

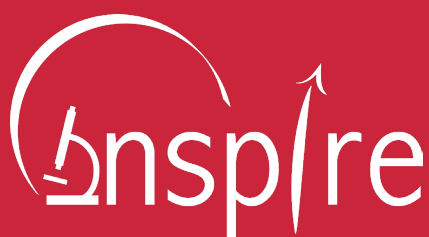
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Student Health Sciences Research Journal





Student Health Sciences Research Journal

Editors

Yaqeen Alkaabi
Cardiff University

Uashar Badakhshan
University of Exeter

Ben Craig
University of Plymouth

Sam Hartnoll
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Imogen Ransome
University of Exeter

Sarah Rafique
University of Plymouth

Eleanne Robinson
University of Plymouth

Kate Williamson
University of Bristol

Yuan Jing Xin
Cardiff University

Joyce Yuen
University of Bristol

Managing Editor

Michelle Preston

Contact

inspirestudentjournal@gmail.com

Website

www.inspirestudentjournal.co.uk

Design

Cris Sutera www.crissutera.co.uk

Welcome to the Spring 2026 issue of the INSPIRE Student Health Sciences Research Journal!

Hello and welcome, dear reader, to our final issue of INSPIRE Student Health Sciences Research Journal.

The INSPIRE Journal was first launched in 2016, with 13 issues published since then. This 14th and final issue was also written and peer-reviewed by students, for students, with the editorial board consisting of students from universities of, Bristol, Cardiff, Exeter and Plymouth (INSPIRE Journal founding institutes). You can read all our past issues at www.inspirestudentjournal.co.uk.

The INSPIRE Journal was created as part of the INSPIRE Scheme which aimed at providing a platform for Medicine, Dentistry and Veterinary Students to engage in and experience research. The INSPIRE Journal offered students an opportunity to publish their research projects and engage in the peer-review process. Through the INSPIRE Journal, we hope students have not only gained valuable research experience but also discovered new areas of academic interest that helped inspire their future careers.

As we bring this chapter to a close, we would like to thank and celebrate the remarkable contributions of the students, authors, referees and previous editorial teams who have shaped the INSPIRE journal over the years. We would also like to extend our sincerest thanks to the INSPIRE leads, authors, referees, designer and all those involved in bringing this final issue to fruition.

We hope you enjoy reading this journal as much as we have enjoyed putting it together!

So long, and thanks for all the fish!

Best wishes,

INSPIRE Student Health Sciences Research Journal Senior Editors

From the INSPIRE leads:

"It is with a heavy heart that we say goodbye to this INSPIRE Student Health Journal and the amazing team that have kept it running for a number of years. The team, currently led by Michelle Preston and previously by José Ruffino and Julie Clayton, have achieved two major successes. The first being the training of student editors and reviewers each year. This is an incredible opportunity for the students involved and, equally, a huge challenge that the students have all risen to. The second, giving the opportunity to medical, dental and vet students across Bristol, Cardiff, Plymouth and Exeter to publish their research and truly experience the academic research writing and reviewing process. The GW4 INSPIRE Leads past and present thank all that have been involved in this amazing journey."



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Why medical students belong in research

Uashar Badakhshan

Year 5, Medicine, University of Exeter

Email: ub218@exeter.ac.uk



Early in medical school, we are introduced to the principles of research, including study design, statistics and critical appraisal, but are taught far less about the role we can play in shaping its future. Now, as a final-year medical student with a strong interest in research and medical education, I have witnessed the lasting impact that research can have on our growth as future healthcare professionals.

Integrating research into the student experience is key, not only for developing analytical thinking, but also for creating evidence-based practice. However, the limited time and availability to provide this level of support remains a challenge. Therefore, this article explores why research should be more than an academic add-on in medical education.

Introduction

Today, medical research is advancing at an unprecedented pace.¹ While students are routinely taught to use research, through clinical guidelines, trials and systematic reviews, far fewer are encouraged to contribute to its conception. This disconnect risks students simply becoming recipients of knowledge, rather than future leaders in the development of important research.

Early involvement in research can influence how students learn, think and apply their knowledge.² However, research is often seen as the exclusive domain of experienced academics or senior clinicians.³ For students, it serves as a powerful educational resource that sparks curiosity and clinical reasoning. Nonetheless, accessing these opportunities is often difficult, especially without established networks, previous experience or institutional support.⁴ This mindset underestimates the potential of students to contribute meaningfully, not just to published literature, but to the culture of inquiry that underpins good clinical care.

Drawing on my own experiences as a final-year medical student engaged in research, I hope to offer a fresh perspective on the barriers, benefits and untapped potential that research holds for students. This article argues that embedding research opportunities within the medical student journey is not merely beneficial, it is essential.

Early research involvement

Research is often seen as the pathway to a publication, but really, it is about much more than that. It is the first spark in curiosity, critical thinking and resilience in students that often leads to a publication. For many prospective students, getting involved in research early on can be transformative. It gives a sense of ownership over their learning and a clearer view of how evidence shapes the care we provide. That said, not every student has the same exposure or interest in research. Across the UK, what students experience can vary widely depending on the institution, mentors and the types of projects available. Certain medical schools integrate research more formally into the curriculum, while others rely heavily on optional routes or extracurricular involvement, which can create inequalities in access.⁵ Even when opportunities exist, students may face barriers such as lack of confidence in research or uncertainty about how to get involved. Together, these differences mean that the level of research experience is highly variable.

Engaging with research at an early stage develops the passion and inquiry necessary for a future generation of clinicians who are not only well-informed but also equipped to challenge outdated practices.

Figure 1 demonstrates that by encouraging research involvement, we are not just helping students build skills. We are investing in a future generation of doctors who are thoughtful, adaptable and ready to tackle the complex challenges of modern healthcare.



Figure 1. The cycle illustrates how student involvement in research develops critical appraisal and evidence-based practices, driving academic and professional growth – created with BioRender.

Access to research

Despite the clear benefits of research, participation and involvement remain a privilege rather than a standard part of medical school. Opportunities often depend on who you know, not what you know. This disproportionately affects students from underrepresented backgrounds, those without academic mentors, or those studying at institutions with fewer research resources. Without action to address these structural inequalities, research can become inaccessible to many.

Equity must underpin all efforts to integrate research into medical education. This includes creating accessible entry points, funding student-led projects (e.g. the INSPIRE scheme) and normalising research within the curriculum. One example is the UNIQ+ programme run by the University of Oxford, which allows students who are ordinarily underrepresented in research to have access to world-leading opportunities.⁶ Similarly, research opportunities should be universally accessible rather than dependent on privilege or connections. At the same time, students face an additional challenge: navigating a field where not all research is rigorous or evidence based. In an era of questionable scientific standards, equipping students with the skills to critically appraise research is more important than ever. By supporting all students to engage meaningfully and critically with research, we are protecting the integrity of evidence-based medicine. Educators and institutions therefore play a central role in addressing these challenges. First, providing structured research opportunities within the curriculum, such as student-selected components, intercalated degrees or elective projects, ensures that research is accessible to all.

Second, effective mentorship is crucial. Supervisors should be supported with training and recognition, while mentorship schemes can connect students to academic clinicians, ensuring consistent guidance and realistic expectations. In addition, workshops in study design, statistics and writing, alongside institutional support can enable students to contribute meaningfully and reduce potential barriers.

Finally, cultivating a research-positive culture, through student research days, awards and recognition, reinforces the value of research. Ultimately, by structuring opportunities, providing quality mentorship and improving access to resources, institutions can mitigate common barriers and empower students to thrive as both clinicians and researchers.

Bridging the gap

There is a persistent gap between students and research culture. Many view it as something distant, overly technical, or reserved for postgraduates and academics. This perception is reinforced by a lack of visibility, mentorship and examples of pathways into research. Therefore, bridging the gap requires more than optional modules or occasional electives; it requires cultural and institutional change. Medical schools should normalise the idea that students belong in research spaces, not as outsiders, but as early-career researchers. However, involving medical students in research is not without its challenges.

Many students require teaching and close mentorship to build the confidence and competence required for research. However, not all academics have the time or capacity to offer this level of support. At the same time, medical students are navigating demanding schedules, clinical placements and exams, which can make it challenging to fully commit to research projects. Some may also question whether students, given their limited experience, can meaningfully contribute to high-quality research. While these concerns must be acknowledged, rather than discouraging student involvement, they underscore the importance of supportive research environments. With appropriate mentorship, realistic time commitments and clear expectations, students can successfully engage in research alongside

their clinical training.

Thus, embedding research longitudinally into the curriculum, pairing students with active clinical researchers, and celebrating student-led inquiry can demystify research and make it more approachable. In doing so, we not only enhance student learning but also create a culture of curiosity.

Conclusion

Medical students belong in research, not just to enhance their portfolios, but to shape the future of medicine. Early exposure equips students with the curiosity, critical thinking and resilience needed to navigate modern healthcare. To achieve this, institutions must commit to embedding structured opportunities, accessible mentorship and a supportive culture that values inquiry. By doing so, we can ensure that medical students are active contributors to its progress and prepared to challenge outdated practices, alongside shaping the future of medicine.

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Grammarly (AI-assisted tool) was used during the writing process to support spelling, grammar, and clarity improvements.

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Uashar Badakhshan

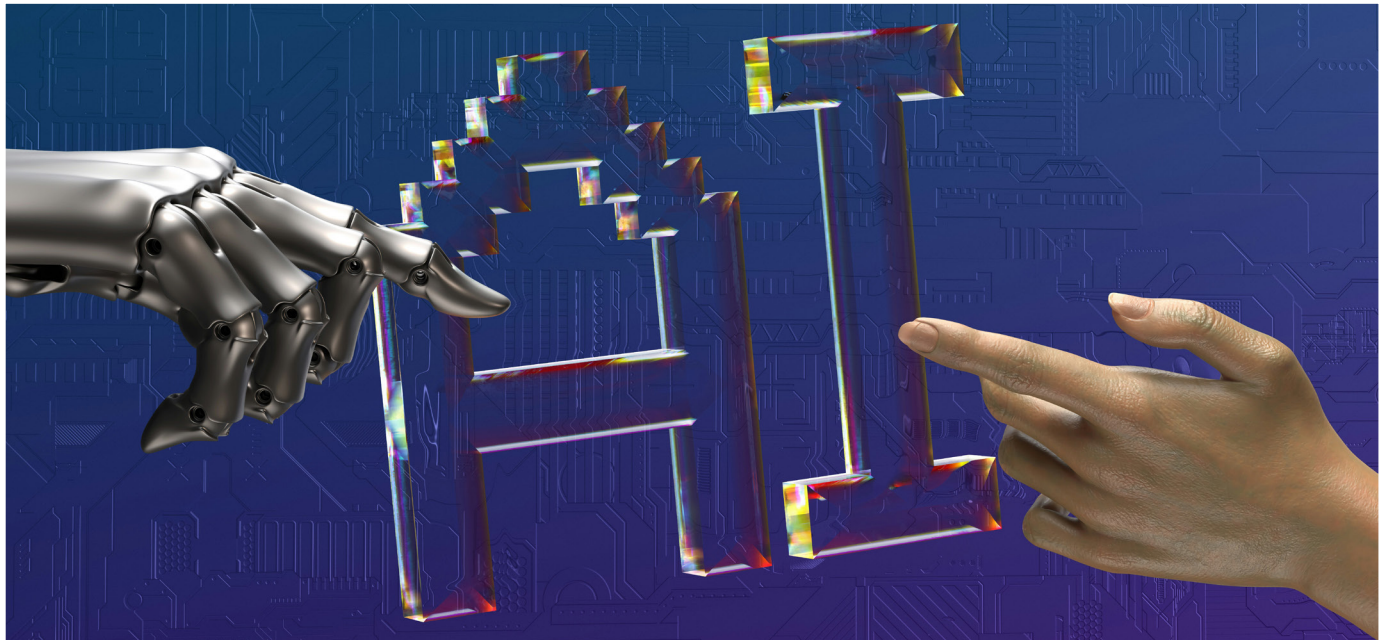
Uashar is a final-year medical student at the University of Exeter, where he ranked in the top decile of his cohort. He was awarded the prestigious Wellcome Trust Biomedical Scholarship by the University of Oxford to conduct research into ethnic disparities in breast cancer at the Cancer Epidemiology Unit, Old Road Campus. This work builds on his recently published systematic review examining ethnic disparities in burn injuries across the UK. He has presented his research at both national and international conferences and has been recognised with several accolades, including the Dame Clare Marx Prize and the Young Investigator Award.

Artificial intelligence in improving access to healthcare for underserved populations

Peter-Dave Chukwujama

Year 2, Medicine, University of Plymouth

Email: peter-dave.chukwujama@students.plymouth.ac.uk



Abstract

Underserved populations experience barriers to timely, affordable and culturally appropriate healthcare. Artificial intelligence (AI), including machine learning (ML), deep learning (DL) and natural language processing (NLP) can mitigate these barriers by enabling and enhancing remote diagnostics, optimising service location and delivering scalable health education. Empirical examples include ML supported mobile computed tomography (CT) screening; ML based geospatial facility siting; DL diagnostic tools for cardiology, ophthalmology and dermatology; and NLP chatbots for maternal health and mental engagement. While these interventions show expanded reach to underserved populations, deployment is constrained by infrastructure gaps, dataset bias, limited external validation and uncertain cost-effectiveness. Inclusive data collection, rigorous multicentre evaluation, economic assessment and equity focused governance are required to ensure AI translates into equitable improvements in access to care.

Abbreviations

AI - artificial intelligence

AIATM - AI-assisted telemedicine

CT - computed tomography

DLAI - deep learning AI

DL - deep learning

ML - machine learning

NLP - natural language processing

NLP AI - natural language processing AI

ROP - retinopathy of prematurity

Introduction

Underserved populations face barriers to access of healthcare services, causing significant disparities in health outcomes.¹ These barriers often stem from key social determinants of health factors, encompassing poverty, geographic isolation, cultural barriers and social discrimination.^{1,2} Artificial intelligence (AI) has emerged as a tool for supporting healthcare systems to improve efficiencies, across diagnosis, treatment and prevention of illness.³ Harnessing AI may also contribute to improving health access and outcomes in underserved populations through data-driven evidence-based methods such as ML, NLP⁴ and telemedicine applications.⁵ This research explores how ML, NLP and telemedicine applications can improve access to healthcare for underserved communities.

Underserved populations

Underserved populations are people and communities who systematically face barriers to timely, culturally appropriate and affordable healthcare. Examples include people on low incomes, living in poverty, or living in remote or rural residents.⁶ Racial and ethnic minorities such as Black, Asian and other minority communities often face this challenge as well as refugees, asylum seekers and recent immigrants including those with limited English proficiency. Homeless and unstably-housed people and those with physical or mental disabilities can also be considered underserved. These groups often overlap, compounding disadvantage; for instance, the Office for National Statistics reports that people living in the most deprived areas have a life expectancy 9.5 years shorter than those in the least deprived areas, highlighting health inequalities driven by social and

economic disadvantage.⁷ These issues are closely linked to income, with 18% of the UK population living in absolute poverty.⁸

Many healthcare disparities experienced by underserved populations stem from historical and structural processes. Slavery, colonialism, forced displacement and discriminatory laws created and concentrated social and economic disadvantage for racial and indigenous communities. Industrialisation and ensuing deindustrialisation produced regional economic decline, leaving some communities with underinvestment in services. Policies such as segregation, criminalisation of poverty and discriminatory employment practices have limited opportunities for wealth, education and health for particular groups.^{9,10} Modern policy decisions such as austerity, uneven infrastructure investment and underfunding of public services have reinforced these patterns.^{11–13} The result is persistent geographic, economic and social exclusion, poorer transport and broadband access, fewer local health providers and lower health literacy,¹⁴ all of which are barriers reducing access to healthcare. Moreover, members of the LGBTQIA+ community face barriers in the form of gaps in provider knowledge and variable access to culturally competent services.¹⁵ Consequently, individuals exhibit decreased healthcare utilisation, leading to poorer health outcomes.¹⁵ It is important to note that these factors can interact to multiply barriers to healthcare, for instance being an immigrant while earning low income in a rural area. Therefore, addressing the needs of underserved populations requires targeted and structural interventions which consider historical context and intersecting identities.

Machine learning AI

ML, a subdiscipline of AI, develops algorithms and statistical models that consolidate data and improve performance over time. Telemedicine is the diagnosis, treatment and monitoring of patients by means of remote telecommunications technology. AI-assisted telemedicine (AIATM) is the integration of AI applications into telemedicine platforms.

AIATM has shown great potential in addressing lack of access to healthcare by pairing powerful AI applications, such as ML models, with the advantages of telemedicine. A study by Toa et al demonstrates how ML can enhance lung cancer screening by facilitating remote diagnostic assistance, using remote CT with ML support. Mobile CT units were sent to three underserved community screening sites for two months, allowing registration of 28728 residents and screening of 19571 residents. ML algorithms performed the initial reviews of the CT scans. A retrospective cohort study encompassing individuals' demographics, health history and CT images was then conducted. The results showed high engagement, with 67% of registered individuals participating in the study. Of these, 2.68% were found to be at high risk for lung cancer, and the majority received timely treatment. This study demonstrated the high efficacy with which ML algorithms can improve access to care for underserved communities and potentially decrease disparities in health outcomes.¹⁶

This study contributes valuable evidence addressing healthcare disparities in lung cancer screening in resource-constrained settings. Deploying mobile CT units with remote AI assistance demonstrates a promising strategy to overcome geographical and infrastructural barriers prevalent in underserved communities in western China. The high participation rate suggests strong potential for community acceptance and engagement with such initiatives. However, the study has a limited observational period and relies on initial outcomes, which necessitates caution when interpreting long-term effects on cancer diagnosis and survival rates. Furthermore, the study lacks comprehensive cost-effectiveness analysis and may suffer from inconsistencies in screening protocols across different sites.¹⁶ These limitations call for more rigorous evaluations such as longitudinal studies and cost-effectiveness analyses before widespread implementation. Additionally, researchers were unable to complete follow-up tracking for all participants, which could

have contributed to biased results. Future research should focus on longitudinal studies to assess the long-term outcomes of AIATM, particularly cancer staging and patient survival rates over time. Investigating standardisation of screening protocols across different sites and assessing potential disparities in AI model performance due to infrastructural and demographic variability would further enhance reliability. Comprehensive cost-effectiveness analyses are also necessary to evaluate the sustainability and scalability of deploying AI-assisted CT units in underserved communities.

ML can also be used to improve access to healthcare through infrastructure planning. A study by Douard et al developed an ML-based geospatial methodology to identify suitable locations for new healthcare facilities in northern Ghana, aiming to improve equitable healthcare access.¹⁷ The methodology used population density maps from sources like WorldPop and national statistics agencies, along with data on existing facilities, to label potential sites. They employed a fast and accurate ML classifier known as Light Gradient Boosting Machine to rank prospective locations, then used a clustering algorithm to group suitable sites. The cluster centres were surrounded by Voronoi polygons, which estimated the service area if a facility were built there. To assess how much a new facility would improve local access, measures such as travel time to the nearest existing facility, the number of people per facility, and combined scores were calculated within each polygon. Candidate sites were prioritized based on the model scores to identify those that most enhanced accessibility. Limitations include reliance on existing data, which may introduce bias since facility locations are used as a proxy for site suitability. Validation through field studies is necessary. The model also does not consider cost-effectiveness or optimise for both impact and affordability,¹⁷ suggesting future inclusion of resource-allocation analysis.

Deep learning AI

Deep learning AI (DLAI) is a class of ML suited to analysing large, complex and unstructured healthcare data including clinical notes, electronic healthcare records and medical images. DLAI has shown remarkable efficacy in applications relevant to underserved populations.

Retinopathy of prematurity (ROP), and specifically plus disease, is a leading cause of childhood blindness that disproportionately affects underserved communities with limited access to ophthalmology specialists. Wagner et al developed and validated DLAI models for automated detection of plus disease. One bespoke model and one code-free model (usable without coding expertise) were trained on diverse retinal image datasets from premature infants in London and externally validated on data from the USA, Brazil and Egypt. Both models achieved high accuracy comparable to experienced clinicians in separating healthy retinas from pre-plus and plus disease. Results suggest potential for DLAI driven ROP screening in resource-limited environments. Strengths of the study include diverse training data and multi-country testing.¹⁸ Limitations included poorer code-free performance for pre-plus disease, reduced accuracy across images from different devices, and small external validation datasets. There was also a lack of individual-level confounder data such as sex and ethnicity, as well as inter-observer variability between training image graders, particularly junior ophthalmologists.¹⁸ Addressing these limitations requires large-scale, multicentre prospective validation, longitudinal assessments of clinical impact, and standardised grading protocols for training data. Evaluation of cross-device deployment is also important to further understand the efficacy of the DLAI models. These steps would help ensure the AI-driven ROP tools are both effective and equitable when deployed in the required healthcare environments.

In cardiology, a randomised controlled trial by Kumar et al shows that DLAI-enhanced ultrasound devices can improve access to quality cardiac imaging for underserved communities. DLAI aided clinicians without prior sonography training to acquire echocardiograms more

efficiently. Thirty-eight internal medicine residents without prior sonography training used devices with or without DLAI guidance over two weeks. The DLAI software provided real-time instructions for probe placement and image assessment.¹⁹ Results showed the DLAI group achieved higher image-quality scores and significantly faster scan times. This suggests DLAI-aided ultrasound can empower healthcare providers with limited training, thereby expanding diagnostic access. Limitations of this study include the use of a single hospital setting, short follow-up, potential bias from open-label design, and use of routine patients rather than patients with challenging cases.¹⁹ Future research should involve large, multicentre blinded trials and long-term performance assessment to validate clinical utility and inform broader implementation.

DLAI has also shown promise in improving access to healthcare through diagnostic imaging in dermatology. A systematic review by Behara et al analysing 95 studies from Scopus, IEEE and MDPI, highlights DLAI's effectiveness in skin cancer detection. Using image processing and feature extraction, DLAI improves lesion classification, enabling faster diagnosis and broader dermatological care, especially in resource-limited settings with specialist shortages.²⁰ A study by Carvalho et al included in the systematic review demonstrated how DLAI allows patients to upload skin images for automated review, benefiting remote communities by reducing the need for in-person visits. While promising, further studies are needed to confirm these findings across diverse populations and settings.²⁰

Natural language processing AI

Natural language processing AI (NLP AI) is a subdiscipline of AI which enables machines to interpret, generate and respond to human language. Advances in NLP AI chatbots also offer potential to improve access to healthcare to underserved populations.

A study by Khan et al explores the potential of NLP AI chatbots in primary care depression management, to improve accessibility, early detection and patient engagement. The study shows that NLP AI chatbots have simulated human like conversations, provided psychoeducation, offered behavioural support, and tracked mood and symptoms through ongoing interactions with users.²¹ Chatbots were also able to tailor interventions based on user responses, and flagged changes indicating worsening depression. In regard to underserved communities, access to depression care is enhanced by decreasing the need for in-person appointments with mental healthcare providers, particularly in areas where access to mental health services are more scarce.²¹ A systematic review by Aggarwal et al supports results from Khan et al. The study shows more of the promising efficacy of AI chatbot algorithms in promoting health-behavioural changes in large and diverse populations. Of the 15 included studies, six showed high efficacy in promoting healthy lifestyles, four in promoting smoking cessation, two in promoting treatment adherence, and one in promoting reduction of substance abuse.²² These studies are limited by the absence of a meta-analysis to statistically combine and synthesise findings. However, its current findings show promise and can act as a platform for randomised controlled trials to establish more definitive conclusions.

In addition, Guvava et al developed ZimHealthBERT, an Android- and iOS-compatible multilingual conversational NLP AI framework for mother-and-child health in Zimbabwe, aiming to address language barriers to healthcare access.²³ The model was trained with patient dialogue and expert-informed qualitative data, including a medical knowledge graph and cultural adaptation layer to provide contextually relevant responses in major local languages: Shona, Ndebele and English. In a pilot study involving 30 clinicians and 60 patients, interviews and surveys reported a 21% increase in prenatal attendance, a 20.6% rise in medication adherence, and a 35.5% improvement in patient comprehension.²³ While ZimHealthBERT showcased promising results, several limitations are important to consider. The study's focus on urban areas restricts generalisability to rural communities with distinct challenges,²³ and its short time

frame limits understanding of long-term impacts. Self-reported data on patient and provider satisfaction could introduce bias, and the AI model's reliance on technology excludes some individuals. Critically, a cost-benefit analysis is needed to assess economic viability. Despite these limitations, ZimHealthBERT offers valuable insights into AI's ability to provide a nuanced approach to improving access to healthcare.

Current challenges and future directions

Implementation of AI technologies may face technological and infrastructure barriers that can hinder their effectiveness and accessibility. Individuals in underserved populations may lack adequate internet access and necessary computing hardware and software.²⁴ This can hinder access to applications such as telemedicine and remote monitoring. This can be addressed by government and private investment in broadband infrastructure in underserved areas and by upgrading existing facilities such as computers and servers to support AI systems.

Data bias may also be a challenge when implementing AI technologies for underserved populations. AI algorithms learn from historic data; therefore, inherent biases may be reflected in results. Historic data are more likely to represent less-deprived socioeconomic groups due to lack of healthcare access for underserved populations. As a result, AI algorithms may yield less accurate results for underserved communities if trained on unrepresentative data, potentially perpetuating disparities in treatment, diagnosis and health outcomes.²⁵ This issue can be addressed by collecting data from diverse populations to account for various demographics, including underserved groups. Technologists and healthcare providers should also involve underserved communities in data collection to gain insight into specific needs and cultural contexts that may be overlooked.

Conclusion

AI presents an opportunity to mitigate unequal healthcare access for underserved populations through enhancement of diagnostic capacity, facilitation of remote care delivery, augmentation of health education, and service planning.

Empirical evidence from DL, ML and NLP has shown efficacy against a range of barriers to healthcare access. Nonetheless, the translation of these innovations into equitable public-health impact requires rigorous safeguards, such as further validation and cost-effectiveness studies. Deliberate efforts must also be made to mitigate algorithmic bias to prevent exacerbation of existing inequalities. Investment in digital infrastructure and workforce capacity, alongside regulatory frameworks that embed ethical and accountability mechanisms, is also required to support sustainable implementation. When deployed with methodological rigor and equity-centred governance, AI can serve as a scalable enhancer to conventional health systems for narrowing entrenched disparities in access to care.

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Peter-Dave Chukwujama

Hi, I'm a second-year medical student and a co-founder and President of the Health and Medical Technology Society. My interests include surgery, medical technology, and healthcare innovation. I am also interested in exploring and addressing healthcare disparities through research and practical efforts.

Can AI be used to explore and improve COVID-19 vaccine hesitancy in the Black British community?

Peter-Dave Chukwujama

Year 2, Medicine, University of Plymouth

Email: peter-dave.chukwujama@students.plymouth.ac.uk



Abstract

This paper explores the potential of hybrid artificial intelligence (AI) techniques to analyse COVID-19 vaccine hesitancy within the Black British community. Recognising the disproportionate hesitancy and associated health disparities, the study critically evaluates existing AI-based sentiment analysis approaches, highlighting their methodological strengths and limitations. Building on this critical evaluation, the research proposes a culturally sensitive, tailored strategy that involves focused social media data collection. This approach incorporates hybrid AI models trained with community-specific annotations and utilises geospatial mapping to elucidate regional and socio-economic factors underpinning vaccine hesitancy. The objective is to inform the development of community-centred intervention strategies aimed at enhancing vaccine uptake within the Black British population. Additionally, the study underscores the importance of ethical considerations, particularly regarding surveillance, privacy and data misuse, and advocates for mitigation measures to minimise potential risks.

Abbreviations

AI - artificial intelligence

BAME - Black, Asian and minority ethnic

BERT - Bidirectional Encoder Representations from Transformers

DL - deep learning

ML - machine learning

NLP - natural language processing

VADER - Valence Aware Dictionary and sEntiment Reasoner

Introduction

The Black British population has disproportionately high rates of COVID-19 vaccine hesitancy in the UK. Studies report hesitancy levels as high as 71.8% among Black British groups compared to 18% in the general population, with considerably lower rates in White British and Irish groups.¹ This issue may contribute to the mortality rate from COVID-19 in Black British individuals being over three times higher in comparison to White British individuals.² Multiple large-scale studies and meta-analyses also show that vaccinated individuals are at lower risk of death from COVID-19.³ Studies indicate that historical issues in the form of structural and institutional racism, as well as community-level racism create and reinforce deep-rooted mistrust in the healthcare system and the government. These issues are major contributing factors to vaccine hesitancy in the Black British community.⁴⁻⁶ As COVID-19 vaccination campaigns and booster rollouts continue, it is important to improve current understanding of COVID-19 vaccine hesitancy in the Black British community to promote healthcare equity, both now and in future public health crises.

AI, often employing natural language processing (NLP), machine learning (ML) and deep learning (DL) are increasingly used in public

health surveillance and communication research. NLP enables automated extraction of topics, sentiment data and discourse features from textual data. ML models can detect and classify text, while DL models can capture complex patterns from large unstructured datasets. Social media platforms offer vast amount of data reflecting public attitudes which can be analysed using these AI techniques. Currently there is a notable research gap for AI-driven sentiment analysis specific to the Black British community, particularly concerning COVID-19 vaccine hesitancy. Therefore, this research compares two studies employing AI-driven sentiment analysis to assess vaccine hesitancy with the aim of proposing a tailored strategy for the Black British population. Two studies, one by Hussain et al⁷ and one by Lanyi et al⁸ were strategically selected for comparative analysis.

These studies have a combination of relevance, methodological diversity and transparent articulation of strengths and weakness, thereby providing a solid framework for developing a tailored sentiment analysis strategy for the Black British population. Both studies focus on the UK, ensuring geographic relevance, with each covering a significant period of the pandemic to capture vaccine sentiments. Their methodological similarities and differences allow for direct evaluation of approaches, facilitating adaptation to create a more context-specific framework that considers the unique challenges and ethical considerations involved.

National sentiment analysis

Hussain et al analysed over 300,000 Facebook and X posts related to COVID-19 vaccines from the UK and the USA, spanning from 1 March to 22 November 2020. The study employed a hybrid ensemble model that combined multiple AI techniques. NLP techniques, utilising the Valence Aware Dictionary and Sentiment Reasoner (VADER) and TextBlob, formed the foundation for analysing social media posts, employing methods for topic extraction and text processing. An ML method, specifically a deep learning technique known as Bidirectional Encoder Representations from Transformers (BERT), was subsequently used to classify the processed textual data into three sentiment categories: positive, neutral or negative. The researchers then applied a mixed-method approach to examine public sentiment towards COVID-19 vaccines. Quantitative analysis involved aggregating sentiment scores and producing temporal trend graphs alongside geospatial maps to illustrate sentiment variations over time and across regions. Qualitative analysis entailed manual review of the social media posts to validate findings and elucidate the context behind observed trends. The analysis identified concerns related to vaccine safety, largely attributed to the rapid development and approval processes. Negative sentiment was also directly associated with the increasing anti-vaccine movement and the dissemination of misinformation and 'fake news'. Mapping the geographic distribution of negative sentiment revealed specific areas in both the UK and the USA where vaccine hesitancy was most prevalent.⁷

This study conducted a large-scale, comprehensive sentiment analysis, capturing a broad spectrum of opinions across the UK and the US. It offers a robust and replicable methodological framework for exploring vaccine hesitancy through AI-driven social media analysis. The study employed a hybrid AI model, combining lexicon-based approaches such as VADER and TextBlob, which provide rapid analysis and interpretability,^{9,10} with BERT, which excels at recognising contextual dependencies and detecting subtle nuances in language.^{11,12} These are key strengths that balance efficiency with a nuanced understanding of sentiment. Another notable strength of the study is the use of geospatial mapping, which enabled the identification of regional variations in vaccine sentiment, thereby informing focused intervention strategies

However, limitations include the potential homogenisation of opinions, as large-scale analysis may dilute the contextual specificity of localised and community-based issues, potentially overlooking important variations in sentiment. Although the AI methodologies

applied are advanced, they were predominantly pre-trained on general language datasets, which may reduce their effectiveness in grasping community-specific language and terminology.¹³ This may lead to misinterpretations of the expressed sentiments. The timeframe of the analysis corresponds to the initial stages of the pandemic, prior to vaccine approval, when public sentiment was chiefly characterised by hope, anticipation, uncertainty and scepticism.⁷ While sentiment analysis during this period provides valuable insights, it omits critical phases during and after vaccine rollout, when attitudes were likely influenced by data on efficacy and side effects. Incorporating analysis of these subsequent periods could offer a more comprehensive understanding of vaccination sentiment across different stages of the pandemic.

Real-time regional analyses

Lanyi et al examined vaccine hesitancy in a low-uptake region in London using "Wordnerds," a hybrid text analysis platform that utilises NLP and ML tools to facilitate real-time analysis of social media data. The study aimed to identify primary barriers impeding vaccine uptake. Using a search strategy comprising keywords related to COVID-19 vaccines, vaccination and relevant pharmaceutical companies, X posts were collected over a nine-month period between November 2020 and August 2021. Wordnerds employed NLP techniques to determine whether posts expressed positive, negative or neutral sentiments towards COVID-19 vaccines. It then used ML methods to group tweets based on their topics. The researchers subsequently conducted qualitative analysis by manually coding the negative posts into specific hesitancy themes which were: 1. Mistrust, 2. Safety, 3. Ineffectiveness, 4. Access, 5. Under-representation, 6. Complacency. A subset of these categorised tweets was closely examined to gain deeper insights into the context and nuances behind each theme. Under-representation emerged as a particularly salient theme linked to the experiences of the Black British community. For example, one tweet within this hesitancy theme noted that one of the vaccines had only been tested on White people, which contradicts the evidence that BAME (Black, Asian and Minority Ethnic) groups are at higher risk and have historically been neglected in research.⁸

This study demonstrated the potential for rapid analysis of public sentiment from a sizeable sample, using an affordable, efficient, off-the-shelf NLP tool. This approach is especially valuable during dynamic and fast-moving situations like a pandemic. The hybrid methodology, combining NLP with ML, alongside qualitative document analysis, can provide a nuanced understanding of public attitudes. Real-time analysis of public sentiments was performed, also. This would enable timely identification of emerging concerns, rapid response interventions and monitoring of response effectiveness. However, the study lacked detailed demographic information about the X users, which could have contributed to a more nuanced understanding of vaccine hesitancy. Additionally, the AI model may have struggled with linguistic and cultural nuances, as off-the-shelf NLP tools such as Wordnerds are typically pre-trained on large, general datasets covering a wide range of topics and language styles. While this broad training enables strong performance on standard NLP tasks, it may limit the tools' ability to capture community-specific language, potentially reducing the accuracy of sentiment analysis.^{14,15} The study's temporal scope focused on the initial approval and rollout of vaccines in the UK, capturing sentiments during vaccination campaigns related to safety, access and the impact of emerging variants. While analysis during this period is valuable, examining sentiments from pre-vaccine and post-rollout phases could offer a more holistic understanding of community attitudes towards the vaccines.

Proposed strategy for sentiment analysis of COVID-19 vaccine hesitancy in the Black British community

To analyse vaccine sentiment within the Black British community, an effective methodology can draw on the strengths and address the limitations identified in Hussain et al and Lanyi et al Neither study

focuses directly on the Black British community: national-level data may obscure community-specific concerns, while regional data improves specificity but can be further developed for demographic focus. Although Hussain et al used a robust hybrid ensemble approach and Lanyi et al employed a more affordable, rapid method, neither is tailored to capture linguistic nuances specific to the Black British community. Both studies analyse important pandemic periods but continuous monitoring is necessary to capture evolving sentiments. The following hybrid strategy could be used to tailor analysis to the Black British population.

- Focused social-media data collection, concentrating on platforms and spaces frequently used by the Black British community (for example, community Facebook groups and local X accounts). Keyword refinement should include community-specific terms, hashtags and colloquialisms.
- Employ an AI model similar to the hybrid ensemble used by Hussain et al, combining lexicon-based NLP (VADER, TextBlob) with BERT. The model should be fine-tuned on a dataset annotated by members of the Black British community to capture linguistic nuance and cultural context.
- Conduct qualitative analysis by manually coding a subset of the data to identify key themes and validate AI performance. Community involvement at this stage is necessary to ensure cultural sensitivity and accurate interpretation.
- Identify key geographic areas with substantial Black British populations. Map aggregated sentiment scores to these areas to visualise patterns of vaccine hesitancy. Overlay sentiment maps with demographic data (socioeconomic status, access to healthcare, occupation) to identify correlations and inform tailored interventions.
- Perform real-time analysis to identify emerging concerns promptly, enable rapid responses, implement tailored interventions and monitor campaign effectiveness. Continuous monitoring and event-driven analyses may be necessary to support sustained improvements in vaccine uptake.
- Protect privacy when leveraging public data. Personally identifiable information (names, email addresses, phone numbers and precise locations) must be redacted. Data should be aggregated to an appropriate level of granularity to minimise re-identification risk¹⁶ and comply with data-protection and security regulations.

Key limitations of the proposed strategy

Despite the strengths of the proposed method, important limitations remain. Sampling bias poses a major challenge to sentiment analysis in the Black British community. Analysis of publicly available data will exclude individuals who are reluctant to share sensitive views on public platforms, narrowing the spectrum of captured opinions. Mitigating this limitation may require collaboration with community organisations and complementary data collection approaches (surveys, interviews) to reach less visible individuals and groups.¹⁷ The Black British community is not monolithic but comprises diverse ethnicities, cultural backgrounds and socioeconomic statuses; consequently, findings from sentiment analysis may not be generalisable to all segments. Employing stratified sampling techniques that analyse data within specific subgroups can reduce the risk of overgeneralisation and better reflect the complexity of vaccine attitudes.¹⁸

Sentiment analysis conducted on vulnerable populations raises ethical concerns regarding privacy, surveillance and potential misuse of data. Systematic monitoring may be perceived as invasive, potentially discouraging open discussion and undermining trust. There is also a risk that findings could be intentionally or unintentionally misused, leading to stigmatisation or discrimination. To address these challenges, a rigorous framework for data governance must be implemented, incorporating strict protocols for encryption, anonymisation or aggregation of sensitive information.^{19–21} Transparency, in the form of clear communication

about how data will be used, stored and shared, is also important to build and maintain trust between researchers and the community.

Translating findings into interventional strategies

Translating findings into interventions requires commitment to cultural sensitivity, leadership engagement and ethical action. Collaboration with local health authorities is important for trust building. For example, key findings (for instance, mistrust stemming from historical injustices) can be translated into videos featuring Black British healthcare professionals addressing these concerns directly. Partnerships with community radio stations can help dispel circulating vaccine myths using culturally resonant messaging. Hosting accessible community events that provide vaccine information, leaflets and on-site sign-up opportunities may improve uptake.²²

In addition, outreach workers from within the Black British community, prioritising those with lived experience of the healthcare system can be recruited. Training can be provided on historical and contextual concerns (for example, the Tuskegee Syphilis Experiment)²³ delivered in a culturally sensitive manner. Furthermore, Collaborations can be established with respected community figures, such as sports personalities, Black British academics and social media influencers, to share personal experiences and address concerns openly.²⁴

Adhering to these principles can help translate sentiment-analysis findings into interventions that are empowering and effective in increasing COVID-19 vaccine uptake in the Black British community.

Conclusion

Artificial intelligence-driven sentiment analysis has the potential to address COVID-19 vaccine hesitancy within the Black British community. However, current methodologies are limited by sampling bias, linguistic subtleties and ethical concerns related to privacy, surveillance and data misuse. A contextually tailored strategy that integrates advanced hybrid AI models, culturally sensitive data-collection practices and proactive community engagement may enhance both methodological accuracy and cultural validity. The implementation of comprehensive data-governance frameworks and ongoing community engagement is essential to mitigate risks of stigmatisation and unethical data use. Integrating these insights into culturally competent, real-time intervention frameworks may improve COVID-19 vaccine uptake and advance health equity within the Black British population.

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Peter-Dave Chukwujama

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Why ENT should not be an afterthought in medical education: a call for early exposure

Umar Choudhury

Year 2, Medicine, Newcastle University

Email: U.choudhury2@ncl.ac.uk



Abstract

This opinion piece highlights the underrepresentation of ear, nose and throat (ENT) teaching in UK undergraduate curricula, despite ENT conditions accounting for up to 10% of GP consultations.¹ Written from a student's perspective, it argues that reserving ENT for late clinical attachments leaves graduates unprepared to manage common issues such as ear infections and hearing loss, resulting in unnecessary referrals. To address this gap with minimal disruption, we propose three low-barrier, high-impact steps: early structured e-learning on ENT fundamentals; simulation-based skills workshops integrated into core clinical training; and brief ENT mini-placements within existing rotations. Embedding these interventions earlier can build essential ENT competence and improve patient care.

When I asked my first-year peers what they knew about ENT, the responses were strikingly narrow: "It's just ears, noses and throats, right?" Even when I have mentioned my interest in ENT to older generations, I am often met with surprise: "Why not neurosurgery or something more prestigious?" For many medical students, ENT remains a vague, peripheral concept, overshadowed by more familiar specialties like cardiology or orthopaedics. Unless someone has a parent working in ENT or has personally dealt with sinus surgery or hearing loss, the specialty rarely extends beyond the textbook definition. But the truth is, ENT is far more complex, impactful, and clinically relevant than it gets credit for – and its near invisibility in undergraduate education is doing future doctors, and their patients, a disservice.

This disconnect is surprising when you consider how central ENT conditions are in everyday clinical practice. ENT-related complaints make up approximately 10% of general practice visits, underlining the need for stronger ENT training in undergraduate programmes.

Emergency departments also frequently manage epistaxis, peritonsillar abscesses and foreign bodies. Despite this, many UK medical schools dedicate only around 1.5 weeks to ENT teaching, often without formal assessment. Some offer no clinical ENT placement at all.

Speaking to older students and foundation doctors, I have noticed a recurring theme: many feel underprepared to handle even common ENT presentations. Skills like using an otoscope confidently and managing nasal bleeds – though essential in both A&E and GP settings – are often under-taught. This is also underpinned by several studies: a systematic review found that the majority of final-year medical students and clinicians were not confident in assessing and managing ENT patients.²

This gap does not just affect exams – it carries real clinical consequences. In the early years of practice, junior doctors are often the first to assess patients with ENT-related issues, especially in emergency settings or during out-of-hours shifts. If medical schools have not provided adequate training in examining the ear, nasal passages, or identifying red flags like unilateral hearing loss, patient safety can be compromised. Underexposure also breeds uncertainty – it is not uncommon for students to feel hesitant or even anxious when faced with ENT complaints on the wards. And for those who might have considered ENT as a career, the lack of early contact may cause them to overlook a specialty that is dynamic, diverse and deeply rewarding.

While advocating for greater ENT integration, it is important to acknowledge potential barriers, including limited space within an already packed medical curriculum and the prioritisation of high-profile specialties such as cardiology and general practice. However, this challenge underscores the need for strategy rather

than neglect. Ignoring ENT's place in the curriculum risks graduating doctors who lack confidence in managing a substantial portion of clinical presentations, potentially compromising patient care in both primary and emergency settings. Moreover, marginalising ENT teaching may dissuade capable students from exploring a specialty that is foundational to surgical and medical practice alike.

So, what could help bridge this gap? From a student's perspective, even small steps would make a big difference. For example, introducing mandatory ENT examinations, such as otoscopy and throat inspection, earlier in clinical skills sessions would help students feel more familiar with these systems — just as we do with heart and lung exams. Student-led ENT teaching events or revision workshops could also create space to explore the specialty beyond what is formally taught. And as we progress into GP and hospital placements, having ENT conditions embedded into teaching cases — like how to recognise when a sore throat needs referral — would help us see ENT as part of everyday clinical thinking, not something separate or niche. We do not need to be experts, but we should feel confident recognising and responding to the basics.

ENT might stand for ear, nose and throat — but its reach extends far beyond that. It sits at the intersection of surgery and medicine, of chronic disease and acute emergencies, of paediatrics, oncology, audiology, and more. Yet, despite this breadth, it remains underrepresented in medical education, often to the detriment of both students and patients. As future doctors, we should be trained in what we are most likely to encounter — and ENT, by any measure, deserves a firmer place in that foundation. Reframing ENT as core rather than peripheral is not just a curriculum issue, it is a clinical one. The earlier we make that shift, the better prepared we will all be.

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Umair Choudhury

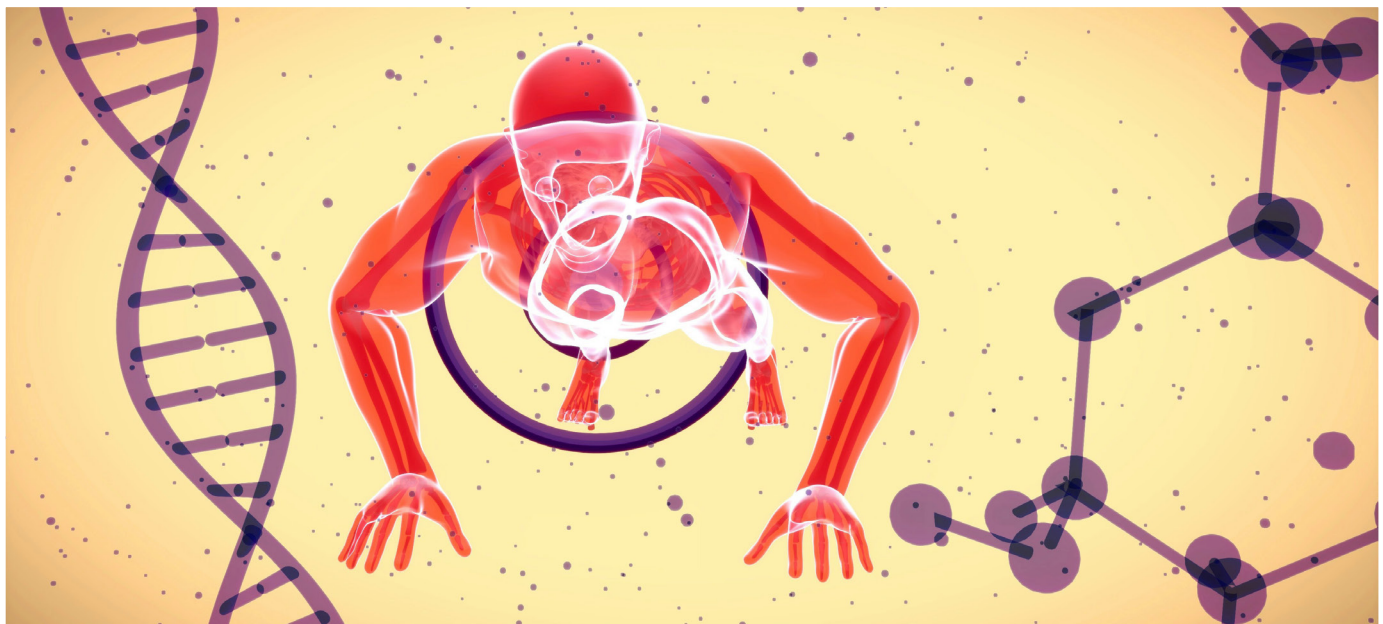
Umair Choudhury is a medical student at Newcastle University. His interests include ENT, medical education, and improving primary-care confidence in common presentations. He is currently co-developing a BPPV education resource with GPs and ENT specialists, contributing to literature mapping, focus-group design and facilitation, and iterative prototyping of a dual-format leaflet/web page informed by thematic analysis.

Artificial intelligence and pharmacogenomics: the optimisation of drug prescriptions and reduction of side effects

Elizabeth Codner

Year 1, Medicine, University of Plymouth

Email: elizabeth.codner@students.plymouth.ac.uk



Abstract

This opinion article discusses the numerous benefits surrounding the introduction of artificial intelligence (AI) to the field of pharmacogenomics, specifically in relation to drug prescription optimisation and side effect reduction. This topic is paramount to the future of medicine, AI potentially providing a realistic approach to the rolling out of personalised medications tailored to an individual's genetic profile. This could help patients to experience much more efficient treatment programmes with limited adverse effects. Additionally, this model may have the ability to decrease treatment expenditure, helping to improve the healthcare system in a more general sense. The aim of this article is to outline the advantages AI brings to pharmacogenomics, as well as to also show the current limitations that would prevent its implementation.

Introduction

Medicine is a constantly evolving field, with new discoveries and research involving patient care being integrated into healthcare continually. With artificial intelligence (AI) becoming increasingly more interwoven with our daily lives, the question of how it could be combined with healthcare and biomedicine is a consideration that has been researched by many – a common theme being how it can be used to improve efficacy within the field of personalised medicine and pharmacogenomics to treat conditions.

Personalised medicine, as stated by the European Union, is “a medical model that aims to provide tailor-made prevention and treatment strategies for defined groups of individuals.”¹ One branch that personalised medicine takes into consideration is pharmacogenomics, which combines the principles of pharmacology and genomes to study how an individual's genetic profile can influence their drug responses. Despite other elements affecting drug efficacy, such as lifestyle and environmental factors, genomics is believed to be the key in the major advancement of personalised medicine.²

This article aims to discuss the impact AI may be able to have on pharmacogenomics, highlighting advantages and disadvantages that may be associated with its use in this context. Specifically, there is a large focus on AI's influence on the optimisation of drug prescriptions and the reduction of side effects.

Methods

To explore the impacts of AI on pharmacogenomics with relation to drug prescription optimisation and side effects, a narrative review of the literature was conducted. Several databases were searched, consisting of PubMed, Google Scholar, ScienceDirect and Web of Science. The key search terms used initially were “artificial intelligence”, “pharmacogenomics” and “personalised medicine.” To ensure this article's relevance, searches were limited to articles published between the years 2015 and 2025, with the exception of one article published in 2009, which defines pharmacogenomics and states its relevancy to the future of healthcare.² Papers included in the

research of this article were selected based upon their relevance to key themes, including areas like AI efficiency, personalised medicine, drug prescription optimisation and side effect reduction.

Why is this topic important?

Pharmacogenomics aims to resolve the uncertainty around which genes influence drug responses. This could help to distinguish whether treatment plans will have a positive or adverse reaction for a specific person. Additionally, it may provide an insight into how to create personalised drugs that will have the maximum efficacy for individuals. This field could massively decrease NHS expenditure, through limiting the number of failed drug trials; decreasing the time it takes for drug approval; shortening the length of treatment plans; and predicting how disease may affect specific populations.²

AI can help reduce these costs further, with many economic advantages associated with its roles in personalised medicine. AI's ability to prevent adverse events that could hospitalise patients for longer than necessary is a significant area of both financial benefit and patient journey improvement. AI can help identify early risk to avoid additional treatment costs, as well as optimising resource allocation and utilisation. Furthermore, its operational efficiency contributes to freeing up more time so that healthcare providers can redistribute their priorities away from repetitive tasks, such as data entry, and more towards direct patient care. This improves productivity and labour costs.³

To further the progression of pharmacogenomics, the employment of AI within this field shows promise. Through deep learning techniques encoded into the software, AI could revolutionise pharmacogenomics by developing predictive-modelling and efficient data analysis techniques.⁴

Results

How AI can positively impact drug prescriptions and side effects in pharmacogenomics

There are numerous benefits in uniting pharmacogenomics and AI, the ability to process genomic-wide data efficiently using such resources showing potential in the world of individualised medicine. Additionally, the ability to identify the biological-level causation of variation of response to specific treatments between individuals could be achieved on a wider scale.⁵

A person's genome can affect multiple stages in drug response, including drug receptors, uptake, breakdown and targeted development. AI can impact each of these steps, helping to provide further insight and improve efficiency of pharmacogenomic drug research. In turn, this will help to optimise genetics-based treatment plans.⁶ For example, regarding drug receptors (which can vary dependent on a person's DNA), AI can measure drug-binding affinity through its ability to recognise similarities or differences between a drug and its target.⁷

Specifying dosages on a person-to-person basis instead of more general categories could help transform drug prescriptions and reduce adverse reactions.⁵ To address this, intelligent software has been made to develop prediction models that consider pharmacogenomic variants to attempt to forecast treatment outcomes. However, a limitation that was identified was the training of these technologies to do this, due to the number of variables the software would have to use far exceeding the samples available to prime the methods. Henceforth, alternate approaches were considered that would reduce the number of these variables – for example, through the introduction of P value thresholds of a genome-wide association study.⁵ Despite this, one study used artificial neural networks and machine learning to identify common variants of cytochrome P450 enzymes which were believed to contribute to negative drug reactions. It concluded that AI, in this case, was capable

of categorising adverse reactions to treatments based on a person's genomic profile. As research progresses, the study claimed that more genomic variations could be integrated into the software to improve its performance and predict on a wider range of drugs and conditions.⁸ There have also been multiple experiments researching the effects of anti-depressants on individual treatment outcomes that combine AI and pharmacogenomics – many show promise, supplying accurate predictions of responses, helping to provide individuals with the most appropriate anti-depressant medications. This development could majorly improve drug prescriptions, reactions and the reduction of harmful side effects.⁹

Furthermore, the success of pharmacogenomics is heavily reliant on clinical trials, which is consistently problematic due to difficulties involving patient matching and design. It is for this reason that AI integration is a sensible option, as large quantities of genomic and patient history data can then be easily handled. This can massively impact drug discovery, as well as diagnostic prediction and accuracy.¹⁰ With the application of AI, it has even been suggested that whole genomes should be sequenced from birth to help enrich our understanding of genes, although this topic has huge cause for debate. However, improving our understanding of causation can improve our understanding of medication prescribing choices.¹¹

Another dilemma is that “phenotype-genotype concordance is limited,”¹² as stated by a recent study researching alternate phenotyping strategies. The article went on to explain how AI was able to ‘learn’ using training data, before moving onto unknown data to predict phenotypic outcomes, as well as who would respond to a certain drug and who would not.¹² For example, with respect to drug uptake and breakdown, a decrease in gene expression for organic anion transporter 1B1 (a type of transporter protein) can lead to a decrease in statin uptake. Therefore, using AI to help screen for this would be beneficial, as to not provide these individuals with drugs that will be ineffective.⁶ This research can help optimise drug prescriptions through ruling out medications that would have little or no effect, rather than trialling and re-prescribing.

Drug prescription optimisation is also affected by when a treatment is started. Genomic testing and analysis can be laborious and time consuming, limiting the scope of patients that individualised genetics-based medicine can reach.¹³ However, when combined with AI, genomic analysis (for example, next generation sequencing and genome sequencing) is achieved far quicker, leading to faster decision making.⁴ It can help by looking for specific variants; supporting clinicians in extracting and studying both genotypic and phenotypic data; and explaining test results. AI can make genomic analysis more efficient, thus potentially prescribing earlier and improving the effect of a person's genetics-based treatment.¹⁴

In addition to scanning for known genes that cause disease, AI can help to discover new genes which potentially cause harm, as many genetic conditions are not yet known.¹⁴ For example, a study involved in neurodevelopment disorders found evidence for 28 genetic disorders when combining exome sequencing and AI. Some limitations include challenges such as the reliance on input data quality and sample size. However, the benefits of AI helped in areas of scalability and efficiency, able to handle large datasets.¹⁵ Therefore, more potentially harmful genes can be screened for in patients, and consequently, more treatments can be developed around this.¹⁴ With there potentially being thousands of impactful genes that have not yet been investigated, one group of researchers used AI to support them in finding possible drug targets.¹⁶ Treatment plans could become more specific because medical professionals can begin to separate peoples' medicinal paths and categorise them based on genetic findings – this could make these routes much more efficient.¹⁴

Lastly, AI can also be of use in the manufacturing of genetics-based medications. This can be achieved through its ability to 3D print drugs that have been designed by smart drug delivery systems, which in turn, can then enhance its positive impact on individual

patients.⁶ It can save time for users of these systems, as well as additional expenditure on the collection of further data to allow them to operate. AI can also maintain printers, helping to prevent the supply of medications being interrupted as a result of machine failure.¹⁷ One study successfully implemented AI in the customisation of capsules in the pursuit of 3D printing personalised medications. They accomplished this through the encoding of capsule geometry to investigate how they would dissolve in the body. However, there were several limitations in this study that required addressing. These consisted of using only one type of material, a limited range of drug types and the lack of in vivo application. The authors therefore encourage further exploration in these three areas.¹⁸

Limitations

As highlighted in the discussion above, a common theme is 'the future'. As much as AI is showing great potential, it is still in its early stages and there are a lot more improvements to be made. For example, the training of AI is still a work in progress,⁵ and the current range of conditions AI can predict on is also limited.⁸ For AI to progress in this field, the dilemma surrounding the minimal pharmacogenomics data needs to be resolved. Without the appropriate quantity, training data can become majorly skewed, negatively impacting the machine's ability to learn. Furthermore, there are a surplus of variables when trialling drugs that idealistically need to be controlled, as otherwise, the relevancy of the data collected is difficult to extract. Simultaneously, data also needs to be extracted from varying subunits of the population to ensure that genetic and environmental diversity between communities is accounted for. If this is ignored, it can lead to an algorithmic bias within the AI system which could exacerbate the issue surrounding healthcare inequities for underrepresented groups. However, there is hope, with techniques like federated learning and cloud computing being developed that allows shared prediction models between a multitude of study sites.¹⁹

As well as quantity, the quality of training data is also important for AI in pharmacogenomics. Achieving this requires much effort and huge expenses, as identifying relevant information from datasets is extremely complicated. For AI to recognise relevant links between particular variables, these datasets need to be cleaned so that incorrect information, missing values and outdated statistics can be appropriately removed. This is a dilemma that has a huge impact on AI's ability to work in this field, and unfortunately there are limited suggestions as how to overcome this problem.¹⁹

Another issue is data security, with the danger of AI being at threat from cyber-attacks. Patient records and research data, for example, could be at risk. Not only does this pose a concern to the protection of private and sensitive information, but it also incurs large costs to healthcare services. This means continuous monitoring and updates will be necessary. Although these endeavours can be expensive to pursue, meaning many smaller healthcare providers may not have the sufficient budget to invest in the appropriate cyber-security measures. There are also risks from human error, in which data may be accidentally sent to cyber-criminals. This could be through means of phishing attacks, for example. This is where a hacker may impersonate others to trick employees into believing they are someone else, hence gaining access to sensitive information. To limit these data breaches, it is vital that strict regulations are imposed in relation to patient information, with repercussions for organisations that do not follow them. Regulatory oversight would be mandatory. More time and money need to be spent on developing robust security systems, which are consistently updated so that they always adhere to the latest safety standards as technology advances.²⁰

In terms of ethical quandaries, as briefly addressed, there are concerns that algorithmic biases could arise from the data used to train the software. These can lead to systematically incorrect conclusions and perpetuate biases. This may be solved through research into AI's rationale behind certain decisions it makes and integrating more

ethics-based research into the software. Transparency amongst these systems is a crucial step in mitigating this issue.¹⁰

For the reasons listed above, there are many steps that need to be taken before AI can be implemented in pharmacogenomics on a wider scale. However, some of the current applications include algorithms trained on genomic data in oncology to help personalise treatment; AI combining genomic and proteomic (information about proteins) data to predict cardiovascular complications; the revealing of more actionable insights in endocrinology; and the use of AI in pharmacogenomics to help improve antidepressant efficacy and reduce side effects in mental health interventions.²¹

Conclusion

To conclude, I believe, based on the evidence at hand, that AI is the way forward in pharmacogenomics. Even in its early development, AI has shown great potential, proving that it can aid healthcare professionals and researchers in the progression of pharmacogenomics. It has so many positive qualities, helping to optimise drug prescriptions and reduce side effects. However, before AI is employed further in the pharmacogenomics industry, its limitations do need to be addressed and overcome. Some potential next steps that could allow for this would be the introduction of strict regulations of AI in this field, to try and mitigate the dangers of data breaches. More research should be conducted into ensuring satisfactory cybersecurity, as well as enhancing the transparency with which AI makes decisions to solve issues surrounding algorithmic bias.

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Elizabeth Codner

Elizabeth Codner is a second-year medical student at the University of Plymouth. This paper was completed during her first year. She conducted an independent literature review exploring her academic interests, which involve artificial intelligence and pharmacogenomics.



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Delivering medical excellence through cytology in financially constrained settings: lessons from veterinary student placements

Adam Maher

Year 5, Veterinary Science, University of Bristol

Email: js21234@bristol.ac.uk



Abstract

Cytology is a rapid, minimally invasive, and cost-effective diagnostic tool with wide application in first-opinion veterinary practice. This article presents two anonymised cases encountered during a student placement, where cytological assessment significantly influenced clinical decision-making when advanced diagnostics were not financially feasible. One case involved an incidental mandibular mass identified during a routine dental procedure; the other revealed a mast cell tumour among multiple skin lesions presumed benign. In both cases, cytology provided immediate, practical information that shaped client discussions and welfare-focused decisions. The article also highlights the student's role in proactively performing and interpreting cytology under supervision, using established references to inform owner communication. These reflections emphasise the clinical value of patient-side cytology and the opportunities for students to contribute meaningfully during placements. The lessons extend across veterinary, medical, and dental contexts, underscoring how accessible diagnostic tools can deliver medical excellence where financial or logistical constraints limit advanced options.

Abbreviations

MCT - Mast Cell Tumour

In first-opinion veterinary settings, where financial constraints frequently limit access to advanced diagnostics, cytology offers a practical and underutilised means of delivering medical excellence. During a summer placement in 2025, I observed two cases on a single day that illustrated how cytology, when used resourcefully, can support and facilitate sound clinical decision-making even without

histopathology or advanced imaging. Importantly, these cases also demonstrate how student initiative and curiosity can contribute to patient outcomes when integrated thoughtfully into practice.

Both patients were older, medium-sized, neutered dogs presenting for routine procedures, yet clinical decisions had to adapt dynamically when unexpected findings arose. In the first case, a 10-year-old female neutered collie was admitted for dental work and excision of a known gingival mass. Examination under sedation revealed an incidental radiopaque mandibular mass contralateral to the surgical site. Although the owner had not reported any clinical signs, the lesion warranted investigation. Differential diagnoses included osteosarcoma, fibrosarcoma, and other malignant soft-tissue sarcomas. With the patient under sedation, a buccal flap was raised, and fine-needle aspiration (FNA) was performed intraosseously. Immediate cytological assessment demonstrated pleomorphic mesenchymal cells with anisocytosis, prominent nucleoli, and indistinct cytoplasmic borders, findings most consistent with osteosarcoma (**Figure 1**).^{1,2} Histopathology would have provided confirmation, but financial limitations precluded this. The cytological interpretation nevertheless allowed timely discussion with the owner regarding prognosis, referral, palliative care, or euthanasia. Without cytology, this lesion might have gone undetected until late clinical deterioration, delaying welfare-focused decisions.

The second case involved a 12-year-old male neutered foxhound cross admitted for dental work and removal of multiple skin masses. The owner had considered the lesions benign, but one was aspirated as a learning opportunity under veterinary supervision. Cytology showed keratinaceous debris consistent with a benign cyst. However, sampling of another mass revealed a round cell population with

cytoplasmic granules and occasional binucleation, diagnostic of a mast cell tumour (MCT) (**Figure 2**). Differentials included histiocytoma and plasmacytoma, but granule morphology supported MCT. Reference to standard cytology texts^{3,4} guided the interpretation, which was subsequently confirmed by histopathology. The diagnosis changed the owner's perspective: they elected for histological grading and commenced oral chemotherapy (toceranib phosphate, Palladia®). This highlighted the communicative value of cytology in reframing owner understanding and enabling proactive treatment planning.

These experiences emphasised that cytology is not merely an academic exercise but a clinically significant tool. Under supervision, I prepared and examined the smears, using textbooks and peer-reviewed literature to interpret cellular features in real time. This initiative, offered without cost to owners, enhanced patient care, supported client decision-making, and demonstrated the active role students can play in diagnostics during placements.

While cytology is invaluable, it is important to acknowledge its limitations. Fine-needle aspiration may yield non-diagnostic samples if poorly prepared or if lesions are necrotic. Certain tumours, such as some sarcomas, may be indistinguishable cytologically, and possible risks include patient discomfort and haemorrhage. Cytology should therefore be viewed as a complementary, not definitive, diagnostic tool, best interpreted alongside clinical context and other available evidence.

Beyond veterinary medicine, parallels exist in human healthcare. Rapid, low-cost cytological techniques, such as cervical smears or fine-needle aspiration of palpable lumps, remain integral in medical and dental practice where they inform clinical planning and patient communication.⁵ These cases illustrate how similar principles can support quality of life discussions in resource-limited contexts across disciplines.

Supportive supervision was also critical. Encouragement to participate in cytology fostered both confidence and competence, consistent with literature showing improved student outcomes from involvement in diagnostic sampling.⁶ Placements therefore represent not only an educational environment but also an opportunity for students to contribute directly to patient care through curiosity and proactive engagement.

In summary, these reflections demonstrate how cytology, which is fast, inexpensive, and minimally invasive, can meaningfully influence clinical decision-making in general practice. They also underscore how student initiative can add value in practice, providing diagnostic insights while enhancing education. For clinicians in veterinary, medical and dental fields, the lesson is clear: medical excellence does not always require expensive technology, but often depends on resourcefulness, foundational skills, and the willingness to look closely at the evidence.

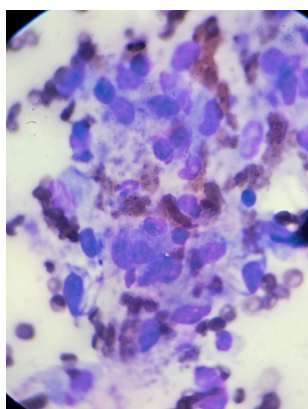


Figure 1. Cytology from an intraosseous mandibular fine-needle aspirate showing pleomorphic mesenchymal cells

with prominent nucleoli and indistinct cytoplasmic borders, consistent with osteosarcoma (Diff-Quik stain, 400x)

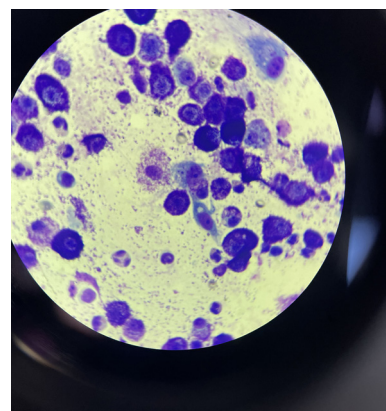


Figure 2. Cytology from a cutaneous lesion showing round cells with cytoplasmic granules and occasional binucleation, diagnostic of mast cell tumour (Diff-Quik stain, 400x)

The figures are images from anonymised samples taken by the author and approved for use by the placement provider.

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Adam Maher

Adam Maher is a veterinary science student at the University of Bristol, particularly interested in research and small animal emergency medicine. Adam is also an international theatre and opera director and probably the only undergraduate vet student with a Laurence Olivier award.

From pixels to plates: does social media heavily influence dietary practices?

Elroy Muza

Year 2, Medicine, University of Plymouth
Email: muzae006@gmail.com



Abstract

Social media has a strong influence over many modern societies. It has been documented, however, that social media's influence over many aspects of daily life, including diet, carries the potential to be quite negative, and in some cases, quite harmful. This piece aims to explore the extent of social media's influence on the dietary practices of young people (children aged 0-17) on a global scale. Advertisements of unhealthy foods and drinks on social media are repeatedly linked to higher unhealthy food and drink intake amongst young people. However, exposure to the potential negative consequences of unhealthy food and drinks equally leads young people towards choosing healthier options, highlighting how influential these advertisements are. Social media is also linked to many health risk behaviours amongst young people, such as alcohol consumption and eating disorders. Social media, therefore, has an evident influence on the dietary practices of young people, but more research will be required to reach more definitive conclusions.

Key definitions

Influencer - a (social media) user high in social standing who has the power to affect their followers' beliefs and purchasing decisions.¹

Non-core foods - foods outside of the five food groups of fruit, vegetables, cereals, meat and alternatives, and milk and alternatives, according to The Australian Guide to Healthy Eating.²

Introduction

Social media is a powerful tool that has gained prevalence over time,³

greatly influencing modern communication dynamics across the world and enhancing the building of global communities. However, exposure to unhealthy food images on social media has been documented to increase responses in the brain linked to memory, reward, attention and decision-making.⁴ This encourages people to seek out and consume these unhealthy foods and therefore engage in unhealthy dietary patterns. This piece aims to highlight the dysfunction of social media amongst young people, to determine whether social media heavily influences dietary practices.

Impact on young people

Consistent evidence indicates that unhealthy food and beverage marketing through social media influences the food choices and intake of young people.⁵ Social media exposure has been observed to increase intake of unhealthy snacks and sugar-sweetened beverages in the diet of children and adolescents, and simultaneously decrease fruit/vegetable intake, independent of age.⁴ Furthermore, social media was seen to be the most preferred channel for obtaining dietary information for young people in Hong Kong.⁶ This further enhances young people's desire for the food and beverages they see on social media.

Engagement with food and drink advertisements on social media has been seen to be linked to a high unhealthy food and drink intake,⁷ with fast food ads on social networking sites holding the potential to influence the purchasing likelihood, fast-food views and eating habits of young audience members.⁸ Evidence exists for a positive relationship between greater engagement with food and drink advertisements, but not exposure, and unhealthy diet. Statistically, the strongest links were observed among students reporting liking

and sharing food or drink posts daily or almost daily.⁷ Additionally, adolescents who reported more engagement with posts of non-core foods on social media were found to be much more likely to report greater consumption of these non-core foods.⁹ Furthermore, a systematic review that found a link between social media marketing exposure and diet-related outcomes noted that young people were aware of the influence social media has on their diet.⁵ This suggests that young people may be easily swayed by the temptations of the food adverts they see on social media platforms.

However, it has been documented that young people choose healthy options when a sedentary or overweight influencer promoted the unhealthy options.^{10,11} This suggests that young people and adolescents may only avoid unhealthy options if confronted by the potential negative consequences of unhealthy food. This implies that young people possess the capacity for independent dietary decision-making; they may possess a degree of resilience against social media influences.

Alongside this mentioned influence, many people may have limited options as to where they source their dietary information. It has been seen that professional athletes often have easy access to advice from professionals around their diet and training (e.g. sports nutritionists, strength and conditioning coaches, etc.). By contrast, many regular gym users do not have easy access to this level of professional advice (beyond personal trainers) and, in many cases, it is not free of charge. This leads them to obtain a lot of information about nutrition and supplements from the internet and social media.¹² This was fairly common during the COVID-19 pandemic. Less commuting took place, and people enjoyed more leisure time. When this was combined with increased online/social media workouts, they were key drivers for the use of social media to obtain dietary information.¹³ This has been seen to be particularly harmful, given that many younger social media users (particularly youths on TikTok) may be exposed to content containing unsubstantiated health claims about certain dietary products, such as muscle-building and weight-loss supplements, which may be harmful and under-regulated.¹⁴

Associated health risks

Beyond these direct impacts on diets, social media use has also been linked to many health risk behaviours amongst adolescents, including increased alcohol and unhealthy dietary behaviours.¹⁵ Additionally, the strong desire to conform to societal ideals creates a greater risk of engaging in unhealthy eating behaviours.¹⁶ This includes disordered eating behaviours, which evidence has shown to have significant links to social media use, particularly the promotion of harmful and under-regulated products, such as the muscle-building and weight-loss supplements that I have previously mentioned.^{14,17} Additionally, a study found social media addiction to have a weak positive relationship with eating disorders, notably bulimia and food preoccupation.¹⁸

Many social media influencers showcase highly edited images of their bodies they claim to have achieved through diet, alongside exercise, or even products they promote; exposure to this content is linked to increased risk for disordered eating.¹ This is further enhanced by the 'healthy' #fitspiration trend, which may be triggering new surges in disturbed eating pathology, resulting in a population of young people in danger of corroded body image, and an increased likelihood of partaking in compensatory disordered eating behaviours.¹⁹

Discussion

Limitations

There are many things to consider when assessing the strength of this piece. Firstly, there is very little mention of the positive benefits of social media, such as ease of communication, which can occur on a global scale, and the ability to rapidly spread information between

parties. Secondly, very little distinction was made between the effect of social media on the dietary practices of young people of different ages, such as 5-year-olds and 17-year-olds, which is a significant age gap within which substantial development occurs for a child.

Additionally, whilst there was some mention of specific social media platforms, such as TikTok, these mentions are infrequent. As a result, the precise influence of individual social media platforms (e.g. Instagram, TikTok, Snapchat, etc) on the dietary practices of young people is difficult to infer.

Conclusion

Overall, it is clear that social media carries an evident potential to have a heavy (and quite negative) influence on dietary practices amongst young people, due to the negative messages portrayed and the somewhat aggressive promotion of food and beverage items. Further research will be necessary, however, to obtain more definitive conclusions around the true extent of social media's influence on dietary practices. Despite this, the discussed harmful impacts of social media on dietary practices may warrant additional research into interventions, such as the promotion of dietary advice based on nutritional guidelines, or even the education of young people on more appropriate usage of social media, as a means of mitigating the negative influences of social media on dietary practices and easing strains on global healthcare systems.

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Elroy Muza

I am a second-year medical student at the University of Plymouth. Carrying a strong passion for cardiology and public health, this piece began as an SSU project in my first year; I'm hoping to explore the topic further in future research. Outside of my studies, I'm part of Plymouth's Christian Union, and I enjoy reading, particularly general non-fiction.

Rethinking motivation in medical education: a journey of 2650 miles

Poppy Wardley

Year 5, Medicine, University of Sheffield

Email: pnwardley1@sheffield.ac.uk



Despite record numbers of people applying for medical school in the UK,¹ the National Health Service (NHS) is facing an acute crisis in attrition rates of doctors. The disparity is astonishing, but current medical students are signing up for a promising career of which the reality is remarkably different.² Those entering training are feeling the effects, and in my third year at medical school, I found myself among the '1 in 5 medical students' considering leaving the course.³

Before I began medical school, my expectation was that the journey would lead me to a secure, socially impactful, highly-regarded career. However, poor work-life balance, career uncertainty and growing public scrutiny have led to a disconnect between the identity I imagined during my application process and the reality of the career. The 2025 GMC Workplace Experiences Report, published by the General Medical Council, recognised that despite emotional resilience being a quality strongly associated with being a doctor, the majority find it difficult to cope with the fatigue and stress of the job.⁴ I felt my own resilience towards these sacrifices wear down and made the decision to leave.

I thought about what to do next and spoke to my pastoral team at university. I already felt removed from the course, and my plans to take a year to intercalate became a convenient stopping point. The medical school persuaded me to take a leave of absence before making any major decisions. Although I felt certain I was not coming back, I saw the benefit of their advice and took it.

The idea of long-distance hiking had been in the back of my mind for a while. I knew time spent outdoors and the repetitive nature of

a hike could help me unpick my thoughts, so I packed my tent and sleeping bag and boarded a flight to America. Just days later, I was at the Mexican border.

Ahead of me was nothing but the sand dunes and stunted shrubbery of the Californian desert. I had decided to walk north across the desert towards the snowy peaks of the Sierra Nevada, onwards to Oregon's forests and the alpine plains of Washington. Eventually, I would try to reach Canada.

Once I started hiking, I immediately enjoyed the familiarity of moving my body. Finding it to be comfortably meditative, soon the expanse of the California desert stretched into long, hot, monotonous days. I thought about my own personal narrative: who I was and why I chose to do things. I knew my identity could be a powerful tool in maintaining my motivation. After all, we are all more likely to engage in behaviours when they reflect our authentic values⁵ and are much more likely to stick to them.

By investing time in the hike, I was doing something that resonated with me and helped me get to know my authentic self. Every sunburn, blister popped, or lost toenail was building up my personal narrative about who I was. I struggled with my own identity and whether I felt I had the resilience, empathy or generosity to sacrifice my time to pursue this career. However, I realised that developing these qualities within myself is what defined 'success' for me. In fact, medicine offers the perfect challenges and opportunities for these foundations to grow. By better understanding my goals, I could intentionally choose a path in medicine that I found deeply motivating. Instead

of obsessing with the outcome, I could gain a sense of achievement from being an authentic version of myself.

My misconception was that my passion for becoming a doctor would mindlessly propel me through five years of training. However, as I moved through medical school and my perception of what it meant to 'be a doctor' started to change, I struggled to continue, as my motivation was so fixed to the outcome. But the advantage of being motivated by identity is its ability to supersede and endure specific career goals.⁵ For me, I value a career providing the intellectual and social stimulation to grow the aspects of my identity that are important to me. Whilst the role of an NHS doctor may be drastically changing,⁶ these internal details of your interests and desires remain a dynamic alternative to strive for.



By the time I reached Canada, 5 months and 2650 miles later, returning to medicine felt right. The months of walking helped me reflect on how my experiences outside of medicine could grow my confidence and enthusiasm for the course, and transform the meaning of the career for me. Now I see how becoming a doctor is about being open to growth and new learning, as the finish line is constantly changing. By knowing your authentic self and finding achievement in becoming that person, it is the most sustainable way to improve your wellbeing and lifelong practice.

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Poppy Wardley

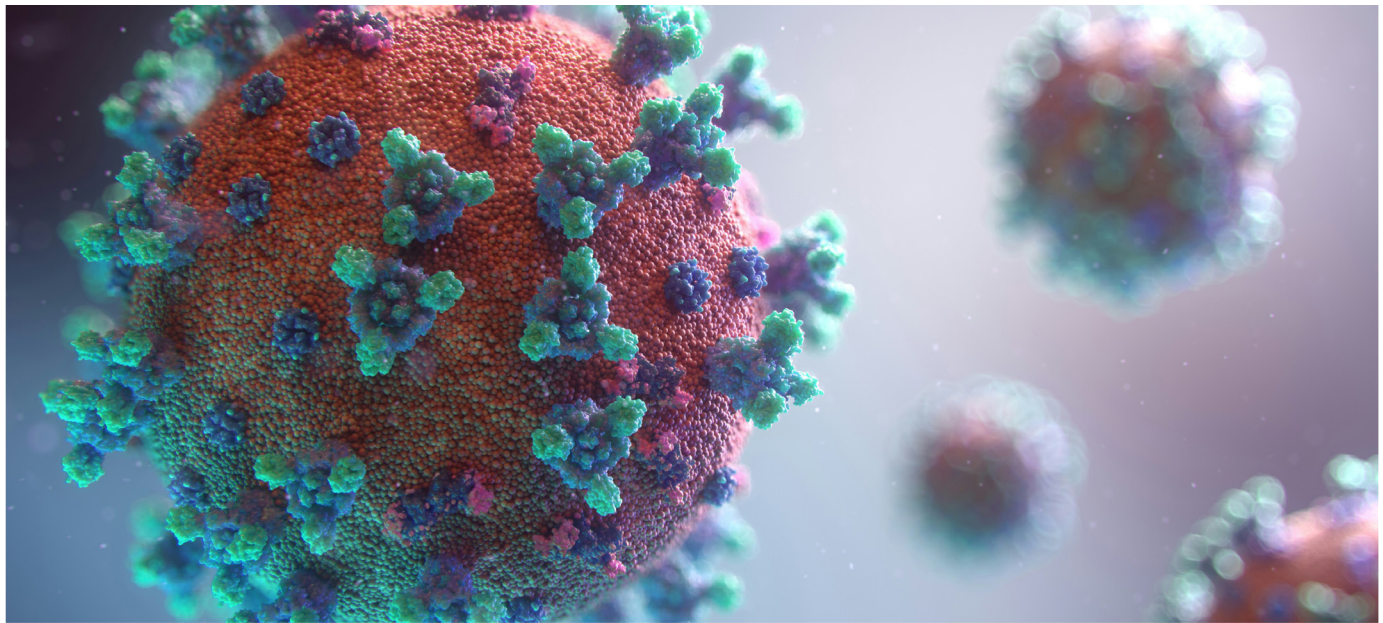
Poppy is a fifth-year medical student at the University of Sheffield. She has a keen interest in both emergency medicine and sports medicine, and her experiences in America grew her awareness of the interplay between mental health and time spent in nature. She continues to advocate for medical students mental health, and has presented her case report at the UK 'Mind Health for Medical Students' Conference and in the 'Dirtbag diaries' podcast. Outside of medicine, she loves doing anything outdoors, whether that's running, climbing, camping or wild swimming.

Evaluate the effectiveness of antiviral drugs in the treatment of COVID-19

Janae Breanna Black

Year 2, Medicine, University of Exeter

Email: jbb213@exeter.ac.uk



Abstract

COVID-19 is a viral disease that emerged in late 2019. It is characterised by many symptoms, with the most common being fever, cough, fatigue, dyspnoea and the presence of sputum. This review aims to evaluate the current drugs available in the UK for the treatment of COVID-19 to determine which is the most effective. These are nirmatrelvir plus ritonavir, sotrovimab, molnupiravir and remdesivir. Effectiveness was measured by three parameters: prevention of hospitalisation, reduction in the average time spent in the hospital, and reduction of mortality. The relevant literature was collated using the PubMed and TRIP databases. The research carried out found that nirmatrelvir plus ritonavir correlates with the largest decrease in the likelihood of hospitalisation, while sotrovimab is associated with the largest reduction in hospitalisation time and mortality. As sotrovimab was found to be the most effective in two out of the three parameters, it was concluded that sotrovimab is currently the best available drug in the UK. However, more research must be carried out, as some of the research used was on old variants of the SARS-CoV-2 virus and so may no longer be relevant.

Abbreviations

COVID-19 – coronavirus disease 2019

SARS-CoV-2 – severe acute respiratory syndrome coronavirus 2

Introduction

Newly emerging viruses have been an increasing problem in recent years. One such virus, SARS-CoV-2, emerged in Wuhan, China, in late

2019.¹ The disease it causes, COVID-19, has many symptoms, with the most common being fever, cough, fatigue, dyspnoea and the presence of sputum.² The COVID-19 pandemic was declared on the 11 March 2020.¹ Many drugs have since been developed to prevent the replication of the virus in the body. Due to the sudden nature of the outbreak, these drugs were produced and released simultaneously, with many drugs of various effectiveness available. They are usually only given to those considered at high risk of progression to severe COVID-19, for example, individuals with Down's syndrome and people with asthma on oral corticosteroids.³

Four antiviral treatments have been recommended by NICE for use in the UK: nirmatrelvir plus ritonavir, sotrovimab, molnupiravir and remdesivir.

Each drug works by a different mechanism. Nirmatrelvir works by inhibiting a cysteine residue in the 3-chymotrypsin-like protease enzyme in SARS-CoV-2, which prevents viral replication.⁴ It is administered with ritonavir, which inhibits the enzyme CYP3A4.³ As this enzyme metabolises nirmatrelvir, this allows the drug to stay in the body for longer.

Sotrovimab is a monoclonal antibody that works by targeting an epitope in the SARS-CoV-2 spike protein, preventing it from binding to human cells.⁵ As this epitope is highly conserved, the drug works for multiple strains of the virus.⁶

The final two drugs are prodrugs. Molnupiravir is converted to N4-hydroxycytidine once in the body.⁶ This then undergoes a series of reactions that lead to mutagenesis in both the viral virions and the host cells.⁶ These mutations inhibit viral replication. Remdesivir

inhibits viral replication by blocking the viral RNA polymerase, delaying chain termination.⁷

This review aims to evaluate each of these drugs to determine which is the most effective. For this review, effectiveness is defined by three clear parameters: prevention of hospitalisation, reduction in time spent in the hospital, and reduction in mortality.

Materials and methods

Relevant literature was sourced using the PubMed and TRIP databases. For each drug, the search terms “drug name” OR “brand name” AND “hospital*” were used. For example, “nirmatrelvir plus ritonavir” OR “Paxlovid” AND “hospital*.” This was because some articles referred to the drugs by their brand name as opposed to the drug name. Patient information booklets were excluded because they were unlikely to be in the required detail to use in this review. Papers from before 2020 were also excluded, as remdesivir was developed before this for the treatment of different diseases. Any research conducted on children was not included because their bodies were still developing – this may have affected their response to the drug. Studies with potential conflicts of interest were not excluded, but any relevance was considered when interpreting their findings. The titles and abstracts of each article were then filtered based on their relevance and the type of research involved. Only meta-analyses, reviews, cohort studies and clinical trials were included. This is summarised in **Figure 1**.

Discussion

Nirmatrelvir plus ritonavir

The use of nirmatrelvir plus ritonavir has previously been associated with a lower risk of hospitalisation from any cause.^{8,9} A retrospective cohort study carried out in 2022 found that in vaccinated patients who commenced treatment with nirmatrelvir plus ritonavir within 5 days of diagnosis, 0.8% were hospitalised for any reason.⁸ This was compared to 2% of people in the group receiving standard treatment, corresponding to a 60% relative risk reduction.⁸ A second cohort study obtained similar results, with 1.1% of those who received nirmatrelvir plus ritonavir being hospitalised within 28 days, compared to 2.4% of those receiving a placebo.⁹ A strength of the second paper was that it involved both vaccinated and unvaccinated individuals, which was relatively uncommon for studies on COVID-19 drugs. As it had similar results to the study on just vaccinated adults, this suggests that nirmatrelvir plus ritonavir had a similar effectiveness in both groups. However, a key issue with both studies was that they were not solely on high-risk individuals, who are most likely to be offered the drug. As many other studies included in this paper only included high-risk patients, this may make it difficult to directly compare it to other research.

Three studies found that the use of nirmatrelvir plus ritonavir did not have a significant effect on the time spent in the hospital.^{8,10,11} The reason for this is unclear. One possible reason for this may have been that these patients experienced a rebound in their symptoms after treatment.¹² This phenomenon is more common in people taking nirmatrelvir plus ritonavir than those taking other treatments.¹²

In most studies, very few patients died.^{4,9,11} As a result, these studies reported hospitalisations and deaths together. A double-blind, randomised, controlled clinical trial found that nirmatrelvir plus ritonavir was associated with an 88.9% reduction in hospitalisations and deaths.⁴ A retrospective cohort study also reported similar findings, with the reduction in 28-day mortality being larger in high-risk patients.¹³ Both studies assessed individuals that were classed as high-risk. This means that if a similar study was conducted on healthy individuals, the results may not be repeatable.

Sotrovimab

A randomised clinical trial found that treatment with sotrovimab was associated with a significantly lower risk of being hospitalised within 28 days, with a relative risk reduction of 81%.⁵ However, a cohort study found that there was only a relative risk reduction of 63%.¹⁴ This difference in results may have been because the clinical trial was only carried out on those infected with the Delta variant of SARS-CoV-2, while the cohort study was conducted on those affected by multiple variants.^{5,14} This suggests that sotrovimab may be more effective on the Delta variant than any other form of the virus.

The above clinical trial also found that sotrovimab causes a significant decrease in the time spent in the hospital.⁵ However, very few individuals were hospitalised in both the control group and the group treated with sotrovimab, and so the risk reduction was not calculated.⁵ No other research was found on this area, and so it is important to note that the results may not be repeatable. The reason for this lack of research may be unclear, but it could be due to it being highly effective at preventing hospitalisation.

Research also suggests that sotrovimab has a large impact on mortality. The above clinical trial found that sotrovimab reduces the risk of death by up to 79%.⁵ A cohort study obtained even higher results, with a relative risk reduction of 86%.¹⁵ This difference in results could, similarly to the research on hospitalisations, have been due to the cohort study looking at multiple variants while the clinical trial only researched the Delta variant. There was a large difference between the results obtained in the two studies, so more research must be done to obtain a reliable figure.

Molnupiravir

Molnupiravir was not generally found to reduce the likelihood of hospitalisation in people infected with SARS-CoV-2.^{16,17} This was unexpected as a drug must show clinical benefit to be approved. However, one study suggested that molnupiravir might reduce hospital admissions within 30 days when treatment was commenced within five days of a positive diagnosis.¹⁸ There was a relative risk of 35% when compared to a control.¹⁸ This large difference in results could have been due to many reasons. It was suggested that molnupiravir was effective in non-vaccinated people but ineffective in vaccinated people, but no significant difference was found between these two groups.¹⁸ There may have also been residual confounding in the study due to those being treated with molnupiravir having a higher average age and more risk factors on average.¹⁸ The study was also only carried out on people with at least one risk factor for developing severe COVID-19.¹⁸ This meant that molnupiravir may only have been effective in high-risk individuals. To determine the true effect, a cohort study should be carried out to compare the effect in high-risk individuals and the general population.

No research was found on the average time spent in the hospital after use of molnupiravir. This may have been because molnupiravir is usually not the first drug to be offered, due to evidence suggesting that other drugs are more effective.¹⁷ This means that it is likely to be offered later in treatment, and so its effect on the time spent in the hospital cannot reliably be measured.

Molnupiravir was not generally found to reduce mortality in patients infected with SARS-CoV-2.^{17,19} However, studies carried out on only patients infected with the Omicron variant found that it was effective.²⁰ The difference in results could be due to some forms of the virus being resistant, however, this cannot be stated definitively as the other studies did not specify which variants the patients were infected with.

Remdesivir

Only one study could be found that assessed the effect of remdesivir on the likelihood of hospitalisation. It suggested that in high-risk

patients, remdesivir reduces the risk of hospitalisation and death by up to 87%.²¹ This study had a large sample size of 562 patients undergoing the randomisation process, which may increase reliability.

Remdesivir was found to increase the average time spent in the hospital by three days in one study.²² This was unexpected, as an effective drug should decrease the time spent in the hospital. Remdesivir must be administered intravenously for three days; this meant that it was associated with an increased use of hospital beds.²² No other studies were found on this topic area.

The same cohort study also found that remdesivir has no impact on mortality.²² However, another retrospective cohort study found that remdesivir is associated with a 17% reduction in mortality.²³ This reason for the difference in results was unclear, as the individuals being observed in both studies were very similar. For example, both had a similar median age, with that of the first cohort study being 67 years, while that of the second cohort study was 66.8 years.^{22,23} A possible reason for the difference was that the second cohort study was carried out over a longer period, allowing the effect on more SARS-CoV-2 variations to be measured. If this was the case, this means that remdesivir was much more effective on later variations of COVID-19.

Conclusion

In conclusion, the evidence above suggests that sotrovimab is the most effective drug for the treatment of COVID-19. It has been associated with the largest decrease in hospitalisation time and the largest decrease in mortality. As it is the most effective in two of the three of the parameters used, this suggests that it is the best COVID-19 drug currently available in the UK.

However, more research must be conducted. There has not been enough research on molnupiravir and remdesivir to obtain a definite conclusion. Some of the research used was also carried out in 2020 and 2021; the strains of the virus circulating then are unlikely to still be circulating now. Retrospective cohort studies spanning periods of approximately a year should be carried out to find out which drug is the most effective against the SARS-CoV-2 variants currently circulating.

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Janae Breanna Black

I am a second-year medical student from the University of Exeter with an interest in hepatology, geriatrics and respiratory medicine. This article was originally written for a Special Study Unit in my first year of university, and it has made me realise that I have a passion for academic medicine. Outside of university, I enjoy swimming and playing tennis.

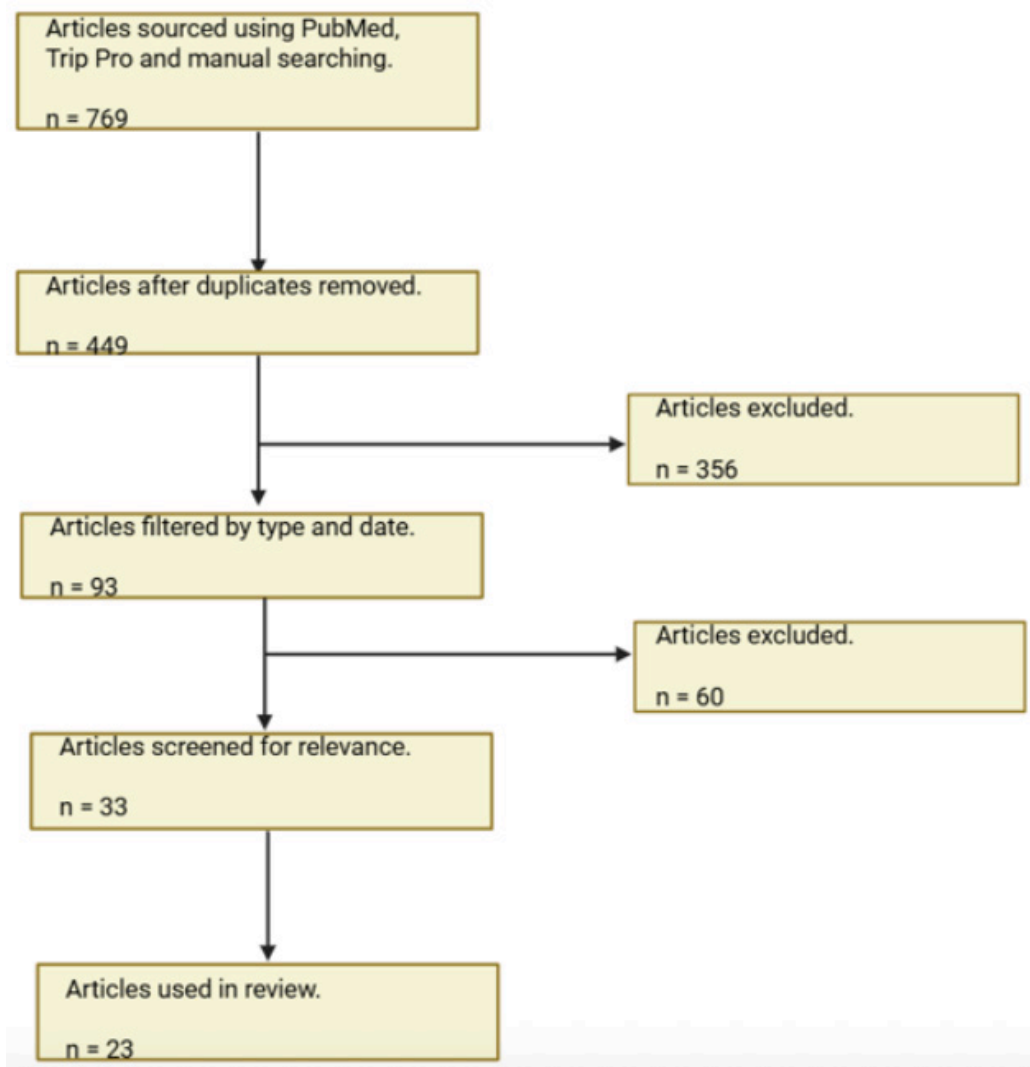


Figure 1. A PRISMA diagram showing the process by which sources were selected for this study. Created in BioRender.com

The role of endodontic sealers in achieving optimal root canal outcomes

Zayd Mazhar Dar & Jawad Hussain

Year 5, Dentistry, King's College London

Email: zaydmazhardentistry@gmail.com



Abstract

Root canal treatment (RCT) relies on eliminating infection and creating an adequate seal within the canal system. Endodontic sealers are essential in this process, filling gaps between the canal walls and core material to prevent microbial leakage. Traditional sealers like zinc oxide-eugenol and epoxy resins have been widely used, however, concerns about cytotoxicity and limited biological activity have led to the rise of calcium silicate-based (bioceramic) sealers. These newer materials offer better biocompatibility, antibacterial properties, and promote tissue healing. This review explores the evolution, properties and clinical performance of endodontic sealers, with a focus on calcium silicate formulations. Clinical studies suggest they reduce postoperative pain and support faster periapical healing, though limitations remain in their ability to be retreated and their cost. Material choice should be guided by case-specific needs, obturation techniques and clinician preference. Overall, calcium silicate-based sealers represent a shift toward biologically active materials that enhance healing and long-term outcomes in endodontic treatment.

Abbreviations

ISO – International Organization for Standardization

MTA – mineral trioxide aggregate

RCT – root canal treatment

ZOE – zinc oxide-eugenol

Introduction

Successful root canal treatment (RCT) relies on the complete elimination of microbial infection and the establishment of a long-lasting seal within the root canal system. Endodontic sealers play a critical role in this process by occupying the space between the canal walls and the core obturation material, filling irregularities, and preventing the ingress of microorganisms and fluids back into

the canal system.¹ The efficacy of these materials can significantly influence treatment outcomes, particularly in cases involving challenges such as complex root anatomy or periapical pathology.

Historically, sealers such as zinc oxide-eugenol (ZOE) and epoxy resin-based compounds like AH Plus have been considered the gold standard due to their handling characteristics and established outcomes.² Classic endodontic texts have also documented the enduring relevance of these materials in clinical success over decades.³ However, the past decade has seen a growing shift toward calcium silicate-based or “bioceramic” sealers, which are prized for their superior biocompatibility, bioactivity and sealing capacity. These materials have demonstrated promising results in both in vitro and in vivo studies, particularly in terms of periapical healing and reduced post-operative symptoms.^{1,4}

As RCT outcomes are multifactorial, the contribution of the root canal sealer alone cannot be isolated from the broader clinical context when discussing the success or failure of treatment. Nevertheless, a critical evaluation of modern endodontic sealants reveals their potential to enhance the predictability and longevity of treatment outcomes when selected appropriately. This essay explores the evolution, properties, and comparative clinical performance of endodontic sealers, with a particular focus on their impact on healing, biocompatibility, and long-term success in root canal treatment.

Historical and material evolution of endodontic sealers

The development of endodontic sealers reflects broader advancements in biomaterials and a growing recognition of the biological demands of root canal treatment. Initially, the primary role of sealers was to serve as a gap filler between gutta percha and the canal walls, with little emphasis on biocompatibility or bioactivity. As the understanding of endodontic pathology evolved, expectations

shifted towards materials that could contribute to healing while providing long-term sealing integrity.⁵

ZOE was one of the earliest materials used and was favoured for its antimicrobial effects and ease of use. However, issues such as high solubility, tissue irritation and limited long-term sealing compromised its performance.⁶ The introduction of epoxy resin-based sealers such as AH Plus improved the standard of care by offering better dimensional stability, lower solubility and improved adhesion. These materials became widely adopted and, in many practices, AH Plus remains the standard.⁴ Nevertheless, concerns regarding their cytotoxicity and lack of regenerative potential spurred further research into alternative options.¹

In response to these limitations, calcium silicate-based sealers emerged as a new generation of endodontic materials. Drawing from the clinical success of MTA, these sealers were engineered to offer not only excellent sealing ability but also bioactivity and enhanced compatibility with periapical tissues. Their ability to form hydroxyapatite in situ promotes a biologically integrated seal at the dentin–sealer interface.⁴ Clinical and in vitro studies have shown that these sealers, including formulations like EndoSequence BC Sealer and Bio-C Sealer, are associated with less post operative inflammation and may encourage faster periapical healing.⁷⁻⁸

The clinical adoption of calcium silicate-based sealers has increased steadily in recent years. A survey of Romanian dental practices found a growing preference for bioceramic sealers among both general dentists and endodontists, who cited their superior handling and biological properties as key advantages.⁹ Nevertheless, resin-based sealers continue to be widely used, especially in cases where clinicians prefer obturation techniques such as warm vertical condensation.

In summary, the progression from ZOE to resin-based and now to calcium silicate-based sealers illustrates a shift in endodontics toward materials that not only seal effectively but also actively support periapical healing and tissue regeneration.

Key properties of root canal sealers

The selection of a root canal sealer plays a central role in determining the quality of obturation and the biological outcome of root canal treatment. An ideal sealer should exhibit a combination of favourable physical, chemical and biological properties that contribute to an effective seal, inhibit microbial leakage and encourage tissue healing. As material science advances, modern sealers are increasingly evaluated not only for their mechanical performance but also for their impact on periapical healing and long-term success.

One of the fundamental properties of an effective sealer is its sealing ability. This involves the capacity to adapt closely to the canal walls and obturating material, filling microscopic voids, isthmuses and accessory canals. Poor sealing can result in persistent microbial leakage and eventual treatment failure. Calcium silicate-based sealers have shown superior adaptability to canal irregularities due to their hydrophilic nature, which allows better flow in moist conditions commonly encountered in clinical settings.⁴ These materials also undergo slight expansion upon setting, which may enhance the tightness of the seal.¹ In contrast, resin-based sealers, although dimensionally stable, may shrink slightly during polymerisation, potentially compromising the apical seal.⁶ In comparative microleakage assessments, calcium silicate-based sealers like Bio-C Sealer exhibited significantly less dye penetration compared to resin-based options, supporting their effectiveness in long-term sealing.¹⁰

Biocompatibility is another key consideration. A sealer should not provoke a prolonged inflammatory response when in contact with periapical tissues. Traditional sealers such as ZOE and some resin-based products have been associated with cytotoxicity in their unset states, especially when overextended beyond the root apex. Calcium silicate-based sealers have consistently demonstrated superior

biocompatibility, exhibiting minimal cytotoxic effects in vitro and promoting favourable histologic responses in vivo.⁷ Their alkaline pH and ability to release calcium ions are thought to support periapical repair by promoting mineralisation and tissue regeneration.⁸

Antimicrobial activity is also a desirable property, particularly given the complex nature of root canal infections. While no sealer can eliminate microbial presence, materials with sustained antimicrobial action may reduce bacterial survival in inaccessible areas of the canal system. The high pH of calcium silicate-based sealers creates an environment that is hostile to common endodontic pathogens such as *Enterococcus faecalis*. Some studies report that this antimicrobial activity persists even after setting, although its clinical significance continues to be investigated.¹¹ Resin-based sealers, on the other hand, typically lack intrinsic antimicrobial effects and rely more on the overall mechanical obturation and disinfection achieved during the canal preparation process.¹²

Other essential characteristics include flow, working time, radiopacity and solubility. A sealer must have adequate flow to penetrate the complexities of the canal without extruding excessively beyond the root apex. Radiopacity is necessary to evaluate obturation quality radiographically. Calcium silicate-based sealers generally meet ISO standards for these properties although their relatively slower setting times and potential for post-setting solubility under some conditions remain under scrutiny.^{1,13} AH Plus, a commonly used resin-based sealer, excels in dimensional stability and radiopacity but may not match the biological activity or antimicrobial potential of newer alternatives.

In clinical terms, the ideal sealer should strike a balance between handling convenience, long term sealing performance and biological safety. The growing body of evidence supporting the biological superiority of calcium silicate-based sealers has led to their increasing integration into both general and specialist practice. Their performance appears particularly advantageous in cases with periapical pathology, immature root apices, or endodontic retreatment, where tissue compatibility and healing capacity are especially important.

As material science continues to evolve, the ideal root canal sealer is no longer defined solely by its ability to fill space. Its contribution to healing, biological stability, and the overall prognosis of treatment has become equally critical to its clinical value.

Clinical outcomes and evidence-based performance

The clinical success of root canal treatment is often measured by parameters such as post-operative symptoms, radiographic healing and long-term tooth retention. The choice of root canal sealer contributes substantially to these outcomes, particularly through its sealing ability, tissue compatibility and biological performance. In recent years, evidence from both randomised controlled trials and systematic reviews has increasingly supported the superior clinical behaviour of calcium silicate-based sealers when compared with traditional alternatives.

One of the most immediate clinical indicators of success is post-operative pain. Several studies have examined whether the type of sealer influences discomfort following treatment. In a randomised trial comparing a calcium silicate-based sealer with AH Plus, patients treated with the bioceramic formulation reported significantly lower pain scores within the first 72 hours.⁷ This may be due to the lower inflammatory response associated with the high biocompatibility and alkaline pH of calcium silicate materials, supporting periapical repair.

Healing of periapical tissues is the ultimate goal of endodontic therapy alongside preserving the tooth inside the mouth. Longitudinal

studies evaluating radiographic signs of healing have demonstrated that teeth obturated with calcium silicate-based sealers often show faster and more complete resolution of periapical radiolucencies. For instance, a 5 year follow up study revealed that teeth filled with calcium silicate-based sealers exhibited periapical healing rates comparable to or higher than those treated with resin-based sealers, with no difference in obturation quality.¹⁴ Moreover, the ability of bioceramic sealers to induce apatite deposition at the sealer-dentine interface may help create a biologically integrated seal that supports regeneration rather than simple repair.⁴

In more challenging clinical situations, such as endodontic retreatment or large periapical lesions, the properties of the sealer may become even more critical. Some evidence suggests that calcium silicate-based sealers perform well in these complex cases. Their antimicrobial action and bioactivity can be particularly advantageous in endodontic retreatments where microbial load is often higher and canal morphology more compromised.⁸ Their capacity to form a chemical bond with dentine and remain dimensionally stable under moist conditions may help prevent reinfection in teeth with compromised apical anatomy or resorption defects.

Randomised clinical trials and systematic reviews further support the efficacy of bioceramic sealers. A meta-analysis by Amoroso-Silva et al¹¹ demonstrated that calcium silicate sealers were associated with equal or greater success rates when compared to resin-based sealers over 12–24 months. Similarly, studies comparing success rates based on clinical and radiographic criteria have concluded that calcium silicate-based sealers can achieve predictable outcomes, particularly in teeth with necrotic pulp or apical periodontitis. While some studies report no significant difference in outcomes between the two classes of sealers, the biological advantages of bioceramics may become more apparent in situations where healing potential is challenged.

The success of a root canal sealer is also affected by procedural factors such as obturation technique and operator experience. Warm vertical condensation and other thermoplastic techniques may influence the physical behaviour of the sealer, particularly its flow and penetration into the canal space. Resin-based sealers like AH Plus have been favoured in such techniques due to their thermal stability and long working time. However, calcium silicate-based sealers are increasingly being used with single-cone techniques, capitalising on their flow characteristics and ability to set in the presence of moisture.⁴ While these techniques simplify obturation, they may require clinicians to adapt to the handling properties and setting behaviours of the newer materials.

Paediatric applications and pulpotomies in primary teeth have also benefited from the properties of calcium silicate-based materials. In a systematic review on primary molar pulpotomies, Silva et al¹⁵ reported higher success rates with calcium silicate cements compared to formocresol or calcium hydroxide, underscoring the value of these materials in both the permanent and primary dentition. Their ability to support dentine bridge formation and maintain pulp vitality aligns with the goals of minimally invasive endodontics.

Despite the encouraging data, it is important to acknowledge that the success of endodontic treatment is multifactorial. The role of coronal restoration, pre-operative periapical status, canal disinfection and clinician expertise all interact with material properties to determine the outcome.⁵ Even the most biologically advanced sealer cannot compensate for inadequate cleaning and shaping, poor isolation or deficient coronal sealing.

In summary, calcium silicate-based sealers have shown favourable clinical performance across a range of treatment contexts. They appear to reduce post-operative discomfort, support periapical healing, and perform reliably in both straightforward and complex cases. As the evidence base expands, these materials are increasingly viewed not merely as sealing agents, but as contributors to regenerative healing and enhanced long-term prognosis.

Clinical considerations for sealer selection

The clinical selection of root canal sealers is influenced by an interplay of material characteristics, procedural demands and case specific biological considerations. While *in vitro* studies offer comparative data on physicochemical properties, clinical decision making must also account for handling preferences and material choice.

In cases with necrotic pulp or extensive periapical pathology, calcium silicate-based sealers are often favoured due to their demonstrated bioactivity and ability to support hard tissue formation. These properties are particularly beneficial in situations requiring regenerative potential, such as immature apices or endodontic retreatment with persistent lesions.² In contrast, when the priority is obturation precision and compatibility with thermoplastic techniques, epoxy resin-based sealers like AH Plus are widely preferred because of their long working time, dimensional stability, and established bond strength to both gutta percha and dentine.¹⁶

Handling properties and procedural efficiency are also critical in material selection. Premixed calcium silicate-based sealers allow for simplified delivery and are increasingly used with single cone obturation methods, which reduce chair time and procedural complexity.¹² However, these materials can be sensitive to ambient moisture, and some clinicians report a learning curve in mastering their placement.¹ For complex cases requiring extended manipulation or staged treatment, the predictable behaviour of resin-based sealers may provide an advantage.

The potential for apical extrusion and its consequences also influences sealer choice. Studies have shown that while extrusion of any root filling material can delay or impair healing, calcium silicate-based sealers tend to provoke a milder inflammatory response compared to glass ionomer or resin-based counterparts.¹⁷ This difference is important in teeth with compromised apical constriction or during endodontic retreatment.

Economic and logistical factors further complicate material selection. Though calcium silicate sealers are often more expensive, their simplified techniques and potential to improve clinical outcomes may offset initial costs.²⁰ Some products with extended setting times may not be ideal in cases requiring immediate post space preparation or restoration, which makes resin-based sealers more suitable in those workflows.⁴

Ultimately, the optimal choice of sealer must be tailored to each case. Pulpal status, root anatomy, restorative plan and clinician experience all contribute to this decision. As endodontic materials continue to evolve, clinical adaptability and thoughtful selection remain essential to achieving consistent and predictable treatment outcomes.

Discussion and synthesis

The progressive evolution of endodontic sealers has led to a shift in clinical expectations from merely filling voids to actively contributing to periapical healing and treatment success. Calcium silicate-based sealers have emerged as promising materials with distinct advantages over traditional zinc oxide-eugenol and resin-based sealers. These benefits include superior biocompatibility, bioactivity, and a capacity for chemical bonding with dentinal walls, adhering to the philosophy of biologically centred endodontics.⁷

Nonetheless, while bioceramic sealers show clear advantages in terms of antimicrobial activity and reduced cytotoxicity, their clinical superiority remains subject to ongoing investigation. A recent study comparing resin-based and bioceramic sealers reported no statistically significant difference in overall success rates, highlighting that both material classes can perform reliably when used under optimal conditions.⁸ Furthermore, despite their positive biological

profile, bioceramic sealers may present limitations in endodontic retreatment cases due to the difficulty of complete removal from root canal walls.¹⁹

Clinical factors such as obturation technique, tooth anatomy and restorative considerations continue to play a substantial role in outcomes. Bio-C Sealer, for example, has demonstrated excellent adaptation to canal walls, especially in the apical third, but its performance may vary depending on the sealing strategy employed.²⁰

There is also a broader issue regarding the gap between in vitro findings and real-world performance. While many calcium silicate-based sealers exhibit promising properties in controlled laboratory settings, the limited availability of long-term clinical data highlights a need for further well-designed studies to substantiate their effectiveness in diverse patient populations and treatment scenarios. Considering these complexities, the decision to adopt bioceramic over resin-based sealers should not be guided solely by material properties but must be contextualised within the clinical context. The integration of biological compatibility, procedural efficiency, and case-specific requirements offers a more nuanced approach to sealer selection. Future research should aim to clarify the long-term impact of newer sealers across a variety of treatment contexts and provide clinicians with evidence-based guidance that extends beyond theoretical advantages.

Conclusion

The evolving landscape of endodontic sealers reflects a broader transformation in clinical endodontics, one that places increasing emphasis on biological compatibility, healing outcomes, and long-term treatment success. While earlier sealers such as zinc oxide-eugenol and epoxy resin formulations met the mechanical demands of obturation, their limitations in biocompatibility and regenerative potential have prompted a shift toward more biologically active alternatives. Calcium silicate-based sealers represent this progression, offering properties that align with contemporary expectations for materials that not only seal but also contribute to tissue healing and microbial control.¹¹

Clinical evidence has shown that these bioceramic sealers perform effectively across a variety of treatment scenarios, including cases with periapical pathology and immature apices.⁸ Their ability to simplify obturation and promote periapical healing makes them a compelling choice for both specialists and general practitioners. However, their limitations, particularly in the ability to be retreated and their cost, underline the importance of thoughtful case selection and operator familiarity.

Ultimately, the choice of sealer must be informed by a balance of material science, clinical context and practitioner experience. No single sealer is universally superior, but when aligned with the biological needs of the case and the technical parameters of treatment, calcium silicate-based sealers have the potential to elevate the standard of care.

As endodontic practice continues to evolve, the thoughtful integration of biologically active materials represents a critical step toward more predictable, regenerative and patient-centred outcomes.

Contribution statement

Both authors had significant contributions to the research, writing and revising of this piece critically for important intellectual content, and the final approval of the version to be included in Inspire. Zayd Mazhar Dar is responsible for the integrity of the work as a whole.

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Zayd Mazhar Dar

Hello! I am a final-year dental student at King's College London with a keen interest in oral surgery and its integration within multidisciplinary care planning, particularly in cases involving developmental and craniofacial dental conditions. I completed a BSc in Pharmacology, which sparked my interest in the drug discovery process and the development of medicines used in everyday clinical practice. This experience deepened my appreciation for evidence-based dentistry and the biological mechanisms underpinning oral disease and treatment. I'm passionate about the evolving relationship between pharmacology, surgery, and minimally invasive approaches to patient care. Outside of clinics, I'm always on the lookout for the best flat white in London.



Jawad Hussain

Hey! I am fifth-year dental student at King's College London, with particular interests in oral surgery, restorative/aesthetic dentistry and prosthodontics, including the role of implants in modern clinical care. Alongside the course, I have contributed to the Dental Academia Team, supporting students in lower years with clinical guidance and study resources. I'm fascinated by ways in which developmental dentistry and interdisciplinary collaboration can redefine long-term patient outcomes. Outside of dentistry, I love travelling and exploring and am an avid reader.

What is the potential for JAK inhibitors to treat type 1 diabetes?

Sareena Khan

Year 3, Medicine, University of Exeter

Email: sk916@exeter.ac.uk



Abstract

Type 1 diabetes (T1D) is an autoimmune disease, causing hyperglycaemia. Evidence suggests Human Leukocyte Antigen Class I (HLA-1) hyperexpression causes CD8+ T-cells to destroy pancreatic β -cells, reducing insulin. This is caused by interferon stimulation via the Janus Kinase (JAK) – Signal Transducer and Activator of Transcription (STAT) pathway. No cure exists, creating urgency to design drugs targeting disease pathology. JAK inhibitors show promise in reducing HLA-1 expression. This review aims to explore how JAK inhibitors can target this pathway to treat T1D, by considering hallmark features, driving mechanisms and targeting. Studies conclude HLA-1 hyperexpression is observed in human islets, with interferon signalling causing and driving hyperexpression. Studies also agree JAK inhibitors target this, which reduces hyperexpression in mice; this is reflected in humans by producing more insulin. Longer randomised controlled trials should be conducted, in individuals at risk of disease with predictive biomarkers, to prevent disease pathology and reduce onset.

Abbreviations

CTL – Cytotoxic T lymphocyte
 FFPE – Formalin-fixed paraffin-embedded
 HLA-1 – Human Leukocyte Antigen Class I
 IFN – Interferon
 JAK – Janus Kinase
 MHC-1 – Major Histocompatibility Complex Class I
 NOD – non-obese diabetic
 RCT – randomised controlled trial
 STAT – Signal Transducer and Activator of Transcription
 T1D – type 1 diabetes

Introduction

Type 1 diabetes (T1D) is an autoimmune disease leading to the destruction of insulin-producing pancreatic β -cells, causing hyperglycaemia, which is high blood glucose in this case from lack of insulin.^{1,2} Around 376,000 people in the UK are affected,³ with nearly 90% of children and young people with diabetes having type 1.³ Currently, there is no cure and individuals require exogenous insulin replacement for survival to prevent life-threatening complications such as ketoacidosis,¹ emphasising the need for new therapeutics to reduce β -cell demise early on, potentially delaying or preventing T1D.

A characteristic feature of T1D is the hyperexpression of Human Leukocyte Antigen Class I (HLA-1), encoding the Major Histocompatibility Complex Class I receptor (MHC-1).⁴ As part of protein synthesis, its transcription, where mRNA is synthesised from DNA, is regulated by cell signalling molecules called cytokines. A family of cytokines called interferons (IFNs), α and γ , regulate this via the Janus Kinase (JAK) – Signal Transducer and Activator of Transcription (STAT) signalling pathway.⁵ IFNs bind to receptors on their target cells. This activates receptor-associated enzymes of the JAK family, which phosphorylate each other by transphosphorylation, which leads to another addition of a phosphate group in phosphorylation of STAT transcription factors. Phosphorylated STAT1 and/or STAT2 then dimerise and translocate to the nucleus, where they regulate and modulate target gene transcription and cause downstream effects, causing HLA-1 hyperexpression. IFN α -induced hyperexpression is mediated by members of the JAK family JAK1/TYK2, and IFN γ by JAK1/JAK2. Since JAK1 is present in both pathways, it is sensible to target this for maximal effect.⁴

MHC-1 is essential for CD8+ cytotoxic T-cell interaction. Hyperexpression causes identification of β -cell antigens as non-

self, precipitating selective destruction by cytotoxic T lymphocytes (CTLs).⁴ This significantly reduces insulin production, making HLA-1 hyperexpression central to T1D pathogenesis.⁴ JAK inhibitors can reduce CTL-mediated demise, by inhibiting STAT phosphorylation. This prevents downstream effects of IFNs and reduces HLA-1 hyperexpression, preserving β -cell function and insulin secretion which maintains normoglycaemia. This review aims to explore how JAK inhibitors target the JAK-STAT pathway to treat T1D by evaluating evidence of HLA-1 hyperexpression on β -cells, understanding how IFNs drive this, and exploring JAK inhibitor potential to target this pathway.

Methods

PubMed, Cochrane Library, Trip Database and Web of Science were searched, using the search string: ("type 1 diabetes" AND "HLA-1 hyperexpression") OR ("MHC-1") OR ("type 1 diabetes" AND "JAK" OR "STAT") OR ("type 1 diabetes" AND "JAK inhibitor") OR ("type 1 diabetes" AND "STAT1" AND "beta cells"). Randomised controlled trials (RCTs) and clinical trials were included, and papers not written in English were excluded, which yielded 115 results. After screening and forwards and backwards citations, nine studies were selected. **Figure 1** illustrates the process of primary evidence synthesis.

Results and discussion

HLA-1 hyperexpression

A study by Coppieters et al found HLA-1 hyperexpression specific to T1D.⁶ Contrastingly, Skog et al reported intense HLA-1 staining in more T1D subjects than controls, for formalin-fixed paraffin-embedded (FFPE) pancreatic specimens,⁷ however, even distribution was observed with frozen specimens. Protein data is supported at mRNA level, as RNA sequencing showed comparable mRNA expression of HLA-ABC, common HLA-1 isoforms, and no difference for MHC-1 in islets between people with diabetes and people without, suggesting hyperexpression due to staining artefacts. Oppositely, Richardson et al reported HLA-1 hyperexpression in T1D islets,⁸ at protein and RNA levels, since RNA expression of HLA isoforms in laser captured islets was elevated compared to controls. Benkahla et al supports this,⁹ finding HLA-1 hyperexpression in T1D donor islets.

Most favourably, Coppieters et al had the largest sample size,⁶ increasing generalisability and reducing anomalous participant skew. Richardson et al and Benkahla et al had moderate sample sizes,^{8,9} however Richardson et al obtained samples from three significant T1D pancreas collections, thus is more representative. However, Skog et al's is the least generalisable with eight subjects.⁷

All studies used human pancreas samples, either frozen and/or FFPE pancreata, to obtain islets,⁶⁻⁹ increasing transfer ability to humans, although each has limitations. FFPE preserves proteins, however they become denatured so antibody binding may differ between active and inactive forms, limiting staining value, whereas freezing may provide more accuracy through preservation in their active state.¹⁰ Additionally, nucleic acids are not preserved well so are not ideal for molecular genetic analysis, contrarily to frozen samples,¹⁰ affecting precision and accuracy of FFPE tissue. This may explain Skog et al's discordant results. FFPE protocol is not standardised, so no guarantee of similar preparation exists,¹⁰ affecting reproducibility. Skog et al claims reported hyperexpression is due to formalin-fixation techniques.⁷ However, Richardson et al confirmed staining specificity in FFPE samples, using a secondary antibody to confirm HLA-1 hyperexpression detection.⁸ Despite similar staining findings, this increases Richardson et al's cross-validity, considering Skog et al used only one antibody.

Islet isolation processes may alter HLA-1 expression.⁷ RNA expression reflects the time of sampling. To minimise downregulation, Skog et al immediately reduced biopsy temperature to reduce tissue metabolism,⁷ although no RNA elevation may be due to this. However,

laser-capture microscopy verifies these findings through RNA expression, though only two individuals were used: Richardson et al used more,^{7,8} so is more reliable. Benkahla et al goes further than Skog et al, by quantifying HLA-1 in islets, providing further evidence of this hallmark feature.⁹ Using high resolution confocal microscopy, instead of light microscopy, creates higher-resolution imaging than Skog et al,¹¹ improving accuracy. Despite Skog et al's unconvincing evidence against HLA-1 hyperexpression, data disproves this hypothesis, with further supporting studies suggesting HLA-1 hyperexpression is a hallmark feature of T1D and not artefactual.

Role of interferons

Marroqui et al reports IFN α activated STAT1-3, inducing MHC-1 expression in human cell line EndoC- β H1 and human islets.¹² They observed IFN α and IFN γ inducing similar MHC-1 expression. STAT1 knockdown prevented IFN γ -induced MHC-1 expression but not IFN α -induced expression. Both STAT2 and STAT1/STAT2 double knockdown, almost completely prevented IFN α -induced expression, implicating STAT1 in IFN γ and both STAT1 and STAT2 in IFN α pathways. Richardson et al observed elevated STAT1 in hyperexpressing β -cells.⁸ A Spearman's Rank Coefficient of $r=0.5454$, $p<0.0001$ reported between STAT1 and HLA-ABC, suggests a statistically significant positive correlation between the two, supporting STAT1's role in HLA-1 hyperexpression. Another study by Coomans de Brachène et al reported IFN α induced MHC-1 production in EndoC- β H1 cells, however, upon withdrawal, MHC-1 remained overexpressed in human islets.¹³ Additionally, JAK inhibitors did not accelerate MHC-1 decrease when added post-IFN withdrawal. However, pre-treatment with JAK inhibitors prevented IFN α -induced HLA-ABC expression dose-dependently, suggesting continuous IFN α signalling is unnecessary for long-lasting MHC-1 hyperexpression in human β -cells. Early intervention may be promising as type 1 IFN α signature expression precedes autoantibody detection in children at risk for T1D. If signature detection became part of routine follow up for at-risk children, it could indicate an ideal moment for intervention.¹³

Studies using the human cell line EndoC- β H1,^{12,13} should be interpreted with caution. Despite glucose-responsiveness and insulin production, islet cytokine responsiveness is not fully reflected,¹⁴ nor proliferation and insulin content.¹⁵ Furthermore, islet composition or orientation is not imitated, nor β -cell interactions with other cells.¹⁶ Although similarly expressing β -cell specific genes,¹⁷ data from this line needs validating with human islets, which increases transferable potential to humans *in vivo*.

Two studies used anti-MHC-1 antibodies during staining; Marroqui et al's was derived from rabbits and Coomans de Brachène's mice.^{12,13} In canine tissue, rabbit antibodies have higher antigen affinity than mice antibodies, although this differs from human tissue results.¹⁸ Therefore, differences may exist in antibody affinity between studies, introducing confounding variables and reducing accuracy.

Despite the limitations of human cell lines, results were validated with human islets, providing congruent results linking IFN α and γ with STAT1 and STAT2, to induced HLA-1 hyperexpression and MHC-1 upregulation.

JAK inhibitors

Trivedi et al found AZD1480, a JAK1/JAK2 inhibitor, inhibited IFN γ -induced STAT1 phosphorylation, preventing MHC-1 upregulation in non-obese diabetic (NOD) mouse and human islets.¹⁹ Supporting *in vivo* results show $\geq 50\%$ STAT1 phosphorylation decrease, causing significant MHC-1 expression reduction. Concordantly, Ge et al's use of JAK1 inhibitor ABT317, showed similar results in mice β -cells, corroborated by significant MHC-1 expression reduction in treated C57BL/6 mice islets.²⁰ This suggests JAK1 and/or JAK2 inhibitors reduce MHC-1 hyperexpression.

Trivedi et al found 78% treated mice remained normoglycaemic

during treatment, although Ge et al found that this was 93.75% with high dosage.²⁰ However, Trivedi et al's mice became hyperglycaemic 1-week post-treatment-cessation,¹⁹ whereas Ge et al's normoglycaemic drugged mice remained so for 10 days, suggesting T1D can be reversed transiently. At 100 days, 43.75% high-dosage mice displayed reversed diabetes, suggesting ABT317 can reverse T1D and displays prolonged effects.

Different mice models illustrate both a gene knockout and polygenic T1D model.^{21,22} C57BL/6 mice are inbred and genetically identical, thus free of impactful genetic differences.²¹ Such uniformity increases reliability and internal validity by reducing confounders. NOD mice are inbred, however, are more applicable due to autoantibody development prior to T1D onset, like humans.²² Although pre-clinical models are beneficial, differences exist between human and rodent β -cells. Two genes encode rodent insulin but one in humans, and β -cell cytokine sensitivity differs.¹⁷ The complexity of differences reduces translation potential from mice to humans and affects applicability.

BANDIT, a double-blind, placebo-controlled RCT, investigated Baricitinib, a JAK1/JAK2 inhibitor,²³ and measured mean C-peptide levels, indicating β -cell function.²⁴ Median C-peptide increased by 48% in the Baricitinib cohort compared to placebo,²³ indicating reduced β -cell demise and increased insulin secretion. Consequently, mean daily insulin dose required became lower for Baricitinib-treated patients than baseline and placebo,²³ indicating improved β -cell function.

Using clinical trials to validate results in humans improves JAK inhibitor data applicability, enabling practical conclusions to be drawn in humans *in vivo*. BANDIT spans four Australian sites,²³ increasing demographical representation. Despite this, $\geq 87\%$ participants in both cohorts are white, limiting global generalisability, although the participant population was representative of the Australian new-onset T1D population in terms of ethnicity. The randomisation and double-blind features reduce allocation and maintenance bias. A placebo-controlled cohort allows valid comparison, with baseline characteristics similar in both groups. During the trial, COVID-19 occurred, so 27 individuals suspended drug or placebo for ≥ 5 days. No consistent C-peptide changes were observed post-COVID-19, with no evidence of alteration at the endpoint, so this limitation appears to be minimal. Insulin pumps used by 15 participants displayed lower daily insulin dosage than those with injections, introducing a potential confounder, decreasing internal validity. With regards to safety outcomes, none of the adverse events recorded were attributed to baricitinib or placebo, suggesting no significant safety concerns.

Pre-clinical data suggests JAK inhibitors reduce hallmark features of T1D, potentially reversing disease in mice. Despite limitations of mice models, data appears to translate into human clinical outcomes, suggesting preserved β -cell function and increased insulin production.

Conclusion

Studies show HLA-1 hyperexpression is exclusively present in T1D. Skog et al disagrees, claiming it is artefactual, however, small sample size and tissue preservation testing limitations, prevent reliable conclusions from being drawn. This is disproved by the concordance of other studies, confirmed at protein and mRNA levels, so HLA-1 hyperexpression is not artefactual.

Two studies demonstrate IFN α and γ are implicated in hyperexpressing HLA-1, agreeing STAT1 and STAT2 are present in downstream phosphorylation and lead to such expression. The third study implicates JAKs in this pathway, by preventing JAK-STAT phosphorylation to reduce MHC-1 expression. Importantly, highlighting interventional timings demonstrates HLA-1 hyperexpression can be prevented before IFN stimulation, an ideal

interventional stage screened for with biomarkers.

Mice models show JAK1/JAK2 inhibitors reduce MHC-1 hyperexpression, seemingly translating into clinical outcomes. Despite variable success levels, studies agree all drugs tested display a basic framework to reverse/dampen T1D, demonstrated by biomarkers and glycaemia.

Convincing evidence exists to suggest the mechanism hypothesised for T1D via the JAK-STAT pathway, which can be targeted by JAK inhibitors. These show potential, with correlations between extent of HLA-1 expression reduction and endogenous insulin production, thereby reducing exogenous insulin treatment requirements. Fundamentally, treatment displays groundwork to successfully target this pathway. Since HLA-1 hyperexpression is present, reducing this is vital to dampen CTL activity, preventing β -cell demise and insulin reduction. Safety profile must be considered in depth in future trials. Longer term RCTs with a JAK inhibitor, such as Baricitinib, should be conducted in individuals at risk of T1D, with detectable type 1 IFN α signature, or another predictive biomarker, prior to disease onset, to inhibit IFN-induced HLA-1 hyperexpression before IFN overstimulation occurs.

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Sareena Khan

Sareena Khan is a third-year medical student at the University of Exeter. She has an avid interest in public health and global health policy, focusing particularly on health inequalities. She is very passionate about obliterating the gender inequalities that exist for women, particularly in cardiovascular health. She is a firm believer that passions outside of medicine should be explored, and so in her free time she loves to paint, play golf, and explore the Cornish coastline.

Figure 1.

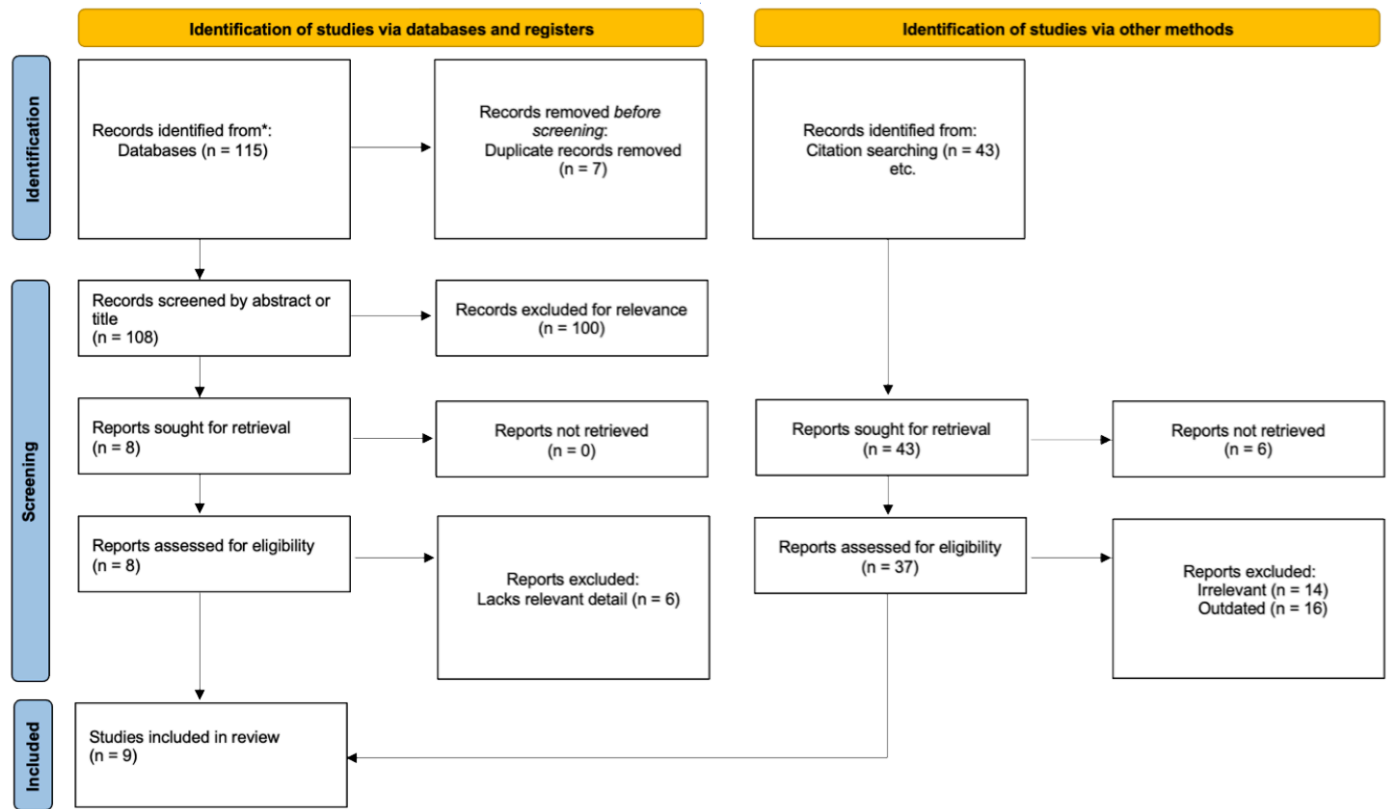


Figure 1. demonstrates a PRISMA diagram outlining primary evidence literature synthesis for this review. This PRISMA diagram has been adapted from the BMJ Prisma 2020 Statement.²⁵

Emerging ethical considerations of semaglutide use to induce weight loss

Isabella Munro

Year 2, Medicine, University of Plymouth
Email: bellamunro72@gmail.com



Abstract

This narrative review explores the emerging ethical considerations surrounding the use of semaglutide for weight loss. While semaglutide has shown clinical benefits in treating obesity, its rapid rise in popularity has raised concerns related to patient safety and access inequality. Off-label use, misinformation and counterfeit products compromise informed decision-making and patient autonomy, undermining ethical principles such as non-maleficence and beneficence. Additionally, high costs and limited NHS or insurance coverage restrict access to semaglutide, disproportionately affecting marginalised populations and violating principles of distributive justice. Through critical evaluation of recent studies, this essay highlights the need for stricter regulation, accurate patient education, and equitable distribution strategies to ensure the ethical and effective use of semaglutide in addressing obesity.

Abbreviations

FDA - Food and Drug Administration
GLP-1 - Glucagon-like peptide-1
WHO - World Health Organization

Introduction

Semaglutide is a drug that has recently become increasingly popular as a means of inducing weight loss. This is an important subject in the rising obesity epidemic. In 2022, 890 million adults were living with obesity which increases the risk of cardiovascular disease, type 2 diabetes, and other non-communicable diseases.¹ This places significant strain on healthcare systems and makes semaglutide a

topic of growing clinical and ethical interest.

Although it has been beneficial for many individuals trying to lose weight,² semaglutide raises several ethical issues which should be considered, given its increasing popularity.² This essay aims to evaluate the ethical issues of safety and access inequalities surrounding semaglutide.

This review uses primarily western research, many of which are North American and focus on how accessible the drug is with health insurance. However, access inequalities can also be applied to the NHS which restricts semaglutide prescriptions to specialist services and limits accessibility. It is important to remember there are differences in approval of similar drugs between the UK and US.

Methods

A search was conducted on the Medline (Pubmed) database using the search string: (semaglutide) OR (Glucagon-Like Peptide-1 receptor agonists) OR (GLP-1 receptor agonists) AND (weight loss) OR (obesity) OR (safety) OR (ethics). All results before 2021 were excluded to ensure research remained current. This yielded 14 studies after irrelevant results were overlooked, most of which were systematic reviews. A limited number of other sources were retrieved from reputable websites including the World Health Organization (WHO) and the Food and Drug Administration (FDA).

Background of semaglutide

Semaglutide works by activating specific receptors (GLP-1), increasing glucagon secretion and slowing gastric emptying through hormonal

mechanisms. By leaving individuals feeling fuller for longer, it reduces calorie consumption to induce weight loss. Although initially introduced to treat patients with type 2 diabetes, it can also be used for weight loss as it slows gastric emptying and decreases gastric motility, thereby reducing appetite and providing a less invasive alternative to bariatric surgery for patients with obesity.

Many recognise the brand names Ozempic, Wegovy and Rybelsus, all of which contain semaglutide as their active ingredient. However, only Wegovy has been approved for use as a weight loss medication in the UK, while approved uses of Ozempic and Rybelsus are limited to treatment for patients with type 2 diabetes.

Safety

Ensuring the safety of individuals taking semaglutide is a fundamental ethical principle. It has therefore undergone the necessary clinical trials to ensure both safety and efficacy before being approved for use. This respects patients' autonomy and right to beneficence when prescribed as approved. Recent studies including meta-analyses of randomised controlled trials³ and systematic reviews^{4,5} have confirmed that semaglutide is effective in reducing weight and causes mostly mild or moderate side effects such as nausea and vomiting. Despite this, off-label use and counterfeit products still threaten patient safety when taking semaglutide. In addition to this, more severe side effects or serious adverse events such as pancreatitis and acute kidney injury have been observed in 9.4% of patients taking prescribed semaglutide which may pose an even greater risk to those using off-label semaglutide.³

Safety concerns regarding semaglutide are often caused by off-label use: when the drug is used for purposes beyond those officially approved. Although Wegovy was approved for use as a weight loss medication by the FDA in 2021,⁶ Ozempic is not currently approved for weight loss in the UK, but continues to be accessed through unregulated channels, without having its safety, effectiveness or quality reviewed for this purpose.⁷

Some semaglutide use occurs illegally, for example without prescription, complicating efforts to assess its true usage and associated risks. To address this, several studies have examined online information about the drug to provide insight into the misconceptions surrounding it. One study that analysed content available on an online streaming service concluded that information on important topics to be aware of, such as side effects, the risk of counterfeit products and the long half-life of semaglutide were insufficient.⁸

These concerns were reinforced by a recent observational study that assessed online information regarding semaglutide. They found that the information on semaglutide and drugs that target the same receptors was of low quality and that exaggerated advertisements were prevalent.⁹ This limits information available to individuals purchasing the drug online and threatens their autonomy if they are not able to make informed decisions.

The danger of misinformation is evident and illustrated by a recent case report, where an unintentional semaglutide overdose occurred due to a lack of knowledge shared by both the patient and prescriber,¹⁰ leading to adverse effects. Similar concerns around off-label semaglutide use are featured in an international study that assessed global search interests and social media data, suggesting media focus on semaglutide is responsible for the surge in off-label use.^{11,12} This reaffirms that safety is often overlooked in online content regarding use and may contribute to overdoses and an increase in adverse effects. This is particularly relevant to off-label and online prescriptions of semaglutide, as patients taking these may lack knowledge on side effects or dosages, without consulting a medical professional.

Another recent study that analysed online searches regarding

semaglutide confirmed the potential negative effects of social media. It was concluded that media attention played a significant role in increasing demand for semaglutide, as well as being responsible for an increase in illegal sales, meaning that increases in online search volume coincided with increases in illegal sales of semaglutide products.^{11,13} When linked to the ethical pillar of non-maleficence, this suggests a neglect of preventing harm to the public, due to failed enforcement of safety regulations and the absence of credible information, undermining the public's ability to make informed decisions.¹⁴

This issue of media attention was further supported by a qualitative study that confirmed the active selling of semaglutide by illegal online pharmacies, which were accompanied by significant increases in calls to poison centres regarding semaglutide.⁷ Although details of these calls are not explicitly clear, they most commonly reported dosing errors which, in turn, exacerbated side effects. This is a clear example of individuals coming to harm as a result of misinformation, showing a clear undermining non-maleficence.

Another issue regarding safety when using semaglutide is the sale of illegal counterfeit products. The FDA is aware that counterfeit Ozempic has been marketed in the US,⁶ further contributing to public health risks as this introduces unknown factors that can cause adverse effects and may be contaminated with other substances. This means that, although the drug is often used safely, significant safety concerns arise when it is prescribed against established medical guidelines.

Ultimately, although patient autonomy allows them to decide whether to initiate treatment using semaglutide, misinformation, particularly online, and counterfeit products can mislead individuals into treatment that is potentially harmful and needs to be addressed.

Access inequalities

If semaglutide can be adequately regulated to ensure patient safety, equitable access should also be prioritised. Access inequalities are a concern regarding semaglutide. Due to high demand for the drug, it is considered relatively expensive¹² and is typically not covered by healthcare insurance for weight loss. This raises ethical concerns regarding distributive justice: the fair allocation of resources within society, as access to the drug may be limited by socioeconomic factors which often exacerbate ethnic or racial disparities.¹¹ The current failure to consider the social determinants of health means distributive justice has been overlooked and exacerbates health inequalities.

One recent cross-sectional analysis investigated semaglutide accessibility in North America. They found that a significant number of people who were eligible for treatment with semaglutide were likely unable to afford it. Within this group, there was a significantly larger proportion of Black and Hispanic people,¹¹ reflecting broader racial and ethnic disparities. This contributes to health injustice: an unfair and avoidable difference in healthcare outcomes between different groups in society. Although this study is insightful, it is important to be mindful that semaglutide had only been approved for use as a weight loss medication a year prior to it being published. Therefore, there may have been some changes to accessibility through insurance companies, which often do not fund semaglutide.¹⁵

Similar issues of access were identified by a cohort study that also identified broader sociodemographic factors that altered individuals' ability to access semaglutide treatment,¹⁶ including sex and industry of employment. However, it appears that access inequalities are not limited to North America, as another cohort study conducted in Sweden also mirrored American results, establishing that people accessing the drug are most commonly those with high socioeconomic status, who belong to the majority ethnicity.¹⁷

Access inequalities can also be linked to the safety of the drug by a

population-based study that assessed reports of accidental overdose with semaglutide and similar drugs. They concluded that the lack of affordability, availability and inadequate access of these drugs has led more people to seek them online, which increases prescription errors such as incorrect dosages or being prescribed to inappropriate individuals, such as those at a healthy weight. It is also suggested that these differentially affect specific racial, ethnic and socioeconomic population.¹⁸

These findings solidify the suggestion that there are significant access inequalities surrounding semaglutide and this is ethically problematic as access should be determined by medical need, not financial means. Such disparities can cause those from lower socioeconomic backgrounds and minority racial groups to either endure more suffering, or resort to counterfeit products.

Conclusion

To conclude, it is undeniable that semaglutide can be beneficial to individuals trying to lose weight.¹⁹ To allow more people to benefit from it and address ongoing public health risks moving forward, it is important that there is an expansion of current safety regulations that can be actively enforced. This will aim to eliminate circulation of counterfeit products and ensure those taking the drug are fully informed of correct dosages and side effects. Equally important is the introduction of distributive guidelines to address social determinants of health and ensure the drug is delivered to those who need it most. This will understandably be a costly process. However, the benefits of reducing the burden of obesity on healthcare systems and the associated health risks will undoubtedly be advantageous long-term.

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Isabella Munro

I am a second year student at Peninsula Medical School. I initially discovered this topic during year one while doing one of our Special Study Units. Although not an area I had previously been focused on, I have found the writing experience thoroughly enjoyable. Beyond this, I am most interested in emergency medicine and neurology.

Polygenic risk scores in cardiovascular medicine: a critical review of their role and limitations

Jonathan Ramnarace

Year 2, Medicine, University of Exeter
Email: ramnaracejonathan@gmail.com



Abstract

Background: Cardiovascular disease (CVD) is the leading cause of death worldwide, yet commonly used CVD risk calculators do not incorporate genetic predisposition and are based only on clinical and lifestyle factors.

Aim: This review evaluates the role of polygenic risk scores (PRS) in cardiovascular risk prediction.

Methods: This review is a narrative synthesis of studies on PRS in CVD. A systematic PubMed search of articles published in the last five years, supplemented by reference screening, was used to identify relevant papers.

Findings: PRS modestly improves risk prediction when combined with conventional models, particularly in younger populations. However, on its own PRS lacks sufficient predictive power to serve as a replacement. Its clinical utility is limited by cost, lack of guidelines, and reduced accuracy in non-European populations due to biases in genome-wide association studies.

Conclusion: Although PRS provides genetic insight, its practical application remains limited. Future research must address ancestry biases and cost-effectiveness for equitable integration into CVD prevention strategies. Hence, PRS should be considered as a supplemental tool and not as a standalone predictor in cardiovascular risk assessment.

Abbreviations

CAD – coronary artery disease
CVD – cardiovascular disease
FHx – family history
GWAS – genome-wide association studies
PRS – polygenic risk scores

Introduction

Cardiovascular disease (CVD) is the leading cause of death, causing 32% of global deaths every year.¹ Coronary artery disease (CAD) is the most common form of CVD, accounting for 66,437 deaths in the UK in 2023.² CAD is caused by the buildup of plaque on the inner walls of coronary arteries, reducing blood flow to the heart and increasing the risk of a heart attack.³ Accurate risk prediction is critical for early intervention and prevention strategies, with models such as the Pooled Cohort Equations, Framingham Risk Score and Systematic Coronary Risk Evaluation being used for CVD risk prediction. These models are used in primary care to predict the risk of CVD based on lifestyle and clinical factors like age, blood pressure, smoking, diabetes, cholesterol and family history (FHx) of CVD.⁴ However, while these models incorporate FHx as an indirect measure of genetic risk, they do not account for genetic variability that is distributed across the entire genome.

To address this, polygenic risk scores (PRS), a new approach to

quantifying genetic risk by aggregating multiple genetic variants has been proposed to enhance the prediction of CVD. PRS is a genetic-based approach that uses the total effect of multiple genetic variants to determine an individual's risk to a disease. Unlike traditional risk factors, PRS is stable throughout the life course and properly captures the inherited predisposition. PRS is calculated from genome-wide association studies (GWAS), which are large-scale studies that determine genetic associations with a disease across a population.⁵ Thus, through combining the effects of these variants into a single value, PRS provides a quantitative measure of genetic risk.

This review critically evaluates the role of PRS in CVD risk prediction, focusing on its predictive accuracy, applications in the short and long term, and challenges associated with its applications in diverse populations. By addressing these key issues, this review aims to provide a comprehensive understanding of PRS and its potential role in shaping the future of cardiovascular risk prediction.

Methods

The PubMed database was searched on 28 February 2025 to identify relevant studies on PRS and CVD risk stratification. The search terms ("Polygenic Risk Score" OR "Genetic Risk Score" OR "PRS") AND ("Heart Attack" OR "Myocardial Infarction" OR "Coronary Artery Disease") AND ("Risk Prediction" OR "Risk Stratification" OR "Cardiovascular Risk") were used. Studies were included if they were systematic reviews, randomised controlled trials, observational studies, meta-analysis or clinical trials and published within the last 5 years. Furthermore, non-human studies, single-gene mutation research, non-peer-reviewed articles, and non-English papers were excluded.

The search initially yielded 144 articles, which were reduced to 14 after applying the inclusion and exclusion criteria. Following an in-depth review, 11 studies were selected for their relevance to PRS and CVD. Additionally, 8 supplemental articles were obtained from a manual review of reference lists, and a further 6 references were obtained for definitions and background information.

As this is a literature-based review, ethical approval was not required. No statistical analyses were performed.

Results

Eleven studies were selected for their relevance to PRS in CVD (**Table 1**). These included large prospective cohorts, clinical cohorts, randomised trial sub-studies, one meta-analysis and one systematic review. Sample sizes ranged from 1002 to 979,286.

A summary of the populations, sample sizes, study designs, and key findings of the included studies is presented in **Table 1**.

Discussion

Evaluating PRS against established cardiovascular risk models

Recent studies have compared the use of PRS with established CVD risk models. A study of individuals aged 70 years and older found that PRS was less accurate than established models by 14.81% and was also worse than several single clinical predictors, such as sex, cholesterol, creatinine and age, using receiver operating characteristics.⁶ An observational study of UK Biobank participants aged 40-69 years supported these findings.⁷ These results indicate that while PRS captures genetic predisposition, it does not capture the lifestyle factors that drive the progression of CVD, which traditional risk models better incorporate.

However, genetic predisposition is currently assessed through FHx, which remains a strong predictor of CVD as FHx incorporates both genetic and shared environmental factors. A large-scale observational study using FinnGen study Data Freeze 7 found that PRS and FHx

have independent but complementary effects on risk prediction. The study reported that PRS explained only 10% of the effect of FHx, while FHx explained 3% of PRS variance,⁸ indicating that PRS does not simply replace FHx but provides additional information for risk stratification.

Given this, researchers have assessed the use of PRS alongside traditional risk models to enhance predictive accuracy. A Danish study found that the incorporation of PRS into conventional risk models for CAD enhanced predictive capability by 4%.⁹ A systematic review of cohort studies reported that PRS increased the predictive capability of CAD by an average of 0.006 in C-statistic, which is modest but statistically significant.¹⁰ Although these findings support the FinnGen study,⁸ their clinical significance remains uncertain, particularly when considering the cost-effectiveness of integrating PRS into clinical practice.

The accuracy of PRS is dependent on the method used to derive the score. A meta-analysis found that weighted PRS methods, such as LDpred and metaGRS, outperform unweighted methods in CAD prediction by 1.6%.¹¹ These findings were supported by a systematic review.¹⁰ This is due to unweighted PRS assigning equal weight to all genetic variants regardless of their effect size, which oversimplifies the genetic architecture of complex traits. However, weighted PRS uses variant specific effect sizes derived from GWAS to improve predictive accuracy, especially for complex traits like CAD, by accounting for the relative contribution of each variant to disease risk.

Even though PRS seems promising, its clinical application remains limited due to cost and accessibility barriers. Although genomic sequencing is expensive, PRS calculations typically rely on genotype data obtained from genotyping arrays, which are more affordable and widely used in research settings.⁵ However, health systems lack cost-effective methods for integrating PRS, and until its predictive value outweighs costs, widespread implementation remains uncertain.

PRS for short-term vs long-term risk: identifying the optimal use case

How PRS is implemented determines its value to patient care, for example, for long-term primary prevention or short-term clinical management of high-risk patients.

In long-term risk primary prevention, PRS provides a genetically informed measure of risk, allowing high-risk individuals to be identified from birth since PRS remains stable throughout life, unlike traditional risk factors, which fluctuate over time, allowing for earlier intervention.¹²⁻¹⁴ Studies show that PRS-based CAD stratification is particularly effective in younger populations with the odds ratio of disease per standard deviation of incident CAD being higher.¹⁵ This suggests that PRS could serve as justification for early pharmacologic interventions, such as early statin therapy initiation, given that earlier, more aggressive LDL cholesterol reduction has shown to improve long-term cardiovascular outcomes.^{12,13,15} Furthermore, digital health programmes that incorporate PRS has enhanced the adherence to lifestyle changes,^{16,17} showing how PRS may support prevention efforts. However, PRS is rarely accompanied by specific management guidelines, limiting its utility in young adults who do not have other risk factors.^{18,19}

PRS has also been applied to the prediction of recurrent cardiovascular events. Research has shown that among patients with a history of heart attack, those with high PRS are more likely to experience a recurrence and should be treated more aggressively.¹³ A recent study supports this, as individuals with high PRS has a 1.65 times increased risk of recurrent cardiovascular events compared to those with low PRS and with an odds ratio of disease per standard deviation of CAD incident of 1.12.¹⁵ This suggests that PRS could help guide secondary prevention strategies by identifying individuals who require more intensive intervention.

However, there are limitations in the short-term applications of PRS in older individuals, as traditional risk factors increase in predictive value of cardiovascular events with age, while genetics decrease in predictive values. Moreover, clinical guidelines focus on modifiable risk factors and do not account for genetic predisposition, which hinders the direct incorporation of PRS into treatment plans.⁷ As ongoing research refines PRS methodologies, their role in cardiovascular risk management may become more clearly defined. In the end, for short- and long-term risk prediction, which of the two is more appropriate depends on the context. For pre-symptomatic prevention, PRS identifies high-risk individuals before they develop symptoms and allows for lifestyle changes and early drug therapy.¹⁴ While lifestyle is a short-term risk estimation, PRS enhances the risk assessment to ensure that patients are managed optimally.²⁰ Therefore, the best approach may be to use PRS in two ways: for screening high-risk individuals from childhood and optimising treatment in high-risk adults.

PRS across diverse populations: accuracy, bias and ethical considerations

Despite the potential of PRS to enhance CVD risk assessment, their accuracy is substantially influenced by ancestry-related biases in GWAS. The predictive accuracy is reduced for non-European populations as the vast majority of GWAS datasets are derived from European populations. This is due to differences in allele frequencies, genetic architecture (the number, frequency and effect sizes of variants contributing to a trait), and linkage disequilibrium, meaning some genetic markers tend to be inherited together. These factors reduce the transferability of PRS across ancestries, since linkage disequilibrium patterns vary between populations and influence how genetic effects are estimated.^{21–24}

The efforts to improve PRS generalisability have resulted in the development of multi-ancestry PRS models that incorporate genetic data from various populations. These models are more accurate than the European-derived PRS, but the accuracy differs based on the population studied.^{21,23} Notably, African ancestry populations present a challenge, as higher genetic diversity within these populations makes risk prediction more complex.²³ Therefore, while multi-ancestry PRS models are a step in the right direction, they are not a full solution as they still rely heavily on European-based GWAS datasets.^{21,23}

Beyond technical limitations, the lack of PRS accuracy in non-European populations raises ethical concerns regarding health disparities. As PRS is increasingly incorporated into precision medicine, populations with lower PRS accuracy will get unreliable risk assessments, leading to inaccurate predictions of risk.²⁵ It is possible that some individuals will be denied needful interventions and others will be overtreated. This is particularly a concern in CVD, where the disease burden has already been disproportionately high on historically underrepresented groups.^{21,25} However, the same issue is present with multi-ancestry PRS models, as the GWAS data is still mainly European.¹¹ To reduce these inequalities, current studies are focused on expanding genetic datasets and developing better methods to improve PRS accuracy across various populations.²¹ Risk thresholds will have to be standardised to be able to incorporate PRS into clinical guidelines to make sure that the interpretation is consistent across populations.

Strengths and limitations

As shown in **Table 1**, the studies included in this review were mixed in quality and design. Large cohorts like UK Biobank, FinnGen and the China Kadoorie Biobank provided strong statistical power, but most participants were of European or Chinese ancestry, which limits how generalisable the findings are. Smaller clinical groups, such as Dan-NICAD and CAPAR-CAD, gave useful insights into how PRS might work in practice but their sample sizes were relatively small. Randomised trial sub-studies like ODYSSEY OUTCOMES suggested

that patients with high PRS may respond differently to treatment, though these were post-hoc analyses and need confirmation in prospective studies. Meta-analysis and systematic reviews supported the overall message that PRS only modestly improves prediction, but overlapping datasets may have inflated their results.

This review also has its own strengths and limitations. The use of a systematic PubMed search and the inclusion of a wide range of study designs gives a broad and up to date overview of the evidence. On the other hand, the search was limited to one database and to English-language studies from the last 5 years, so some relevant work may have been missed. This could mean that studies from non-European or non-Chinese populations were underrepresented, which is important as these groups are already less well covered in PRS research. Finally, because this was a narrative rather than a quantitative review, results could not be pooled, which means the exact size of the effect could not be measured.

Conclusion

PRS is a stable measure of genetic susceptibility to improve cardiovascular risk prediction. However, the evidence suggests that although PRS adds independent predictive value, it fails to outperform traditional risk models that are based on modifiable risk factors that are known to influence the disease progression. The studies show that the combination of PRS with conventional models improves risk stratification only slightly, especially in the intermediate risk population, but the clinical utility of PRS alone is limited. Because these improvements are small in magnitude, the cost-effectiveness and other practical aspects of routine PRS application need further consideration.

The main limitation preventing the adoption of PRS is its reduced predictive accuracy in non-European populations, since GWAS used to calculate PRS is almost exclusively of European descent. This leads to misclassification and disparities in preventive care. Future work must include congregating genomic studies of diverse ethnicities to fine-tune the PRS models and apply them equally to clinical practice across different populations.

Moving forward, PRS should be viewed as a complementary tool rather than a replacement for traditional risk models. If clinical guidelines and equity issues are addressed, PRS has the potential to refine CVD prevention strategies, enabling a more personalised, genetically informed approach to CVD management.

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Contribution statement

I contributed to the conception, design, and interpretation of this review. I wrote the paper, revised it critically, and approved the final version for submission to INSPIRE.

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Jonathan Ramnarace

I am a second-year medical student at the University of Exeter with a broad interest in surgery and interventional medicine. My recent work has explored how polygenic risk scores could influence cardiovascular care, reflecting a curiosity about how genomics may shape future clinical practice. Outside of medicine, I enjoy golf and cricket and recently took up rock climbing.

Table 1. Summary of studies evaluating polygenic risk scores (PRS) in cardiovascular disease (CVD)

Author (Year)	Population (setting)	Sample size	Study design	Key findings
Lu et al. (2022)	Chinese adults	95,408 participants	Prospective cohort	PRS modestly improved prediction, stronger in younger adults
Elliott et al. (2020)	UK Biobank participants (40-69 yrs)	352,660 participants	Prospective cohort	PRS linked to CAD risk but added little beyond clinical scores
Damask et al. (2020)	Post-ACS patients (ODYSSEY OUTCOMES)	11,953 patients	Randomised trial (genetic sub-study)	High PRS patients had greater benefit from cholesterol-lowering therapy (alirocumab)
Christiansen et al. (2021)	Patients with stable chest pain, Denmark (Dan-NICAD)	1617 patients	Clinical cohort	Adding PRS to standard risk models improved prediction by about 4%
Yun et al. (2022)	Various cohorts	Varied	Systematic review	PRS modestly improved CAD prediction across cohorts
Neumann et al. (2022)	Older adults (≥ 70 yrs), Germany	3261 participants	Cohort study	PRS was less accurate than standard risk models in older adults
Temtem et al. (2024)	European adults (Eur J Prev Cardiol cohort)	5351 participants	Prospective cohort	Adding PRS improved cardiovascular event prediction, especially in intermediate-risk adults
Verma et al. (2022)	CAD prevention clinic patients (CAPAR-CAD)	1002 patients	Randomised trial	PRS use prompted early prevention action, showing feasibility as a risk communication tool
Agbaedeng et al. (2021)	Various cohorts (Europe, US)	979,286 participants	Meta- analysis	Weighted PRS predicted CAD $\approx 1.6\%$ better than unweighted scores
Mars et al. (2022)	FinnGen biobank	306,418 participants	Biobank cohort	PRS and FHx were independent predictors; combined risk was highest, showing complementary value
Fahed & Natarajan (2023)	Review of global studies	N/A	Narrative review	PRS can support early prevention, refine middle-age risk, and aid secondary prevention

¹ Patients = clinical cohorts; participants = biobank/population cohorts.

The role of SARS-CoV-2 in triggering autoimmune thyroid diseases

Aaisha Rashid

Year 2, Medicine, University of Exeter

Email: air205@exeter.ac.uk



Abstract

Coronavirus disease 2019 (COVID-19) is an infectious disease caused by acute respiratory syndrome coronavirus 2 (SARS-CoV-2). There has been recent evidence published suggesting it may contribute to autoimmune thyroid disorders. Relevant studies were sourced from online databases such as PubMed, TRIP and Web of Science. Research has identified a temporal relationship between COVID-19 and thyroid dysfunction, with reports of subacute thyroiditis and thyroid autoimmunity following infection. Proposed mechanisms include Angiotensin-Converting Enzyme 2 (ACE2) receptor-mediated entry into thyroid cells, cytokine-driven inflammation, and molecular mimicry triggering autoimmune responses. Additionally, several studies have reported the presence of non-thyroidal illness syndrome (NTIS) among hospitalised COVID-19 patients. NTIS is a systemic response to critical illness and may explain transient thyroid abnormalities observed during COVID-19, without direct thyroid involvement, raising questions regarding the extent to which COVID-19 stimulates autoimmune thyroid disorders. Evidence also discusses altered thyroid hormone levels and the presence or absence of thyroid-specific antibodies in some patients, adding complexity to the debate over whether thyroid dysfunction in COVID-19 is autoimmune or systemic. This review evaluates current findings, highlighting the multi-causal mechanisms by which SARS-CoV-2 may influence thyroid function, emphasising the need for further research to clarify these associations.

Abbreviations

CACE2 – angiotensin-converting enzyme 2

COVID-19 – coronavirus disease 2019

FT3 – free triiodothyronine

FT4 – free thyroxine

IL-6 – interleukin-6

mRNA – messenger ribonucleic Acid

NTIS – non-thyroidal illness syndrome

SAT – subacute thyroiditis

SARS-CoV-2 – severe acute respiratory syndrome coronavirus 2

Tg – thyroglobulin

TMPRSS2 – transmembrane Protease, Serine 2

TPO – thyroid peroxidase

TPOAb – thyroid peroxidase antibodies

TSH – thyroid-stimulating hormone

TSHR – thyroid-stimulating hormone receptor

Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by the acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has led to universal morbidity, prompting extensive research into its systemic effects. Whilst mainly recognised as a respiratory illness, emerging evidence suggests that SARS-CoV-2 has significant impacts on extrapulmonary organs, including the thyroid gland.¹ Thyroid dysfunction correlated with COVID-19 has been reported, ranging from transient thyrotoxicosis to hypothyroidism, eliciting concerns regarding the potential for SARS-CoV-2 to behave as a trigger for autoimmune thyroid disorders such as subacute thyroiditis (SAT) and Graves' disease.^{2,3} There are several potential long-term health implications of post-COVID-19 thyroid dysfunction. Thyroid disorders can have profound systemic effects, including cardiovascular,

metabolic and neurological consequences, making it essential to understand the pathogenesis of the disease.⁴ Despite the ever-growing appreciation of the thyroid's involvement in COVID-19, evidence and research remain limited, and significant uncertainties remain. Key outstanding questions include the extent to which SARS-CoV-2 directly invades thyroid tissue, the role of cytokine-driven hyperinflammation, and the potential contribution of molecular mimicry to immune dysregulation.⁵⁻⁷ In the absence of conclusive data, the understanding of these mechanisms and their clinical relevance remain uncertain. This review aims to summarise and critically appraise current evidence on the relationship between SARS-CoV-2 and autoimmune thyroid disorders. It will synthesise findings on clinical presentations, prevalence and underlying mechanisms, identify knowledge gaps to guide future research and clinical decision-making. Due to limitations of existing research, this review will accentuate the need for further and more longitudinal studies to confirm these links clarifying the repercussions for patients and healthcare systems.

Methods

Relevant literature for this review was sourced using PubMed, TRIP Pro, and Web of Science databases. Search terms included "COVID-19," "thyroid disorders," "autoimmune thyroid disease," "molecular mimicry" and "cytokine storm." Boolean operators were used to refine results: "AND" was used between terms such as "COVID-19" and "thyroid disorders," while "OR" was utilised to include broader variations like "COVID-19 OR SARS-CoV-2." Studies published prior to 2010 were excluded, including non-peer-reviewed content, blogs and patient information booklets. Articles were screened by title and abstract for relevance, followed by a second round of filtering based on article quality, depth of biomedical information, and type of research, prioritising primary studies. Additional relevant articles were identified through reverse referencing. The studies included range from 2010–2024, and 15 studies were included in the final review: 2 case reports, 1 case series, and 12 cohort or cross-sectional studies. A summary of the literature selection process is presented in **Figure 1**.

Discussion

Clinical presentations and types of thyroiditis

It is well established that viral infections are known triggers of autoimmune thyroid disorders, including SAT. Recent evidence suggests that COVID-19 may act as such a precipitator. Two case reports regarding young and previously healthy women report elevated free thyroxine (FT4) and free triiodothyronine (FT3) with suppressed thyroid stimulating hormone (TSH), all post-COVID recovery. Increased inflammatory markers such as C-reactive protein, the imaging results, clinical findings, and laboratory data were all consistent with SAT and thyrotoxicosis respectively.^{2,8} This suggests that COVID may act as a stimulator for SAT, even in mild cases. However, there is limited generalisability as patient variability (e.g. age, severity of infection, and co-morbidities) was not accounted for due to the single-case nature of both reports. Moreover, the absence of control to compare post-viral thyroiditis from other infections limits the ability to extrapolate from these findings. Additional evidence suggests a temporal relationship between COVID-19 and the manifestation of autoimmune thyroid diseases.³ This is due to Hashimoto's thyroiditis, Graves' disease and SAT occurring post-COVID-19 infection in individuals with no prior thyroid conditions.³ Like the previous cases, each case presented with characteristic abnormalities in thyroid function tests, for example, elevated TSH, and altered free T4/free T3 levels.³ To further confirm thyroid damage, ultrasound findings consisted of thyroid enlargement, heterogeneity and low vascularity, all of which align with autoimmune processes.³ Further analysis of these studies is illustrated in **Table 1**. Each of these thyroid conditions developed 6–8 weeks post-COVID-19, which highlights a potential indirect effect of COVID on the thyroid, driven by an overactive or dysregulated immune response. Whilst this case series provides stronger evidence than previous isolated case

reports, there is an apparent selection bias. Due to this paper being a case series, the individuals were likely selected as their conditions were noteworthy, hence the study cannot reflect the presentation of thyroid dysfunction in the average post-COVID population. While these reports provide preliminary evidence of a link between COVID-19 and thyroiditis, larger studies encompassing diverse populations are essential to confirm this association and determine its clinical relevance.

Prevalence of thyroid autoimmunity post-COVID-19

The increased prevalence of thyroid autoimmunity following COVID-19 is supported by a cohort study reporting that 17.5% of COVID-19 survivors expressed thyroid autoimmunity, alongside a significant increase in thyroperoxidase antibodies (TPOAb) prevalence (15.7%) compared to age- and sex-matched controls (7.7%).⁹ Similarly, another cohort study found that among 191 patients with COVID-19, 13.1% exhibited thyroid dysfunction, highlighting the potential impact of COVID-19 on thyroid health.¹⁰ Contrasting to the previous studies, despite the increased rife-ness of thyroid autoimmunity, 95% of patients had TSH levels within the normal range, suggesting that distinct thyroid dysfunction was not stimulated by the autoimmune response.⁹ This may propose that thyroid involvement in SARS-CoV-2 infection is heterogeneous, alongside a spectrum ranging from mild subclinical changes to thyrotoxicosis or hypothyroidism. This highlights that only a portion of individuals with thyroid autoimmunity progress to clinically consequential thyroid disorders, which stresses the variability in individual susceptibility, raising questions about the extent to which COVID-19 directly triggers thyroiditis.⁹ Additionally, another study discovered that thyroid dysfunction in most individuals is not predominantly mediated by autoimmunity as anti-thyroid antibodies were not drastically elevated or were relatively absent.¹⁰ This point reinforces the concept that autoimmunity is not solely responsible for thyroid dysfunction in COVID-19 but involves an intricate interaction of direct viral effects and systemic inflammation.¹⁰ Most patients showed normalisation of thyroid function post-recovery, implying that COVID-related thyroid dysfunction may be transient and not chronic. For example, abnormalities such as low TSH and low FT3 were shown to resolve instinctually in most patients during recovery, substantiating the point that thyroid dysfunction in COVID-19 is often temporary and reversible.¹¹ However, these studies primarily involve hospitalised patients, excluding those with asymptomatic or mild infections. This limitation reduces the generalisability of findings to the broader spectrum of COVID-19 survivors. The lack of pre-infection reference data further complicates the analysis of these results, making it challenging to determine whether the thyroid dysfunction observed was stimulated by COVID or a pre-existing illness. Short follow-up periods also do not account for potential late-onset thyroid dysfunction, which could lead to an underestimation of the prevalence of post-COVID autoimmune thyroid disease. Larger and more diverse studies with extended follow-up periods are required to clarify the mechanisms underlying thyroid dysfunction in COVID-19 and identify individuals at greater risk of developing long-term thyroid disorders.

Mechanisms linking COVID-19 to autoimmune thyroid disorders

There is a large body of evidence demonstrating that the expression of ACE2 receptors on thyroid tissue plays a pivotal role in COVID-induced thyroid dysfunction.^{12,13} Studies have demonstrated that ACE2 messenger ribonucleic acid (mRNA) is abundantly expressed in human thyroid tissue and primary thyroid cell cultures, authenticating the potential of the thyroid gland as a direct target for COVID-19; ACE2 is crucial for viral entry.¹²⁻¹⁴ Transmembrane Protease, Serine 2 (TMPRSS2), is a protease required for COVID spike protein activation and is mainly expressed in colloid and vasculature rather than follicular cells, making direct viral invasion of follicular cells unlikely.⁶ Additionally, severe COVID-19 is correlated with hyperinflammation, showcased by cytokine storms and elevated IL-6 and ferritin levels, contributing to immune activation and local thyroid inflammation.⁷ This hyperinflammatory state may induce SAT, with initial thyrotoxicosis followed by hypothyroidism due to

follicular cell damage, as mentioned in the study by Brancatella et al.⁸

Molecular mimicry has also been proposed as a mechanism, where SARS-CoV-2 peptides share statistically significant similarities with thyroid antigens, potentially triggering autoimmunity in genetically pre-disposed individuals.^{5,15} A 2024 review synthesising bioinformatic and laboratory data found widespread peptide and structural homology between SARS-CoV-2 proteins and human antigens at levels far exceeding chance, with several thyroid autoantigens specifically implicated—thyroid peroxidase (TPO), thyroglobulin (Tg) and the TSH receptor (TSHR).¹⁶ Evidence includes linear epitope homology (5–9-mer peptides), 3-D structural similarity across ~6% of the viral proteome, and antibody cross-reactivity between SARS-CoV-2 and human autoantigens.¹⁶ Taken together, these findings establish homology and cross-reactivity, satisfying the first two steps of classical mimicry causality criteria, while highlighting the need for epidemiologic and animal-model confirmation in thyroid-specific disease. However, the study by Khoo et al discusses the proposition that thyroid hormone changes are simply a part of a holistic systemic response rather than direct viral invasion – contradicting ideas from other studies.¹¹ This is due to the presence of mild and transient thyroid abnormalities, a euthyroid state present during both admission and illness, in most patients, a temporal relationship with illness severity, and non-involvement of thyroid-specific autoantibodies.¹¹ Therefore, there is a high likelihood that in these individuals, the changes observed were not immune-mediated.¹¹ Several studies have reported the presence of NTIS among hospitalised COVID-19 patients, correlating with disease severity.^{17,18} NTIS may explain transient changes in thyroid function tests during COVID-19, as it manifests as low T3 syndrome, due to diminished peripheral conversion of T4 to T3, without direct involvement of the thyroid gland.¹⁹ Therefore, not all thyroid dysfunction in COVID-19 is immune-mediated or due to direct viral invasion. Transient abnormalities, like NTIS, may reflect systemic responses to severe illness, emphasising the complexity of COVID-19-related thyroid dysfunction, highlighting the need to distinguish systemic effects from autoimmune mechanisms. Together, all these mechanisms highlight a multifactorial process by which SARS-CoV-2 could damage thyroid tissue, consisting of direct viral effects, immune-mediated injury, and cross-reactive autoimmunity. Whilst these mechanisms offer valuable insights, their broader applicability is limited by the heterogeneity of COVID-19 presentations. The lack of functional assays in studies examining ACE2 and TMPRSS2 expression and reliance on histological findings without controls or longitudinal data leave gaps in understanding the link between SARS-CoV-2 and thyroid dysfunction. Future research should focus on integrating molecular, functional, and clinical data across larger, diverse populations to confirm these mechanisms and their role in autoimmune thyroid diseases.

Conclusion

In conclusion, the studies highlight strong evidence suggesting a pivotal role of SARS-CoV-2 in triggering autoimmune thyroid disorders via several mechanisms. All studies suggest that thyroid dysfunction post-COVID-19 may present as SAT, Graves' disease or Hashimoto's thyroiditis – often linked to inflammatory responses and immune dysregulation. Mechanisms such as ACE2 receptor-driven viral entry, molecular mimicry, and cytokine-mediated hyperinflammation provide credible yet under-researched explanations for these associations and a definite cause remains unproven. Whilst thyroid dysfunction in most cases appears transient and reversible, the long-term risk of secondary autoimmune effects requires further investigation; future research should encompass more longitudinal studies. Larger, diverse populations are needed to explore the progression and solutions of thyroid dysfunction post-COVID-19. Moreover, assays examining ACE2 and TMPRSS2 expression in thyroid tissues and analyses of cytokine profiles in affected patients are necessary. Designing studies that distinguish NTIS from true autoimmune thyroid diseases using markers such as anti-thyroid antibodies and detailed hormone profiles would be beneficial. Finally, researching the role of molecular mimicry in genetically

susceptible individuals could clarify its contribution to thyroid autoimmunity. These actions could help refine our understanding of COVID-19's impact on autoimmune thyroid diseases and guide tailored prevention and treatment approaches. Such efforts will be essential to establish causality, guide early diagnosis, and inform targeted prevention and therapeutic strategies for post-COVID-19 thyroid disease.

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Aisha Rashid

Hello, my name is Aisha. I am a second-year medical student at the University of Exeter with a primary research interest in neuroendocrinology and the regulation of cellular function in health and disease. I have conducted literature reviews on autoimmune thyroid disease and fully closed-loop insulin delivery systems in type 1 diabetes. I am currently involved in a neuroendocrine research project using zebrafish models to investigate mechanisms of beta cell regeneration. My broader academic interests lie in neurology, immunology and translational medicine. I intend to pursue a career as a physician–scientist focused on research-driven clinical practice.

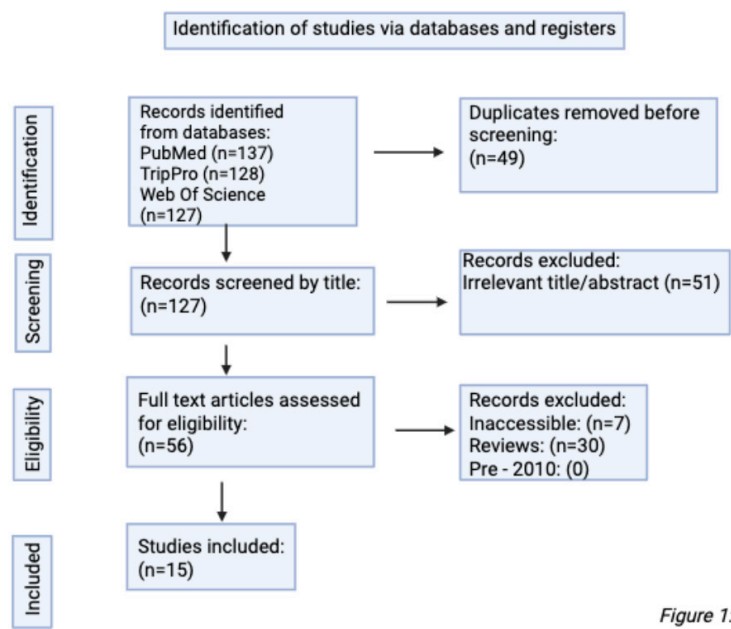


Figure 1: PRISMA Diagram

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Figure 1. PRISMA diagram

Study	Design of Study	Methodology	Findings	Implications
Hashimoto thyroiditis, Graves' disease, and SAT post-COVID-19 infection	- Case series of three patients (females aged 33-41) presenting with thyroid dysfunction following COVID-19 resolution. Explores the temporal relationship between COVID-19 and autoimmune thyroid disease.	- Evaluated clinical presentations, lab results (TSH, fT4, T3, antibodies), thyroid imaging, and response to treatment. - Assessed time of thyroid symptoms onset relative to COVID-19 infection (6-8 weeks).	- Patient 1: Hashimoto thyroiditis with TSH 136 mIU/L, elevated anti-TPO, and anti-Tg antibodies. - Patient 2: Graves' disease with suppressed TSH, elevated T4 and T3, high TSI, and hyper vascular thyroid on ultrasound. - Patient 3: Subacute thyroiditis followed by hypothyroidism, showing low TSH and low radioiodine uptake initially and later elevated TSH.	- COVID-19 may act as a trigger for autoimmune thyroid diseases like Hashimoto's thyroiditis, Graves' disease, and subacute thyroiditis. - Need for comprehensive endocrine follow-up in COVID-19 survivors with thyroid dysfunction.
Subacute thyroiditis associated with COVID-19	- Case report describing a previously healthy 37-year-old female. - Location: Mexico.	- Patient presented with odynophagia and anosmia, and later developed severe neck pain. - Thyroid function tests, ESR, CRP, anaemia evaluations, iodine scan.	- Elevated ESR (72 mm/hr), CRP (66 mg/L), anaemia, low TSH (0.01 mIU/L), and elevated FT4 and FT3. - Thyroid iodine scan: no radioactive iodine uptake.	- SARS-CoV-2 linked to subacute thyroiditis via inflammatory response. - Highlights the role of ACE2 receptors in thyroid tissue. - SAT can occur with mild or no COVID-19 symptoms. - Suggests testing for SARS-CoV-2 in SAT cases.
Increased prevalence of autoimmune thyroid disease post COVID-19	Single-centre, prospective, observational cohort study. 599 COVID-19 survivors were evaluated three months post-hospitalisation for autoimmune thyroid disease (ATD) prevalence and thyroid dysfunction. The study compared survivors to 498 pre-pandemic controls for thyroid function and autoimmunity markers.	- Inclusion criteria: Patients discharged from COVID-19 wards or emergency departments. - Exclusion criteria: Prior thyroid disease, medications affecting thyroid function, kidney/liver failure, pregnancy. - Thyroid function tests (TSH, fT3, fT4) and antibodies (TPOAb, TgAb) measured. - Positive antibody patients underwent an ultrasound for thyroiditis.	Prevalence of thyroid autoimmunity was 17.5% in COVID-19 survivors, double that of pre-pandemic controls (15.7% vs. 7.7%, p=0.002). - 94.9% of patients with positive TPOAb or TgAb displayed ultrasonographic thyroiditis. - TSH remained normal in 95% of patients; TFTs abnormalities were minor.	Highlights SARS-CoV-2 as a possible trigger for thyroid autoimmunity via mechanisms like molecular mimicry and inflammation. - Recommends longitudinal studies to assess the long-term impact of ATD triggered by COVID-19. - Suggests routine evaluation of TPOAb and TFTs in long COVID patients.
Thyroid dysfunction in relation to immune profile, disease status and outcome in 191 patients with COVID-19	Observational, cohort study conducted in Queen Mary Hospital, Hong Kong.	- Included 191 adult COVID-19 patients (mean age: 53.5 years, 51.8% male). - Thyroid function tests (TSH, free T4, free T3) and antithyroid antibody levels were measured on admission. - Patients with known thyroid disorders or on medications affecting thyroid function were excluded. - Inflammatory markers (CRP, ESR) and SARS-CoV-2 PCR cycle threshold (Ct) values were assessed.	13.1% of patients showed thyroid dysfunction: 7.3% with subclinical thyrotoxicosis (low TSH), and 6.7% with low free T3 (non-thyroidal illness syndrome, NTIS). - Low TSH was linked to lower Ct values (higher viral load), suggesting a direct effect of SARS-CoV-2 on the thyroid. - Low free T3 was associated with elevated inflammatory markers (CRP, ESR) and tissue injury markers (LDH, AST), highlighting the role of systemic inflammation. - Patients with low free T3 had worse clinical outcomes, including prolonged hospitalisation and higher oxygen requirements.	Clinicians should monitor thyroid function in COVID-19 patients, especially those with fever, low Ct values, and systemic inflammation.

Table 1. Summary of key studies

Eating disorders and intimate partner violence: exploring the psychosocial links and the impact of social support

Fajar Ali Rasool

Year 2, Medicine, University of Plymouth

Email: fajar.alirasool@students.plymouth.ac.uk



Abstract

Eating disorders, including bulimia nervosa and anorexia nervosa, frequently co-occur with intimate partner violence (IPV), with social support acting as a protective factor. This review examines psychosocial mechanisms linking IPV and disordered eating, showing how trauma and relational distress contribute to maladaptive coping behaviours. Addressing these links underscores the need for trauma-informed practice and policy. Strengthening social networks and reducing systemic barriers are essential for improving outcomes and informing future research in this underexplored area.

Abbreviations

CTS – Conflict tactics scale

DSM-IV – diagnostic and statistical manual of mental disorders, fourth edition

DSM-5 – diagnostic and statistical manual of mental disorders, fifth edition

HARK – Humiliation–Afraid–Rape–Kick screener

IPV – intimate partner violence

SCID-IV – Structured Clinical Interview for DSM-IV

Introduction

Eating disorders are complex mental health conditions associated with significant psychological and physical harm. Intimate partner violence (IPV) is a major public health issue with severe psychological and social consequences. Recent research indicates that over 25% of women with eating disorders have experienced IPV.¹

The mechanisms underpinning this association are multifaceted, involving factors such as social withdrawal, fear of loneliness and diminished interpersonal functioning, which can both increase vulnerability to abusive relationships and exacerbate disordered eating behaviours.² Social support appears to buffer these risks, yet cultural norms, stigma and socioeconomic barriers often limit access to such resources. While much of the literature focuses on women, emerging research suggests that men and gender-diverse populations are also affected, though they remain underrepresented in existing studies.

What are eating disorders?

Eating disorders are mental health conditions marked by persistent eating disturbances, often driven by concerns about weight, body shape or the control of food as a way to cope with emotional challenges. Eating disorders are not limited by age, gender or background—anyone can be affected. The causes are complex, involving a mix of biological, psychological and social factors.³

Bulimia nervosa is a type of eating disorder characterised by binge eating followed by purging to prevent weight gain. The bingeing and purging behaviours often serve as coping mechanisms to manage the emotional distress and trauma resulting from abuse, offering a temporary sense of control.⁴

The second most common is anorexia nervosa. It is characterised by an intense fear of gaining weight and a distorted body image, leading to restricted food intake.⁵ Understanding these disorders is crucial for exploring their connection to IPV.

What is intimate partner violence?

Intimate partner violence refers to any behaviour within an intimate relationship that causes physical, psychological or sexual harm to those involved, including acts such as slapping, hitting, forced sexual intercourse, insults, humiliation and controlling behaviours.⁶ In the UK, IPV is recognised as a significant public health and human rights issue, affecting people across all socioeconomic, cultural and age groups, though women are disproportionately impacted. National studies estimate that around 27% of women and 15% of men in England have experienced IPV at some point in their lives, with the consequences extending beyond physical injury to include serious mental health impacts such as self-harm and suicidality.⁷ The UK legal framework and international guidelines emphasise that IPV can occur in both current and former relationships, regardless of gender or sexual orientation, and often involves a pattern of coercive or controlling behaviour as well as physical and emotional abuse.⁸

Recent national data from the Office for National Statistics (2024) indicate that domestic abuse remains a significant issue across the adult population in England and Wales, affecting individuals of all genders. These findings underscore the widespread nature of intimate partner violence and the importance of inclusive, evidence-informed approaches to prevention and support.⁹

Methods

This article synthesises evidence from epidemiological surveys, clinical assessments, and systematic reviews identified through comprehensive searches on PubMed and ScienceDirect. Included studies utilise validated tools for assessing IPV (such as the Conflict Tactics Scale), diagnose eating disorders via structured clinical interviews or DSM-5-aligned questionnaires, and analyse the relationships between trauma, social support and disordered eating. Both cross-sectional and longitudinal research with large samples, including studies with up to 13,632 participants and national data from the Office for National Statistics (2024), are prioritised. Consideration is given to research involving both female and non-female populations, alongside a critical examination of the limitations of self-report trauma measures and the impact of systemic barriers on access to support and treatment.

Evidence of association

Bundock et al (2013) conducted a systematic review including eight observational studies, cross-sectional studies and longitudinal designs with 13,632 participants. Their findings demonstrated that individuals with eating disorders, such as bulimia nervosa and anorexia nervosa, report higher rates of lifetime IPV, including physical and sexual violence. The prevalence of lifetime physical intimate partner violence (IPV) among individuals with eating disorders ranged from approximately 22.7% to 40%, which is substantially higher compared to individuals without eating disorders as reported within the same study.¹⁰

Key studies mentioned in the article, including Kaner et al (1993)¹¹ and Mitchell et al (2011), reported prevalences of lifetime physical IPV among women with bulimia nervosa of approximately 34.6% and 40%, respectively.¹² Furthermore, Waller (1991) found that sexual IPV was reported by 15.4% of women with bulimia nervosa.¹³

The results consistently suggest that individuals with eating disorders, both male and female, are approximately two to four times more likely to have experienced intimate partner violence at some point in their lives, according to the increased odds reported in the systematic review.¹⁰ This emphasises that there is perhaps a bidirectional relationship between IPV and eating disorders, primarily driven by complex psychosocial factors. The authors emphasise that trauma, fear and emotional dysregulation are common psychological factors shared by both conditions, with disordered eating behaviours

often serving as maladaptive coping mechanisms in response to abusive relationships. Social factors, such as societal norms and stigma, further exacerbate feelings of helplessness and social isolation, which may perpetuate both IPV and disordered eating in the same individual.¹⁰

Therefore, recognising these links suggests that interventions should adopt a holistic approach, addressing not only the individual's psychological health but also their social environment and support networks.

A strength of Bundock et al's 2013 study is its focus on validated measures. Only studies that used validated diagnostic tools were included to ensure reliable findings. These included the Structured Clinical Interview for DSM-IV (SCID-IV), a clinician-administered interview for diagnosing mental disorders, including eating disorders, and the Conflict Tactics Scale (CTS), which measures the frequency and severity of physical violence in IPV.¹⁰

However, some limitations of the study include the variability in measurement methods for IPV among the included studies. Only one study used a validated instrument such as the CTS, while others relied on self-developed questions. This heterogeneity affects the comparability of results and could lead to inaccuracies in estimating the true prevalence and strength of the association between eating disorders and IPV.

Another notable limitation is the inadequate control of potential confounders. Most studies did not account for important factors like childhood abuse or co-morbid psychiatric conditions, which are known to influence both eating disorders and IPV. This lack of adjustment could result in biased associations, making it difficult to determine whether the relationship observed is direct or influenced by these other variables.

Childhood trauma and the risk of developing eating disorders

Groth et al (2019) conducted a study utilising a cross-sectional design, assessing adolescent patients diagnosed with eating disorders to explore their histories of childhood trauma using detailed trauma questionnaires and The Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition (DSM-5), which provides standardised criteria for the diagnosis of mental health conditions.^{14,15}

Similarly, Smyth et al (2008) demonstrated a relationship between the severity of trauma and eating disorders symptomatology, especially bingeing and purging behaviours. Their findings supported the concept that multiple trauma types intensify symptoms.¹⁶

Furthermore, Rayworth et al (2004) proposed that physical abuse might lead victims to feel a loss of control, which could trigger the development of eating disorders as a maladaptive coping mechanism. Their conceptual model suggests that such behaviours serve to regain a sense of mastery.¹⁷

Overall, the findings demonstrated a significant association between experiences of violence, particularly physical abuse, and the severity of bulimia nervosa symptoms, notably uncontrollable bingeing and purging behaviours. Childhood traumas can disrupt emotional regulation, foster feelings of helplessness, and contribute to a distorted self-concept. As a result, individuals might engage in disordered eating as a maladaptive coping strategy—an attempt to regain control over their bodies and emotions.¹⁴ This highlights that eating disorders are not merely about food or weight but are complex responses rooted in psychosocial distress.

A strength of the study is its use of clinical samples and real-world data. Data were obtained from adolescents receiving treatment, demonstrating practical applicability for clinicians working directly with this demographic.

As well as its comprehensive assessment of trauma types and severity, by evaluating multiple categories of trauma and summing their severity, the Groth study offers nuanced insights into how different trauma experiences relate to eating disorder symptomatology, supporting a layered understanding of these complex relationships.

However, one limitation is the reliance on self-reported data collected from clinicians, which may introduce biases and affect the accuracy of trauma and symptom assessments. Additionally, the study did not include information about participants' Axis I comorbid diagnoses, which indicates other mental health disorders, such as depression or anxiety, that frequently co-occur with eating disorders and can influence their severity and treatment outcomes. This, therefore, limits the ability to account for the influence of other mental health conditions that often accompany eating disorders and trauma, thus potentially affecting the findings' comprehensiveness.

The impact of social support on eating disorders in women exposed to IPV

Schirk et al (2015) conducted a cross-sectional analysis and found that higher levels of social support were significantly associated with a reduced risk of eating disorders. The study observed that women exposed to IPV exhibited varying levels of risk for developing eating disorders, with those reporting stronger social networks showing notably lower vulnerability. Participants, including women aged 18–64 years with a history of IPV, were recruited from primary care and domestic violence services.¹⁸

IPV exposure was assessed using the Humiliation–Afraid–Rape–Kick (HARK) screener, which evaluates experiences of rape, physical assault, emotional abuse and humiliation, representing a targeted measure of intimate partner violence in contrast to the broader diagnostic instruments utilised in the studies described earlier.¹⁹

These findings suggest that social support functions as a protective psychosocial factor, buffering the negative mental health impacts of IPV, particularly regarding disordered eating. In this study, social support was defined as overall functional support, encompassing emotional, tangible and social interactional aspects, and measured using a modified eight-item Medical Outcomes Study Social Support Survey (score range 0–32, with higher scores reflecting stronger networks). The study reinforces the significant interplay between social and psychological variables in the development of eating disorders among IPV-exposed women, underscoring the value of strengthening support networks in prevention and treatment strategies. Interventions should incorporate psychosocial support alongside nutritional therapy, as promoting social connectedness and community engagement may foster healthier eating behaviours and improve outcomes for both women and men affected by IPV.¹⁸

Schirk et al (2015) make a valuable contribution by utilising validated instruments and comprehensive analytical methods to examine the relationship between social support and eating disorder risk among women exposed to intimate partner violence. Its focus on this vulnerable population emphasises the potential for social support as a modifiable protective factor, with significant implications for clinical practice and intervention development.

However, the cross-sectional design limits the ability to infer causality, underscoring the need for longitudinal research to establish temporal relationships between social support and the development of eating disorders. Additionally, the sample's limited ethnic diversity and reliance on self-report measures may restrict the generalisability of the findings and introduce response biases. Future studies incorporating diverse populations, objective assessments and qualitative approaches could deepen our understanding and inform culturally sensitive, trauma-informed strategies to reduce eating disorder risk within this high-risk group. Despite these limitations, the study highlights important avenues for targeted interventions and provides a foundational basis for ongoing research in this vital

area.

Conclusion

Disordered eating behaviours often serve as coping mechanisms in response to the psychological trauma and social adversity associated with IPV. This suggests that eating disorders are not simply about food or weight, but represent complex responses rooted in psychosocial distress.^{1,2}

Recognising these links highlights the importance of incorporating psychological and social assessments into nutritional and psychiatric interventions. Trauma-informed care, together with stronger social support networks, can help mitigate the harmful effects of IPV on eating behaviours.¹⁸ Reducing stigma and addressing cultural and socioeconomic barriers are also essential to ensure equitable access to support.⁶

However, current evidence is limited by reliance on cross-sectional designs, self-reported measures, and the underrepresentation of men and gender-diverse populations. Future research should adopt longitudinal approaches and consider structural inequalities. For example, disparities in access to healthcare and social support among women from lower-income or rural backgrounds, as observed in the Schirk et al (2015) study, can help provide a more comprehensive understanding. This can inform inclusive, evidence-based interventions and guide policy development to reduce the prevalence of eating disorders linked to IPV.

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Fajar Ali Rasool

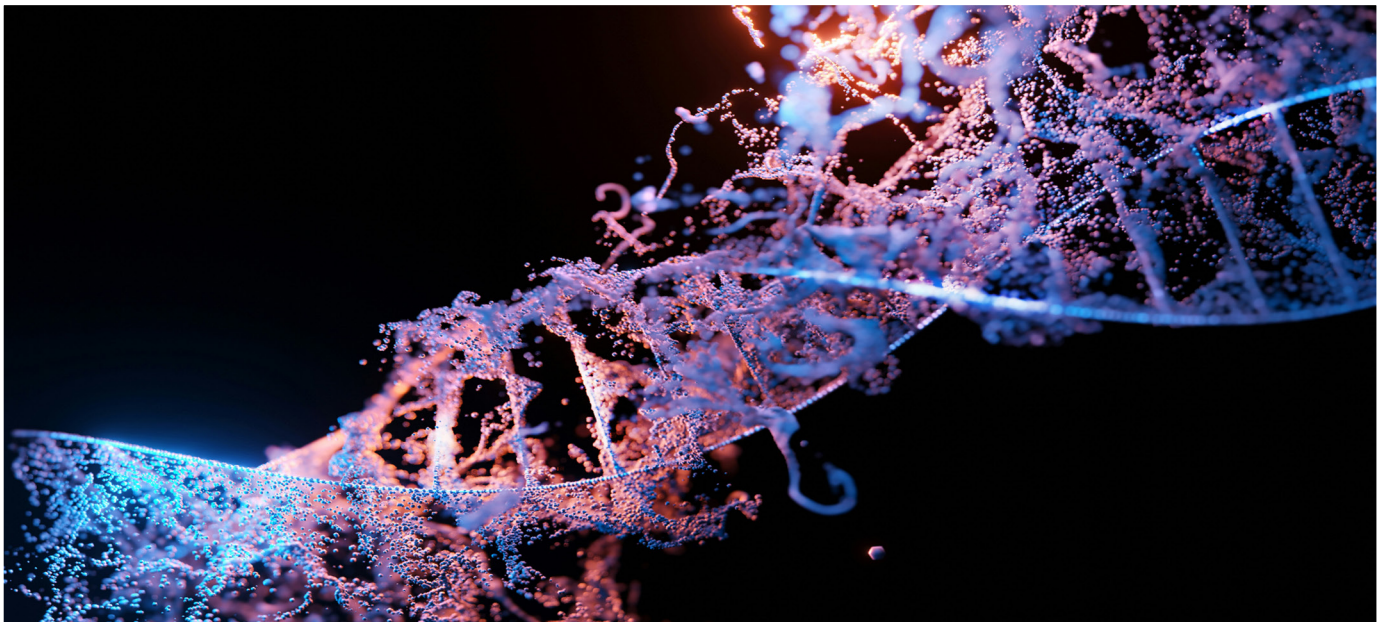
Fajar is a second-year medical student at the University of Plymouth with a growing interest in neurology. This article was written as part of her Student-selected Component, which she completed during her first year. Her work explored the complex relationship between eating disorders and intimate partner violence (IPV). She hopes to continue exploring the intersection between mental health, gender-based violence, and social inequality, with the aim of contributing to research that improves holistic, trauma-informed care.

The role of folate in preventing spina bifida (myelomeningocele): molecular mechanisms and interventions

Fajar Ali Rasool

Year 2, Medicine, University of Plymouth

Email: fajar.alirasool@students.plymouth.ac.uk



Abstract

Folate, or vitamin B9, is essential for preventing neural tube defects (NTDs), including myelomeningocele, through its major role in DNA synthesis. This review discusses biochemical, epidemiological and policy evidence to examine the molecular mechanisms underpinning folate's protective effects, and the effectiveness of public health measures such as supplementation and food fortification. These efforts are vital for informing clinical strategies and public health initiatives aimed at reducing the global burden of NTDs, including myelomeningocele.

Abbreviations

NTDs- neural tube defects
RCTs- randomised controlled trials
SAM- S-adenosylmethionine
THF-tetrahydrofolate

Introduction

Neural tube defects (NTDs) are serious congenital malformations and impose a significant healthcare burden globally. Among these, myelomeningocele is a common and severe form. Folate, also known as vitamin B9, plays a crucial role in preventing NTDs, particularly myelomeningocele. It is vital for DNA synthesis, methylation and homocysteine regulation—processes that are essential for proper

neural tube formation. This article covers the current evidence on the role of folate in preventing myelomeningocele. Research indicates that approximately 8 out of 10 cases of NTDs can be preventable through adequate folate intake, underscoring the importance of understanding its molecular mechanisms and implementing effective preventive interventions.¹

Although this review focuses on myelomeningocele, the molecular pathways by which folate acts are shared across all NTDs. Consequently, evidence from studies of NTDs in general is directly relevant to myelomeningocele. The specific emphasis on myelomeningocele reflects not only its prevalence but also its clinical severity within the broader spectrum of NTDs. This article, therefore, examines folate's protective mechanisms, considers the role of related nutrients, and evaluates current public health strategies, including supplementation and food fortification, in reducing the incidence of NTDs such as myelomeningocele.

What is myelomeningocele?

Myelomeningocele, the most severe form of spina bifida, is a congenital birth defect characterised by incomplete closure of the spine and spinal canal during foetal development. This condition results in a fluid-filled sac protruding from the baby's back, containing part of the spinal cord and nerves.² This usually occurs in the lower spine with symptoms such as weakness or paralysis in the legs, loss of sensation, bladder and bowel problems, hydrocephalus (excess fluid in the brain), and learning difficulties. While the exact cause is

unknown, genetic and environmental factors, including insufficient folic acid during pregnancy, are believed to play a key role.³

In the UK, recent data highlights the concerning prevalence of NTDs, including myelomeningocele. A comprehensive study (2000–2019) found an overall rate of 12.5 per 10,000 births in England, rising from 12.1 (2010–2014) to 13.6 (2015–2019); myelomeningocele comprised 46.8% of all the cases.⁴ These statistics highlight the need for continued research and prevention strategies for reducing myelomeningocele's prevalence.

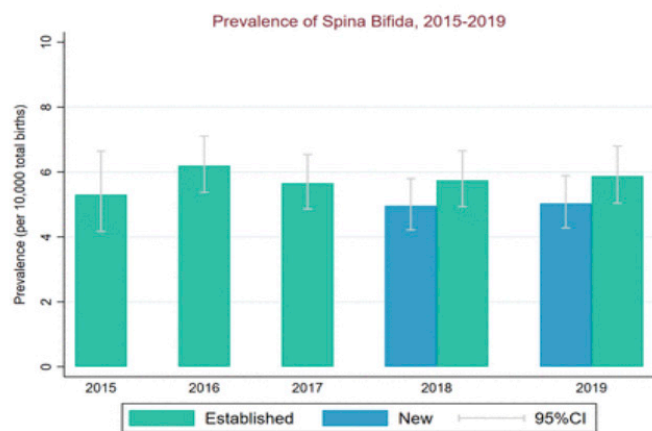


Figure 1. Total birth prevalence of spina bifida between 2015 and 2019 for established and new regions of the National Congenital Anomaly and Rare Disease Registration Service. Figure reproduced from Broughan et al, with thanks.⁴

The data in **Figure 1** reveal a slightly increasing trend in prevalence across the years for both groups, with minor fluctuations. The 95% confidence intervals illustrate statistical consistency but also underscores the need for further research into the molecular mechanisms through which folate reduces risk, such as its role in DNA synthesis, repair and epigenetic regulation.

The UK's plan to fortify non-wholemeal wheat flour with 250 µg of folic acid per 100 g by 2026 aims to cut NTD rates by 20%, saving the NHS £20 million and delivering £90 million in economic benefits.⁵ The strategy aims to prevent NTDs effectively by integrating public health and economic goals, drawing on successful programmes in Australia and New Zealand.⁶

What is vitamin B9?

Vitamin B9, commonly known as folate or folic acid, is a water-soluble B-group vitamin essential for numerous critical physiological processes. The naturally occurring form found in foodstuffs is folate, whilst folic acid is the synthetic version used in dietary supplements and food fortification. This vital nutrient plays a pivotal role in cellular metabolism, supporting fundamental biological functions including DNA synthesis, cell division and red blood cell formation.⁷ During pregnancy, folate is particularly crucial as it helps prevent NTDs, including myelomeningocele, in the developing foetus. The recommended daily intake for adults is up to 400 µg, while pregnant women and those planning conception are advised to consume higher doses.⁸ Dietary sources rich in folate include verdant leafy vegetables, legumes, nuts and certain fruits such as oranges and strawberries.⁹

Vitamin B9 and its association with myelomeningocele

Folate plays a crucial role in nucleotide synthesis and DNA function. It acts as a coenzyme in these processes essential for proper cell

division and growth. During embryonic development, particularly in the neural tube formation, rapid cell division occurs. Adequate folate levels ensure that these processes can proceed normally.⁷

Folate is also integral to one-carbon metabolism. One-carbon metabolism is a series of biochemical reactions in the body that involve the transfer of one-carbon units such as methyl, formyl or methylene groups, between molecules. Folate, primarily in the form of tetrahydrofolate (THF), serves as a universal one-carbon acceptor and donor.¹⁰

It is essential for the synthesis of S-adenosylmethionine (SAM), a key methyl donor involved in DNA methylation, which is crucial for gene expression regulation and neural tube closure during embryogenesis. Folate deficiencies can disrupt these processes, increasing the risk of NTDs.¹¹

Research also suggests that folic acid may prevent NTDs by rescuing de novo thymidylate biosynthesis.¹¹ De novo thymidylate biosynthesis refers to the process by which cells create thymidylate, an essential component of DNA, from scratch and needs folate. This process is crucial for DNA repair and impairment can lead to an increased risk of developing NTDs, including myelomeningocele.¹² Molecular mechanisms

Imbard et al 2013 conducted a comprehensive literature review to investigate the relationship between folate, vitamin B12, and NTDs. The researchers collected various types of data, including nutritional data focused on maternal intake of key nutrients such as folate, vitamin B12 and choline during the periconceptional period. It is a critical period in women that includes oocyte growth, fertilisation, conceptus formation and early embryonic development up to week 10 of gestation.¹³

The researchers referenced epidemiological studies linking maternal folate and vitamin B12 levels to NTD prevalence. Their findings demonstrate that folic acid supplementation significantly reduces NTD risk while emphasising the roles of vitamin B12 and choline. Low vitamin B12 and high homocysteine levels are associated with an increased risk of NTDs, as homocysteine contributes to oxidative stress and endothelial dysfunction, impairing neural tube development.¹¹ Adequate folate levels help regulate homocysteine metabolism, further reducing NTD risk.

A strength of the study is its comprehensive overview of the relationship between folate and other key nutrients, integrating findings from multiple studies. It highlights the importance of public health initiatives to increase folic acid intake among women of childbearing age. The research combines insights from genetics, biochemistry and public health, offering a multifaceted perspective. The methodology ensured thorough data collection through participant retention during pregnancy, likely using either longitudinal or cross-sectional designs.

However, while the review discusses associations, it notes that animal studies have not sufficiently clarified the metabolic and genomic mechanisms underlying human folic acid responsiveness. The studies referenced may vary in design, population, and methodology, which can complicate the interpretation of results and their generalisability. Interventions

Wald (2022) conducted a comprehensive review of existing literature on folic acid and its role in preventing NTDs, including historical studies and randomised controlled trials (RCTs). Wald also analysed the effectiveness of current public health policies on folic acid fortification and their impact on NTD rates. The research compared outcomes from countries with and without fortification, assessing the effectiveness of different approaches.¹

The study concludes that the proposed UK policy is expected to prevent only about 10% of NTD cases, which is insufficient. The

research advocates for a more robust fortification strategy that could prevent up to 80% of NTDs, suggesting that fortifying staple foods like flour and rice is essential.¹

The study's postscript highlights this further by referencing the UK MRC Vitamin Study, which demonstrated an 83% reduction in NTD risk with a daily intake of 4 mg of folic acid,¹⁴ it advocates for fortifying flour with 1 mg of folic acid per 100 g to achieve optimal serum folate levels (44 ng/ml).¹⁵ This consistent intake of fortified foods addresses public health challenges more effectively than intermittent supplementation. By monitoring serum folate, interventions can be tailored, enhancing understanding of folate's molecular mechanisms in neural development and reducing the incidence of myelomeningocele globally.

A strength of the study is its use of a robust set of data collection methods. It includes health outcomes data from national databases to track NTD incidence before and after fortification policies were implemented. Additionally, dietary intake was assessed through food frequency questionnaires and national dietary surveys to evaluate changes in folic acid consumption.

However, the effectiveness of folate fortification varies depending on local diets and food supply chains, which the study may not fully address. Confounding variables, such as genetic predispositions and environmental influences on NTDs, remain insufficiently explored.

Conclusion

Overall, folate is essential for preventing myelomeningocele due to its crucial role in DNA methylation, homocysteine metabolism, and genetic interactions. While these mechanisms help explain its protective effects, the exact process is likely complex, involving both genetic and environmental factors.

Mandatory folic acid fortification of staple foods has been significantly shown to reduce the incidence of NTDs. Countries that have implemented such policies have observed substantial declines in spina bifida cases, reinforcing the need for widespread fortification to ensure populations at risk receive sufficient folate. Hence, the UK's plan to fortify non-wholemeal wheat flour with 250 µg of folic acid per 100 g by 2026 may not be enough. Increasing the fortification level of non-wholemeal wheat flour from 250 µg to at least 400 µg can enhance its effectiveness.

However, as the exact cause of myelomeningocele remains unknown, fortification should be approached with caution to prevent potential toxicity. Further research into its metabolic pathways can help develop more effective prevention strategies, ultimately improving health outcomes for affected children. Additionally, the NHS' economic burden can be reduced, by focusing on the prevention of myelomeningocele rather than its treatment.

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Fajar Ali Rasool

Fajar is a second-year medical student at the University of Plymouth with a growing interest in neurology. This article was written as part of her student-selected component, which she completed during her first year. Her work investigated the molecular mechanisms of folate and vitamin function in relation to brain health. She has since developed a strong enthusiasm for research and hopes to contribute to advancements in neurological understanding and treatments that can benefit a broad range of communities.

Can game-based interventions improve executive function to reduce age-related cognitive decline?

Keerthiga Vinayagamoorthy

Year 3, Medicine, University of Exeter

Email: kv286@exeter.ac.uk



Abstract

Determining effective interventions for age-related cognitive decline is significant as the proportion of the world's population aged 60 and over is rapidly increasing. Ageing has been associated with deterioration of the brain, with specific regions corresponding to different functions affected. Therefore, this literature review aims to explore how video games and other forms of play, such as physical activity, could be an effective intervention to improve executive function. Clinical studies have demonstrated the potential of various video game genres, including real-time strategy, brain training and puzzle games, to induce structural changes in different brain regions. Volumetric grey matter increases, particularly in the frontal lobe, are associated with improvements in executive function. A study of another form of play, physical activity, showed similar volumetric changes as observed in video game training interventions.

The structural changes reported in the video game-based intervention groups can be considered clinically significant, as shrinkage of the brain's cortices has been associated with age-related cognitive decline. However, to fully understand the effectiveness of such interventions, further research is crucial. This research should explore the different types of video games, as there is significant diversity between video games and their neural correlates.

Introduction

The rate at which the population is ageing has been at an unprecedented, rapid pace over the past decades.¹ The percentage

of the world's population aged over 60 years will almost double between 2015 and 2050, from 12% to 22%.² The ageing population contributes to the challenges the NHS faces, for example, the cost of care and increased admissions.³ This demographic shift highlights the importance of the need for effective interventions that can improve executive function (a set of skills such as working memory, task switching, reasoning and inhibition), to reduce age-related cognitive decline.

During ageing, shrinkage of brain volume can often lead to cognitive impairment and reduced executive function. Therefore, it is essential to evaluate interventions that prevent a decrease in the volume of brain regions due to ageing.⁴ Cognitive functioning and decision making are often associated with activity in the frontal lobe, especially the orbitofrontal cortex in the prefrontal cortex region.⁵ However, the orbitofrontal cortex is not solely responsible for cognitive functioning and decision making. It is part of a complex system that involves cortical structures, such as the amygdala and the insular cortex.⁶

Play is complex and, therefore, the definition of play is considered ambiguous.⁷ Play is also unique to an individual; thus, one activity may be considered playful to one and not to the other. This means that in different people, play can be triggered by various forms, such as video games, music and exercise.⁸ The five elements of play presented by Peter Gray will be used in this literature review to address the interventions explored, namely: self-chosen, intrinsically motivated, structured based on rules, imaginative, and a playful state of mind.⁸

Video games are a form of play for many individuals.⁹ Video games

may require players to make decisions from many choices through encountering situations where they are required to adapt their strategy quickly. Additionally, they may be required to solve a puzzle by manipulating various components. These abilities employed during playing a video game can be classified under executive function, which involves skills such as working memory, task switching, reasoning and inhibition.¹⁰ These aspects of executive function are often associated with activity in the frontal lobe, especially the prefrontal cortex.¹¹ Age-related impairment, especially after 60 years, in executive function has been reported to be the greatest. This finding has been supported by observed age-related declines in the associated regions, such as the frontal lobe.^{12,13} Therefore, interventions to improve, particularly executive function, are crucial because they can improve physical and mental health as well as overall quality of life.¹⁴

This literature review aims to look at structural plasticity (which is the quality of being easily shaped) changes in the brain, particularly in the frontal lobe, in healthy adults after playing video games of the genres: real-time strategy, action, brain training and puzzle games. Secondly, it aims to compare the observed effects through video games with physical activity, another play. Moreover, it aims to explore what the observed structural changes consequently mean for executive function in age-related cognitive decline.

Method

The relevant literature was found in May 2024, using PubMed and TRIP. The search terms used were "Game", "Interventions", and "Executive function" linked by the word "AND". In addition, "OR Executive control" included conjunction with "Executive function" to broaden the results. Papers from clinical trials were included if the participants were 18 years and older and had no mental disorders. Meanwhile, papers were excluded if the participants had prior experience playing the game and if they were outside the scope, determined by the title or abstract. In total, seven papers were used for the discussion. Additionally, backward citations and articles from the World Health Organization, the National Institute for Play, and the NHS were used.

Discussion

Structural plasticity effects in healthy adults

Volumetric changes in the brain were reported by a study conducted by Basak et al, in which 20 healthy adults, with no prior experience in video games, played a real-time strategy video game; the participants spent a total of 23.5 hours playing. An increase was found in the volumes of the middle frontal gyrus, postcentral gyrus, dorsolateral prefrontal cortex, anterior cingulate cortex, and cerebellum using high-resolution magnetic resonance imaging after video game training compared to the initial scans.¹⁵ Similarly, volumetric changes in a study by Colom et al of structural changes in the brain after 16 hours of video game practice showed an increase in grey matter, particularly in the frontal lobes of the brain, in the intervention group compared to the control group. The genre of the video game played was brain training and puzzle games. However, no significant associations were found between the structural changes and general cognitive ability tests.¹⁶

A limitation of the study conducted by Colom et al is that it involved only female participants, which may not allow generalisation to males, as there could be gender distinctions. Additionally, the mean age of the participants was 18.95 years, which may limit extrapolation to the elderly population.¹⁶ On the other hand, the study by Basak et al involved participants of a mean age of 70.1 years old. The study by Basak et al involved only participants of Caucasian background, which limited the findings to this specific group, as variations may exist between different ethnicities.¹⁵ Both studies also consisted of a small sample size, limiting the external validity of these findings.^{15,16}

A study by Kühn et al also observed a significant increase in grey matter, with $p < 0.05$, in the dorsolateral prefrontal cortex of the intervention group that had played an action game for a mean of 50.2 hours. The action game required skills to navigate a three-dimensional environment and the use of effective strategies.⁹ However, this study involved financial rewards for the video game training group; this would go against one of Peter Gray's elements of play, intrinsic motivation.^{8,9} Therefore, although the intervention is game-based, the results may not be considered as a result of play for these participants.

Furthermore, a limitation of all of the studies of the video game interventions discussed is that there is no inclusion of a control group that is given a similar technical device to that of the video intervention group. This is important to ensure that the observed effects are a result of the playful activity and not the exploration of the new device provided.⁹

Structural changes and brain function

The significance of these observed structural changes for brain function, especially executive function, was highlighted by Basak et al. They found that the intervention group showed significantly improved performance in cognitive tasks involving executive function, such as working memory, task switching, inhibition and reasoning, compared to the control group, which received no video game training. This was determined by having participants complete various cognitive tasks before, during and after video game training.¹² This shows the potential of video game training to cause transfer to executive control skills in healthy older adults. Moreover, the study by Kühn et al highlighted a smaller prefrontal cortex volume to be a risk factor for neurodegenerative disease, indicating the video game-induced volumetric changes in the brain to be effective as an intervention to counteract that.⁹

However, no significant transfer of training to executive function has been reported after playing video games of certain genres, such as simple arcade games, by some studies. This indicates that what the video game consists of, for example, whether it is complex and variable in nature, is crucial to the effectiveness of improving specific cognitive skills.^{12,17} Therefore, the elements of a video game need to be considered when determining which video games can be effective as an intervention to improve executive function and reduce age-related cognitive decline.

Other interventions

On the other hand, physical activity may trigger play for some. Similar findings were reported in a study by Erickson et al, in which participants' walking amounts and volumetric changes in the brain were measured. They found that greater physical activity, specifically walking in this study, was associated with increased volumes of grey matter in the frontal and other lobes of the brain. To detect this increase, walking approximately six to nine miles per week was required. The study also concluded that greater grey matter volume following physical activity reduced the risk of cognitive impairment by approximately double, indicating improvements in executive function. Some strengths of this study were that the length of this study was 9 years, which allowed more long-term changes to be seen, and the large sample size consisting of 299 adults allowed increased external validity.¹⁸

Moreover, a randomised control trial conducted by Adcock et al involved older adults aged 65 years and over, who were assigned to either an intervention group consisting of exergame sessions or a control group, where participants continued with their daily lives. The exergame sessions involved exercising through interactive video games. Although inhibition and working memory were found to have improved significantly in the intervention group compared to the control, no significant effects were noted for brain volume.¹⁹ This highlights the uncertainty of the time frame for structural plasticity to

be induced and indicates the need for further study of the underlying mechanisms to find an optimum design for interventions.

Drawing links between all the studies explored, it can be summarised that various genres of video games can bring about improved executive functioning. This can be linked to structural changes in the different regions of the brain, which were illustrated in the results of studies.

Conclusion

In conclusion, game-based and other interventions, such as exercise, which may be considered play to some, have shown potential to improve executive function through structural changes, particularly in the frontal lobes of the brain and subsequent transfer of skills in tasks requiring executive function. The associations between the volumetric changes in the brain and transfer skills highlight the potential of these neural changes to reduce age-related cognitive decline, in which patterns of deterioration of the brain cortices have been noted.

However, there are many limitations in this field preventing certain conclusions from being made. For example, the experiments are not standardised across different types of video games to make valid comparisons. Furthermore, longitudinal studies consisting of larger sample sizes are required to ensure the results are more universally applicable and to explore the permanence of the structural changes. Additionally, this literature review did not explore all types of video game genres to determine video games as an effective intervention or explore the different lengths of time playing to a large extent. In summary, video game training has shown neural changes, similar to those after exercise, associated with improvements in executive function, which have the potential to reduce age-related cognitive decline.

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Keerthiga Vinayagamoorthy

My name is Keerthiga Vinayagamoorthy and I'm a third-year medical student at the University of Exeter. This article was written as part of a Special Study Unit about 'The physiology of play - the mechanisms through which play can promote engagement and wellbeing,' which enabled me to learn about the significance of play in promoting engagement in education.

How can AI be utilised to improve diagnostics for coronary artery disease and heart failure?

Lily Worrall-Downes

Year 2, Medicine, University of Plymouth

Email: lily.worrall-downes@students.plymouth.ac.uk



Abstract

Cardiovascular diseases, such as coronary artery disease and heart failure, are some of the leading causes of death across England. They are commonly diagnosed via electrocardiograms (ECGs) and echocardiograms. However, these techniques are subject to a lot of human error in assessments and accessibility to these services can be inadequate. This article examines the various methods that AI can be used to combat this issue and aims to review the innovations made through AI for healthcare in this area. It discusses the benefits and limitations of using AI to predict mortality and cardiovascular disease risk, detecting asymptomatic left ventricular dysfunction (ALVD) and assessing left ventricular ejection fraction. This avenue of AI is beneficial to healthcare as it can outperform traditional mortality and disease risk estimates, such as demographic data, allowing clinicians to utilise this information in personalised patient treatment, reducing the risk of a serious hospital stay. It can diagnose early-stage ALVD, helping to treat it before progression to heart failure, alongside increasing accessibility to echocardiograms by reducing assessment times. However, one of these AI models uses coronary artery inflammation as a marker for heart attack risk, but this has not yet been proven to be related. Therefore, this article concludes that further research is required to assess the safety and efficacy of these AI systems in clinical practice, and if these requirements are met, then AI systems could be vital to solving the issues with the diagnosis of coronary artery disease and heart failure.

Abbreviations

AI – artificial intelligence

AIRE – AI-ECG risk estimator

ALVD – asymptomatic left ventricular dysfunction

CAD – coronary artery disease

CTCA – computed tomography coronary angiography

CVDs – cardiovascular diseases

ECGs – electrocardiograms

LVEF – left ventricular ejection fraction

Introduction

Cardiovascular diseases (CVDs), such as coronary artery disease (CAD) and heart failure, are currently one of the leading causes of death across the world.¹ CVDs cause more than 39,000 of the deaths under 75 in England, as reported in 2022.² Some of the key interventions in diagnosing and treating common cardiovascular diseases are the use of ECGs (electrocardiograms) and other cardiac imaging techniques such as echocardiograms. In 2021, it was reported that 64,962 people in England had to wait for 6 weeks or more to receive an echocardiogram,³ which could have detrimental effects on the quality of care for patients suffering from CVDs. Without the use of cardiac imaging for diagnostics, the doctors responsible for patient care cannot determine whether an individual requires an urgent intervention or not.³ Moreover, although there are currently methods of predicting cardiovascular disease risk, they are unable to provide specific disease risks and time-to-event predictions.⁴

Artificial intelligence (AI) systems are being developed, which could potentially resolve these issues by decreasing the amount of time taken to perform and analyse cardiac imaging and perhaps predicting who is at risk of certain CVDs. For example, AI systems could use ECG data to detect the early stages of heart disease,⁵ predict mortality and risk of cardiovascular diseases and screen for cardiac contractile dysfunction.^{6,7}

The AI used in this research utilises machine learning and deep learning systems. Machine learning is defined as 'a sub-class of

artificial intelligence'. It is self-learning, based on algorithms that learn from their own experiences.⁸ Deep learning systems are machine learning systems that 'are composed of multiple processing layers'.⁹ These layers allow the system to process large amounts of data and create links between each piece of information.¹⁰ However, these vast amounts of data put the system at risk of possible cyber-attacks, which risks patient safety.¹¹ Despite this, these systems are an exciting new avenue of healthcare, as they may improve patient care through rapid analysis of cardiac imaging to decrease wait times for diagnosis and by predicting patient risk of CVDs from ECGs.

Examples of AI systems utilising ECG data for diagnostics

Creating estimations for mortality and CVD risk

In current practice, systems such as QRISK (an algorithm used to calculate a cardiovascular risk score¹²) is used to predict mortality risk for patients with CVD risk factors.⁴ This algorithm does not provide the clinician with specific information that can be used to improve patient care; QRISK can provide the patient's 10-year risk of developing a heart attack or stroke.⁴ The AIRE platform (AI-ECG risk estimator) that has recently been developed utilises an AI system to analyse ECG data, producing time-to-event prediction curves and assigning risk levels to patients.⁶ These graphs provide clinicians with enough information to create patient-specific care plans based on their mortality risk and risk of developing other CVDs. From their research, Arunashis Sau et al concluded that AIRE was superior at predicting mortality when compared to the standard methods of utilising demographic data and "traditional risk factors".⁶ The AIRE model was also superior to traditional ECG analysis and the use of LVEF (left ventricular ejection fraction) to predict future ventricular arrhythmia.⁶

The AIRE model was trained on a substantial amount of data, which was taken from various international sources.⁶ This data was composed of millions of routine ECGs, allowing the AI model to predict risk based on which individuals later died or developed additional CVDs.⁶ Although this admittedly 'large'⁶ dataset allowed the AIRE model to create more precise and patient-specific predictions, this also raises some data security concerns.¹¹ As large amounts of data require cloud-based storage, this leaves them vulnerable to possible cyber-attacks.¹¹ The developers of the AIRE system did undertake measures to protect patients by anonymising all data,⁶ but it is important to consider the possible implications of using such large datasets for AI training.

The use of the AIRE system in clinical practice could improve patient outcomes and care as clinicians can utilise the information provided by AIRE to analyse patients' risk of mortality and CVDs. Individuals could be provided with a preventative treatment plan if their risk of developing a particular CVD is high, which could improve their life span.⁶ Moreover, a heart-failure specific version of AIRE could be used to reduce the 'number of hospital admissions due to undiagnosed heart failure',⁶ as it could allow healthcare professionals to diagnose and treat heart failure before the disease progresses. Despite the clinical benefits of integrating AIRE, it is vital that patient data is sufficiently protected and that informed consent is gathered.¹¹

Detecting and diagnosing asymptomatic left ventricular dysfunction (ALVD)

Asymptomatic left ventricular dysfunction (ALVD) is defined as abnormal ventricular function in the absence of any symptoms.¹³ ALVD is associated with the progression to heart failure and can reduce the quality and length of life.^{13,7} ALVD is found in roughly 3-6% of the general population and as it is asymptomatic,⁷ it can progress to heart failure due to a lack of diagnosis or early treatment. Recently, researchers in collaboration with the Mayo Clinic have developed a platform trained on ECG information to screen for and diagnose ALVD.⁷ This AI system identifies individuals with ALVD by producing

an ejection fraction (a percentage fraction of the blood that is ejected from the ventricles¹⁴). The study found that patients with a positive screen by the AI system were at four times the risk of developing ALVD in the future than those who screened negative for ALVD.⁷

Currently, the most reliable method of screening for ALVD is with an echocardiogram.¹⁵ However, echocardiograms are not commonly available in non-specialist clinics,¹⁵ and there is not currently any form of ALVD screening tool that is "inexpensive, widely available and non-invasive to facilitate early intervention by general clinicians".¹⁵ The AI screening tool for ALVD can help solve this issue as it utilises the low-cost ECG,⁷ which is already used commonly in clinical practice.

On the other hand, in a 2023 study, researchers found that of the two ALVD signs found by ECG (T wave inversions and low QRS amplitude¹⁶), only 57.4% of individuals with ALVD showed T wave inversions and 22.2% displayed a low QRS amplitude.¹⁶ A normal ECG result does not disprove an ALVD or heart failure diagnosis,¹⁷ due to the inconsistency of ECG indications. Therefore, utilising the low-cost ECG to detect ALVD is not as accurate as the standard method of diagnosing via echocardiogram.¹⁸

This tool can help clinicians detect ALVD early before progression to heart failure.¹⁵ As ALVD is a treatable disease, the application of this AI device may be able to improve the quality and longevity of life for people living with the condition,⁷ as clinicians can diagnose and treat ALVD early on. However, it is vital that the diagnostic accuracy of using the low-cost ECG is considered.¹⁷ Despite being a useful screening tool for ALVD, ECGs cannot diagnose heart failure as accurately as an echocardiogram.¹⁸

Examples of AI systems utilising cardiac imaging data for diagnostics

Analysing echocardiograms to assess left ventricular ejection fraction (LVEF)

LVEF is currently used by clinicians to guide decisions on treatments for individuals with CVDs and is mainly determined from an echocardiogram.¹⁹ It is recommended that when assessing LVEF, multiple readings should be taken over multiple cardiac cycles to determine an accurate value.¹⁹ However, in 2021 over 64,962 people in England waited for an echocardiogram for 6 weeks or more.³ This emphasises the issue that despite echocardiograms being vital for assessment and allocation of treatments to patients, the long waitlist can "create a domino effect of disruption to heart care and treatment that puts lives at risk".²⁰ Furthermore, the current LVEF assessment is subject to human error and therefore may not be precise.¹⁹

Research published in Nature in 2023 aims to solve this issue, comparing the accuracy of sonographers (an allied health professional who performs and analyses ultrasounds²¹) and an AI system in assessing LVEF. The research found that the AI system was superior to sonographers in the initial assessment of LVEF and that cardiologists who were performing a secondary assessment took less time to read the AI report than one provided by the sonographers.¹⁹ Moreover, in a 2025 study, it was reported that sonographers, using a combination of their own skills alongside AI assistance, had a 25% reduction in ultrasound scan time.²²

In spite of this, the use of AI could replace the shared decision-making process and reduce the need for hands-on clinical expertise.^{23,24} Sonographers may wonder if AI systems could replace them, due to their efficiency in assessing LVEF and their reduction of ultrasound scan time.²⁵ Moreover, increased AI assistance may hinder core skills development and decrease clinicians' responsibilities.²⁶ Despite this, AI assistance in sonography may not supplant the profession, due to its irreplaceable practical skill.²⁵ Instead, it may increase efficiency and help sonographers to improve their practice.²² By utilising AI assistance in sonography, waiting times for essential echocardiograms could be reduced due to optimised LVEF assessment.

Analysing computed tomography coronary angiography (CTCA) to predict heart attack risk

In current clinical practice, individuals are referred to have a CTCA to determine if they have coronary artery disease (CAD).²⁷ On a CTCA, diagnosis of CAD is determined by assessing the narrowing of the arteries. However, these CTCA scans cannot predict the risk of having a major cardiac event such as a heart attack.²⁸ As of 2021, 20,061 people under the age of 75 died from heart attacks and over four out of five deaths due to CVDs every year across the globe are due to heart attacks.^{29,1} Oxford researchers have developed the Cari-Heart device, which utilises AI systems to analyse CTCA scans to predict future risk of CVDs and heart attacks by detecting coronary artery inflammation.^{28,30} As current CTCA scans cannot detect inflammation,²⁷ the Cari-Heart device could be instrumental in preventing serious heart attacks as it can predict the risk of a serious event long before it happens, allowing clinicians to treat the underlying cause.³⁰

However, NICE does not currently recommend Cari-Heart for use in clinical settings as there is not sufficient evidence to suggest that treating coronary artery inflammation would reduce heart attack risk.²⁷ Furthermore, they suggested that further research is required on different types of CAD to demonstrate whether there is a difference in inflammation. Therefore, it can be concluded that further research is required to assess the real benefit of using Cari-Heart in clinical settings to assess heart attack risk, as it is not conclusive whether or not it would reduce mortality rate or if Cari-Heart can successfully predict patient risk of a serious cardiac event.²⁷

Conclusion

Although a relatively new avenue of research, the applications of AI in diagnostics for CAD and heart failure are wide. From predicting risk of CVDs and heart attacks, to diagnosing ALVD and decreasing assessment times for LVEF, AI represents an exciting method of enhancing patient care and decreasing pressure on clinicians. To advance these technologies so they can be used to their full potential in clinical practice, more research needs to be conducted to prove the value and benefits of using systems like Cari-Heart and ECG-based ALVD assessment. Developers should ensure that further implementation of AI into clinical practice does not threaten the existence of other healthcare roles, such as sonographers, as it is vital that AI is used to improve clinical practice instead of replacing it. If these AI systems can be proven to be useful and safe to use in practice, and patient data is sufficiently protected, it may be key to solving issues currently faced in CAD and heart failure diagnostics.

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Lily Worrall-Downes

I'm Lily, a second-year medical student at the University of Plymouth. This paper was written as part of my first Student Selected Component in year 1 and was so interesting I had to take it further! My current interests in medicine are cardiothoracic surgery and stem cell research, and I am keen to get involved more with research in the future.



INSPIRE

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Liver function test for patients on buprenorphine/Espranor for drug addiction in the community setting: a closed-loop audit

Vincent Ng^{1,2}, Cheuk Ying Li³, Vinit Kundra⁴

¹ Cardiff University Honorary Tutor

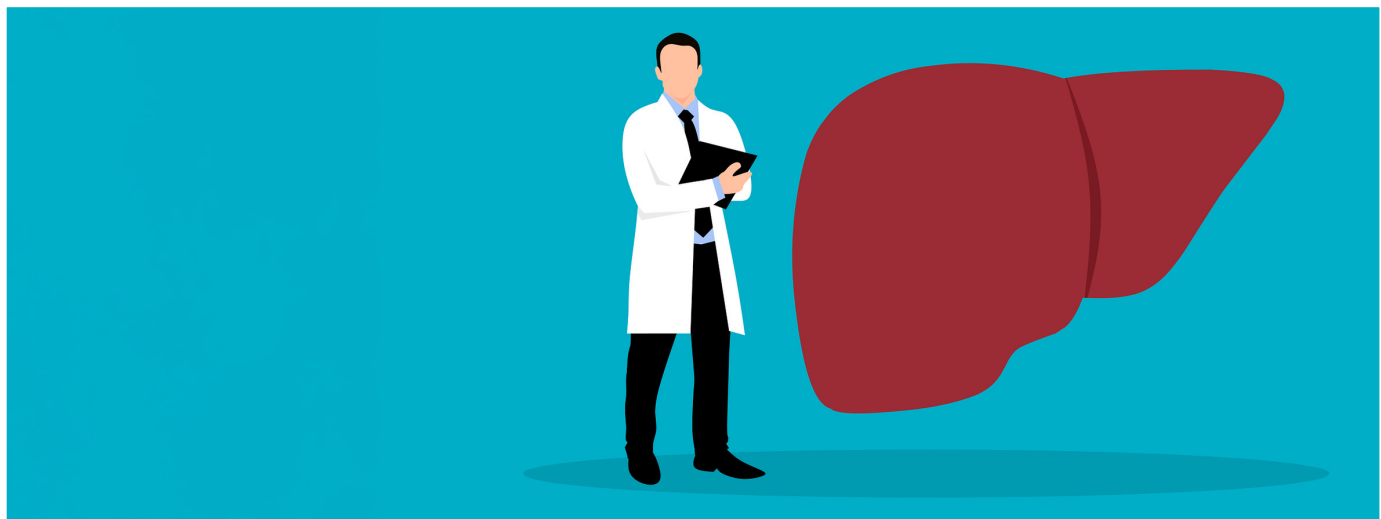
² University Hospitals Birmingham NHS Foundation Trust

³ Year 5, Medicine, Cardiff University

⁴ Sutton Coldfield Group Practice

Corresponding Author: Cheuk Ying Li

Email: licy3@cardiff.ac.uk



Abstract

Buprenorphine, a synthetic opioid, was developed in 1966 and used for pain management and opioid dependence treatment. It acts as a partial agonist of the mu-opioid receptor and offers better management of withdrawal symptoms compared to other opioids. This audit compares the liver function monitoring of individuals on buprenorphine or Espranor in six general practices within the Sutton Coldfield Group Practice (SCGP) to the guidelines set by NICE and BNF.

Data was collected from SystmOne, involving patients prescribed buprenorphine or Espranor within the last three months for opioid dependence. Results indicated that out of the 21 individuals prescribed these medications, only three met the criteria for opioid dependence. Of these, one patient (33.3%) had a liver function test (LFT) within the past year, while two patients (66.6%) had outdated tests. Baseline LFTs were normal for all patients. After identifying gaps in LFT monitoring, an intervention was implemented, including automatic reminders and educating practitioners on the significance of regular LFTs.

The re-audit showed a 100% recall rate for patients requiring LFTs, with increased awareness across the multi-disciplinary team. This audit highlighted how regular liver function monitoring in opioid-dependent individuals could offer early detection of liver issues, reduce the risks of overdose and enable timely intervention.

Abbreviations

BNF – British National Formulary

LFT – Liver Function Test

NICE – The National Institute for Health and Care Excellence

SCGP – Sutton Coldfield Group Practice

Introduction

Buprenorphine is a synthetic opioid, first discovered and developed in 1966 in Kingston upon Hull in England.¹ It was traditionally used as an analgesia for chronic pain worldwide in the 1980s before its approval by the United States Food and Drug Administration for opioid dependence treatment in 2002.¹ Buprenorphine's pharmacodynamics – acting as a partial agonist of the mu-opioid receptor, an inverse agonist at kappa receptors and an antagonist at delta receptors – allow it to effectively manage withdrawal symptoms due to its high receptor affinity and slow dissociation kinetics.^{2,3}

The pharmacological profile of buprenorphine and its diverse formulations (e.g., injectable, transdermal, buccal, sublingual and implantable) highlight its versatility. Subdermal implant and sublingual tablets are mainly used for the purpose of opioid dependence.³ Espranor, a new rapid-dispersing oral formulation of buprenorphine, has a greater bioavailability than traditional sublingual tablets, making it a superior choice for opioid dependency.

treatment.^{4,5} Buprenorphine is metabolised in the liver by cytochrome CYP3A4 and CYP2C8.⁶ Important side effects of buprenorphine overdose include excessive sedation, respiratory depression and hepatitis, which can lead to acute liver failure and death.⁷ Liver-threatening complications from buprenorphine are well documented in patients with hepatic impairment and hepatitis.⁸

Individuals with opioid dependency are also often involved in risk-taking behaviour, including excess alcohol consumption and substance misuse, leading to polypharmacy and interaction with liver enzymes.⁹ Consistent monitoring of LFT will therefore significantly reduce the risks of overdose and potential liver complications from the use of buprenorphine or Espranor. It can also help identify early liver damage and allow early intervention.

Due to elevation in liver enzymes being reported in literature, monitoring of liver function is recommended before and during treatment.^{10,11} The British National Formulary (BNF) and NICE guidelines emphasise this, particularly for patients with pre-existing liver conditions or those at risk of liver damage.¹²⁻¹⁴ Despite these recommendations, there is limited empirical data on the exact percentage of UK patients on buprenorphine who are receiving regular LFT monitoring. A clinical audit is required to assess the adherence of monitoring guidelines.¹⁵

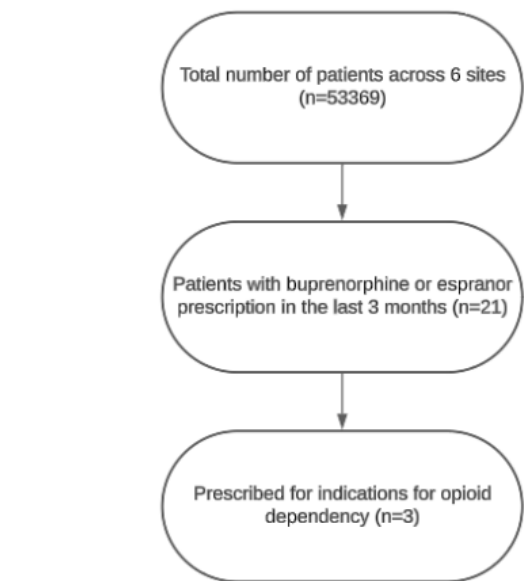
We aim to compare the standard of practice across six general practice sites in covering the North Birmingham region with the NICE guideline in regard to monitoring of liver function for patients on buprenorphine or Espranor prescribed for opioid dependence.

Methods

A closed-loop audit was conducted to evaluate adherence to guidelines. The primary outcome is to examine the adherence of NICE and BNF guidelines by assessing the number of patients receiving an LFT within the last year. The initial data collection and search was executed in August 2024. The search process was highlighted in the flowchart below (Figure 1).

Data collection was performed using SystmOne across six GP practice sites across the North Birmingham region. Inclusion criteria include individuals prescribed buprenorphine or Espranor within the last three months for opioid dependence.

An intervention plan was devised following the initial audit and included re-auditing to measure the impact of implemented changes. The intervention involved education sessions for practitioners and



the use of automated reminders via SystmOne.

Figure 1. Process of data search and collection Ethics have been considered and not required as this is an in-house clinical audit for the region. All information has been anonymised.

Results

Out of 53,369 patients across six practices, 21 patients (0.039%) were prescribed buprenorphine or Espranor in the last three months. Of those, only three patients (14.3%) met the inclusion criteria and were prescribed these medications in the last three months due to opioid dependencies.

The age range of our included patients were from 25 to 66 years old with one (33.3%) male and two (66.6%) females. One patient (33.3%) had their last LFT within the past year. The remaining two patients (66.6%) had outdated LFTs, done 555 and 2,159 days prior (Figure 2). The requirement of having normal baseline LFT results before commencing medications were met by all patients.

One patient was on Espranor oral lyophilisates and two patients were on buprenorphine sublingual tablets. The total dosage of the patient on Espranor oral lyophilisates was 4mg, while the total dosage of the other two patients on buprenorphine sublingual tablets were 200 micrograms–800 micrograms and 600 micrograms respectively.

In general, the prescribing patterns revealed that most buprenorphine/Espranor prescriptions (71.4%) were for transdermal patches, with the primary indication being back pain (38.1%). Moreover, 76.2% of all prescriptions lacked coded indications, reflecting potential gaps in documentation.

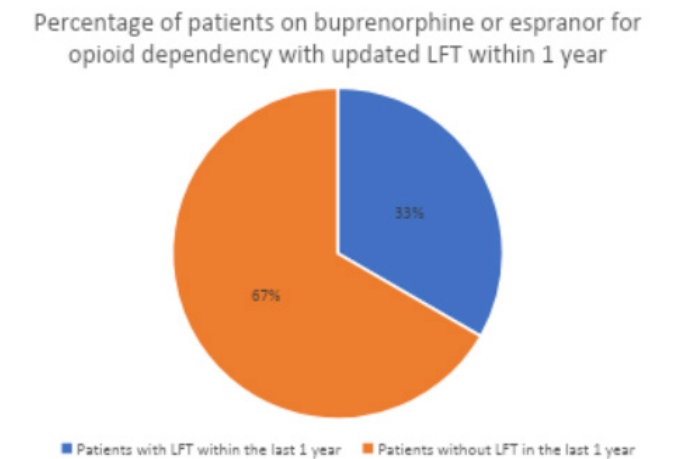


Figure 2. Patients on buprenorphine or Espranor for opioid dependency with LFT within one year

Intervention

Various interventions were implemented upon reviewing the results of the first audit loop. This was broken down to educational initiative, recall system, task automation and enhanced documentation. The plan was to address the current problem and implement changes to ensure regular LFT surveillance in the future. A face-to-face meeting with general practitioners and the substance misuse lead of SCGP was conducted at Ley Hill Surgery to present the findings.

One of the reasons for the lack of regular monitoring was because buprenorphine and Espranor were also commonly prescribed for individuals with chronic pain. Regular monitoring was not required for this group of patients once baseline liver functions were established. In comparison, there was a smaller demographic of patients using these medications for opioid dependence.

Staff education with the use of PowerPoint presentation enabled clear visualisation of the audit results and comparisons with the current evidence in the scientific literature and NICE guideline.

A summary of the results highlighted the importance of regular monitoring of LFTs for patients using these medications for opioid. The PowerPoint presentation was later disseminated to clinical staff members of SCGP.

General practitioners were also educated on the significance of coding indications for medications on SystmOne, particularly for opioid-related drugs and controlled medications for the purpose of monitoring and auditing. Patients who did not meet the requirement were scheduled to repeat tests. Tasking function on the SystmOne was utilised to set automatic reminders for patients' annual repeat LFT to ensure individuals on buprenorphine or Espranor for opioid dependency are not missed.

Results after intervention

Two months post-intervention, the re-audit showed 100% of patients with overdue LFTs had been recalled and tested. Patients were also educated the importance of regular testing. Automatic reminders were active for all relevant patients. The educational PowerPoint presentation received positive feedback from general practitioners and improved their engagement and awareness.

Discussion

This audit identified critical gaps in LFT monitoring for opioid-dependent patients on buprenorphine or Espranor. While our interventions successfully improved monitoring rates, the small sample size limits generalisability. As there was limited empirical data on the compliance and frequency of LFT monitoring for this study population, future research should include larger, multi-centre samples and explore barriers to guideline adherence. With a larger sample size, the data analysis could investigate specific reasons behind outdated LFTs and develop interventions accordingly.

Practitioners often worked under a tight time constraint and high workload, making it difficult to adhere to all guideline recommendations.¹⁶ The automated reminder aimed to streamline this process and prevent human errors. It would also ensure all practitioners were aware of the latest guidelines even if they did not deliberately review the fine prints.

The educational PowerPoint was well-received, with attendees appreciating its clarity and practical guidance. However, ensuring sustained engagement would require ongoing audits and updates to educational materials.¹⁵

Conclusion

This closed-loop audit highlighted the importance of regular LFT monitoring for individuals on buprenorphine and Espranor for opioid dependence. Interventions, including practitioner education and automated reminders, were effective in improving adherence to guidelines. Acknowledging the small sample size, future audits should aim for broader inclusion and more robust evaluation of interventions.

Contribution statement

All authors have contributed substantially to the conception and design of the study and the acquisition, analysis and interpretation of data for the study and have significantly contributed to the writing of the manuscript. All authors have approved the final version of the manuscript to be included in INSPIRE. Dr Vinit Kundra is the guarantor and supervisor of the work.

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Cheuk Ying Li (Coco)

Is a fifth-year medical student at Cardiff University with a keen interest in burns and reconstructive plastic surgery. Passionate about research, she has contributed to various clinical projects and societies, including INSPIRE and OSCEazy. She is also exploring the integration of AI in clinical practice and medical education.

Currently, Coco is on elective in New Zealand, gaining hands-on experience at the renowned National Burns Centre. Outside of medicine, Coco enjoys traveling and visual arts, using creativity as a means to explore new perspectives and express her passion for science and humanity.

Vincent Ng



Is an academic F2 doctor at University Hospitals Birmingham Trust. He has a strong passion for ophthalmology, technology and medical education. He is the co-founder of international medical education platform OSCEazy and he is currently an honorary tutor for Cardiff University and an honorary research fellow for Moorfields

Eye Hospital, specialising in artificial intelligence in ophthalmology research. He graduated from Cardiff University in 2023 and was previously innovation lead for Cardiff University Research Society where he cofounded and organised the Learn2Innovate programme for students with a passion in healthtech and entrepreneurship. In his spare time, he enjoys playing squash and rugby.

Cardiff Refugee Health Project

Yaqeen Alkaabi

Year 3, Dentistry, Cardiff University

A student-led project raising the profile of refugee and asylum seeker health through education and advocacy."

Cardiff Refugee Health Project (CRHP) is a student-led initiative championing the health and dignity of people seeking sanctuary. Through teaching, practical advocacy and partnerships across the city, the group equips future clinicians to work confidently and compassionately with refugees and asylum seekers—while amplifying voices from the communities they serve.

The group was founded in 2021 by Lizzie O'Brien and Makeda Kingue during their time studying medicine at Cardiff University, uniting students who felt passionate about refugee health as a way of taking back control and making a difference in the community at a time where the political environment had taken a turn for the hostile. Since then, three different cohorts of students have volunteered for the group, expanding to healthcare courses beyond medicine, and is now co-led by Rebecca Roberts and Sandra Chirapurath.

The story in brief

- Who they are: A cross-disciplinary student collective centred on refugee and asylum seeker health.
- What they do: Running monthly health education sessions at refugee centres, providing medical education, translating health infographics, and running campaigns to raise awareness.
- Why it matters: People seeking sanctuary face distinct clinical, cultural and administrative barriers to healthcare. CRHP supports free and safe access to healthcare.

In their own words – Interview with Lizzie O'Brien



What inspired the creation of the project?

"The refugee health project sort of formed itself! Myself and Makeda were equally passionate about refugee health and angry at the many

hostile policies the government were coming out with (at the time it was the plan to report refugees to Rwanda) so we felt we had to do something and started working on a couple of projects. The more we got involved, the more ideas we had so we took it from there! The best thing has been realising that so many other students were interested so that's when we had the idea to make it a group. Three years later we now have had three cohorts of students volunteering – and recently students from different courses too, so it's exciting to see it continue to grow!"



What types of events have you run recently and which have been the most impactful?

"We do several projects – one of our favourites is running monthly sessions at Oasis Centre for refugees as it's great to meet so many different people and we learn something new each time! Perhaps one of the most impactful is sharing the Safe Surgeries network with GPs in Wales. We've very much found our way as we went but eventually ended up being put into contact with several networks and policymakers which has meant we've been able to influence change at a larger scale too. It's been particularly rewarding to see that health professionals are interested in us as students – we were asked to present to a conference of Senedd members and doctors and thought, what could we possibly tell them about refugee healthcare that they don't already know?! Instead, they were really supportive and said they were really inspired and hopeful seeing the passion that we brought. I think it's a good reminder that you don't need to be an expert to engage in this space – just caring and being willing to get involved is really all you need!"

Which local organisations/communities do you collaborate with?

"We work very closely with Student Action for Refugees which is a fantastic society at Cardiff running conversation classes every week for refugees and asylum seekers – if anyone wants to get involved check out their Instagram! We visit Oasis refugee centre which is a fantastic space with lots of classes and activities going on every day and also has lots of volunteering opportunities. We're also part of the Patients not Passports campaign which campaigns to improve migrant health rights and access, and other national groups such as Doctors of the World."

What have you personally learned and what advice would you give to students who want to get involved?



"I've learnt so much and I'm still learning each time we do something! One thing that always keeps me going is the connections and friends I've made through volunteering and campaigning – the people in this team are fantastic and having the shared passion to improve refugee healthcare is really inspiring and empowering. Channeling my frustrations about the state of the world into some kind of action helps remind me there are so many people that do care and want to make a difference."



"I've learnt so much about refugee health too, such as the fact that most people spend over 3 years waiting for their asylum decision to be made, and I've seen the reality of this: people don't have the right to work in this time, are entirely dependent on the tiny budget given for travel expenses, phone bills etc. and above all, face the immense anxiety of constant change and uncertainty. Some of us also went to Calais to volunteer in refugee camps over summer and I also saw how so much of this system is entirely manufactured and avoidable: with living sites being forcibly evicted and tents deliberately slashed to beyond useable, often at night to avoid being seen by the public or media. Imagine how much we'd gain if we could spend this money and time on actually useful strategies that support communities instead of trying to divide us."

"My advice for anyone interested would be to definitely get involved!! You don't need to know 'enough' to join; whatever skills you have – whether it's using social media, sending emails, helping fundraisers or giving your time to volunteer – there is a space for you and collectively we can make a massive difference. I've personally gained so many friends, skills and a sense of purpose from working here. And sadly I'm reassured now more than ever that we need to stand in solidarity for migrant justice – whether it's at home against the far right and leaders who seek to divide us, or further afield, against probable genocide in Gaza and international policies that criminalise refugees with no other options but to make dangerous crossings across borders."



Impact in 2024/5

- 7 sessions sharing health information at Oasis centre for refugees
- 2 Safe Surgeries training sessions for medical students (scheme for tackling access to healthcare for migrants), as well as 1 workshop delivered to GPs
- Launch of the dental project
- Volunteering at Calais over the summer, delivering emergency aid to refugees.

How to get involved

"Getting involved with RHP not only supports free and safe access to healthcare but also provides the chance to connect with like-minded individuals who share a passion for equity. We have had the chance to collaborate with student societies such as STAR, national organisations like PNP, and international charities including Care4Calais, broadening the ways we can contribute. We wholeheartedly encourage anyone interested to get involved with the RHP. We believe that healthcare is a fundamental human right that should not be subject to political debate. Now, more than ever, we are committed to standing in solidarity with refugees and asylum seekers and advocating for their right to free, safe, and equal access to healthcare" – Rebecca Roberts and Sandra Chirapurth.

- **Students:** Apply through the volunteer application form linked in the Instagram page, or follow and share to show support.
- **Faculty & clinicians:** Offer supervision, venue support, or help embed content into modules and clinical placements.
- **Supporters:** Contribute funds for interpretation, travel and refreshments to keep events inclusive.

Instagram: @cardiffrefugeehealthproject
Email: cardiffrefugeehealthproject@gmail.com
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Credits & acknowledgements

Lizzie O'Brien, Rebecca Roberts, Sandra Chirapurath, Makeda Kingue.

Photos provided by interviewees.

Dr Aiman Dilnawaz

Clinical Teaching Fellow
University of Bristol graduate



Beyond physical boundaries

This painting splits the human figure into two mirrored profiles, a left side that presents a clinical/anatomical view, and a right side that explores the psychosocial and emotional dimensions of the individual.

This painting reflects the clinician's viewpoint, one rooted in biomedical knowledge, objective measurement and physiological diagnosis. The anatomical clarity and compartmentalisation symbolise the scientific dissection of the human body, which, while essential, risks reducing patients to biological entities. In contrast, the right side of the painting portrays the patient's inner world as a flourishing tree, filled with metaphorical imagery. Within the head, instead of anatomical structures, are circular vignettes representing personal concerns: a beach scene depicting longing/escapism, a family unit representing emotional bonds, and financial symbols denoting economic stress. The tree branches transition through seasons, from the bloom of spring to the darkness of winter, reflecting the emotional complexity, temporality, and evolving nature of human experience during illness or healing.

This painting invites healthcare professionals to move beyond diagnostic categories and consider the lived realities of the individuals they treat. It echoes the principles of narrative medicine, where understanding a patient's story is as crucial as interpreting their symptoms.

Limbic symptom

I created this painting during my first year of medical school, at a time when we were immersed in the challenging neuroscience module. It was a particularly intense week, with a heavy focus on complex anatomy and dense learning material. Among the topics we explored, the limbic system stood out to me, not just for its function, but for its deep connection to human emotion and experience. Inspired by

this, I began visualising symbolic imagery linked to its role, which ultimately led to the creation of this piece.

The anatomical depiction of the limbic system at its centre which is the part of the brain involved in emotional regulation, memory, and motivation. The brain structure, particularly the hippocampus, amygdala, and corpus callosum, is highlighted in rich tones in the centre surrounded by symbolic representations of various emotional states, relationships, and life experiences, visually narrating how the brain interprets and manifests emotion in real life.

The painting shows how the brain processes emotion, showing a dynamic interplay between joy, love, pain and despair. By blending anatomical accuracy with symbolic storytelling, I tried to connect the neurobiologically reality to the structures within our brain.

This is not going to hurt

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, 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.

Limbic symptom



This is not going to hurt



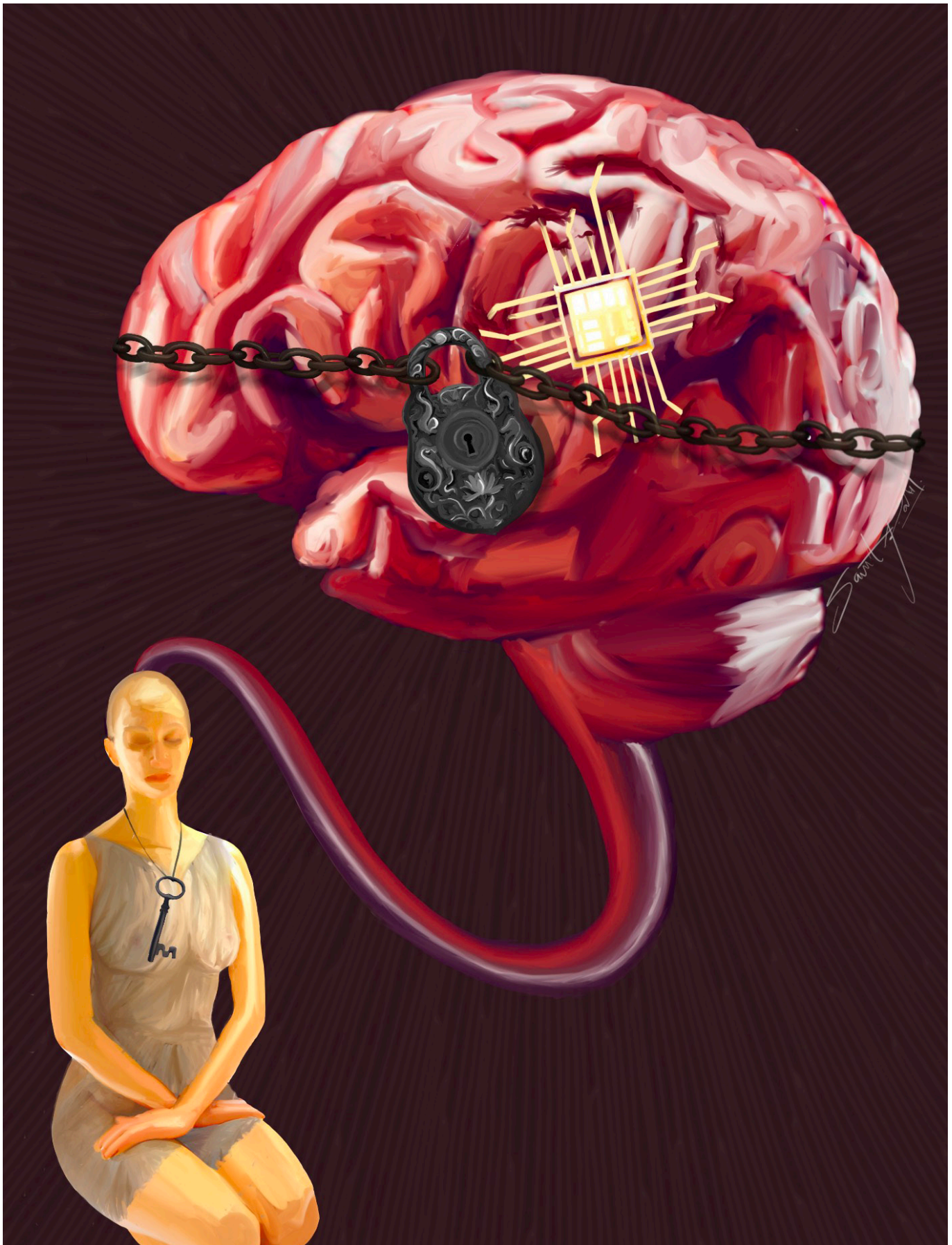


Lois Moore

Year 4, Medicine, University Of Exeter

I created this piece with water based acrylic paint. I chose to paint a baby taking their first breath as a symbol of life and a reminder of why medicine prevails. After spending some time in Obstetrics and

Neonatology placements I found this moment to be pivotal and yet also fragile. The painting captures both the personal intimacy and the medical responsibilities that exist in this moment. Not only is the emotional milestone interesting, but the intricate dynamic physiological process compelling. This was an example to me of how resilient the human body is, leading me to capture this moment in a painting.



Sauvit S. Patil

MSc Molecular Neuroscience, University of Bristol

A woman kneels calmly with her hands folded, wearing a key around her neck. Her brain—detached from her skull—is suspended above her, connected by a thick, fleshy cord, and is wrapped in black chains,

secured with a heavy padlock. A glowing brain-computer interface (BCI) chip is embedded in the brain as its natural extension, while the key she holds quietly hints at her hidden power to unlock or resist it. I name this picture 'The Custodian.' It shows the rise of BCI technology and how she—calm and peaceful, representing all humanity—holds the responsibility and latent power to wield this transformative technology as she chooses.



Sarah Rafique

Year 4, Dentistry, University of Plymouth

Imagine the health system as a patient desperately clinging to life, hooked to drip bags representing veterinary, medical and dental services. Just as the IV drip bags support the patient, these services sustain the vital functions of the health system, delivering care with every drop.



A dentistry student with a keen interest in public and global health. Her interests encompass the role of one-on-one patient care, public health research, and video storytelling in promoting health and well-being. Her aim is to integrate these approaches in order to effectively reach diverse populations.



Lillian Tagg

Year 3, Fine Art, University of Oxford

I created 'Home Body', my crochet anatomy lamp in the second term of my first year studying Fine Art at Oxford University. It was one of my works for our year group anatomy show following our time studying alongside medical students in the dissection room. It was an immense privilege to be able to study anatomy from donors and I found the experience to be quite spiritual and moving.

One thing that struck me from seeing the dissected specimens was how unexpectedly floral we are inside. It seemed almost botanical, like layers of coral rippling over one another. It made sense how all these stems and blooms would work together as a functioning body. This was definitely a huge influence on how I interpreted the organs in my piece. I was thinking a lot about medical sexism at the time

as well, I had recently been diagnosed with PCOS (polycystic ovary syndrome) and I was baffled at how little we really know about the mysterious ways in which female bodies function. Not to mention I was also frustrated with the more discovered medical systems and treatments centring male bodies. My struggles with PCOS led me to feel increasingly disconnected with my body and I felt that if I had a better understanding with how each of my key organs were formed and functioned, I would work through my anxieties as I worked through the body.

I am interested in the use of fibre arts and traditionally women's crafts as an act of protest and mode of creation but before this the only experience I had was a couple rows of knitting done with my nan more than 10 years ago. Luckily, I had several friends on my course who frequently crocheted and they were kind enough to teach me the basics. The yarn was very kindly donated to me by a friend of my anatomy tutor who was a retired GP and following a recent

stroke was not able to use any of her yarn. The yarn was hand dyed and spun, by far the nicest fibres I have worked with. I spent almost two months freeform crocheting each organ over a wire frame, referencing textbooks and observational drawings. I kept the stitches fairly spaced out as I wanted the organs to be light permeable, like I had observed from the donor cadavers.

This was accentuated when I sewed all the organs together and bound them to the stem of a lamp as though it were the spine. I chose the lamp and the title 'Home Body' because I am interested in the sphere of domestic space from a feminist lens and I thought this intersected well with my thoughts around medical sexism. It is intended to juxtapose the body as an object and as a complex system which sustains life and agency. For the exhibition, I made the heart openable and placed a zine about PCOS inside but I think a variety of things could be placed inside for different contexts. Since creating this piece, I have done a couple experiments in crocheting my ultrasounds, and most recently I embroidered an x-ray of my pelvis. Anatomy is something I continue to investigate and this piece is foundational to my expanded use of fibre arts. It really is that easy to pick up a crochet hook and work yourself through anything.

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Lillian Tagg is a Fine Art student at the University of Oxford. Now entering her third year, she explores memory, human connection and touch using paint, textiles and photography. She is particularly interested in sensory memory, the presence of the body and our imprint on objects. Lillian is also the editor of her college's art magazine NoseDive <https://brasenose.wixsite.com/nose-dive>

How one internship could change your career

Sarah Rafique

Year 4, Dentistry, University of Plymouth

Email: sarahzraf@gmail.com



I did not expect one short internship to change how I see dentistry. But it did.

Seeing paediatric patients made me think beyond treating problems once they appear. I could see the enormous value in giving young people the habits, resilience and knowledge to prevent problems in the first place. This led me to begin developing a media-based intervention of my own.

Then, at an INSPIRE taster day, I listened to a researcher, Abby Russell, describe her school-based intervention. She spoke not only about delivering it but about testing whether it truly worked. In that moment, I realised: research is not just labs and statistics; you can design ideas that could change a child's entire future.

That clarity is what drew me into a 4-week INSPIRE Summer Studentship at the University of Exeter's Children and Young People's Mental Health department; it showed me how wide the possibilities are. Whether it is prevention, labs or clinical trials, there are countless kinds of research that can speak to a clinician's interests.

That is why I would say: do not dismiss research. You might be surprised by how much it changes the way you practice.

Research skills I gained

One of the greatest values of an internship is the chance to tackle challenges that push new skills. I was part of the Support Systems for Self-harm and Suicide (4S) study, which examines how schools, colleges and youth organisations across England deliver prevention, intervention and postvention programmes. My role was to extract data for a meta-analysis comparing two approaches: transparent interventions, which directly addressed suicidal thoughts, and opaque interventions, framed more broadly as stress-management workshops.

I had some prior experience with data extraction during a scoping review in my third year of dentistry, but this internship showed me how different the process can be at a higher level. Instead of finishing data extraction on paper in under an hour, I spent hours on each study. A fellow researcher described this kind of data extraction as more challenging than other extractions: "The most detailed it can be — a monster challenge, but an interesting topic." It was exactly that: demanding, but also fascinating.

Another benefit of internships is that they expose you to new ways of thinking and reveal gaps in your own knowledge. I critically appraised a range of papers with different study designs. The process not only strengthened my ability to assess research but also highlighted areas where my knowledge was limited, since I found some JBI questions challenging and beyond my current scope. That awareness itself is useful: it gives you a clearer direction for growth.

What to expect an internship to be like

Internships can also overturn assumptions about what kind of

environment you might enjoy working in. I had always assumed I would not enjoy an office environment, which was part of the reason I chose the hands-on, clinical setting of dentistry. Yet the opposite turned out to be true. Discovering that others shared one of my outlooks on life was energising, and I drew real motivation from the collaboration and exchange of ideas. It taught me not to dismiss a path based on assumption, but to experience it first-hand before deciding.

Take-home message

The lesson you take away from an internship could be different to mine, such as perhaps you might discover a love of lab sciences. For me, this experience strengthened my motivation to develop oral-health interventions for children, alongside wider public health initiatives with a behavioural change focus.

Whatever the outcome, the value is the same: internships reveal where your interests and capabilities truly lie in a way that your degree alone may never can.

Poem by Sarah:

Regret tastes like water

*I only wanted drinks.
Sprite,
Cola,
squash—
I only wanted drinks.*

*Now the cans are gone,
but the evidence remains:
three bright fillings,
lined up like trophies
I never meant to win.
I only wanted drinks.
And maybe tomorrow,
I'll want something else—
a glass of water,
a quiet smile,
a little more enamel
and fewer regrets.
I only wanted drinks.*

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The Invertivet: Benjamin Kennedy

Kate Williamson

Year 4, Veterinary Science, University of Bristol

Email: lh22956@bristol.ac.uk



Benjamin Kennedy is a small animal and exotics clinician with a particular interest in *invertebrate medicine*. He graduated from the Royal Veterinary College in 2016 and currently works as a locum. He has published extensively alongside his clinical work, contributing to journals and textbooks. He is a steering committee member and journal editor of the *Veterinary Invertebrate Society*, a former council member of the *British Veterinary Zoological Society*, and a committee member of the *British Bee Veterinary Association*.

I had the pleasure of speaking with Benjamin about his career path, and the challenges and rewards of working in this field.

Could you give us a quick introduction to how you got to this point and how you came to specialise?

I've dedicated a part of my life to invertebrates, but I'm not a specialist, because there is no qualification that's specific to invertebrates. That's why I always refer to myself as an invertebrate vet. A lot of how I developed in invertebrates started as a vet student. I tried to be open-minded; I got involved in lots of different veterinary fields. The thing that seemed to fit well was exotics, and I saw practice with a vet called Sarah Pellett, who's a phenomenal vet. She had a book on the shelf titled 'Invertebrate Medicine', edited by Gregory Lewbart, and I became quite enthralled.

A lot of what I've achieved has been self-directed and through collaboration. There's an awful lot of stuff we don't know and with that comes a certain level of privilege, because I'm not sure I would be able to achieve what I've achieved in invertebrates if I was trying to do the same on elephants or gorillas. One of the reasons why invertebrates really appealed to me was because when I was a student, I asked myself: where can I achieve the most good?

Could you briefly mention what you've done in terms of working in practice and then locuming?

I was a small animal vet that would see exotics for the first few years of my career. I found when I was trying to be a permanent vet it was difficult to have a balance between doing the invertebrate stuff and the demands from clinical practice. The reason the locuming worked well for me is that I could pick the days I wanted, and if I wanted to take a week off to pursue a bit of research then I could. It works out that about 80 to 85% of my time I'm a conventional vet.

Given that you've published quite a bit, I was wondering how you balance the research side of your interests with locuming and working in practice?

I would view it as a very constructive level of unbalance. If I wasn't doing the invertebrates, I don't think it would be very easy to be a vet. The reality is a lot of this publication stuff happens in my time. I think you learn to understand when to say no and when not to say no, when to make sacrifices, when not to make sacrifices, when to dedicate time and when to perhaps take a step back. How to manage that balance is a lifelong process.

I recently published two articles in *In Practice*, with some fantastic colleagues, on neutering exotic mammals. I'm really proud of those articles because I think those will help a lot of vets neuter animals more effectively. The research is with the mind to help animals. The first paper I ever wrote was on the biochemistry of plasma in *Grammostola rosea*, a very commonly kept tarantula. All of this aligns with what I'm philosophically doing. Ultimately, the invertebrate helps me work, and I work to do the invertebrates.

To what extent would you say that the cases you've seen have fed into and shaped your research interests? Are there any examples of that?

It pretty much all does. In invertebrates, the vast majority of what I see hasn't been seen before. So, an example of a farmed insect case where a parasite had rarely been reported. When you do one of these cases, you realise there's no drug residue data, and they're potentially food animals. That particular case, we developed data about different medications. If you imagine trying to administer a drug to a million insects, you have to learn to think quite differently. A lot of this stuff is ultimately not rocket science. It's just medicine. If you can do it on a cat, you can probably do it on a spider. But then again, that all extends straight through to the exotics because exotic animals don't necessarily have that much data either.

It must be such a challenge, because we're constantly told (to use) evidence based veterinary medicine (EBVM). But what about when the evidence doesn't exist?

I mean, I believe in EBVM, it's what we are all taught, but we're not dealing with populations. Evidence depends on populations. In order to have a p value, you need an n number. If your n number is one, you have no tangible p value. You're dealing with individuals in clinical practice, which is where it's important not to be ruled by evidence-based. We need to be questioning evidence and having a hierarchy of evidence, and an understanding of where a case is holistically. Bearing in mind, lots of evidence is biased or flawed. We're currently dealing with a crisis of academic fraud in many academic fields (including medicine). I think it's important to question every bit of evidence you have.

[Retroactive note: one such example of academic fraud in medicine would be the case of Joachim Boldt, a German anaesthetist, who has, as of the writing of this article, 96 retracted papers. <https://retractionwatch.com/category/joachim-boldt-retractions/>]

I've learned this lesson the hard way. In my first paper, the biochemistry variables included albumin. Previous papers had used albumin on much lower n numbers. It turns out that tarantulas don't have albumin. The only reason it came to light was I started to do a gene analysis to see if the proteins were there and I just couldn't find it. The lesson there is you have to question yourself and be quite honest with yourself.

I was wondering what you see as the biggest issues that are facing exotics medicine at the moment, and what that might mean for future exotics vets?

I think we are on the edge and in the middle of a real crisis within the veterinary profession. I think you see that in the exotic and zoological world and the wildlife world, perhaps in more extremes than we do in more conventional career paths.

The turnover of clinical staff in exotic practices tends to be high, especially in zoos. Want to go into specialism? Well, (there are) a few internships, which may or may not pay very well. Then a three-year residency. You go through all of that, and then you're fighting for a job in a zoo or exotic practice, which are increasingly becoming less and less remunerated. Zoo salaries have not gone up in line with small animal salaries.

To survive in this profession, I just think it's so important to be connected with who you philosophically are, and to have a plan. I don't think students are very well prepared for what the realities of the profession really are. We have to connect with being empathetic with each other and being supportive of each other. You don't become a good vet by being perfect, you become better by being reflective and being connected to what you do. You have to be brave, and you have to stand up for what you believe in and try and do something meaningful with your life. That's ultimately what vets are trying to do.

Has this interview piqued your interest?

You can find more information on Benjamin's work at invertivet.com.

Get involved with the Veterinary Invertebrate Society at veterinaryinvertebratesociety.wordpress.com – membership is free for veterinary students.

Find the British Bee Veterinary Association at britishbeevets.com.

Many thanks to Benjamin for his valuable support and guidance on this piece.

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INSPIRing Research Conference 2025: driving student engagement in research

Uashar Badakhshan, Aaisha Rashid, Jing Xin Yuan, Joyce Yuen



This year's INSPIRing Research Conference was successfully held on 15 November at the University of Bristol, where 181 medical, dental and vet students from Bristol, Cardiff, Exeter and Plymouth came together at the Wills Memorial Building to share their work, build connections, and spark new ideas across a wide range of research fields.

The day began with registration and a spread of drinks and pastries while presenters set up their posters. Highlights of the day included an interactive presentation by Professor Nicola Innes, Head of the School of Dentistry at Cardiff University, on academic careers, mentorship, and the importance of patient-centred care. Dr Danny Chambers MP, a veterinary surgeon and the MP for Winchester, delivered an impactful keynote speech on antimicrobial resistance and the role of clinical researchers in future healthcare.

Throughout the morning and afternoon, several oral presentations were delivered with topics ranging from veterinary science to medical ethics.

The runner-up winner of the oral presentation, delivered by Phoebe Sussman (Year 5 Veterinary Science student at University of Bristol), titled 'Evaluating dog demographics and community knowledge, attitudes and practices surrounding rabies in Namibia' focused on mass dog vaccinations as well as prevailing community culture and attitudes when it came to rabies.

When interviewed on this project, Phoebe commented:

What made you choose this topic?

"I've always been very interested in One Health and rabies control. I did an intercalated masters which allowed me to delve more into this topic in more depth and work with the Cheetah Conservation Fund to gather data on dog demographics access to post exposure treatment and knowledge attitudes and practices surrounding rabies."

What was the research process like?

"It was an amazing experience - I was very lucky to have the opportunity to go out into the field and meet different people within the community, learning more about their lives and the many challenges they face in receiving critical medical care."

How do you feel about winning?

"It was an honour to be recognised. I am very grateful to my supervisors Dr Anne Schmidt Kuntzel and Dr Nicola Rooney for their help with this research. I would also like to thank the Langford Trust, INSPIRE and the Cheetah Conservation Fund for their support of this project."

The winner of the oral presentation, Scott Wallace (Year 4 Medicine student at University of Bristol) focused on the ethics of the Organ Donation (Deemed Consent) Act 2019, titled 'When apathy becomes altruism: was the 2019 introduction of deemed consent for organ



donation in England an ethically justifiable change?’

When interviewed on this project, Scott commented:

What made you choose this topic?

“The changes made to organ donation happened pretty recently and are something that affects all of us. It’s always interesting to assess how things change and work out whether the way we are doing something is the way we should be doing something.”

How did you get into this research?

“I completed this work as part of my intercalated degree in Healthcare Ethics and Law at the University of Bristol. The academics at the Centre for Ethics in Medicine at Bristol were really helpful throughout my time working on the project.”

What was the research process like?

“My goal was to answer a normative question, which meant the research process was a little different to other topics. The vast majority of my research involved analysing and assessing the strength of ethical arguments posed around organ donation in the literature. This involved comparing different arguments against each other, as well as seeing how they balance with the empirical evidence available such as in the NHS transplant reports.”

How do you feel about winning?

“Very surprised! The standard of oral presentations at the conference was really impressive. I was very happy to get a chance to present my work, let alone win!”

In addition to oral presentations, there were over 50 posters presented at the conference, with viewing sessions providing ample time for attendees and presenters to discuss research ranging from lab-based projects to literature reviews.



Runner up: Saanvi Kiran Rai

What made you choose this topic?

“I took an interest in cardiology quite early on. Even in the pre-clinical years, I found the physiology and the complexity of congenital heart disease really fascinating. That curiosity made it a natural choice for me.”

How did you get into this research?

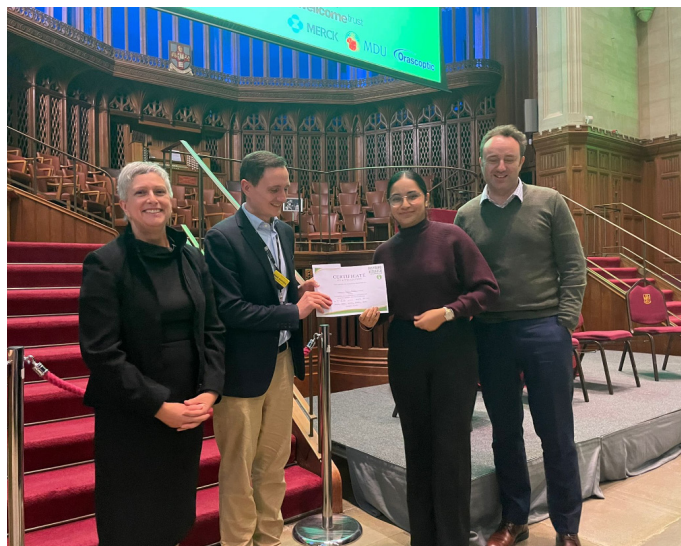
“I approached a congenital heart disease consultant because I knew I wanted to explore this specialty further. We discussed some ideas I had been reading about on my own — mainly physiology and congenital conditions — and together we shaped those into a project. That’s really how the whole thing started.”

What was the research process like?

“It was my first proper research project, so I wasn’t entirely sure what to expect. A lot of it involved picking up new concepts, refining ideas, and learning as I went along. Working closely with the consultant helped guide the process, and it made the experience much more structured than I expected.”

How do you feel about winning?

“I honestly didn’t expect it. It was my first project, and just getting the chance to present was exciting enough. Winning was a really nice surprise — definitely a confidence boost and a great way to start exploring the field.”



Winner: Sirat Ghandhi

What made you choose this topic?

“I wanted a project that would let me explore different areas of medicine, rather than committing to one specialty straight away. When the university advertised this internship over the summer, it seemed like the perfect opportunity. The idea of being able to work across multiple disciplines — and see how research actually happens in real clinical environments — really appealed to me.”

How did you get into this research?

“This internship was advertised through the university, and it immediately caught my attention. I applied because it offered the chance to try out a range of research experiences. Throughout the summer I worked on projects in different disciplines, and in some placements I was the only student there, which was challenging but also really rewarding.”

What was the research process like?

“The research process was really interesting — definitely something I hadn’t experienced before. It was a mix of academic research and patient-based work, which gave me a much broader understanding of how research feeds into real clinical practice. It felt very hands-on and very different from what we usually do during term-time.”

How do you feel about winning?

“It was a shock, if I’m being honest. I wasn’t expecting anything like

that. But it's really nice to know that the work I did over the summer was recognised. It made the whole experience feel even more worthwhile."



Dr Chambers with our editors Joyce and Uashar

From vet to parliament: one health, research culture and rethinking medical careers

Uashar Badakhshan
Year 5, Medicine, University of Exeter
Email: ub218@exeter.ac.uk

I had the privilege of interviewing Dr Danny Chambers, Member of Parliament for Winchester at the INSPIRE Conference 2025 at the University of Bristol, where we discussed their career journey, perspectives on One Health and reflections on research, communication, and the future of medicine and veterinary practice.

Dr Danny Chambers is a British veterinary surgeon and politician. He is the Liberal Democrat Member of Parliament for Winchester (elected in 2024) and serves as the party's Spokesperson for Mental Health. Before entering Parliament, he worked as a vet, founded the online community Veterinary Voices UK, and was a trustee of Vetlife, a charity supporting mental health in the veterinary profession. He was one of the guest speakers at our INSPIRE conference this year.

For our audience, could you briefly introduce yourself and what you do?

"I'm Danny Chambers, the Member of Parliament for Winchester and a Veterinary Surgeon."

How do you think today's conference is going?

"It's fascinating and I really like bringing together medical, dental and veterinary students. I remember being at a conference years ago, a doctor on stage mentioned 'One Health' and my ears pricked up because I'd always thought of it as something vets did but actually that idea that human, animal and environmental health are all linked - is so important and it's something we should all be doing, in an integrated way.

"I think it's vital that before people graduate and disappear into their own professional silos, they understand what other professions do. Even just having contacts and personal friendships across different professions is really powerful. It helps us better understand the challenges each of us are facing and makes it much more likely that we'll find solutions together."

Do you think it is important for students to be involved in research and why?

"Definitely, for two reasons. It will inspire students to keep engaging with research throughout the rest of their careers and I've seen first-hand why that matters. When I was a third-year vet student at Liverpool, I did my dissertation on how much pet owners actually remember and understand from a veterinary consultation. I recorded consultations and then interviewed owners afterwards. On average, they were given about 7.2 pieces of information but only remembered 1.5. You suddenly realise the communication gap between the owner's experience and the vet's experience is huge and I suspect it's very similar in human medicine.

"Another piece of research I did, for my Master's, looked at how the government communicates with the public about influenza outbreaks. I compared broadsheet articles with the original press releases to see whether the key messages came across and how concerned people felt afterwards. That kind of work, thinking about how you translate complex scientific and public health concepts in a way people can actually understand - is one of the reasons I've ended up going down more political routes. In those roles, you're constantly having to communicate quite complicated ideas in a way that feels meaningful and relevant to the people listening."

One of the reasons INSPIRE was established was to encourage students to get involved in research. However, we are currently seeing a decline in the number of academics across many disciplines. Why do you think this is happening and how do you think we can address it?

"My personal experience in veterinary medicine is that research feels much less structured and supported. Once I graduated, any research I wanted to do had to be on my own, with no funding. And that's incredibly hard when you're a new graduate working nights and weekends, with very limited spare time. You're exhausted, and the idea of using the tiny bit of downtime you have to do research that may or may not get published is a big ask. On top of that, even if I did get a paper published, my boss wouldn't really care and it wouldn't lead to a pay rise or obvious progression - so the incentive just isn't there.

"I think that speaks to a wider issue in both medicine and veterinary practice: people are stressed, they feel undervalued and everyone is incredibly busy. Asking them to squeeze in something that isn't formally part of their job description means many will understandably think, 'Why would I spend my precious weekend off doing this?' So research has to be built into the structure of careers and it needs to genuinely count towards progression and there needs to be protected time for it, especially in systems like the NHS. Otherwise, why would people do it? One slight positive is that if someone really isn't enjoying clinical practice, they may move into full-time research but it feels like a shame that people are effectively forced to choose one or the other."

Do you have any advice or final message for students who are

interested in research or who are reading the INSPIRE Journal?

"I think there is a lot of stress and a lot of mental health difficulty in both medicine and veterinary work at the moment but there's also a huge amount of opportunity. I've had a brilliant career so far: it's been varied, it's been exciting. That's not to say there aren't very difficult days and weeks, but overall it has felt very meaningful and very rich. No job is worth your mental health, though.

"What we often forget as doctors and vets is that our degrees give us the same, if not more opportunities as anyone else with, say, a biological sciences degree. Big organisations, major supermarkets, international bodies - they all recruit people with science backgrounds into their graduate training schemes. Marks & Spencer, for example, has a management training programme that someone with a biology degree could go into, but as doctors and vets we rarely think, 'Oh, I could do that.' We don't always realise how transferable our skills are, whether that's into industry, research, teaching. You should never feel completely trapped on a purely clinical path.

"I still enjoy clinical work, and I enjoy being an MP. I didn't leave practice because I disliked it. But I've seen so many friends who are struggling, and who might not have fully considered the range of options out there that could offer a less stressful career path for them. Knowing that you have choices is incredibly important."



The GW4 INSPIRE Leads and especially the Bristol INSPIRE Society headed preparations and organisation for the conference. Logistics began well before summer and involved organising registration, sending out calls for abstract submissions, booking the conference space, arranging refreshments, and contacting speakers. Reflecting on the process, Julian Chan and Ed Klein, students from Bristol, described the extensive work involved in bringing the conference from concept to reality.

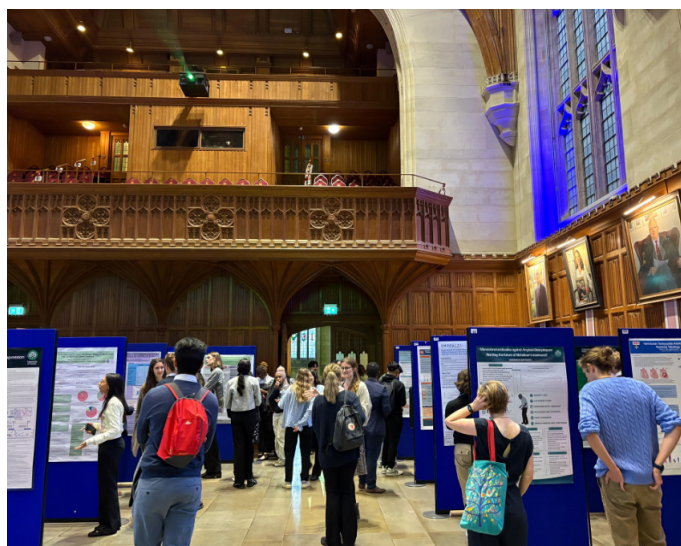
"The conference was more than a year in the making. It started with conceptualising the theme: exploring different angles such as pathways into research, the nature of impact, and the role of industry; and having to [make decisions like] scrapping the hackathon in favour of having more presentations and flash talks", which Julian believes are "the way [conferences] are progressing". Much of this conceptual work took place before the summer, alongside the practical logistics of securing Wills Memorial Building, drafting the programme, organising poster sessions, and managing sign-ups. Interestingly, they had expected to extend the registration deadline but were met with far higher engagement than anticipated.

Choosing keynote speakers was another major part of the preparation. Julian and Ed recalled that they had a list of suggested speakers from the INSPIRE leads, and they think it is a privilege to have these options.

"We've had a lot of liberty [with organising the conference], especially in choosing the themes and speakers, to work out what students want to see, attending the GW4 committee meetings and seeing how much [work] goes into it."

Behind the scenes, they also recruited INSPIRE ambassadors from Bristol to help set up for the conference and support operations on the day. Both felt that gaining insight into how an event of this scale is delivered has been an invaluable experience.

"I'm delighted with the way it turned out," Ed shared. "I've been buzzing for it for weeks."



After the poster session, a panel discussion followed, giving students the chance to ask questions and gain insight into research and academic career paths. Finally, the awards for the best oral and poster presentations were announced.

Overall, the day was a success, bringing students together to learn from one another and showcase their efforts.

Prizes for the best oral and poster presentations:

Oral presentations
Winner: Scott Ritchie Wallace
Runner-up: Phoebe Sussman

Poster presentations
Winner: Sirat Ghandhi
Runner-up: Saanvi Kiran Rai

Sponsorship for the conference came from Orasoptic, Merck and the MDU, with support from the Wellcome Trust and the Academy of Medical Sciences.

With thanks to Mark Gormley and Alex Gormley and the organising team.

Some photos taken by authors and some provided by Mark Gormley.

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BSPED National Conference 2025

Kezia Stanford

Year 4, Medicine, Cardiff University

Email: StanfordK2@cardiff.ac.uk



My name is Kezia Stanford, and I am a fourth-year medical student at Cardiff University. I currently have an interest in paediatric medicine.

On the 13-14 November 2025, thanks to funding from INSPIRE, I had the opportunity to attend the BSPED National Conference 2025 to deliver an oral presentation. BSPED, (British Society for Paediatric Endocrinology and Diabetes) held the annual conference at Cutler's Hall in Sheffield.

The theme of this year's annual meeting was innovation in paediatric endocrinology. There was a vast array of presentations and posters over the few days with separate endocrinology and diabetes tracks running alongside each other. The conference was attended by medical students, paediatric trainees, consultants, allied health professionals and more! The diversity of attendees' experience, job roles and qualification levels enabled me to speak to so many different people and was an invaluable experience.

Throughout the conference, I loved learning about new and upcoming research in paediatric endocrinology. On Thursday, I attended the diabetes tracks where I was especially interested by the emphasis on screening and early detection of type 1 diabetes. Multiple healthcare professionals presented their research in this area, and it led to some interesting conversations about how this could affect future diabetic diagnosis and control. Another area focused on was complications from excess weight. I heard about current and future pharmacological and non-pharmacological therapies alongside the psychological impact of living with excess weight.

On the Friday, I attended some of the endocrinology sessions and was interested in the upcoming uses of artificial intelligence in medicine. In addition, the session on late effects of oncological treatment in paediatrics was very thought-provoking leading me to read further into the topic. The theme of innovation in paediatric endocrinology was clear throughout the day as further research explored the upcoming screening methods, new pharmacological treatments and improved diagnostic testing.

On Thursday 13 November, I delivered an oral presentation about my quality improvement project titled: "A quality improvement innovation to improve the early diagnosis of type 1 diabetes in children and young people in Wales: has it made an impact?" In my third year of university, I had the privilege to work on this project with Dr Ambika Shetty and the paediatric diabetes team at the Noah's Ark Children's Hospital for Wales. The background of this project is that most children present with symptoms of type 1 diabetes to primary care. Delayed diagnosis is common and associated with increased risk of developing life-threatening diabetic ketoacidosis (DKA). In the context of an increasing trend of DKA, quality improvement (QI) initiatives were rolled out in Cardiff in 2018 to try and improve this. Our project aimed to analyse the effects of the QI across six-year period on the incidence of DKA at diagnosis across Wales and to improve healthcare pathways to ensure early diagnosis of T1DM. It was a brilliant opportunity to present our research at a national level and communicate the importance of early diagnosis of type 1 diabetes. I was grateful for the opportunity to present my research and learn from both the poster and oral presentations of others. As a medical student, I felt inspired by many paediatricians who have done many years of hard work in the field.

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Senior Editors, Spring 2026

Yaqeen Alkaabi

Year 3, Dentistry, Cardiff University

Studying dentistry, I have never felt more sure of myself and of my passions; my avid interest in health research has been further fuelled by my continued learning as well as clinical and interpersonal experiences. Taking the role of senior editor has been an invaluable experience which has taught me so much about the publishing process for scientific journals, an experience that I am sure to take forward. I am particularly interested in public health, increasing access to healthcare and addressing disparities within different communities, especially in the dental field. As such, I have been involved in the Cardiff Refugee Health Project for the past year and hope to take on more endeavours of the like.



Uashar Badakhshan

Year 5, Medicine, University of Exeter

My academic interests centre on exploring the intersection between health inequities and ethnicity. I recently ranked in the top decile of my cohort and was awarded the Wellcome Trust Biomedical Scholarship by the University of Oxford, which enabled me to pursue research into ethnic disparities in breast cancer. I have presented my findings at both national and international conferences and have been recognised with the Dame Clare Marx Prize and the Young Investigator Award. Alongside my research, I previously served as President of the Clinical Education Society and currently act as an Associate Editor for the INSPIRE Journal, a role that has strengthened my skills in critical appraisal and academic writing. Beyond academia, I am Chair of the Army Cadet Force's Multicultural Network, where I work to promote diversity, equity, and inclusion on a national scale.



Ben Craig

Year 4, Medicine, University of Plymouth

Hello! My name is Ben and I'm currently a fourth-year medic studying at Plymouth. I've really enjoyed being an editor with the INSPIRE student magazine and have loved reading some of the submissions that have been sent in; they've all been hugely interesting and I'd really encourage student readers to submit a piece themselves! Besides from medicine, I enjoy going for runs at the weekend and hiking around Dartmoor.



Sam Hartnoll

Year 5, Medicine, Cardiff University

Hi, my name is Sam, a final year student at Cardiff University. My academic interests include infectious disease and the immune dysregulation underlying autoimmune conditions. Last year I had the opportunity to intercalate at Imperial College London, undertaking research with the Paediatric Infectious Disease group. I carried out a translational research project, looking at the development of a point-of-care lateral flow test to discriminate between viral and bacterial infection using markers of host gene expression. Being an INSPIRE editor, I have been able to build on skills I developed during my iBSc, including the critical analysis of primary research and literature searching. It has been exciting to collaborate with other like-minded students to allow student-led publication across many interesting disciplines.



Imogen Ransome

Year 3, Medicine, University of Exeter

Hello, my name is Imogen and I am interested in pursuing a research career, particularly in immunology or cancer therapy. I have also always been fascinated by a career in surgery and I am currently on the committee for Exeter's Surgery Society. I recently completed an internship in a CAR-T cell research laboratory, where I was inspired by the innovative work being done with regards to cancer immunotherapies. As an INSPIRE editor, I have enjoyed exploring a wide range of medical topics, especially around Alzheimer's disease and mental health topics. I am also passionate about addressing the underrepresentation of women's health needs and with my peers I am establishing a Women's Health Society at Exeter University to create a space for discussion and advocacy around the healthcare experiences of women and people assigned female at birth. Outside of medicine, I enjoy triathlon, dancing and playing the piano.



Sarah Rafique

Year 4, Dentistry, University of Plymouth

I'm a fourth-year dental student with a keen interest in translating research into public health interventions that promote physical health and mental wellbeing, helping people live healthier lives. By reviewing articles, I have enhanced my academic writing skills, which have enabled me to write an opinion piece on oral health and its links to systemic disease. I'm interested in the ways to communicate health research, so I co-created a podcast episode for this journal and contributed art and poetry. These experiences have inspired me to pursue interventions on behavioural change and continue making health information accessible, impactful and, most importantly, fun.



Senior Editors, Spring 2026

Aaisha Rashid

Year 2, Medicine, University of Exeter

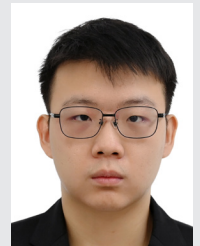
Hello! I'm Aaisha, a second-year medical student at Exeter. My research interests lie in neuroendocrinology and translational medicine, with a particular focus on diabetes, autoimmune disease, and nervous system regeneration. I recently completed an INSPIRE studentship investigating autonomic regulation of pancreatic beta cell regeneration in zebrafish, and I am now undertaking an internship in Alzheimer's disease research. I've particularly enjoyed engaging with the literature submitted, reading and critically analysing cutting-edge papers has deepened my appreciation for the research process and sharpened my curiosity. Outside of medicine, I train in Jiu-Jitsu, practise the piano, and try to read whenever I can!



Yuan Jing Xin

Year 2, Dentistry, Cardiff University

Hi! I am Jing Xin, a second year student at Cardiff University. I am particularly interested in clinical research and learning about new dental procedures and materials that could be used to facilitate a greater quality of care for patients. I am currently investigating the content and relevance of dentistry-related apps in delivering advice and knowledge to patients. In my spare time I enjoy volunteering with the community and going to the gym. As an editor of the INSPIRE Journal, I have learnt how to critically review and manage papers as well as collaborate with others. I am grateful to have been given this opportunity as it has been significant in bolstering my skillsets and expanding my perspective in the field of healthcare.



Eleanne Robinson

Year 5, Medicine, University of Plymouth

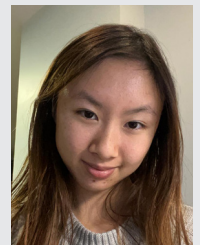
This summer, I visited Slovakia to complete an elective placement in anaesthetics and intensive care medicine - an area I am interested in pursuing as a career. One of my favourite extra-curricular experiences from previous years was leading the in-house clinical training team for Plymouth Night Patrol (a student-led volunteer group that provides welfare and medical support to students and members of the public on nights out). In my spare time, I enjoy sea swimming, travelling, music, and exploring the Devon coastline. Volunteering for the INSPIRE Student Journal is helping me to learn about peer review, editorial management, and collaboration with other students.



Joyce Yuen

Year 2, Medicine, University of Bristol

Hello! I'm Joyce, a second-year medical student at the University of Bristol. My research interests lie in translational neuroscience, focusing on pharmacological and immunological interventions for nervous system disorders and drug addiction. I am honored to serve as an editor for the INSPIRE Student Journal and to develop my skills in critically appraising academic articles; I have thoroughly enjoyed the editorial process and look forward to contributing to the publication of insightful and impactful student research. As part of the committee of the newly-affiliated Bristol INSPIRE Society, I also participate in running our journal club, helping to promote research engagement amongst our students. Outside of my studies, I have a passion for music and enjoy playing badminton in my spare time.



Kate Williamson

Year 4, Veterinary Science, University of Bristol

My academic interests include pathology, small animal surgery and animal welfare. Growing up with exotic pets sparked a curiosity that I hope to explore further throughout my education. I currently serve on the committee of the Bristol PAWS project as Treasurer, gaining insight into the challenges and rewards of charity medicine. I also acted as Small Animal Representative of University of Bristol's Animal Welfare Society and as Rota Secretary for Bristol Nightline, a confidential listening service where I volunteered as a trained listener. INSPIRE struck me as a unique opportunity to collaborate with other health sciences students, develop editorial and research skills, and contribute to an exciting student-led publication.



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Cardiff School of Medicine Co-Leads: Dr William Davies, Reader (Basic Science), Dr Emma Tallantyre, Clinical Reader
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