An Early Career Perspective on the Value of Interdisciplinary Training Networks: Reflections on the Medical Research Foundation's National PhD Training Programme in Antimicrobial Resistance Research

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Abstract

As a global society, we face various challenges that threaten economic, social, and ecological stability and security. Tackling complex global challenges, such as antimicrobial resistance (AMR) and climate change, requires collaboration and the integration of diverse perspectives from across the full spectrum of disciplinary approaches. This requires an increasing number of effective interdisciplinary researchers. In this reflective article, I present a case study narrative based on my own experience to examine how my interactions with an interdisciplinary training scheme (the Medical Research Foundation's National PhD Training Programme in Antimicrobial Resistance Research (MRF-PhD-AMR Programme)) helped me develop as an interdisciplinary early career researcher. I describe three key interactions I had with the MRF-PhD-AMR Programme during and after my doctoral studies, and how these interactions offered me different opportunities to develop the capacity to effectively navigate interdisciplinary spaces. My reflections help highlight the importance of supporting doctoral and postdoctoral researchers in engaging in training opportunities that cross disciplinary boundaries, to enable them to become more effective interdisciplinary researchers.

Keywords: super-wicked problems; interdisciplinarity; transdisciplinarity; researcher development; antibiotic resistance; one health

Background

As a global society, we face complex, and increasingly urgent, challenges that threaten economic, social, and ecological stability and security. These include environmental challenges, such as climate change and biodiversity loss: public health challenges, such as novel infectious diseases and antimicrobial resistance (AMR), and geo-political challenges, such as poverty, inequality, armed conflict, and mass displacement of people. Furthermore, these challenges intersect with, and potentially exacerbate, each other (**IPCC, 2022; Mattar et al., 2021; POST, 2023**).

Tackling such complex interrelated challenges, through combined strategies of prevention, mitigation, and adaptation, requires collaboration and the integration of diverse perspectives from across the full spectrum of disciplinary approaches (**Beaumont, 2020; Elixhauser et al., 2024; Morris et al., 2022**). Technological and scientific solutions alone are insufficient to tackle these complex, human-driven challenges, especially 'super-wicked problems' such as climate change and AMR (**Levin et al., 2012; Littmann et al., 2020**). In recognition of this, there are increasing calls from researchers, funding bodies, and policymakers for interdisciplinary solutions that recognise and value diverse perspectives from across STEMM (science, technology, engineering, mathematics, and medicine) and SHAPE (social sciences, arts, and humanities) disciplines (**BEIS, 2022; Flanagan et al., 2023; Warren et al., 2024; Wilsdon et al., 2023**). This article defines interdisciplinary working as the integration and synthesis of knowledge and methods from different disciplines, leading to new discourses and knowledges (**Beaumont, 2020; Warren et al., 2024**).

However, there can be barriers to effective interdisciplinary working, which include narrow disciplinary training and silo-working, inadequate communication (e.g., use of jargon, differences in terminology meanings), misunderstandings between disciplines (e.g., (mis)valuing methodologies, lack of respect, hierarchies of knowledge), physical distance between people and institutions, and the additional time and resource required. (**Warren et al., 2024**). To help overcome these barriers, we need mechanisms that enable researchers to train in, and thrive in, interdisciplinary spaces. One such mechanism is the provision of interdisciplinary training opportunities for postgraduate researchers (PGRs) and early career researchers (ECRs) (**Hein et al., 2018**).[i]

In this article, I present a reflective case study based on my own experience, showcasing how interdisciplinary training opportunities can contribute to the development of ECRs who are better equipped to navigate and work in interdisciplinary spaces. I will share insights from my own ECR journey, with reference to my experiences of interacting with one such interdisciplinary training programme – the Medical Research

Foundation's National PhD Training Programme in Antimicrobial Resistance Research (MRF-PhD-AMR Programme). As this programme has now hosted its final conference and training events, it feels appropriate to take the opportunity to share some of my reflections on how this programme has contributed to my professional development. I will first provide an overview of why AMR is an interdisciplinary challenge. I will then outline the programme, how I have interacted with it at different time points, and the influence this has had on my development as an interdisciplinary ECR working on super-wicked problems.

Why AMR is an Interdisciplinary Challenge

Antimicrobials (e.g., antibiotics, antifungals) are widely used to treat and prevent infectious diseases, but the use of these drugs in humans, animals, and the environment, is driving increasing rates of AMR amongst microbes (**Laxminarayan et al., 2013**). This increasing prevalence of AMR represents an urgent public and animal health threat (**WHO, 2015**). Infections in humans, animals, and plants that are caused by AMR microbes are harder (and sometimes impossible) to treat with our existing drug therapies (**van Hecke et al., 2017; L. Xu et al., 2017**). If we do nothing to intervene, AMR-related infections are predicted to cause more deaths than cancer by 2050 (**Review on AMR, 2014**). Successfully tackling AMR and improving the use of, and access to, antimicrobials worldwide require effective interdisciplinary working. AMR is often cited as the quintessential One Health problem (**Robinson et al., 2016**) – we cannot 'solve' AMR by attempting to address it within only one domain (**Mitchell et al., 2023; Sealey et al., 2023**).

At first glance, the challenge of AMR can be seen in terms of the (micro)biological, medical, and veterinary sciences. For example, efforts can be focused on better understanding the genetic transmission of AMR between microbes, mapping patterns of AMR-related disease across the globe, developing new drugs and diagnostic tools, and improving human and animal nutrition to reduce disease burden (**FAO, 2016; Review on AMR, 2015b; WHO, 2015**). Perspectives from engineers and environmental scientists are also increasingly valued, as they work to reduce environmental pollution from AMR by creating better technological solutions for sewage and slurry management, or monitoring and limiting antimicrobial discharge from pharmaceutical manufacturing plants (**Berendonk et al., 2015; Bürgmann et al., 2018; Lübbert et al., 2017**). However, as with other global challenges such as climate change - where there has traditionally been an emphasis on technological solutions (**Devine-Wright et al., 2022**) - humans are at the heart of the AMR challenge (**Tonkin-Crine et al., 2015**). Although AMR is a process that can, and does, happen without human interference, it is human usage of

antimicrobials that is driving increasing rates of AMR (**Booton et al., 2021; Laxminarayan et al., 2013**). Furthermore, rates of AMR and patterns of infectious disease will change due to human-driven climate change, environmental degradation, and habitat and biodiversity loss (**POST, 2023**).

We therefore need to understand the psychological, sociological, economic, and political drivers of AMR (**Flowers, 2018**), just as much as the biological, ecological and technical. For example, doctors and veterinarians can feel pressure to prescribe antimicrobials in situations where clinical need is ambiguous, or even lacking (**Pinder et al., 2015; Servia-Dopazo et al., 2021**). Economic considerations can influence treatment choices, treatment adherence, infection control measures, and drug development (**Golding et al., 2019; Laxminarayan et al., 2013; Review on AMR, 2015b**). Members of the public might use antimicrobials in ways not intended, such as sharing prescribed courses with others or by self-medicating (**Erku et al., 2017; Lv et al., 2014**). Lack of financial means or resources, inadequate supply chains, or ineffective political and governance systems can also mean unequal access to antimicrobials (**Laxminarayan et al., 2016; Review on AMR, 2015a**). Input from the social sciences, arts, and humanities are therefore vital, as these disciplines can help us understand – amongst other things - what motivates people to use antimicrobials or engage in infection control measures, how to implement and evaluate governance mechanisms, how to take account of local contexts and cultural norms when developing interventions, and how to address the inequitable access to antimicrobials globally.

The MRF-PhD-AMR Programme

2024 marks the winding down of the MRF-PhD-AMR Programme, as wider cohort-building activities cease and most PGRs funded by the programme work towards completion of their studies. This ambitious interdisciplinary training programme - led by Professor Matthew Avison and colleagues from across the UK – was formally launched in 2018 with the purpose of enabling more effective interdisciplinary working in AMR research, by helping PGRs and ECRs to build interdisciplinary networks. Over 6 years, the programme has brought together a diverse cohort of PhD students from across the STEMM and SHAPE (social sciences, arts, and humanities) disciplines to learn from and work with each other.

A key goal of the MRF-PhD-AMR Programme was to expose PGRs to interdisciplinary ways of working, to encourage them to think and work outside their own disciplinary silos, and to gain confidence in navigating interdisciplinary spaces. The programme achieved this through two key areas of activity:

1. Funding a *core cohort* of approximately 30 interdisciplinary PGRs, across different UK-based institutions, who would complete their AMR-focused doctoral training embedded within interdisciplinary teams of supervisors, researchers, and practitioners.

2. Creating a *wider cohort* of over 200 interdisciplinary PGRs, by hosting funded annual conferences, residential and online training weeks, and other activities, to bring together a greater diversity of AMR researchers and strengthen interdisciplinary networks. Any PGR based in the UK working on AMR was eligible to apply to the wider cohort, regardless of discipline or research question.

As of March 2024, a review of the programme's website[ii] indicates a variety of outputs have resulted from this interdisciplinary training scheme, including more than 50 peer-reviewed papers co-authored by core cohort PGRs, a webinar series showcasing research and career journey stories from the wider cohort, and a blog featuring multiple contributors. Policy impacts include changes to death certificates in England, with AMR-related deaths now able to be recorded, and submission of evidence to the UK parliament for the Health and Social Care Committee's AMR Inquiry.

Why I Joined the MRF-PhD-AMR Programme

Interdisciplinary teams are crucial when researchers attempt to understand such complex and applied problems as AMR. My own interdisciplinary PhD research, funded by the Economic and Social Research Council, was supervised by a farm animal veterinarian, Dr Helen Higgins, and a health psychologist, Professor Jane Ogden. I used different social science methods (interviews, surveys, and experiments) to explore the psychological, social, and environmental factors that influence antimicrobial usage in UK veterinary medicine and livestock farming (**Golding et al., 2019, 2021 & 2022**). Although the PhD I was awarded was in health psychology, I could not have conducted the work without Helen's input. Her specialist knowledge and experience of farm animal medicine were invaluable in helping Jane and me better understand the context and challenges of antimicrobial prescribing in UK livestock farming. The studies we designed would have looked very different without input from multiple disciplines.

During my doctoral training, I applied to be a member of the wider cohort of trainees in the MRF-PhD-AMR Programme. Despite having very good supervision, I was not part of a wider AMR research team and did not have many peers who were working on this topic. Given the complexity of AMR (**Department of Health, 2014**), I felt it would be helpful to interact with PGRs from different disciplines, who were working on related but different

aspects of the challenge. I was also excited by the prospect of interacting with more established academics who were involved in the programme, and I was thrilled when my application was successful. I was invited to attend the first residential training week in August 2018. Then, in May 2021, I took part in the programme's webinar series, as an invited speaker to showcase my completed PhD work. Finally, I was honoured to be invited back by the programme team to contribute to their final annual conference in August 2023. Attending this final conference prompted me to reflect on the different ways in which these three interactions with the programme contributed to my professional development as an interdisciplinary researcher both during and beyond my doctoral training.

How the MRF-PhD-AMR Programme Supported My Development

My first interaction with the MRF-PhD-AMR Programme was as a PGR, during the third year of my doctoral training. I attended the first residential training week hosted for the wider cohort, which involved a variety of different learning and development activities. These included presentations from academics and practitioners, as well as site visits to a microbiological laboratory, dairy farm, or hospital. The speakers represented a range of disciplines and sectors, including experts on communicating research to non-academic audiences. The week also included a one-day inaugural conference, where PGRs presented lightning talks or posters, providing an opportunity for us to practice our academic presenting and questioning skills.

Built into the activities of the week were several sessions of group work (the Challenge Teams). Each Challenge Team consisted of around five PGRs from different disciplines, and each group was allocated to one of three grand challenges associated with AMR – improving diagnostic tools, improving drug discovery, and reducing the prevalence of AMR. The goal was to work together to understand the nature of the challenge and then co-produce an interdisciplinary policy brief on the issue, culminating in a press conference-style presentation to a panel on the final day. The panel included representatives from research funding organisations and a clerk from the UK's House of Commons Health and Social Care Committee, who were interested in AMR but were not topic experts. In our Challenge Teams, we had to work quickly and collaboratively to liaise with experts, identify and synthesise key insights from different literatures, identify potential solutions, make recommendations for potential policy options, and then effectively communicate our findings to a panel of non-experts.

Working on these policy briefs was a particular highlight – it felt high stakes, important, and stretching, but also safely bounded, as we were told that the development of the policy briefs was predominantly a training exercise. However, after the week had completed, we were advised that our presentations had been considered of such good quality that all the policy briefs would be collated and submitted as written evidence to the House of Commons Health and Social Care Committee's AMR Inquiry (Medical Research Foundation National PhD Training Programme in Antimicrobial Resistance, 2018). This felt like an incredible collective achievement, and I was immensely proud to have been a part of this wider team effort. It also meant that I could add something to the 'Impact' section of my academic CV!

Being part of the residential week was an extremely valuable experience for me and it helped me develop my skills and confidence as an interdisciplinary PGR. I had the pleasure of getting to know my fellow trainees, as well as interact with more established academics and practitioners. These positive interactions across the week helped give me the courage to volunteer to present our diagnostics policy brief on behalf of my Challenge Team. My site visits included a trip to a hospital diagnostics laboratory. As a social scientist who hadn't been in a lab since my biology A-Level, this visit was utterly fascinating. The programme of activities in the residential training week benefitted us PGRs by providing us with a safe and non-judgmental space in which to ask questions, time to engage in interdisciplinary conversations and debates, and the opportunity to reflect upon the assumptions and language conventions embedded within our own disciplinary approaches.

My second interaction with the MRF-PhD-AMR Programme was as an ECR in the spring 2021, just over a year after completing my PhD. A series of webinars was organised by the programme, and I was invited to present an overview of my PhD research, as well as share some of my experiences post-PhD (**Golding, 2021**). This was a hugely affirming experience for me – it felt good to be asked to share my work with the interdisciplinary audience of core and wider cohort PGRs and ECRs. I enjoyed revisiting my findings, and they also helped cement for me the idea that I really had made a novel and useful contribution to knowledge! I also discovered there is something heart warming about being able to share your own reflections of being on 'the other side of the viva' with PGRs who are still deep in the midst of their PhD work. I know how valuable it was for me as a PGR to have such interactions with ECRs who were not too far past the completion of their own doctoral work, and it felt good, if a little surreal, to realise I was now in a position where I could start to 'pay it backwards'.

As a result of this webinar, I was also invited to present my work to the Farm Animal Discussion Group at the Bristol Veterinary School. This group consisted of veterinary students, lecturers, and practitioners, and was linked to a group of veterinary-led researchers who were exploring the social dimensions of antimicrobial use in dairy farming. I had long admired the work of AMR Force,[iii] led by Professor Kristen Reyher, and was excited to be offered another opportunity for networking and knowledge exchange with veterinary academics and practitioners. I had met Kristen and some of her PGRs at the residential training week in 2018, as well as at other conferences in subsequent years. By this stage, I was beginning to realise that building academic and practitioner networks is a gradual process – and that this is perfectly normal! As PGRs we are encouraged to build our networks, to look for opportunities to share our findings, and generate impact – but what we aren't always explicitly told is that this takes time. Being part of the MRF-PhD-AMR Programme benefitted me by helping me to understand that collaborations and networks are sometimes developed slowly, perhaps as a result of multiple but occasional interactions.

My third interaction with the MRF-PhD-AMR Programme was in August 2023, when I was invited to contribute to the final annual conference as one of several ECR alums from the core and wider cohorts. By this point in my ECR career, I had worked as a researcher on several interdisciplinary health-related projects (**Dibb et al., 2021; Husted et al., 2022; Weber et al., 2023; S. Xu et al., 2021**). In early 2022, I started working in a knowledge exchange role, for an interdisciplinary network-building and knowledge exchange project called ACCESS (Advancing Capacity for Climate and Environment Social Science),[iv] which aims to champion the social science contribution to environmental challenges such as climate change and biodiversity loss. Being part of the programme's residential week had certainly contributed to my development as an interdisciplinary researcher – which had helped me in each of these different ECR roles – but as I had not worked directly on AMR projects for about three years, I was unsure whether I would have much to contribute to the conference. The organisers reassured me that my post-PhD experiences and my training as a social scientist would mean I could make a valuable contribution.

I took part in two-panel discussions during the conference. The variety of panellists, who were ECRs from the core and wider cohorts, plus experienced researchers from the core academic team, illustrate how the MRF-PhD-AMR Programme has built interdisciplinary networks and provided spaces for PGRs and ECRs to engage in interdisciplinary debate. The first panel, chaired by Becky McCall from the core cohort, explored how we might help raise AMR back up the policy agenda, following the

shift in focus away from AMR during the Covid-19 pandemic (**McCall et al., 2023**). Some of the discussions included the potential pros and cons of linking AMR to other super wicked problems such as climate change – could this help raise AMR up the agenda or risk diluting the focus? My fellow panellists included a parliamentary researcher with a background in pharmaceutical science, a pollution scientist who examines sewage for pathogens and AMR prevalence, an epidemiologist from the UK's Health Security Agency, and a geneticist working with CRISPR technology to remove AMR genes. The second panel, chaired by Matthew Avison, explored the role of interdisciplinary teams and networks in the context of AMR (Avison et al., 2023). Prompted by questions from the audience we discussed the challenges of doing interdisciplinary research and whether universities offer sufficient support to enable PGRs to become proficient interdisciplinary researchers. On this panel, I sat alongside a microbiologist and chemist, a hospital pharmacist, and a biomedical engineer.

It was a pleasure to take part in this PGR-focused conference and I enjoyed meeting other PGRs and ECRs working across such a variety of questions related to the overall challenge of AMR – their enthusiasm gives me hope! I particularly appreciated talking to other social science PGRs, hearing about their projects and sharing experiences of being one of a few SHAPE disciplinary representatives in rooms full of STEMM researchers. The organisers also asked me to be one of the poster judges for the 'AMR and Antimicrobial Use: Interventions and Behaviours' stream of posters. This was the first time I had been a poster judge, so it felt a little nerve-wracking, especially as all the posters were of a high standard – judging was hard, and I was pleased to not be doing it alone! It was also wonderful to re-connect with some of the other people who had been at that first residential week with me, who are now also forging their own interdisciplinary ECR careers.

Concluding Remarks

When I reflect on the variety of opportunities offered to me by the MRF-PhD-AMR Programme, I am hugely grateful to everyone involved, including the academic team, the project support team, my fellow PGRs and ECRs, and of course, the Medical Research Foundation for funding the programme. I realise now how being involved in these different activities, at different stages of my PGR and ECR career, has benefitted me by enabling me to develop my skills as an interdisciplinary researcher. The programme helped to overcome some of the traditional barriers to interdisciplinary working (**Warren et al., 2024**), by providing time, space, and resources to bring researchers from different disciplines together to learn from each other. I value the way the programme gently scaffolded me (and I am sure others), by providing a range of small but safe

development opportunities (e.g., presenting posters, communicating findings across different audiences, summarising key insights, evaluating other people's work). I also realised how the programme offered me several 'firsts'; my first residential training school, my first presentation prize, my first time as invited webinar speaker, my first time as a poster judge, my first time as an invited panellist.

I could have learnt some of these skills in discipline-specific settings, but I don't think that would have equipped me to become the interdisciplinary ECR I am today. I have always been motivated to work on applied research projects, exploring questions related to population-level health challenges, such as AMR (**Martínez et al., 2023**) and obesogenic food environments (**Golding et al., 2022**), as well as the intertwined environmental crises of climate change and biodiversity loss (**Marselle & Golding, 2023**). Solving such complex challenges can only be achieved with interdisciplinary cooperation, and providing ECRs with opportunities to engage in interdisciplinary training is vital in supporting them to develop appropriate skills and pursue interdisciplinary research careers (**Elixhauser et al., 2024; Hein et al., 2018**). Indeed, this is a core part of the work I now do as a Knowledge Exchange Fellow on the ACCESS project – convening and facilitating spaces for interdisciplinary working, by deliberately designing activities that encourage conversations, networking, and the integration of disciplinary approaches. Such spaces, and the interactions they enable, are valuable, even if it is hard to immediately assess their impact.

My experiences as part of the wider cohort of the MRF-PhD-AMR Programme have also benefitted me in my current role in other ways. For example, I was able to draw on my experiences at the AMR residential training week in 2018 when working with ACCESS colleagues to develop our own residential, interdisciplinary Winter and Summer Schools for PGRs and ECRs – I wanted to ensure we could inspire our own delegates by including a mix of presentation formats, interactive sessions and range of dynamic, interdisciplinary speakers (**Golding, 2023; Warren, 2023**). My interactions with others on the MRF-PhD-AMR programme helped me practice and develop some of the seven principles recommended for effective interdisciplinary working, such as respecting all disciplines equally, communicating openly and honestly, and sharing experiences of working in interdisciplinary teams and spaces (**Beaumont, 2020**). By valuing my disciplinary perspective, the programme also helped me develop my own confidence as a social scientist. I learned I did have something useful to contribute, both in terms of the specifics of my PhD studies and my broader understanding of human behaviour and society. Again, this is an experience I have been able to carry into my current role with ACCESS, where I help to champion the unique contribution, the social

sciences can offer in tackling super wicked problems such as climate change and biodiversity loss.

To conclude, reflecting upon my own experiences of interacting with the MRF-PhD-AMR Programme has highlighted for me the vital importance of all actors across the research ecosystem valuing the opportunities afforded by interdisciplinary training, and I would like to encourage different actors to consider how they can best support this. For example, funding bodies can creatively shape funding calls to enable the provision of interdisciplinary training, while research leaders and PGR supervisors can encourage PGRs and ECRs to be bold and engage in relevant opportunities. It is important to invest in activities that offer PGRs and ECRs chances to network and gain confidence in interacting across disciplines. Whether one-day events or longer-term initiatives, such opportunities offer researchers the space and time to learn to engage with other disciplines with respect and empathy, help build stronger communities and networks of researchers, and help us produce better responses to complex global challenges (**Beaumont, 2020; Elixhauser et al., 2024; Hein et al., 2018; Wilsdon et al., 2023**). Importantly, these spaces need to be safe and non-judgemental to enable people to learn, make mistakes, and share experiences with peers. I strongly believe that the provision of such interdisciplinary training spaces is invaluable for the ongoing development of cohorts of effective interdisciplinary researchers.

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Endnotes

[i] In this article, I use the term postgraduate researcher (PGR) to refer to people who are currently enrolled on a doctoral training programme, such as a PhD or practitioner doctorate programme, while I use the term early career researcher (ECR) to refer to people who have completed their doctoral studies within recent years. I acknowledge that there are different ways that these terms can and have been defined and used, but for readability in the article (and clarity of distinction between doctoral and postdoctoral researchers), these are the definitions I have adopted here.

[ii] See: https://amrtraining.ac.uk/

[iii] See: https://www.bristol.ac.uk/vet-school/research/amr/

[iv] See: https://accessnetwork.uk/