mean gestational age of neonates born to confirmed mothers was on average one week earlier than the neonates born to mothers without SARS-CoV-2 (37.41 weeks).[16] These findings are similar to previously mentioned studies by Moreno et al and Yan et al.

Contrasting with this, Knight et al completed a large prospective cohort study in the UK using the UK Obstetric Surveillance System (UKOSS). Here, 427 pregnant women with COVID-19 were included and 265 neonates were tested using nasopharyngeal swab or blood samples. Twelve out of 265 (4.5%) neonates showed a positive PCR result. Details regarding the outcomes of neonates with COVID-19 were not recorded, however one neonate of the 12 was admitted to intensive care.[17]

Discussion

Across all studies included in this review, a total of 988 women with confirmed SARS-CoV-2 were included and 822 neonates were tested for infection. Shah et al developed a classification system whereby congenital infection in live born neonates is confirmed by PCR detection of viral RNA in the umbilical cord or neonatal blood within 12 hours of birth or in amniotic fluid prior to membrane rupture.[18]

> *Twenty-four neonates had a positive PCR SARS-CoV-2 swab test after birth, indicating the vertical transmission rate is approximately 2.55%.*

There was some conflict between studies with regards to the outcomes of infected neonates. Di Guardo et al and Knight et al both described a higher rate of vertical transmission than other studies, with Di Guardo et al reported mortality in 6% of neonates. most commonly due to acute foetal distress. Despite finding a 0% rate of vertical transmission, 61.9% of infants were admitted to NICU in the study by Moreno et al. Prematurity and low birthweight were the most common causes for NICU admission in the study. A limitation of Di Guardo's study is that only 21 neonates were included, whilst other studies focused on many more participants.

Five of the eight studies included in this review have used samples such as cord blood or amniotic fluid, rather than solely nasopharyngeal swabs to test vertical transmission. It is suggested that vertical transmission should be tested for using placental biopsies, whilst vaginal secretions can be used to detect intrapartum transmission.[19] Therefore, the studies including cord blood and amniotic fluid samples may be a more reliable example of vertical transmission than those which exclusively included pharyngeal swab testing. Furthermore, it is difficult to distinguish if the neonate was infected with COVID-19 in utero, during birth or post-partum as the neonate was not isolated from the mother after birth in most studies. Wei et al separated the neonates from mothers at birth for 14 days and no neonates tested positive for COVID-19. The other seven studies had neonates roomed in and breast fed by mothers. In all studies nasopharyngeal swab testing occurred within 48 hours of birth, however, Zhang et al found two neonates had a positive test after seven days post-partum – it is likely these were infected via droplet spread rather than in utero.

A study by Schwartz et al investigated the placentas from six neonates who were suspected of acquiring COVID-19 via transplacental transmission and all six placentas demonstrated chronic histiocytic intervillositis and necrosis of the syncytiotrophoblast (inflammatory change at the placental interface). These placental findings were similar to the placentas of stillborn infants and contrasted to healthy placentas from non-infected neonates. Chronic histiocytic intervillositis and syncytio necrosis are associated with poor obstetric outcomes including miscarriage, intrauterine growth restriction and preterm delivery.[20] Microvasculopathy, which may be due to altered coagulopathy seen in SARS-CoV-2 and pregnancy, has been demonstrated in placentas taken from women with SARS-CoV-2 in a separate study. This resulted in maternal and fetal malperfusion, however no transplacental transmission was observed, despite the detection of viral RNA in placental tissue and umbilical cord.[21] On the other hand, Zhang examined 101 placentas from positive mothers and did not find an increase of placental pathologic features when compared to negative mothers.

The role of antibodies in vertical transmission in the above studies is unclear. A study by Flannery et al detected IgG antibodies in the cord blood of 87% of neonates born to asymptomatic women and women with severe symptoms. IgM was not detected in cord blood. Therefore, Flannery et al suggest that transplacental transfer of SARS-CoV-2 IgG antibodies assist in neonatal COVID-19 immunity.[22] The transfer of antibodies in breastmilk has also been investigated: Pace et al analysed milk samples from 18 women following SARS-CoV-2 diagnosis and found that they did not contain SARS-CoV-2. 76% of milk samples from infected mothers contained IgA whilst 80% contained IgG, therefore breastmilk is a beneficial source of SARS-CoV-2 antibodies.[23] The study by Pace et al therefore supports the WHO guidance to continue breastfeeding during maternal COVID-19 illness.[24] The ability for infected mothers to breastfeed was a large concern raised during discussions with pregnant women, therefore, understanding the role of antibody transfer in breastmilk is useful to provide advice for women who are considering breastfeeding.

Filiz Halici-Ozturk et al was the only study to investigate early transmission of SARS-CoV-2 as most of the other available literature included mothers in their third trimester. No evidence of transmission was detected in this study, however, more research must be done to determine the effect of infection in early versus late pregnancy. A further limitation of the literature discussed was that most studies were retrospective and only Liu et al included a case group for comparison. Studies with a strong suggestion for vertical transmission were most commonly case studies, which are less reliable than large cohort studies and therefore not included in this literature review.

Discussions amongst pregnant women also reveal a large concern surrounding preterm labour. Zhang et al did not find an increase in preterm delivery, however, Di Guardo et al and Yan et al observed preterm labour in 38% and 21.2% of pregnancies respectively, suggesting higher rates of preterm delivery than the national average, which was 7.8% in the UK in 2019.[25] Dumitriu indicated that severe SARS-CoV-2 is associated with a preterm labour of one week earlier on average than babies born to mothers with mild SARS-CoV-2. Preterm labour may be a result of previously mentioned placental changes. Yan et al also recorded iatrogenic preterm birth, fetal distress, poor obstetric history and preeclampsia as causes of preterm birth in their study. Despite finding the risk of any preterm birth before 37 weeks is increased in COVID-19 infection, their study did not indicate there is an increased risk of spontaneous preterm birth before 37 weeks.

Conclusions

Informal discussions with women reveal anxieties experienced during pregnancy surrounding the health of their unborn neonate and the potential for in utero infection, leading to distress and, in some cases, social isolation. However, vertical transmission is a very rare complication of SARS-CoV-2 infection in late pregnancy, with a transmission rate of approximately 2.55%. Infected mothers may be at increased risk of preterm delivery and placental abnormalities, although the evidence regarding placental abnormalities is conflicting.

Author	Study Location	Duration	Study Design	Total Number of Pregnant Women and mean gestational age	Number of Pregnant Women with SARS-CoV -2	Total Number of neonates	Number of Neonates positive for SARS-CoV -2 after birth	Samples taken	Vertical Transmission	Vertical Transmission Confirmed By	Neonatal Outcome
Halici-Ozturk et al	Turkey	September – December 2020	Prospective Study	210 women with pregnancy loss before 24 weeks of gestation	24	NA (early pregnancy loss)	NA (early pregnancy loss)	Maternal Nasopharyngeal Swabs Placental biopsy and samples from abortion material	No (0%)	SARS-CoV-2 Quantitative RT-PCR	NA (pregnancy loss) No difference between SARS-CoV-2 positive and negative mothers
Zhang et al	New York	March – August 2020	Prospective Study	219	142	143	1/138 (tested after birth) (2 more positive after 7 days)	Nasopharyngeal Swabs of Mother and child Placental Histopathology	Yes (0.72%)	SARS-CoV-2 Quantitative RT-PCR	Infected babies were asymptomatic
Di Guardo et al	Italy	March – July 2020	Retrospective Analysis	145 (36 weeks)	145	145	7	Amniotic fluid, placenta samples Cord blood	Yes (5%)	SARS-CoV-2 Quantitative RT-PCR	2 deaths among covid positive neonates
Dumitriu et al	New York	March – April 2020	Retrospective Cohort analysis	100	100	101	2	Nasopharyngeal swab for mother and neonate	Yes (2%)	SARS-CoV-2 Quantitative RT-PCR	Both infected babies were asymptomatic
Moreno et al	Jamaica	March – April 2020	Retrospective observational study	19 (37 weeks)	19	21	0	Nasopharyngeal swabs on mother and neonate	No (0%)	SARS-CoV-2 Quantitative RT-PCR	61.9% admitted to NICU No neonatal mortality
Yan et al	China	January – March 2020	Retrospective Cohort Study	116 (38 weeks)	116 (99 delivered)	100	0	Maternal and neonatal Nasopharyngeal swab. Amniotic fluid, cord blood, vaginal secretion and breast milk samples.	No (0%)	SARS-CoV-2 Quantitative RT-PCR	47% admitted to NICU No neonatal mortality
Liu et al	China	January – March 2020	Prospective Study	48	15 confirmed 17 Suspected	48	0	Samples from amniotic fluid, placental swab, gastric lavage fluid, neonatal serum, throat swab and faeces Oropharyngeal and faeces swab	No (0%)	SARS-CoV-2 Quantitative RT-PCR	No difference in neonatal outcomes in those born to mothers positive for COVID19 and those born to negative mothers
Knight et al	United Kingdom	March – April 2020	Prospective Cohort Study using UKOSS	427 (34 weeks)	427	265	12	Nasopharyngeal swab or blood for mothers and neonates	Yes (4.5%)	SARS-CoV-2 Quantitative RT-PCR	1 infected neonate was admitted to a neonatal unit 25% neonates admitted to NICU

Table 1. Table of results summarising the eight articles analysed for vertical transmission and neonatal outcomes

> *Further studies should be conducted to determine if preterm delivery is truly an adverse outcome of antenatal COVID-19 infection.*

Neonates infected with SARS-CoV-2 are most commonly asymptomatic and there is little evidence for increased neonatal morbidity. Vertical transmission is not affected by mode of delivery. Breastfeeding is safe and may provide antibodies against SARS-CoV-2. Further studies using more samples from amniotic fluid, cord blood and vaginal secretions must be conducted to determine whether the virus is transmitted in utero, during delivery or postpartum. With the recent development of the vaccine, further studies should be conducted to determine the role of vaccination in reducing rates of vertical transmission and improving neonatal outcomes.

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Copyright

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Appendix

Appendix 1: Search terms input on Medline

1. Exp COVID19
2. SARS-CoV-2
3. COVID19
4. Novel coronavirus
5. 2019 novel coronavirus
6. SARS-CoV2
7. COVID-19
8. Exp infectious disease transmission. Vertical
9. Vertical transmission
10. Contact transmission
11. Transplacental transmission
12. Delivery transmission
13. Post partum
14. Mother-to-child
15. Maternal
16. Fetal
17. Foetal
18. Fetus
19. Child
20. Baby
21. Embryo
22. Mother adj3 child
23. Mother adj3 baby

Tamsin Mantel-Cooper

I'm currently in my 4th year at Cardiff University studying medicine and I have a keen interest in obstetrics and gynaecology. I have explored my passion for women's health by participating in the committee for the 'CoppaFeel!' University society, raising awareness for breast cancer amongst the public. I hope to pursue these interests throughout my career.

Research article

Student perspectives of sustainable healthcare education: a focus group study of Cardiff medical students

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Abstract

Introduction

The climate crisis is a health crisis. The General Medical Council has responded to the threat by requiring that all medical graduates need to be able to apply principles of sustainable healthcare to their practice. Cardiff University's own environmental policy affirms its intention to teach sustainability effectively. However, these aims are not yet met within the curriculum. Cardiff Medical School intends to revise its curriculum, including an incorporation of sustainable healthcare teaching.

Methods

To determine the best way to go about including sustainable healthcare in the Cardiff medical curriculum, this project aimed to assess student knowledge on the topic and collate student voices regarding how to teach and exam it. The study involved hearing from 28 students in six focus groups and comparing the data with requirements for graduates and with literature about best teaching practice.

Results and Conclusion

Core teaching on sustainable healthcare is inadequate, and students feel disempowered to address the health needs of the world they will graduate into. Addressing these deficiencies would involve implementing teaching early in the curriculum, and encouraging students in later years to apply the principles of sustainable healthcare to quality improvement and their daily practice.

Abbreviations

GMC – General Medical Council
ISCE – Integrated structured clinical examination
NHS – National Health Service
SBA – Single best answer
SSC – Student-selected component

Introduction

The climate crisis is a health crisis. From threatening food security to causing mass casualties through severe weather events, it is already having a broad range of health effects across the globe. These are projected to only increase in scope and severity.

According to the Lancet's most recent Countdown report, *"on the current trajectory, climate change will become the defining narrative of human health"*.[1] The dangers posed by climate change demand responses from the healthcare sector, and the General Medical Council's (GMC) Outcomes for Graduates, published in 2018, now includes requirements for new doctors to be *"able to apply the principles, methods and knowledge of … sustainable healthcare to medical practice"*.[2]

Unfortunately, significant discrepancies between the need for sustainable healthcare teaching and what is delivered still exist UK medical schools.[3] This is especially so at Cardiff University, where a recent international assessment rated it the lowest of 31 medical schools for the promotion of planetary health.[4] A review of the curriculum and teaching methods are needed to prepare students effectively for the world they will graduate into.

Aims

In light of these needs, this study aimed to inform planning for curricular revision, by:

1. Assessing the current knowledge of Cardiff medical students, and gaining insight on their thoughts regarding sustainable healthcare teaching, and

2. Comparing these results with relevant literature, in order to produce tailored and contextualised recommendations to the medical school.

Methods

Design

The primary aims of the study were achieved through a series of focus groups. Focus groups were chosen as a study design due to the richness of data obtainable, and the semi-informal setting which would encourage free speech, thereby allowing participants to prompt each other and stimulate inter-participant contributions. Ethical approval was granted by the School of Medicine Research Ethics Committee in February 2022.

Data collection

Participants in the study were current undergraduate Cardiff University Medicine students. The study was advertised via online noticeboards (such as Learning Central and the Cardiff Medics Facebook group) and through personal contacts. All participants completed a consent form to confirm that they understood the aims of the research and how their data would be used. Participant consent was also checked verbally at the start of each group discussion.

A total of 28 participants were interviewed in six groups, which were stratified by year of study. Three groups ran in person, and three online, according to participant availability and preference. Each group discussion lasted between 45 and 60 minutes. The content of the discussion followed a semi-structured format, in which participants were encouraged to speak freely about the topic with the facilitator offering prompting questions at intervals. The prompts used were derived from the aims of the study and informed by the background reading:

a. *Opening Question: What are the current and projected future health impacts of climate change?*
   i. Who is/will be most affected?
b. *Transition Question: How does healthcare contribute to climate change?*
c. *Transition Question: What role and responsibilities, if any, do healthcare professionals have in addressing climate change?*
   i. Do you feel adequately prepared to meet this role in future as graduates?
   ii. What can/should medical student do to help address climate change?
d. *Key Question: What teaching have you had that is relevant to climate change and sustainable healthcare?*
   i. What do we know about the physical basis for climate change?
e. *Key Question: Should sustainable healthcare have greater representation in medical curricula?*
   i. What should be taught?
   ii. How should this topic be addressed, and at what stage of the Cardiff medical curriculum (for example) might it be most appropriate to address it?
   iii. What are the barriers to engaging students in sustainable healthcare education?

Data analysis

Focus group discussions were audio and video recorded to enable coding and analysis. The researcher took notes on each recording, including some verbatim transcriptions of quotes from participants. Transcripts were anonymised in this process. Participants' contributions were coded by theme, with the themes being generated in part from the questions used, and in part from the data itself (i.e. grounded theory). The coded data was analysed with reference to the relevant literature, to contextualise an understanding of it within the body of work on sustainable healthcare teaching as a whole.

Results

Participants

The characteristics of the six groups and the coding assigned to the 28 participants are described in **Table 1**. The coding structure assigned to the data is described in **Table 2**.

Group Number	Year of Study	Number of Participants	Anonymised Code Assigned
Group 1	2	6	P1-6
Group 2	2	6	P1-6
Group 3	1	4	P1-4
Group 4	3	4	P1-4
Group 5	2	5	P1-5
Group 6	4 & 5	3	P1-3

Table 1. Composition of focus groups by year of study

Theme	Subtheme
Student Knowledge	The Health Impacts of Climate Change
	The Contribution of the Healthcare Sector to Climate Change
	Waste Production and Disposal
	Misconceptions
Perceptions about the Roles and Responsibilities of Healthcare Professionals	Raising Awareness
	Personal Integrity
	Feeling Disempowered
	Feeling Underprepared
Teaching Sustainable Healthcare	Limited Teaching Received
	A Crowded Curriculum
	A Need For Examination
	The Format and Content of Teaching

Table 2. Themes and subthemes identified during analysis of focus group data

Student knowledge

Students were asked what they knew about the impacts of climate change on healthcare and health needs, and conversely, the contribution of the healthcare sector to climate change.

The health impacts of climate change

All groups were able to suggest a few effects of climate change that directly related to health, such as threats to life from flooding or forest fires, or a greater burden of disease due to a wider spread of infectious diseases. Most participants could describe some of the more general manifestations of climate change, such as rising sea levels, but struggled to link these directly to health effects. Students in almost every group associated climate change with increased air pollution; other forms of pollution were also considered, such as a build-up of microplastics in the environment and bioaccumulation of drugs and drug products, especially in potential food sources.

Students were asked about who would be most affected by these threats. Overall, vulnerability to the health effects of climate change was understood to be in line with current vulnerabilities to other health risks. For example, many groups believed that those with existing multiple comorbidities were at greater risk. Students gave examples of regions that were more vulnerable to weather events,

like tropical storms in Haiti, wildfires in Australia, or flooding in Venice. The majority of groups described how people in resource-poor countries would be more at risk, with people with a lower income within each country likely to be affected most. Students described how climate change may be especially detrimental to populations where employment depends on agriculture, and may pose a risk of malnutrition for populations in hotter climates. Moreover, there was a recognition that food insecurity could cause conflict. These themes are exemplified in the following quotes:

FG2-P2: *"Lower income countries will see more of the effects of climate change, because they don't have the means to defend against it."*

FG3-P1: *"The poorest people are always going to feel the effects of climate change the worst. People in poorer countries are already feeling the effects of climate change. A lot of people, agriculture-wise, rely on seasonal rainfall, or can't afford fertilisers or genetically modified or drug-resistant crops."*

FG3-P1: *"Climate change could cause war over water and resources. It's difficult to get a healthcare system running in conflict."*

The contribution of the healthcare sector to climate change

Students recognised that like all large organisations, the healthcare sector's operations are highly energy intensive, which to some degree depends on the burning of fossil fuels. Some examples given were the amount of power that scanners used, the NHS's use of vehicles, including the travel of patients to healthcare centres (increasing with the specialisation of tertiary care centres) and commuting of staff, the production of food and drugs given to patients, and the transportation necessary in the supply chain. Some contributions independent of energy usage were also identified, such as the use and leakage of anaesthetic gases.

One student recognised that the heart of the problem was a concern for patient care without consideration of the environmental impact.

FG5-P3: *"We're trying to do more and more and more, without the idea of the environment in our minds. We're constantly adding new things to the NHS that we can do, without thinking about the impact that it's going to have on the future. I think that that's where a big problem has been. It's one thing to try and get better, but no-one's thinking about what problem we're going to create in the future afterwards."*

Waste production and disposal

Perhaps surprisingly, all groups linked climate change with the healthcare sector's production of waste. In fact, in five of the six groups, it was the very first factor offered in answer to the question, 'How does healthcare contribute to climate change?'. While single-use items were important to maintain sterility and patient safety, students believed that this was overdone, and was both inefficient and wasteful due to the *"… extreme usage of material per procedure"* (FG5-P1). The link between waste production and climate change was characterised through an explanation that disposal of waste, especially the biohazardous materials produced by modern healthcare, often involved incineration and carbon emissions.

Misconceptions

Some participants clearly did not appreciate that the intention of sustainable healthcare is to attend to the needs of present-day patients whilst safeguarding the needs of future patients. Several students associated themes of sustainability more strongly with protection of the natural world, rather than with care of patients' best interests.

FG5-P1: *"Is sustainability and reducing our environmental impact no matter the cost the most important thing? When you start talking about it in that regard, you start taking money away from looking after people to say, 'actually let's make sure we don't damage the environment.' What's more important? ….it depends on what you value more… sustainability and being environmentally sound, at the expense of potentially saving more money put into research areas that could actually make a real difference to people's lives."*

Perceptions about the roles and responsibilities of healthcare professionals

Students were prompted to discuss the responsibilities of individual practitioners, and the healthcare sector as a whole, in addressing these issues.

Raising awareness

Some participants described the helplessness that they felt about responding to climate change while still students. In response, others reasoned that their main responsibility whilst students was to become educated about the environmental impact of care. This could be done actively, in holding the medical school accountable for teaching sustainable healthcare in a relevant and engaging manner.

Some groups argued that doctors also have a role in educating patients about the health impacts of climate change, just as they do about the impact of their lifestyle choices. They believed that this responsibility is linked to the privileges that doctors have in being trusted and in interacting with large parts of the population.

FG3-P3: *"I think people need to understand that climate change is a health problem too. People think that climate change is only environmental."*

Personal integrity

Students were keen to discuss how doctors should be exemplary in their personal lives, so as to not undermine the efforts towards sustainable healthcare made in their professional roles. In fact, in their opinion, part of the medical school's teaching should encourage this attitudinal development.

FG3-P1: *"[We'd value teaching on] reducing your carbon emissions. Everyone should have an awareness of their own carbon footprint and carbon emissions."*

Feeling disempowered

A consistent theme between groups was how students felt that an individual's changes to their everyday practice would not make an adequate difference. Indeed, some students argued that lobbying legislation-makers was a more effective method for doctors to enact change, in comparison to making small-scale changes to their own daily practice. To them, the focus of patient-facing professionals should be on the care of the patient in front of them, whereas scrutinising the system for its sustainability was the responsibility of policy-makers.

FG5-P2: *"Big change has got to come from somewhere that isn't med students or individual healthcare providers."*

FG3-P1: *"There is definitely some stuff that the individual can do around climate change. But the massive stuff that needs to be done, needs to be done by the government: it's changing massive polluters in the industry. The individual does have some role, but you can't forget that it's still these big companies that are responsible for the vast majority of emissions."*

Others expressed how the hierarchical nature of healthcare systems meant that, as a student or a junior doctor, they would not expect to be listened to should they suggest improvements. Additionally, they would not know who to escalate areas of potential improvement to, or how to do it. Their impression was that students and juniors are expected to comply with relevant protocols unquestioningly.

FG6-P1: *"From a hands-on, bottom-of-the-ranks kind of position it feels quite difficult, because you have to stick to the rules that are made by the people above you."*

FG6-P3: *"You get rinsed enough if you even mention something from a medical point of view, let alone something that people are not going to care about. We have a really bad culture within the NHS and healthcare of a hierarchical nature."*

Feeling underprepared

Students consistently described that they felt unprepared to practice sustainably as future graduates. They listed a general lack of teaching (bar a clinical skills session on using bins), and not knowing who to go to for help as the main reasons why they felt underprepared. One student, who believed in making day-to-day changes to practice, still confided that, *"I don't know what those small changes are. That makes it a challenge to say what our responsibility is"* (FG5-P5).

Teaching sustainable healthcare

Students were asked about what teaching they had received and what they wanted to be taught on the topic.

Limited teaching received

Students had received little teaching directly aimed at sustainable healthcare within the medical curriculum. Most participants cited other sources, like the media or secondary school teaching, for their knowledge on sustainability, and they used their own reasoning to provide the links with healthcare.

Facilitator: *"Do you feel that you've received adequate teaching on sustainable healthcare?"*

FG2-P3: *"Obviously, no! We get more resources through what we see on the media, and what's on the TV currently, than what's been given through the medical school… not yet."*

A crowded curriculum

A repeated theme was students' fear that they would not be able to take on any additional work, given the content-heavy state of the curriculum already. For some students, when combined with the misconception that sustainable healthcare is not directly relevant to patient care, this represented strong reasoning against incorporation within teaching. However, the majority of participants recognised that given the urgency of the issue, awareness about sustainable healthcare is desperately lacking.

FG1-P4: *"So much other stuff that you have to learn!"*

FG3-P4: *"We're taught about diseases that are deadly; climate change is also deadly."*

FG4-P4: *"If you think about how Covid-19 was implemented into every single aspect of our curriculum, you couldn't get a single lecture without mention of it. It was a very good thing; it was very poignant for the time. Why can't we do that with sustainable healthcare?"*

A need for examination

A significant amount of time was spent debating the relative merits of examining sustainable healthcare concepts. The consensus was that examination would be needed to reinforce the importance of the topic and to give students an incentive to engage with the teaching in the face of the burden of other examinable content.

FG1-P6: *"I wouldn't do it if it was optional, because of the other stuff that would come up in the exam. We'd fall behind."*

FG2-P6: *"A lot of medic students say, 'am I going to be tested on this? If the answer is no, then I don't care.'"*

The format and content of teaching

The majority of participants favoured learning that was discussion-based or practical over workbooks or lectures, as this would give them opportunity to apply their knowledge. One key suggestion involved formative quality improvement projects that would introduce themes of sustainable practice whilst training graduates in critical thinking skills. Students volunteered a broad range of themes that they wanted further teaching on: for some, they still need grounding in the fundamentals like the health effects of climate change, whereas others recognised that wider teaching on concepts of public health could help them make a difference. Moreover, participants wished to directly associate the concepts taught with the context of patient care.

FG5-P1: *"Also, I feel like sustainability is a practical element, not a theoretical element. It's something that you apply. These are things that you learn through training, through experience, through following policy, not something that necessarily you're going to listen to in a classroom."*

FG1-P6: *"Having not been in a hospital, and not seen many patients, it's hard to know what's realistic, and what could be done."*

Many groups desired the introduction of sustainable healthcare from the early stages of the Cardiff medical curriculum. This approach would have the advantage of setting a context for integrating sustainable healthcare into any subsequent and further teaching. Moreover, it would help ensure that all students gain an equivalent understanding.

FG1-P6: *"If we started it in first year, it would be better because then you have it in the back of your mind when you do everything else. If you do it at the end of second year just before you go into hospital, then you're thinking about it, through everything you learnt."*

Discussion

The results indicate that, overall, students have a vague and elementary knowledge of the topic, insufficient to prepare them for their future practice. This is consistent with Cardiff's poor performance in the Planetary Health Report Card metric.[4] However, students desire serious and realistic teaching that reflects the urgency of responding to climate change, and outlines opportunities for doing so.

Students' understanding

Discussions regarding the links between climate change and health were largely built upon on-the-spot reasoning than prior knowledge or received teaching. For example, analysis of the phrasing of students' contributions reveals that many responses were prefaced with qualifiers such as "I'm not sure" and "I guess". The structure of many students' answers to prompts followed a cause-and-effect chain that suggested that they were formulating their reasoning as they spoke. Furthermore, though groups could collectively succeed in constructing a fairly broad (albeit vague) list of links between health and climate change, it was clear that most individual students struggled to contribute more than a few simple facts on the topic. Students' understanding – conferred on them by media and external sources – was basic at best.

Applying understanding to future roles

This basic understanding is far removed from the GMC's requirements for graduates to be "able to apply the principles, methods and knowledge of … sustainable healthcare to medical practice".[2] Clinical teaching experts have emphasised that future graduates must not

only be taught knowledge but must also develop the skills and attitudes necessary for good practice in sustainable healthcare.[5,6] The lack of confidence and fluency among Cardiff medical students around foundational knowledge indicates that students are still not fully equipped in beginning to develop those skills and attitudes,[7] and much less so to then "apply" that knowledge and those skills to medical practice as desired by the GMC. Indeed, some students were able to sketch out the various spheres in which they might have responsibility in addressing climate change, but none could explain with confidence how they would approach doing anything about it. The majority of interviewees in this project confessed that they did not feel adequately prepared to practise sustainably in their roles as future doctors.

Teaching and examining sustainable healthcare

Learning outcomes for teaching sustainable healthcare already exist and have been trialled at other medical schools.[6,7,8] The key set described by Thompson et al,[9] are:

- *Describe how the environment and human health interact at different levels*
- *Demonstrate the knowledge and skills needed to improve the environmental sustainability of health systems*
- *Discuss how the duty of a doctor to protect and promote health is shaped by the dependence of human health on the local and global environment*

It is easy to imagine how the first outcome can be pursued in the case-based learning model, by integrating a discussion about environmental risk factors into the determinants of health. The second outcome is strongly associated with the Centre for Sustainable Healthcare's *"sustainable value"* in quality improvement, which aims to achieve the best outcomes for patients and populations whilst taking into account a *"triple bottom line"* including not only financial costs but social and environmental costs as well.[10] Student voices from other universities concur with this study in recommending the use of quality improvement projects in the clinical teaching years as a means of encouraging students to analyse healthcare systems in view of this principle.[11]

Other medical students around the UK have expressed views similar to those of participants in this study, that any teaching on sustainable healthcare must be reinforced with examination. *"Pressure on students from the quantity of examinable material means important, but non-examinable, material is easily ignored"*.[12] Indeed, clinical teaching experts also recommend a mix of formative and summative assessments that will motivate student engagement and help them to consolidate their learning.[13] In line with the GMC's requirements that students are able to *"apply"* their knowledge, it is critical that assessment *"not only tests acquisition of knowledge but also its application"*.[13] Suggestions for this extend beyond this study's participants' conceptions of single best answer (SBA) questions, into, for example, models of assessment like an integrated structured clinical examination (ISCE) station where students are asked to identify preventable or environmental causes of disease.[6]

Limitations

Though this study has been very helpful in uncovering gaps in understanding, it cannot be considered to be fully representative of the Cardiff medical student body. This is due to the small sample size, and the method of participant recruiting through purposive sampling rather than random selection. Moreover, though the recommendations for curricular remodelling set forward in this report are founded on qualitative evidence and review of scientific literature, they do not have the authority that direct trials of teaching methods and outcomes would have.

Conclusion

It is the responsibility of medical schools to respond to the impending health crisis that is climate change by adequately preparing their graduates to mitigate further damage and adapt to new global health needs. The future's doctors *"need to be prepared to be champions for sustainable change in our workplace and advocates for our patients who will inevitably be impacted by climate breakdown"*.[14] The author's recommendations for implementing sustainable healthcare education within the Cardiff medical curriculum are:

- Introduce the concept early on, preferably within the Platform for Clinical Sciences block within the Autumn term of first year. This will broach awareness of the topic at the beginning of the spiral curriculum and enable students to see how planetary health is relevant to all future topics covered.
- Include environmental risk factors and potential co-benefits of mitigation measures relating to diet, air quality, transport, etc. within the model of health and disease discussed in case-based learning. This is an excellent opportunity to make use of group discussion to engage students, and to discuss the benefits of early-stage prevention of disease over late-stage interventions.
- Include discussion of the environmental cost of treatment options in case-based learning.
- Revise the third year student-selected components (SSCs) to include the "triple bottom line" and sustainability elements within quality improvement projects.
- Continually review the delivery of the course with regards to sustainability, to set a good example for students, and mitigate further environmental damage.

In short, students' current understanding is vague and basic. However, this in fact presents an excellent opportunity: changes to medical education now will have major positive effects in producing the sustainable practitioners of the future.

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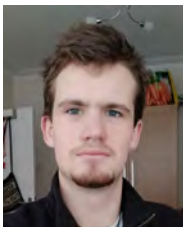

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Case Study

Difficulties f ed by GP trainees in a semi-rural surgery in North Wales during the Coronavirus pandemic

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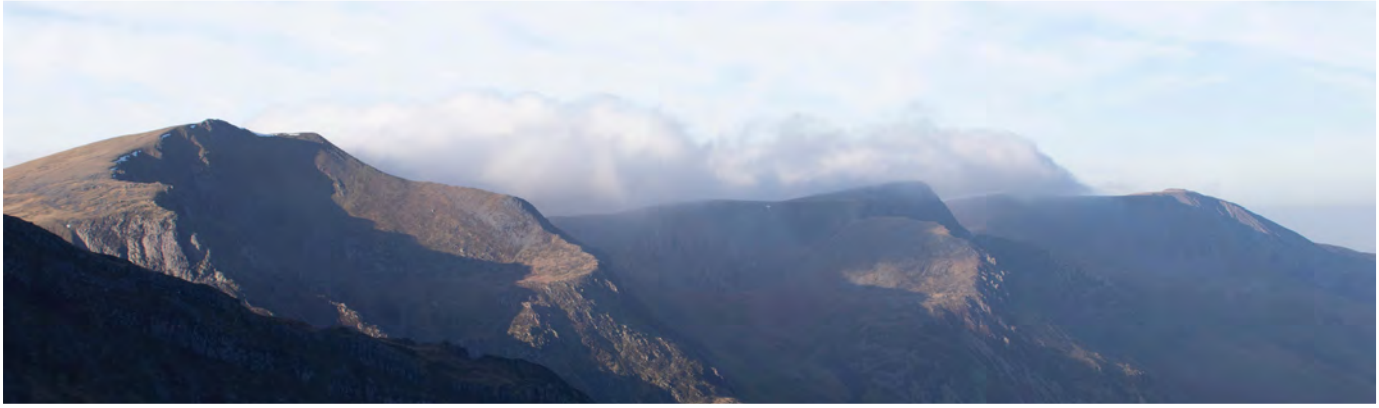

Abstract

This project aims to explore the difficulties encountered by general practice (GP) trainees in a rural area during the COVID-19 pandemic to identify areas of training that can be improved to allow less disruption should future pandemics occur. To do this, I observed two GP trainees in a surgery in North Wales from October 2020 to April 2021 and conducted two semi-structured interviews. Trainees encountered difficulties mainly attributed to resource availability, geographical location, elderly demographics, disrupted training and assessments. Findings suggest that GP training should incorporate pre-determined protocols for reorganising training in the event of a pandemic and focus more on developing trainees' ability to manage stress, loneliness and diminished resources or service availability.

Abbreviations

A&E – Accident & emergency
AKT – Applied Knowledge Test
CCT – Certificate of completion of training
COVID-19 – Infection by Sars-CoV-2
CSA – Clinical Skills Assessment
FeNO – Fractional-exhaled nitric oxide
GP – General practice
HEIW – Health Education Improvement Wales
IT – Information technology
PPE – Personal protective equipment
RCGP – Royal College of General Practitioners

Introduction and aims

The COVID-19 pandemic disrupted medical education in ways not seen for some time. However, it is unavoidable that similar pandemics will occur again.[1] The disruption caused from March 2020 onwards shows that this is unsustainable for the healthcare system. Therefore, it is important we understand how medical training is disrupted so that corrective measures can be put in place. This prevents another pandemic from jeopardising the training of future medical practitioners.

At the same time, there are well-known difficulties to practising medicine in a rural setting which, when combined with the disruption caused by the pandemic, would present unique challenges to doctors. There is little literature on this particular niche but, with future pandemics likely,[1] the execution of training has implications for recruitment and retention in rural general practice.

This study aims to identify difficulties faced by GP trainees during the pandemic, methods developed to overcome them and ways GP training can be improved.

GP training[2,3,4,5]

General practice training is overseen by the Royal College of General Practitioners (RCGP) but, in Wales, it is delivered by Health Education Improvement Wales (HEIW), effectively the Welsh Deanery for specialty training. Specifics differ around the UK but training usually lasts three years and involves 18 months each in a hospital and a GP surgery. Trainees also need to pass workplace-based assessments; the Applied Knowledge Test (AKT) which is a written exam, and the Clinical Skills Assessment (CSA), which is a hands-on clinical assessment. Due to COVID-19, the CSA was replaced with consultation recordings. Trainees must send off 10 recordings of consultations on specified topics for assessment.

In the GP surgery, the trainee will be guided by an experienced GP with further qualifications in training. The trainees I observed had weekly tutorials hosted by their training supervisors on topics they request, and regularly have time reserved for self study. The result is a certificate of completion of training (CCT).

Method

The study was conducted through overt observation in consultations with two GP registrars in a surgery in North Wales, supported by two semi-structured interviews in October 2020 and February 2021. The questionnaires for the interviews were made by the author himself. Questionnaire 1 (**Appendix A**) was used in October 2020 while questionnaire 2 (**Appendix B**) was used in February 2021. Findings were reviewed and common themes and ideas (called codes) were identified (**Appendix C**). This was done because the codes are then reviewed, allowing overarching themes and common ideas to be identified as results. The themes and overarching ideas were also reviewed alongside the responses given by the two trainees so additional insights can be identified that further our understanding.

Results

The trainees I observed were both based in the Bangor stream and in a semi-rural practice. Both started their general practice rotations in early 2020. Before that, one worked six-month rotations in accident & emergency (A&E), paediatrics and care of the elderly, while the other rotated in A&E, obstetrics and gynaecology, and psychiatry. When the study began, both already started recording consultations and attempted the AKT soon afterwards.

There were many difficulties that arose from changes implemented due to COVID-19. Due to the need for social distancing, the CSA was replaced with a recorded consultation assessment (RCA). The RCA caused difficulties with finding patients presenting with the required complaints and keeping consultations within a strict 10-minute limit. The online system used in portfolio management (for recording workplace-based assessments) was also changed during the pandemic, and trainees experienced difficulties migrating content between the old and new platforms which, alongside the RCA, added to their frustrations that the RCGP "don't have any idea of what clinical work is and what it's like on the ground". According to one trainee, he has "more things to do during the year" and "tried to migrate entries across from the old portfolio to the new one, which hasn't worked really well and so now it's impossible to find your old entries", describing the RCGP as "incredible".

Trainees were pleased they could sit their AKT in Autumn 2020 and both passed first attempt. One trainee was pleased that online lectures were able to cover a wide range of topics, from pathology to the everyday business and legal aspects of being a GP. Both trainees sang the praises of their helpful training leads. However, they were unhappy with the administration side of HEIW, such as the poor quality of phone support and conflicting guidance on the requirements regarding their assessments. They were also unhappy that there was a period at the beginning of the pandemic where in-person lectures were halted and they did not receive teaching until lectures resumed online after several weeks, with the topics missed never taught to them afterwards.

Outside of training itself, the GP trainees found that phone consultations added some difficulties to their practice. More specifically, despite the advantages, the lack of visual cues hampered the assessment, diagnosis and management of some patients. Trainees treated some patients based on the empirical diagnosis without performing examinations. As telephone consultations were still relatively new at the time of the study, trainees and their fully-qualified colleagues both worked together and exchanged ideas to improve their clinical practice.

Both trainees overcame the lack of visual cues by keeping their threshold for face-to-face consultations low, bringing in more patients for physical examinations than their fully-qualified colleagues. There were also methods introduced to overcome the lack of visual cues in some patients, for example patients with dermatological lesions could send in pictures instead, although this was not applicable to all conditions. Trainees also expressed an even-lower threshold for paediatric cases to avoid relying fully on a collateral history, corresponding with published literature.[11]

The demographics of rural areas also affect daily practice. There is a larger proportion of elderly,[12] which the trainees felt was harder to manage because of additional comorbidities and contraindications to certain treatments. Both have received outright refusals for admission from patients "for fear of catching COVID" as one trainee put it, and had to factor the distance the patient lives from hospital into consideration when admitting.

Trainees also took larger roles in managing patients as services were less available, in fitting with the literature.[15,19] For example, gonorrhoea swabs (which were orange) were not available in the surgery, so trainees had to make do sending off samples using chlamydia swabs instead (which were yellow). Certain diagnostic tests were also mentioned as not being available, such as fractional-exhaled nitric oxide (FeNO) for asthma. To compensate, trainees and their fully-qualified counterparts alike used alternative investigations and monitored the responses to specific medications to support their diagnoses. However, not every trainee was disappointed, one saw it as a good opportunity for further development, saying "I probably got much more from it" than during normal times.

A surprising challenge was the loneliness felt by the trainees, who mention that they saw family less often than normal. The increased reliance of trainees on colleagues helped foster deeper relationships which was bolstered by the greater sense of community and better work-life balance associated with rural training posts,[19] going some way to countering loneliness.

Discussion, implications for future GP training and limitations

As the assessments including the CSA, RCA, portfolio and AKT are all managed by the RCGP, it was not surprising that the complaints were more directed towards the RCGP than HEIW. Both trainees mentioned that there was a period where they had no lectures at the start of the pandemic. This can be prevented in future by moving to online learning entirely and training more staff members on information technology (IT) skills, allowing this aspect of training to progress smoothly. In fact, studies show that trainees are open to keeping some training online, even after the pandemic.[6,16] Another option would be to communicate to all staff and trainees a standard protocol for how the provision of training will change if face-to-face sessions were halted again.

Telephone consultations are becoming increasingly common. Despite its advantages,[14] the lack of visual cues makes full assessments of patients more difficult. The role of visual cues in assessment and diagnosis is highlighted by the poor correlation between in-person and telephone consultations for the same patients.[13] Unfortunately, the problems posed by a lack of visual cues can only be solved by providing visual cues. Aside from the aforementioned reduced thresholds for face-to-face appointments, other options that could be explored include video consultations and home visits. These areas can be given further emphasis during training due to their increased importance.

Despite the doubts both trainees expressed about their quality of training, both passed their AKT on their first attempt. This shows that the learning objectives determined by the RCGP were met. They worried that with less patient contact, online learning would not sufficiently meet their learning objectives. However, online learning has on multiple occasions and in different specialties shown itself sufficiently capable, although it is not suitable for all specialties[17] and downsides to it, such as reduced participation and a lack of in-person interaction, can contribute to worry.[7]

Healthcare inequality and unequal resource distribution were pre-existing issues[19] the pandemic exacerbated.[20] This is not limited

to the UK and is also seen in other countries, with some American trainees being encouraged to reuse single-use personal protective equipment (PPE),[7] and minorities experiencing higher rates of unemployment, psychiatric illnesses and self-harm.[20] Being relatively young, both trainees were not concerned about their own infection risk but were worried about infecting others, similar to trainees of other specialties.[21] With the ever-present potential for future pandemics, GP training should prioritise managing with reduced availabilities of resources or secondary services.

Training for reduced resource availability or secondary services can take many forms. Since both trainees were in resource-poor areas, they would have benefitted from knowledge of cheaper and less resource- or time-intensive methods of investigating diseases. Efforts to improve trainees' knowledge of physiology and anatomy can reduce dependence on imaging, and increasing their experience with various conditions can allow a greater use of "spot diagnoses", referring to an intuitive recognition of patterns of disease presentation.[22] A study by Heneghan et al[22] also highlights the use of risk scores, which could reduce the number of patients sent for unnecessary investigations. Understandably, these methods are likely less accurate than the use of more specialised diagnostic investigations but would help reduce the burden on (and resources consumed by) such investigations.

Loneliness can have a big impact if lockdowns are once again mandated in future pandemics. It affects the elderly and those living in rural areas more and carries both health and financial consequences.[10] It is also important to note that loneliness also affected clinicians (including trainees), but this was helped by the deeper relationships[9] they had with their colleagues and the better work–life balance associated with rural posts.[19] Therefore, a greater emphasis must be placed on developing a trainee's mental resilience so they can manage both loneliness and the uncertainties of disrupted training, preventing them from further increasing the burden of mental health services.[8] This is especially true for urban trainees, who averaged higher anxiety and stress levels than rural trainees.[18]

There are many factors thought to affect mental resilience. A publication by the United States Marine Corps[23] in 2019 highlighted the importance of unique experiences and interaction with diverse ranges of people as having important roles in training individuals capable of "mental adaptation, thinking outside-the-box…and challenge their perceived world views". Despite being a military publication, these traits are also applicable to doctors of all specialities. A systematic review[24] links hobbies, certain personality traits, workplace freedom and a lighter workload with higher resilience scores.

Although factors such as personality and hobbies are difficult to change, there are many areas that can be addressed to improve the resilience of clinicians. Trainees should be allowed to maintain a healthy work–life balance to engage in hobbies or broadening experiences (ideally with appropriate funding). A change in undergraduate medical education may also be needed, to include more time for enriching experiences (such as longer elective placements) and work alongside various colleagues with different cultures and experiences through exchange programmes with non-medical or even non-academic institutions to produce future doctors able to mentally adapt and think "outside-the-box". This may increase the duration of medical education and GP training but would likely be repaid with fewer sick days taken for mental health in future.

This study does not represent all trainees in North Wales because of the small sample size of two and confinement to a semi-rural and heavily Welsh-speaking area with a majority-Caucasian population. Because the two trainees work at the same surgery, they can influence each other's opinions. Other factors such as the atmosphere and culture of the surgery can also affect their experiences. It is also difficult to generalise the results to other parts of the United Kingdom, or the world, due to the differences in management under different NHS trusts and varying degrees of resource availability, demographics and geographical limitations. Further studies can be done on GP trainees in other parts of Wales and the rest of the United Kingdom to determine if GP trainees in different parts of the country face the same difficulties. The suggestions provided also cannot be generalised to other specialties that require greater levels of practical training.[17]

Conclusion

The combination of the pandemic and a rural setting posed unique difficulties to the two trainees affecting their teaching and practice. Both of these were crucial elements to their training, for which they developed various solutions to overcome. The findings also highlighted the importance of curriculum improvement to increase the ability of trainees to manage under these circumstances and minimise training disruptions future pandemics cause. This should specifically aim for a smoother transition from in-person to online teaching, learning to manage under resource limitations, adapt to the use of telephone consultations and a greater focus on mental resilience.

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Appendix

Appendix A – Questionnaire 1

1. Why did you choose to do your GP training in Bangor?
2. What parts of GP training have you already done so far?
3. Is there anything you can do in GP training here that you can't do anywhere else and vice versa?
4. What difficulties do you feel being in a rural environment gives you?
5. How has COVID changed the way your training was done?
6. are there any other difficulties COVID had given you outside of training?
7. Have you found ways to overcome the difficulties mentioned above?
8. Did anything nice come out of COVID?
9. What is the hardest part of GP training up to this point?
10. What has the deanery done well and what has it not done well?

Appendix B – Questionnaire 2

1. How do you learn and retain information right now?
2. Are there other difficulties in a rural environment you've noticed since we last spoke?
3. Last time you mentioned you weren't able to see many patients due to COVID. Has this changed?
4. Are there other difficulties due to COVID that you've noticed since we last spoke?
5. Have you found ways to overcome the difficulties mentioned above?
6. Did anything nice come out of COVID?
7. You mentioned last time that the hardest thing about GP training was _____. Is that still true?
8. What has the deanery done well and what has it not done well?

Yan Jack Chung

Jack Chung is a current 4th year medical student studying at Cardiff University. He was born and raised in Hong Kong and has never studied in the UK before until he came for college. He has a keen interest in emergency medicine, and outside of medical school his other interests include international relations and military history.

Appendix C – Findings from observations and overarching themes

Codes	Themes
• Less patients seen face-to-face • Training disrupted and experiences vary depending on which specialties they are in during their hospital rotations • Annoyance at RCGP for changing the system used to manage their portfolio in the middle of a pandemic, adding to confusion • Difficulty finding cases relevant for their case recordings they need to submit as specific diseases are required and are not common, and difficulty in gaining retroactive consent from patients that are found to meet the requirements halfway through the consultation • Period of no teaching during the start of the pandemic when transitioning from in-person to online lectures	Training difficulties related to COVID/ COVID-induced changes
• Blatant refusal of certain patients to be admitted to hospital • Patients waiting a long time for certain services such as scans, and trainees having to manage them and their expectations in the meantime • Spirometry and peak flow cannot be done in the surgery	Difficulties in practice related to COVID
• Learning from trial and error with phone consultations • More difficult reassuring patients over the phone than face to face • Difficulty fully assessing children just via phone • Patients not picking up the phone on multiple call attempts • Patients often not being at home during calls, and usually not given a specific time window to expect a call	Difficulties with remote consultations
• Lower availability of mental-health services • Getting used to having different self-referral mental health support options and charities available locally • Taking a larger role in patient care due to the lower availability of services • Some diagnostic testing, equipment not available	Resource availability
• Decision to admit more complicated due to some patients living very far from main hospitals • As many houses in rural areas are named and not numbered, some trainees have had difficulty finding the right houses, especially in the pouring rain • Heavy snowfall over Christmas made travelling to the surgery or for house visits more difficult, especially in more mountainous areas • Cannot see family very often	Difficulties related to geographical location
• A larger proportion of elderly patients that also tend to have more comorbidities and are less able to tolerate certain treatments • Loneliness and mental health being more prevalent in older populations living rurally	Difficulties related to demographics of rural areas
• AccuRx system to allow patients to send pictures in of rashes, sores etc. but quality varies • Only giving 2–3 attempts at calling to not take time from other patients • Bring children and babies in more often to assess them better • If diagnostic tests not available, alternative tests are used if available or their response to treatment is monitored • Trainees know what each other need and give them relevant cases	Methods to overcome difficulties
• Phone line for HEIW only open for a limited time, calls are not always answered	Administration difficulties

Interview

StreetVet Bristol team lead Dr Gabriel Galea

Anoushka Agarwal

Year 3, Accelerated Graduate Entry Program Veterinary Science at the Bristol Veterinary School, University of Bristol.
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The bond between people and their companion animals is profound, mutualistic and provides numerous physiological benefits. In light of the homeless population these pets provide aspects of safety, responsibility and improved emotional and mental health. The socio-economic status of being homeless does not negate one's ability to care for their animals. In the simplest of ways, it teaches us about unconditional compassion and care. The stigma surrounding homelessness and dog ownership can be overcome by understanding the importance of such a companionship to both animal and human health.

StreetVet is a charity aimed at supporting lives of the homeless population and their companion animals across the UK, making often vital-yet-costly treatment affordable and accessible to people experiencing homelessness. Such a charity goes far and beyond to reduce barriers to essential veterinary services such as providing daily essentials, medications, prescriptions, surgery, follow-ups as well as owner education; and helps ensure homeless pet owners are not forced to choose between access to resources and their pet – which for many can potentially perpetuate their homelessness. StreetVet is supported by several renowned organisations. With over 900 current supporters and a great team of qualified professionals, the organisation is always looking for more involvement. Support can be given in the form of donations, volunteering or notifying them of a dog or owner in need. Such will increase outreach, enable delivery of this much needed program, and ensure that people without access to resources to care for themselves and their pets can continue to enjoy the pivotal companionship their pets provide.

Dr Gabriel Galea, the Team Lead of StreetVet Bristol, shares his insights with us.

Where did you undergo your veterinary training and what is your current field of ork?

I did my vet degree at the University of Bristol, which is obviously the best vet school in the world. Obviously. I also did my PhD in Bristol and am now a Principal Research Fellow at the UCL Great Ormond Street Institute of Child Health. My research group studies severe malformations of the central nervous system in children, identifying the genetic and environmental factors which cause them and working towards stem cell therapies to rescue damaged neurons.

How long have you been involved with StreetVet and where do you volunteer?

I started helping provide free vet care for homeless pet owners in 2016, right before StreetVet was officially founded. My initial role was to establish stations in London, where StreetVet started. As we grew, I launched StreetVet in several cities outside of London, including leading the first ever outreach in Bristol. My current role is StreetVet Bristol team lead, although I also volunteer once a month in London.

What aspect grew your inclination towards working in this field? What aspects of it do you particularly enjoy?

As a vet walking through London, I often saw many homeless pet owners and wondered what I could do to help if I thought their pet needed treatment. Providing vet care is not as simple as handing out a coat or food. What I appreciate most about StreetVet is that we have an established system of work, covering everything from Veterinary Medicines Directorate requirements and out of hours provision, to public liability insurance, which means we can help when needed. That's important because many of our service users would not be able to make use of established practice-based charity practices, for many reasons.

What is a 'regular' day like in the life of a StreetVet?

Most of our team volunteer one session every two to three weeks. In Bristol, our weekly session is on Saturday morning. A regular StreetVet day starts around 10am in our lockup, collecting a trolley-full of pet supplies ranging from food to coats. Our volunteers get used to stocking stuff they are likely to need, although it's hard to predict what types of dogs (and the occasional cat) we may see. I remember being really worried about stocking harnesses: vet school did not prepare me for the complexities of which appendage goes through which hole in all the different harnesses styles. Once stocked, they head over to a park where our service users know we'll be. We do not use an appointment system, so you never really know how busy you'll be or what the next patient will need. Our team are good at thinking on their feet! Any patients that need in-practice care are booked in during the week, typically to an amazing Vets4Pets practice in Emersons Green who have been absolutely lifesavers (literally). In a typical session we will see three to six dogs over two

hours, usually giving us a chance to also have a bit of a chat with their owners, providing a bit of companionship and social interaction which is so important for some people. After the session we return the kit and type up our clinical notes to upload them to our cloud-based practice management system. Once a month we then reconvene on Zoom late in the evening for "continuity of care rounds" during which we discuss all the patients receiving treatment from us to make sure we have a joined-up approach. We're very lucky in Bristol that we work alongside the fantastic Bristol Paws Project who coordinate our clinical rounds and present the cases (special shoutout to Holly!).

How has being involved with such a community shaped your perception of the homeless population and their companion animals?

What I did not appreciate before getting involved in StreetVet is just how costly it is to care for a pet when you are homeless. Having a dog automatically excludes you from most housing options, day centres, soup kitchens, hospital appointments, etc. We do our best to help homeless pet owners access services they would otherwise be excluded from because of their pet, for example through the StreetVet Accredited Hostel Scheme. The stigma associated with pet ownership is also heartbreaking and completely unjustified. It is not uncommon for our service users to be verbally abused by misguided pet lovers. I particularly remember an elderly dog with a papilloma on its head for which surgery was not clinically indicated, but passers-by would occasionally berate its owner for leaving his dog with 'cancer'.

Any specific current or growing challenges faced? What changes would you like to see in the forthcoming years?

The biggest challenge we face is ensuring we have volunteers at every scheduled StreetVet session. That's critical: we cannot call our clients (many do not have phones) to tell them we may not be around if we do not have enough volunteers. Some may literally spend all the money they have left to get to us. As volunteer's personal lives and jobs change, we regularly lose experienced volunteers from the team (some end up moving to other StreetVet cities) so it is important that we constantly recruit new vets and vet nurses maintain our care provision.

How would volunteering with StreetVet benefit clinical practioners and veterinary students?

StreetVet is stripped-back vetting. We never have to worry about turnover, or the number of clients in the waiting room, or cutting corners because of owner finances. Whatever is in the animal's best interest, StreetVet will get sorted. I often say it reminds me of the answers I used to give when asked "Why do you want to become a vet?" It was always about that one-on-one connection with the pet and their owner, and it is really fulfilling to see the impact we have on both their lives. I do also enjoy the novelty of it – I love problem solving and thinking on my feet to adapt to new situations (top tip, corn blades are great for removing sutures). The vet students who work alongside us certainly get involved in providing care to our patients at a very early stage. We do need more vet students to help us, with tasks ranging from helping with medicine stocktakes to our monthly StreetVet/Bristol Paws joint session. Our student helpers also get to be part of a welcoming and friendly group of caring vets and vet nurses, expanding their network and meeting future colleagues.

What advice do you have for the new and evolving generation of veterinary students today?

This may be a cliché, and difficult to get used to doing, but I really think it's important to take the good stuff home with you. The patient with an easy diagnosis that you were able to make a quick difference to, the client who is still grateful for your empathy when you euthanised their previous pet, being able to bleed to beagle nobody else could – take those thoughts home with you. Write the rubbish, bad stuff down in a book and understand why they happened. It's possible you need to learn from the bad stuff. Sometimes the lesson is that you need to upskill at something, but sometimes you realise that the practice environment you're in sets you up for failure. If you can't change it, get out of there...

Find out more:
www.streetvet.co.uk

Anoushka Agarwal

Alongside my passion towards the veterinary profession, I took a keen interest in working as an editor with INSPIRE Student Journal earlier this summer. For me, this paves way for the increased dissemination of veterinary-related knowledge across readers and creates opportunities for collaboration across various medical domains that work cohesively to add to an ever-expanding body of knowledge.

Art

Introspection and creativity for future success: the art of medicine

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Is medicine an art form? Is it a profession within which we (in the metaphorical sense) create art by helping our patients? Or is art separate from medicine – a thing to practice in order to explore and gain a deeper understanding of our own emotions? I think it would be interesting to know what people's initial thoughts are. I hope having a background in art and a security in my own continuous medical education are enough evidence to prove I am indeed qualified to talk on both topics and how they interlink (they definitely do).

In domains such as medicine and engineering that branch away from humanities, art projects are often assigned in order to encourage creation and introspection. Our professors and mentors are aware of the benefits of being creative for our mental well-being[1], but also for our practice. If you understand the reason why you react the way you do or know ways to release tension (through things that you enjoy and often do not require much mental energy), you can be happier in future interactions with people. In this feature you will find a copy of one of my works – I do not have the time I used to for art, and this piece was produced as part of a student project – without it, the piece never would have been created. The projects reflect the universities' own introspection, and their recognition of our needs.[2] In this way, art is separate from medicine. It is a way to ensure fully compassionate care and patient satisfaction. It is an advantageous adjunct for preventing burnout.

The benefits of these projects are definitely felt, as seen in the art submitted for the journal, and the artists' own words! All our artists have shown a great love for creating, and a deeper thinking on some of the most important topics in medicine, such as organ donation. These medical students were not assigned to create art for us - submissions are voluntary. This poses the question: do we create art out of necessity, because someone has asked us, or is it just human nature? Jean-Martin Charcot, "the father of modern neurology," was a fantastic painter, and he used this and his visual memory to follow patterns of disease in medicine and anatomy. His drawings of anatomical pathology were one of his key methods of teaching clinical diagnosis[3] – and with a background in treating "hysteria", it is no wonder that one of his students was Sigmund Freud.[4] Who knows, maybe the art we create today will – in the future – also birth the next parent of a much controversial, but highly influential, pseudoscience.

I believe art is not its own separate thing from medicine. I think medicine is art (with the risk of sounding like a Romantic – but even Keats trained as a doctor before becoming one of the most revered poets, after all).[5] Art is more than a painting – it is in the way you speak to a patient, in putting lavender oil on the birthing pillow of an anxious mother, in bringing a magnifying glass with a torch to an elderly man with COPD that used to play the guitar with Bob Dylan and now wants to read about those days. The rules of fine art can also help you understand medicine better – a composition is a very carefully thought-out pattern, as are most diagnostics – learning to see things as a whole, a sum of all their separate parts, is an extremely useful transferable skill. Being able to recognise the golden triangle in a Renaissance painting is the same as being able to identify which blood vessels are pumping within your patient's arm – or paw. Understanding art comes with understanding people. And understanding people comes with medicine.

Everyone has the capacity to create and appreciate art. There is little evidence of a clear distinction between "left" and "right" brain-minded people to use it as an excuse.[6] Some people were more encouraged to do so from a young age, whilst others are now, later, encouraged by INSPIRE. I remember my father buying me my first easel in the autumn I was seven – a framing shop on the corner of a block of flats, a golden haze seemingly evaporating off the artist's materials (it was closing time) – and most of all, the joy I felt. At INSPIRE we invite submissions of art from all students within the medical sectors – dentistry, medicine, and veterinary science – giving these students an opportunity to showcase their creative side that they would not typically have. The promise of being published is a great encouragement for the creation of art!

We need to start seeing medicine as an art form separate from the traditional sense of the word. For fear of sounding redundant, we are inherently artists in the jobs we do. It is time we show that off. Therefore, we ask you for all and any type of art: sculptures, paintings, photography, short stories (3000 words max), cartoons/comics, poetry (we need more medics turned poets, I think), whatever form of expression you might prefer. There is no deadline, no time limit, no pressure. Creation is in your hands – what can we learn from it?

I would like to finally thank the artists of this feature: Aiman, Agbo, Judy, and Megan, whose art is also present on our cover. They have done a marvellous job at proving the importance of art, and a great love for medicine as an art form, which I admire.

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Aiman Dilnawaz

My name is Aiman, and I am a final-year Bristol medical student. I am currently based at Gloucester Academy and am looking forward to starting my foundation job in Bristol. I have always been a keen painter and have enjoyed the creative element which Bristol medical school has always offered us. This painting is one of the recent projects which I have done as a part of my placement.

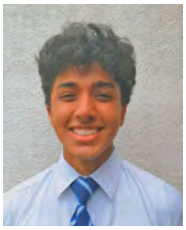
As the title of my painting suggests, this is inspired by the famous book 'This is Going to Hurt' by Adam Kay, which has also recently been featured as a drama series. As a part of our GP block this year, we had to do a project under the title: 'Outside The Box.'

Maybe reading this book and watching the series just before becoming a foundation doctor was not the best time, however, it got me thinking. So many negatives about the job have been highlighted in the book as well as the series - in my painting, I have conveyed through colours that there are not just challenges in future professional life but also successes, satisfaction, and happiness. Sometimes a constant reminder of difficulty can make us overlook the positive aspects, and through this painting, I have tried to bring forth the good part of our profession.

The concept of the doctor standing in the hospital corridor portrays the uncertainty which I have personally felt from time to time, and I have come to accept that this will be the case at the start of my medical career. However, there is always light at the end of the tunnel, which guides our path as conceptualised here. With a balance of different emotions side by side in the painting, it depicts that every difficulty and uncertainty is balanced out by ease and positivity. Good relationships with your spouse, family and friends can be one's support, but sometimes due to immense stress they can be impacted resulting in tension, and this is conveyed by the top figures on the left and right of the painting.

You love most parts of your profession, as shown here by the doctor holding the newborn, but on the contrary, the nature of this profession demands time, and time can be one of the worst enemies when you are trying to balance life and work. The piano in the painting represents one's interests, which are there to de-stress and take one's attention away from stressful and sad situations. Satisfaction in a job is followed by the regret of certain decisions you make as portrayed by the figure on the bottom right of the painting.

In this painting, I have tried to portray the difficulties alongside positives which are often brushed aside under the carpet and eventually ignored or taken for granted. Medicine is a journey full of surprises and I have personally tasted the flavour of this during medical school – particularly in my final year. This is a process of continuous learning, character development and learning to control emotions when facing uncertainty. This painting will be a reminder for me to enter my professional life with the aim that this is not going to hurt.



Agbo Pethiyagoda

My name is Abgo and I am a first-year medical student at Cardiff University. I love public speaking and am interested in surgery. I am also a great fan of sports and an even bigger fan of LEGO (I mean, who is not!). Also, I would never say no to cheesecake!

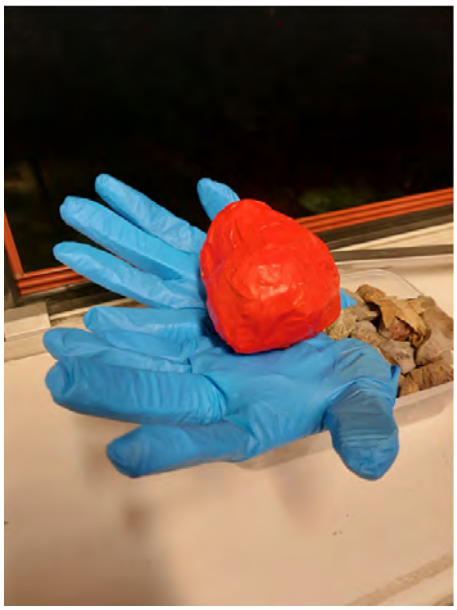
I tried my best to stick to the use of recycled materials so that the environment was not harmed during making this piece. The heart was made from crushed foil that I collected from takeaway containers I had ordered. The gloves are filled with cardboard from a box that was in the recycling bin.

In terms of symbolism, the heart represents the lives of everyone who donate their bodies to science. The rocks: the Earth. And the hands: everyone involved in healthcare.

The heart staying above the rocks (Earth) symbolises the fact that the wonderful people who donated their bodies to science decided to stay with us to help more people, instead of going back to Mother Earth.

The hands are a way of saying thank you to these amazing individuals. In addition, it is also a promise to say that we all would look after all of them with care, love and respect.

Very simply, this piece is to say "Thank You." to everyone who donates their bodies in the name of science.



Judy Tsui

I am Judy and I am a second-year medical student at Cardiff University. I have a strong interest in both arts and science. Being a medical student can be very stressful sometimes and painting is a way for me to relax my mind and express my emotions. I love using many colours and having strong contrast in my artwork, and the boost my creativity and imagination have through painting.

This is an acrylic painting (60x50cm) I made during my three-weeks-long hotel quarantine in Hong Kong in the summer of 2021. Being an international student, COVID made it very hard for me to travel back home and I had to go through a very long quarantine last year before seeing my family! Three weeks in quarantine was definitely a very difficult period for me – being locked in my room and the one thing that I did was stare out of the window every day. It made me appreciate the beauty of home and the time I get to spend with family and friends. The three weeks slowed down my life and made me reflect on how lucky I am to be able to travel and see my family, while a lot of people suffered from tragic loss through the pandemic. Therefore, this is a painting for me to remember this journey.

Megan Hill

My name is Meg and I am a first-year medical student at Cardiff University. This piece was created for my medical humanities assignment this year. My aim was to express my thanks to our anatomy donors and their families. I wanted to show my appreciation for their selfless gift to all of us as medical students. My piece of work is a digital drawing in which I tried to use anatomical words and phrases enclosed in cupped palms to physically represent this gift. The opportunity to learn and the knowledge we gain as a result is something I know we will carry with us for the rest of our medical careers, and I will always be endlessly grateful.

Sofia Ros a-Velea

My name is Sofia, and I am a second-year medical student at the University of Bristol. Based on a small but striking moment with a memorable patient on a geriatric ward, this art piece explores the passing of time and the care we exert into keeping it at bay.

The patient had just requested help with taking their watch off, and as three of us all scrambled to figure out the locking system – a very secure watch, compliments to the manufacturers! – it weighed on me that this might be the only bit of out-of-hospital identity the patient had left, and we were now removing it. I could tell the patient's morale lowered as they became quieter and made a comment that they could not deny their age any longer, even if before their conversation had been quick and witty and fun. When before they had been so in control of their own life – the watch was expensive, one they might have worked hard for – now they couldn't even take it off without help. The change in mood struck me a lot.

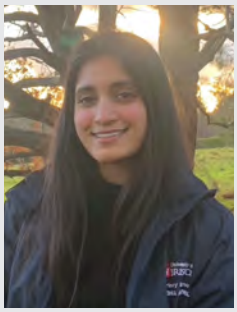
On a geriatric ward you will often see a lack of autonomy, not just through a set daily schedule including shower and eating times, but also through clothing, activity choices and inability to move about. I believe this can take a real toll on patients, especially patients that were very active in previous years, and the time we spend with them is really important in helping them regain a sense of independence and identity – as this is the only time they get to make their own choices.

While initially the artwork started as simply an artistic interpretation of removal of the watch, halfway through I remembered something a nurse had mentioned whilst on the same shift: that five, or 10 years ago, people we see on wards now, would have been at home, especially in the later stages. Now we can provide such a level of care that they remain 'better' for longer, compared to being at home. In a way we are caring for time, as the hands represent, nurturing and keeping it running. I think that's admirable and exciting – the hands are in colourful acrylic to show this, and their lack of definition symbolises the fluidity and ever-changing nature of the interventions we provide.

Painting is the best way for me to express myself creatively, and this is why I chose to explore this encounter this way. The watch, classic and bright against the darkness of the background is not perfect – we cannot guarantee perfect results every time, but we can try; a hand drawn circle is rarely unflawed.

Senior Editors, Autumn 2022

Anoushka Agarwal



University of Bristol

Hi, my name is Anoushka Agarwal, and I am a third-year veterinary student. Alongside my passion towards the veterinary profession, I took a keen interest in working as an editor with the INSPIRE Student Journal earlier this summer. For me, this paves way for the increased dissemination of veterinary-related knowledge across readers and creates opportunities for collaboration across various medical domains that work cohesively to add to an ever-expanding body of knowledge.

Ernestine Ago

University of Exeter

Hi everyone, I'm Ernestine a fifth-year medical student at the University of Exeter. Having graduated with a bachelor's degree in Medical Science, I've always had a keen interest in research. Over my time in medical school, I have been involved in the INSPIRE program in various ways, taking part in the summer research scheme in my first year and then been a peer reviewer in my third year. I have really enjoyed my time taking part in the INSPIRE program and have loved the opportunity to be a senior editor. I especially enjoyed taking part in the behind the scenes work that makes the journal possible, particularly encouraging student involvement in research and helping build links between researchers and students. I believe that research is an important aspect of medical education and from my experience taking part in various research projects, I know there is a vast amount of learning and experience to be had through taking part in research as a medical student. INSPIRE's place as a journal for students by students is something that I feel is important and I'm glad I've had the opportunity to be involved.

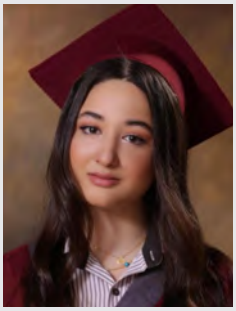
Humaira Ahmed

University of Plymouth

Hi, my name is Humaira Ahmed. I am a third-year medical student, and a BSc (Hons) Biomedical Science graduate. I have a passion for medical microbiology having completed a research placement and thesis in hospital infection control research. Infection control is a huge part of clinical practice within a hospital which is closely associated with my aspiration to pursue a career in medicine. I am currently interested in neuropsychiatry and surgery. Recently, I published a collaborative paper with Dr Tina Joshi and Adventist Health Hospital, California, USA. This paper investigated the isolation of Clostridiodes difficile bacteria from single-use hospital gowns.

As a senior editor for the INSPIRE journal, I hope to encourage others to get involved in medical research. This student journal provides amazing opportunities that I would advise others to get involved with.

Zaina Aloul



Cardiff University

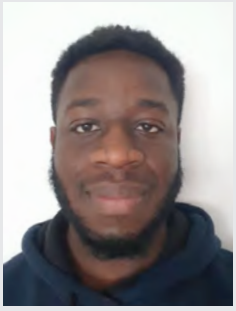
Hi everyone, I'm Zaina, a fourth-year medical student at Cardiff University. I'm thrilled to be part of this year's INSPIRE Student Journal editorial team, to work along my colleagues to publish a Autumn and Winter 2022 issue. I first got involved with academic research by being a peer reviewer for INSPIRE in 2021. After peer reviewing numerous papers written by students on a variety of medical topics, I become fond of academic research and writing. My interests are surgery, cardiology neurology, and genetics! Outside of medicine, I enjoy going on outdoor hikes, and hope to complete the three peak mountain challenges before I graduate. I look forward to reading your papers and helping you publish your research!

Elizabeth Brennan

University of Bristol

I am a third-year medical student at the University of Bristol. I have thoroughly enjoyed being a part of the INSPIRE team as a senior editor. It has allowed me to explore my interest in research and develop greater insight into the field. I have learnt how a journal is run, the importance of timely and effective communication within a team and the roles and responsibilities of an editor. I am particularly interested in global health, surgery and human factors application in medicine.

Joshua Erhabor



University of Exeter

Hi, my name is Joshua Erabor, and I am a final year medical student with an interest in research education. My time with INSPIRE has been amazing so far and I've learnt so much about the publication process! I enjoy neurosurgery and hope to specialise in that field.

Frances Andrea Eslabra

University of Exeter

Hi, my name is Frances Eslabra. I have just finished my fourth year studying medicine at Exeter University and am now intercalating in a masters in Health Data Science. I am particularly interested in how data analysis can inform clinical decision making and improve patient outcomes for the future — it's such an exciting field with so much potential! I aspire to become a surgeon someday, with my preferred field being neurosurgery, but I also really enjoy learning about plastics and orthopaedics. Being an editor for the INSPIRE journal is such a rewarding experience, with my favourite part being reading all the original articles my peers have submitted.

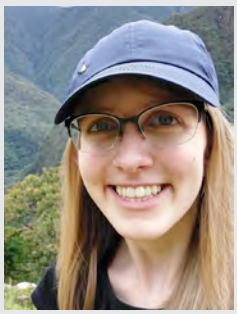
Senior Editors, Autumn 2022

Liam Fletcher

University of Bristol

Hi! My name is Liam and I'm a fifth-year dental student at Bristol. My first exposure to research was during a Nuffield placement I undertook where I got to work with leading academics investigating the role of ALCAM in the HGF signalling pathway in breast and prostate cancers. Since then, my passion for research has grown, leading to my role as editor of this year's INSPIRE Journal. INSPIRE is such a good initiative that gives students the platform to engage in research, the publication process and more and I am very excited to be a part of it this year. My interests lie on the interface of where medicine meets dentistry, and I look forward to reading the work fellow students submit! My interests outside of my BDS include running, football and, currently, Wordle!

Genevieve Lawrence



Cardiff University

Hi! I'm Genevieve and I am currently in my final year of medicine at Cardiff University, having intercalated in Emergency, Prehospital and Immediate Care last year. My intercalated research project was centred on medication safety incidents in the Emergency Department and how they arise. It's exciting to see how research has led to changes in how we practice medicine, even within the short time we have been at university, and this one of the main reasons why I wanted to join INSPIRE!

I'm particularly interested in research in the acute medical setting, such as emergency and prehospital medicine, anaesthesia, and acute medicine. Through INSPIRE, I hope to learn about a wide range of topics in medicine, dentistry and veterinary medicine from the students that are passionate about them. Outside of medicine I love to make pasta, learn languages and go to dance classes. I'm looking forward to seeing the submissions and this year's editions!

Tomas Nicholas

University of Plymouth

Hi, my name is Tomas, and I am an intercalating dental student at the University of Plymouth. I have had a long-standing interest in research, especially relating to oral/systemic links.
This recently led me to undertake a research studentship investigating the effects of a novel mouthwash on microcirculation. I also have an interest in medical/dental education, previously acting as the academic secretary for my dental society where I delivered revision sessions!
I hope other students feel encouraged by the journal, especially dental students, to get more involved and familiar with research, academic writing and the peer reviewing process. Outside of academics, I enjoy spending my time by the sea, listening to electronic music, and exploring Devon and Cornwall with my friends.

Medha Raketla

Cardiff University

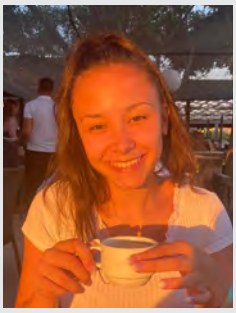
Hello, I'm Medha and I'm a second-year medical student at Cardiff University. My initial experiences with research involved writing literature reviews and gaining insight into laboratory research through INSPIRE's taster days. I am very keen to widen access to research experiences for undergraduates, and I believe INSPIRE provides multiple such opportunities. Being involved at INSPIRE has led me to realise the importance of clinical research in medicine, and I hope through my role as member of the editorial board I can convey the appeal of research to other like-minded students! Outside of academics, I enjoy running and writing :)

Sofia Ros a-Velea

University of Bristol

Hi! I'm Sofia and I am a second-year medical student at Bristol and have had the pleasure of being an Associate Editor at INSPIRE for the past year. I won 'the EPQ with the longest title' award with: "A Comparison Between Exon Skipping and Utrophin Upregulation for the Treatment of Duchenne Muscular Dystrophy" – the project also being my first introduction to research in the medical sector. I loved it, and particularly loved the joy of writing research so that it can be enjoyed by everyone. One of the core principles of INSPIRE is that the journal is by students, for students, and I feel very privileged to be involved for that reason. Knowledge should be selflessly shared. Art, medicine, and the art of medicine are also very important to me, so look out for the art feature in the journal!

Victoria Vincent



University of Plymouth

Hi! My name is Vicky and I'm a fourth-year medical student at Plymouth. Research and quality improvement is so important to allow for the progression of healthcare services. I first got involved with INSPIRE when I submitted a paper on the management of rhegmatogenous retinal detachment. This gave me a flavour for research, but also allowed me to gain an interest on how we could improve the current healthcare setting. I am now extremely passionate about quality improvement, carrying out several audits. My current interests in medicine include maxillofacial surgery and orthopaedics. I am very excited to read the submissions to the upcoming journals and encourage everyone to partake in the submission and publication process.

Advisory board, Autumn 2022

List of referees, Autumn 2022

The INSPIRE scheme is coordinated by the Academy of Medical Sciences and supported by the Wellcome Trust

University of Bristol

www.bristol.ac.uk/medical-school/study/undergraduate/inspire
www.bristol.ac.uk/vet-school/research/inspire

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Bristol Veterinary School Lead: Professor Linda Wooldridge, Chair in Translational Immunology
Bristol Dental School Lead: Mr Mark Gormley, Consultant Senior Lecturer

Cardiff Uni ersity

www.cures.cardiff.ac.uk/inspire

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

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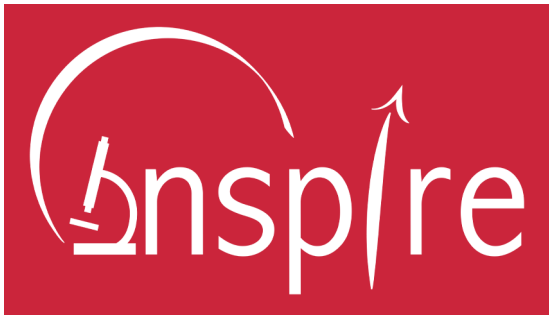
Lead: Dr Joanna Tarr, Senior Lecturer, Faculty of Health and Life Science

University of Plymouth Peninsula School of Medicine and Dentistry

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



Student Health Sciences Research Journal

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