‘How can genomics successfully be integrated into mainstream patient care?’

Genomics is a powerful diagnostic, prognostic, and interventional tool in healthcare and great progress has been made in our understanding and application of genomic science in clinical settings. Early advancements like the identification of the Philadelphia chromosome have redefined chronic myeloid leukaemia from a terminal disease into a manageable chronic condition [1]. More recently, revolutionary gene therapies are changing lives and relieving suffering for many patients [2]. Technological advancements have meant the power of genomics can be further harnessed by other medical specialties across primary, secondary, and tertiary healthcare settings to benefit patients and improve clinical outcomes.

The government agrees that genomics will be an indispensable tool in our future healthcare arsenal. Professor Davies, England’s then Chief Medical Officer, titled her 2016 annual report ‘generation genome’, outlining recommendations as to how genomics can be integrated into the National Health Service (NHS). The report described how genomics could be used to aid cancer diagnoses, develop targeted therapies, and even tackle obesity [3]. In 2018, the Genomic Medicine Service (GMS) was launched along with seven supra-regional genomic hubs, with a mandate to take advantage of data collected from the 100,000 Genomes Project with rapidly evolving genomic technology to improve the health of the nation [4].

Despite these introductions, further measures can be introduced to enable genomics to be used in mainstream care. In 2022, the NHS published a strategy for how genomics can be embedded into practice over the next 5 years, with the foreword suggesting that investing in genomics will play a crucial role in clearing the covid waiting list backlog and improve clinical outcomes [5]. This essay will discuss some possible ways in which genomics can be successfully integrated into mainstream care.

1. **Invest in the genomics multidisciplinary team**

Clinical genomics is a comparatively small speciality that relies on specialised medical doctors, clinical scientists, genetic counsellors, and allied health professionals. Behind the scenes, the service relies on highly trained laboratory scientists and technicians to deliver accurate testing. Without increasing the number of these professionals, it will be difficult to integrate genomics into mainstream care as the service is likely to reach bottlenecks as demand increases.

Clinical geneticists play an essential role in delivering clinical care but are also positioned as experts in the field who can advise other clinicians on genomic queries [6]. The expert knowledge held by these doctors is essential as we expand our use of molecular technology in healthcare. In 2021 the number of ST3 trainees increased, however it will take 4 years until these trainees reach consultancy, by which time the government is hoping to have expanded the use of genomics [5]. Investing in clinical genomics trainees now will provide a cohort of experts who are able to assist with the transition to genomic medicine.

Year	2018	2019	2020	2021
ST3 clinical genomics posts	13	14	13	18
Competition ratio	2.69	1.93	3.08	3.11

Figure 1: The number of ST3 clinical genomics trainees 2018-2021 and the competition ratios [7]–[10].

Over the past few years, clinical scientists have carved a key role in the delivery of genomic medicine and demand for training posts is astronomic: in 2021 27.7 scientists applied for every post available for cancer genomics STP training [11]. These scientists use molecular and cytogenetic techniques to aid with cancer diagnoses, prognoses and to inform treatment and their role is particularly essential

for patients with haematological malignancies [12]. Increasing the number of STP training posts would be a way to upgrade our diagnostic capabilities and improve clinical outcomes for cancer patients. A more unorthodox approach may be to increase the scope of practice of these professionals in a similar way seen with advanced clinical practitioners and physician associates in other specialties[13]. A genomics associate, with expert scientific and targeted clinical knowledge, may be a valuable addition to the multidisciplinary team.

Genomic counsellors are specialist scientists or nurses who have traditionally been based in tertiary care settings. Expansion of these roles into primary and community care may be beneficial and perhaps even necessary. For example, a 2020 study of primary care showed that 25% of GPs were unsure of how to respond to a direct-to-consumer commercial genetic test query [14]. As genomic testing is ramped up, patients will be faced with more data and clinicians should be prepared to explain this data to patients appropriately and accurately to maintain clinical safety.

Investing in all members of the multidisciplinary team will provide a cohort of experts who can not only deliver genomic testing, but also advise policymakers and clinicians working in other medical specialties on genomic queries.

2. Utilise technology to increase equitable access to genomic testing

Next generation sequencing (NGS) is a relatively new technology that allows DNA samples to be sequenced quickly, accurately, and cheaply [15]. NGS has the potential to allow hospitals to offer in-house sequencing services, allowing genomic testing to be accessed more equitably by patients when clinically indicated [16]. Faster sequencing may also allow genomics to be used in more settings and to be integrated into care pathways and bundles to benefit acutely unwell patients.

This technology might create a powerful screening tool in primary care settings. Family history has always been a central part of medical consultations and work on the human genome has elucidated that risks for multi-factorial chronic diseases are influenced by an individual’s genes. Screening might allow those at high polygenic

risk of disease to be identified and prophylactically treated before they become unwell. To give an important example, in the UK, 28% of women die of cardiovascular disease [17]. Genomics is known to contribute to risk factors such as hypercholesterolemia, hypertension, and diabetes thus identification of these traits may allow personalised and more clinically relevant treatments which would benefit patients and decrease the burden of chronic disease on care services [18].

In secondary care settings, technology may allow genomics to be integrated into care pathways. Pharmacogenomics describes how patients metabolise and respond differently to drugs based on their genotype and is mentioned in Professor Davies' address and the NHS 5-year genomics plan as a tool to facilitate safer and more appropriate therapy for patients. The BMJ estimates that 237 million medication errors occur in England annually, at a cost of £98 million [19]. Routine inpatient testing and interpretation could significantly improve pharmacological accuracy and lead to improved clinical outcomes for all patients.

Whilst initial investment in this technology would be expensive, if utilised properly it would reduce the burden of chronic disease leading to a more efficient allocation of NHS resources in the future. It is important that genomic information is interpreted correctly for this to happen, and the genomics multidisciplinary team should play a key role in creating policy and guidance to ensure that the technology is used appropriately and safely by clinicians.

3. **Increase genomics teaching in the medical and post-graduate curriculum**

Although understanding of genomic medicine is developing rapidly amongst scientists, there remains a knowledge gap between scientists and doctors implementing these findings into clinical practice [20]. In a 2017 survey of Australian medical specialists, only 25% felt prepared to interpret and act on genomic information in their practice [21]. Lack of training in genomics in all specialities has a significant risk to be unsafe for patients. A 2019 report from the United States revealed 25 cases where genetic tests were ordered, interpreted, or used incorrectly

leading to patient harm. In 3 of these cases, clinicians misinterpreted the result or did not have sufficient knowledge to interpret the result accurately [22].
One solution to this is to give genomics a larger share of the undergraduate and post-graduate medical curriculum. Genomics has become an essential medical science in which students and practicing clinicians should be encouraged to grow their knowledge of genomics in theory and practice. For practicing clinicians, continuing professional development schemes may be useful to develop practice as the genomic landscape changes.

4. **Collaborate to facilitate cutting edge research and therapies**

Our progress in genomics is a result of decades of collaboration between academia, industry, and the NHS. Discoveries such as the molecular structure of DNA by Franklin, Watson, and Crick laid the foundations on which we now deliver our care, but without the work of others this discovery would not have benefited patients at all. In order to continue our progress, we must invest and collaborate in research.

Clinical genomics trainees are encouraged to invest their time in academia: obtaining a BSc or MSc allows you to complete training 3 or 6 months earlier respectively. Furthermore, trainees may choose to spend one of their training years in an academic or research post [23]. This investment is wise: in the words of Benjamin Franklin, “Tell me and I forget, teach me and I may remember, involve me and I learn”. There is a growing body of evidence that patients who receive care from clinicians who are also involved in research have better clinical outcomes [24]. Research should hold an increasing share in clinical genomics training and trainees should be renumerated properly for taking higher degrees such as MDs and PhDs if they wish to do so, as this will ultimately improve patient care.

Similar support should be made available to clinical scientists and non-medical professionals who wish to advance their practice. Schemes such as Higher Specialist Scientist Training (HSST) are available, which allow scientists to become leaders and teachers in the field. There were no genomics HSST posts advertised in

2022, and only 7 posts in total across all scientific disciplines [25]. We must invest in our scientists now in order to integrate genomics into mainstream care.

Academia and industry have played an essential role in the development of interventional genomic therapies. These treatments colloquially known as gene therapy can treat diseases that have previously been untouchable by our current medical and surgical tools. In March 2021, three dedicated gene therapy innovation hubs in London, Bristol, and Sheffield were opened by the Medical Research Council [26]. The hubs are designed to facilitate clinical trials from gene therapies developed in academia and industry, with the support of a multidisciplinary team of experts and cutting-edge facilities. Supporting these facilities and investing in similar collaborative projects will be essential as we integrate genomics into mainstream care and find new applications for the technology.

Conclusion

Genomics is a powerful tool in healthcare which is currently utilised in the diagnosis and management of an increasing number of conditions, across a range of medical specialties. The government plans to increase the use of genomics in healthcare and this has incredible potential to benefit patients and improve clinical outcomes. In practice, this will not be a simple undertaking, and many factors must be considered for this to be successful. Increasing equitable access to genomic testing is the most obvious first step. However, the interpretation and application of this data by expert professionals is what ultimately will make a difference to patients.

This essay has identified that the skills held by the genomics multidisciplinary team will be essential as we continue to move forwards with genomics in healthcare. These professionals will play a key role as consultants for policymakers and clinicians in other medical specialties as genomic technology is adopted. In order to maintain patient safety and close the knowledge gap, we should increase genomics teaching in the medical and post-graduate curriculum. Finally, we should continue to invest in research and collaboration as we push forwards for new therapeutic tools which can be integrated into mainstream care and benefit patients.

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