

Analysis

Learning Networks in the pandemic: Mobilising evidence for improvement

Manbinder S. Sidhu¹

Gary A. Ford²

Naomi J. Fulop³

C. Michael Roberts⁴

¹ Health Services Management Centre, School of Social Policy, College of Social Sciences, University of Birmingham, 40 Edgbaston Park Rd, Birmingham, B15 2RT, UK

² Division of Medical Sciences, University of Oxford, UK; Oxford Academic Health Science Network, Magdalen Centre, Oxford Science Park, Oxford OX4 4GA UK

³ Department of Applied Health Research, University College London, Gower St, London WC1E 6BT, UK

⁴ SaferCare Victoria, 50 Lonsdale Street, Melbourne, Victoria 3000, Australia

Correspondence to:

Full name C. Michael Roberts

Mailing address Safer Care Victoria, 50 Lonsdale Street, Melbourne, Victoria, 3000, Australia.

Email: mike.roberts@safercare.vic.gov.au

Phone: +61 0456929951

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KEY MESSAGES

- **The paucity of evidence and availability of data during the early phase of the pandemic provided an opportunity for real time learning driven by communities of practice generating clinical and service innovation.**
- **A mix of opportune and strategic support provided by regional and national bodies in England created clinical learning networks which adopted and spread change rapidly.**
- **There is an opportunity for health systems to strategically develop learning networks to co-ordinate resources to innovate, evaluate and implement emerging best practice and evidence for healthcare improvement needed for both pandemic and non-pandemic times.**

Contributors and sources

Prof C Michael Roberts is guarantor for this article. During the first 18 months of the pandemic he was a community Respiratory Physician supporting a COVID virtual ward in Essex, UK, and Managing Director of UCLPartners, an Academic Health Science System, that led a number of COVID related initiatives. He is now CEO of Safer Care Victoria, Melbourne, Australia.

Dr Manbinder Sidhu is first author for this article and a Research Fellow at the Health Services Management Centre (HSMC), University of Birmingham working within the NIHR BRACE Rapid Evaluation Centre. He was part of the NIHR RSET/BRACE team which completed a rapid evaluation of remote home monitoring for COVID-19 patients.

Prof Naomi J Fulop is Professor of Health Care Organisation and Management in the Department of Applied Health Research, University College London. She is chief investigator of NIHR RSET and led the rapid evaluation of remote home monitoring for COVID-19 patients.

Prof Gary A Ford is Chief Executive Officer of the Oxford AHSN, Professor of Stroke Medicine at Oxford University and Implementation Lead for the Oxford and Thames Valley NIHR Applied Research Collaborative. He is a practising consultant acute stroke physician in the NHS. During the pandemic he led the production of rapid guidance for adapting stroke services during the pandemic.

Patient involvement

An early draft manuscript was reviewed by members of the RSET and BRACE COVID Oximetry @home evaluation patient and public involvement group and feedback was provided collectively in a meeting co-led by MS along with another member of the evaluation team. As a result, improvements were made to the manuscript in response to suggestions made by this group.

Conflicts of Interest

We have read and understood [BMJ policy on declaration of interests](#) and have the following interests to declare. Note: where a competing interest exists that might disqualify an author from contributing, it is wise to discuss it with a BMJ editor before writing the article.

C Michael Roberts was previous managing Director of UCLPartners (August 2021).

Manbinder S Sidhu has no conflict of interest to declare.

Naomi J Fulop has the following interests: NIHR Senior Investigator, non-executive director of Whittington Health NHS Trust and trustee of Health Services Research UK. She is a non-executive director of the organisation COVID-19 Bereaved Families for Justice and has legal representation in the UK COVID-19 Inquiry.

Gary A Ford the following interests: Personal financial interest: Non-Executive Director NICE Board, CSL Behring consultancy stroke trial design. Personal non-financial interest: Trustee Picker Institute; NIHR Strategy Board member; Health Services Research UK Trustee; Accelerated Access Collaborative Board member; Chair Pfizer/Bristol Myers Squibb independent atrial fibrillation detection improvement grants panel; Chair Cardiovascular Healthcare Systems Strategic Forum, Novartis funded; Bristol Myers Squibb/PwC Life Sciences 2030 Cancer Moonshot Roundtable; He is Chief Executive Officer of the Oxford Academic Health Science Network, which has multiple joint working agreements and medical education grants with industry partners that are contracts with Oxford University Hospitals NHS Trust the host organisation for the Oxford AHSN.

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Standfirst

In the absence of existing evidence of how to best manage COVID-19, communities of practice were established rapidly to address areas of urgent clinical need. These generated new learning about clinical care and care models. Ad hoc collaborations between applied researchers, Academic Health Science Networks and regional NHS structures formed learning networks that supported rapid sharing of learning, evaluation and incorporation of research evidence and data, and implemented innovative change at pace. This approach was highly effective in the pandemic and deserves the consideration of strategic alignment of existing clinical, evaluation, research and implementation resources to create learning networks as a continuous improvement model for the NHS and other health systems.

Introduction

The challenges of embedding a range of evidence into practice are well known in relation to clinical practice, service organisation, and delivery. Less discussed is an effective mechanism to both generate and implement evidence rapidly into clinical practice at scale. The COVID-19 pandemic presented a unique challenge where clinical practice needed to develop and spread 'emerging novel practice' to both manage COVID-19 patients in the absence of research evidence and adapt existing models of care that were safe for non-COVID-19 patients.

In this paper we discuss how clinicians and researchers came together organically to develop learning networks, in the absence of national or regional co-ordination. We narrate how these networks came to share evidence. At the onset of the pandemic this was reliant on personal relationships and individual leadership but was eventually supported by regional and national NHS systems to facilitate evaluation. We describe three cases where clinically led innovation generated communities of practice which evolved into 'clinical learning networks (CLN)'^{1,2} and produced rapid change at scale to meet the needs of the health system.

The emergence of Communities of Practice and Clinical Learning Networks at the outset of the pandemic

COVID-19 was a new disease and in the absence of specific evidence-based guidance for treatment. Clinicians initially extrapolated from existing evidence of other viral respiratory diseases, but it became rapidly clear previous guidance on SARS-2 infections lacked understanding of the complexities of COVID-19. In this evidence vacuum, clinicians began to share emerging knowledge nationally and then internationally in real time³.

UK Research funders responded to the pandemic by mobilising rolling rapid research calls from February 2020. In parallel, several national and regional groups emerged to develop innovations in practice during the early stages of the pandemic^{4, 5}. Such collaborations 'of shared purpose' are described as communities of practice (CoP)⁶. CoPs provide a mechanism for those working across health services to share tacit knowledge leading to innovative practice and new learning based on a common interest^{7,8}. CoPs move beyond the acquisition of knowledge and centre on three key domains: 1) joint enterprise (what it is about); mutual engagement (the interactions that lead to the shared meaning); and a shared repertoire (of resources such as techniques, tools, experiences or process and practice)⁹⁻¹¹. CoPs allow people to come together to solve complex problems with common goals using knowledge-in-practice-in-context mechanisms, and support for formal and informal interaction between members with resultant learning and knowledge sharing^{12,13}.

A key characteristic of CoPs is the facilitation of communication amongst individuals across networks to promote the uptake of new knowledge in health care settings⁹. We argue this key characteristic forms the essential element of a CLN that can support clinicians with knowledge generation processes and decision-making. Defined elements of a CLN are 1) the structured exchange of information and learning, with members 2) the sharing of practical insights of adaption and adoption of evidence-based protocols, and 3) using innovation to overcome deficiencies in care^{1,6,7}.

During the early pandemic there were no evidence-based protocols, or national data sharing to front line staff nor a national programme of innovative service evaluation. What ensued was a model that shared knowledge of “what works best” back to clinicians in real-time in the absence of robust data or research evidence¹⁴. As the pandemic unfolded these networks were supported, to incorporate data and emerging evidence whilst also generating new evidence, through partnerships with Academic Health Science Networks (AHSNs), NHS Regional Offices, National Institute for Health Research (NIHR) Applied Research Collaboratives (ARCs) and Rapid Research and Evaluation centres.

Learning from new care models during the COVID-19 pandemic

In the following section we refer to examples of new care models and draw out lessons on their approach. We have used a conceptual framework developed by Bertone et al.¹⁵ to assess the impact of CoPs and CLNs.

Case 1: An ICU clinical learning network, that drew in medical specialties, generating real time knowledge changing practice across continents

In March 2020, robust evidence from randomised controlled trials regarding ICU management of COVID-19 was lacking¹⁶. As a pragmatic response, clinicians applied National Institute for Clinical Evidence (NICE) guidance for management of acute respiratory distress syndrome, but adoption was associated with high mortality. The Intensive Care Society (ICS) approached UCLPartners, an academic health science system including an AHSN, to form a collaboration to share emerging clinical experience (e.g. insights from key experts, front line key workers, and patients) between intensivists across the UK. A weekly series of webinars for ICS members was established at which emerging experience was shared including the value of proning and the early recognition of thromboembolic disease.¹⁷ The sessions were recorded, and thematic analysis was undertaken by the AHSN team. Within 24 hours analyses were distributed via email to ICS members. Applied health researchers (NIHR North Thames ARC) supported the group with evidence searches of rapid publication trial data where relevant. Within the first week members had begun to disseminate the summary, via multiple media channels to over 5000 intensivists worldwide. As this shared learning

revealed COVID-19 to be a multisystem disease, experts in renal medicine, haematology, respiratory and cardiology were drawn into the learning network.

Case 2: Development of national remote home monitoring using pulse oximetry of COVID-19 patients using shared learning and research evaluation

This was an example where there was greater alignment of national and regional NHS and NIHR resources to evaluate and to spread practice at scale and pace. This evaluation, completed in two months by the two NIHR rapid evaluation teams ([Rapid Service Evaluation Team \(RSET\) and Birmingham, RAND, And Cambridge Evaluation \(BRACE\) Centre](#)), provided evidence of how remote home monitoring models (also referred to as *virtual wards*) were implemented during the first wave¹⁸, together with a rapid systematic review¹⁹, provided lessons for preparation for the second wave and the national roll out of these services²⁰⁻²². Findings from the evaluation were rapidly disseminated during autumn 2020 through networks which had been established to share best practice, resources and learnings including the COVID-19 Oximetry Community of Practice Group, the National Learning Network and its regional forum-based equivalents facilitated by AHSN Patient Safety Collaboratives, supported by the NHS Futures Platform (a network of NHS staff who want to connect with each other to accelerate their work). Some COPs were established from scratch while others built on established networks such as the National Deterioration Forum, but all brought together clinicians from primary, community and secondary care settings. As a result, a national roll out of this programme across the whole of England was achieved within a matter of weeks in late 2020²³.

Case 3: Adapting non-COVID pathways to the virtual first approach for transient ischaemic attack (TIA) and stroke care

In parallel, the consequence of researchers and clinicians pivoting to focus on managing the pandemic had a significant impact (or lack of) on building the evidence for the provision of services for non-COVID-19 health conditions. Oxford AHSN and programmes such as Getting It Right First Time adopted a learning network approach rapidly producing guidance and resource hubs to support clinicians and health system planners organise non-COVID-19 services during the pandemic synthesising *available* evidence on remote evaluation and management of conditions along with drawing on the early experiences of sites (e.g. guidance on the organisation of stroke and TIA services)²⁴. In some instances, this supported the rapid roll out of service models that had been tested in a non-pandemic context e.g. remote assessment by senior clinicians of acute stroke for reperfusion therapies²⁵. In other instances, e.g. remote assessment of suspected TIA and stroke

more generally^{25,26}, recommendations were based on clinical experience and reasoning without drawing upon a research evidence base as apparent in case studies 1 & 2.

What can be learnt from the cases we present?

The three cases described evolved differently but all show how CLNs established in the absence of evidence and delivered change at pace when facilitated by an administrative infrastructure. CLNs also had the ability to bring together researchers, evaluative/academic organisations, and funders to incorporate emerging evidence. Specifically, there were several mechanisms which enabled CLNs to produce real time 'evidence' in the absence of robust methodological evaluation. First, CLNs generated new learning through collaborative and interdisciplinary working. For example, gathering both evidence-based and tacit knowledge from key experts, front-line clinicians, and patients, which led to the development of new learning applicable to different clinical contexts to treat COVID-19.

Secondly, both evaluation and research were grounded in service need whereby clinical innovation drove the research agenda across CLNs. Notably, it was widely acknowledged by CLNs that transferable learning can be obtained from rapid service evaluation and not just formal research. Lastly, electronic media offered an unrealised opportunity in forming CLNs and then in disseminating learning. This was observed both in the formal use of new media e.g. Microsoft Teams and Zoom to facilitate organised meetings but also informally by the personal use of WhatsApp and Twitter by those with a shared interest. This can be a particularly effective mechanism for spreading learning at scale and pace across clinical specialities as demonstrated in case studies 1 & 2. Electronic media was most effective in CLNs which achieved a high level of trust amongst its members and those which had a clear collective commitment under a common purpose^{27,28}.

What worked well?

A key strength of CLNs was clinicians stepping up and focusing on a clinical priority that brought large numbers of multi-disciplinary experts together in a common cause as part of a shared community of purpose. As part of this community, it was important for those clinicians to be honest about the challenges they faced (and expected) when establishing relationships that grew organically as part of CLNs. For example, CLNs were proactive in getting the 'right' people (i.e. active practitioners and key leaders who were able to share current and lived experiences that are relevant and valuable to others involved) to share knowledge. In part, this may explain why CLNs that emerged during the pandemic were novel in their collaborative and hierarchical structures²⁹.

What also worked well was the engagement between applied health researchers and CLNs which was vital to the speed of knowledge dissemination, as generated by the networks³⁰. A key

component to achieving this engagement was the role of knowledge brokers i.e. people with hybrid professional roles who have membership across several CLNs and CoPs and facilitated interaction and co-ordination¹³.

As the pandemic progressed, regional NHS services provided leadership as part of joined up working with ARCs and AHSNs to support system wide service change. Such co-ordination was absent prior to the pandemic and the risk is that such collaborations will diminish as the health sector returns to business as usual. Yet, there are examples of good practice that go against this trend. The National Patient Safety Collaborative³³ has operated pre-pandemic with support from the AHSN network. The [Manchester Academic Health Science Centre](#) operates across regionally based research and innovation organisations to provide a Rapid Research Response Group³¹. Others evolved during the pandemic including the London Evaluation Cell³² that brought together the NHS Regional Team with three regional NIHR ARCs and three AHSNs to collectively agree pandemic related service changes prioritised for research grade evaluation. Importantly, none of these initiatives had central oversight.

What were the challenges?

First, there was an apparent lack of national planning for or co-ordination of real time clinical learning and service innovation at the onset of the pandemic. In parallel, there was no national plan to use existing administrative structures to support emerging clinical networks. All were initially hampered by the lack of a supportive infrastructure at national and regional level that may have provided access to clinical data, research organisations for rapid evaluation, and planned rather than opportunistic support from AHSNs. As a result none systematically incorporated patient and carer co-design and there was a lack of consideration of health inequities as key drivers, with case 2 being the exception. Many of the CLNs developed during the pandemic to address COVID-19 have now discontinued rather than continue with revised goals through lack of ongoing national or regional NHS support and direction³⁴.

Finally, there was a shortage of capable service evaluation staff who could support rapid evaluation of front-line innovation during the pandemic. The lack of national alignment of the NIHR infrastructure was a result of a pre-existing failure to systematically address the competing pressures from academic and policy worlds whilst many staff were deployed to respond to the national research agendas³⁵.

What barriers existed to shared learning and how were they overcome, where they were? Can we learn from experiences elsewhere?

Across our three cases we identified several barriers. Shared learning was largely limited to members of CLNs whereby disseminating learning in real-time to front-line practitioners took time and constant refinement to ensure messages were clear. Further, traditional dissemination strategies to share learning were paused e.g. suspension of conferences, roundtable discussions, and rapid peer review of academic publications. However, other much faster routes of dissemination were developed e.g. electronic media (WhatsApp, Twitter) as well as NIHR rapid evaluation teams working closely with CLNs to share formative feedback on findings using slide decks and online workshops. National alignment of CLNs with NICE when it occurred helped facilitate shared learning and dissemination but was limited as well as unsystematic.

The presence of organically developed CLNs during pandemic provided an opportunity for an alternative paradigm in knowledge generation linked to rapid implementation compared to the traditional generation of knowledge through research methodology. The NHS has run clinical networks previously and last made major policy changes to these in 2013³⁶; the year that AHSNs were established. The opportunity to formally link the two was however neglected. These previous iterations established effective knowledge sharing, but their impact on bottom-up service transformation was ultimately diminished by top-down government demands³⁷ and an absence of a formal implementation partner. NHS clinical networks lacked the linkage to the academic research and evaluation community and ultimately relevant and contemporary data so never meeting the criteria of a true clinical learning network.

In contrast there are examples of successful CLNs in other countries, including in the United States (100 000 lives)³⁸, Denmark (operation LIFE)³⁹, and Japan (Partners campaign)³⁹. These sought to design and construct a sustainable national learning network for improving health care whose usefulness outlives a time-bounded improvement initiative⁴⁰. Common to all were CLNs that support knowledge generation and exchange: the need to have clear aims and leadership alongside brokering relationships with a range of stakeholders, rapid dissemination of learning to frontline practitioners using web-based applications, and encouraging critique and reflection⁴⁰.

Nationally, common interests broke down silos between specialties and across secondary and primary care. Supported by regional structures including the AHSNs and NHS Regional Offices, CoPs were empowered to develop and deliver innovations at scale and pace with an emphasis on learning from each other in close to real time so forming clinical learning networks. Relationships developed with the research community that highlighted the need for rapid evidence generation through evaluation and research so binding clinicians and academics to an aligned purpose. Most importantly, collaborative knowledge production and mobilisation, as part of CLNs, during a

pandemic required health system improvisation and collective leadership to drive forward an agenda in the absence of evidence.

However there also remains a tension between promulgating 'best practice' prior to robust evidence being available which could result in implementing a clinical practice later proven to be ineffective or harmful. Determining what is 'good enough' evidence to support 'best practice' is an on-going challenge: whether clinicians believe available evidence is sufficiently reliable and relevant to support service change and if further, more robust evidence will be generated. There is a need for a collaborative relationship between CLNs with academics to undertake evaluation rapidly but also to provide research evidence in a format that supports the implementation of evidence into practice. We suggest that alignment of rapid evaluation and applied health research generated by CLNs is essential in creating CLNs based on robust evidence addressing relevant questions for the NHS (e.g. impact on workforce and workflow) so optimising translation at scale and pace.

This approach has been used successfully overseas with strategic partnerships between academic researchers and clinical services such as the United States Veterans Administration's Office of Research & Development⁴¹ and Kaiser Permanente's Health Research Institute⁴². Others have embedded academic researchers within the health system³ to promote research priorities driven by the needs of the health system. Yet, to promote an effective clinician-academic alliance, change is also required throughout the academic research system. A recent analysis of UK research showed that half of all funding is spent on 'underpinning' (understanding normal biological, psychological and socioeconomic processes which forms the basis for subsequent research) and 'aetiology' (the risks, causes and development of disease)⁴³. In comparison just 5.6% of funds were allocated to health service research⁴³ which is further compounded by the very limited capacity within NHS non-research budgets for evaluation.

A summary of the questions we pose for the English government's inquiry into the COVID-19 pandemic are summarised in Box 1., aligned with the COVID-19 Inquiry Terms of Reference⁴⁴.

Box 1. Questions for the COVID-19 inquiry

- Did the national government have adequate plans to support and evaluate the innovation (both clinical and service) required of the NHS during the first phase of the pandemic?
- Should there be a national repository of all NHS service evaluation supported by national funders (such as NIHR) working with ARCs, AHSNs as well as independent university/academic research?
- How should evaluation of NHS large scale expenditure programmes be funded?

- What infrastructure is necessary to integrate research and services, to ensure rapid evaluation of service innovation takes place?
- In what ways can capacity be increased for the NHS to undertake its own local evaluations and what are the appropriate structures to support this?
- How can a system be developed across the NHS for the rapid dissemination of new learning during events such as a pandemic?

So what is the opportunity for the future? Learning from the pandemic experience, government funding bodies, including the NHS and NIHR, can recognise the potential to align clinical communities with evaluation, research and implementation resources to establish clinical learning networks. Linking multi-professional clinical communities, working with patients and carers, into existing regional and national infrastructure can create an effective change system. What evolved from the experience in England were learning networks driven by clinical need, incorporating clinician experience supported by a range of knowledge production methods, and implemented at scale and pace using new media and support from regional NHS funded structures. Decisive leadership from those who commission AHSNs, ARCs and other regional support structures, to ensure alignment, is now required if we are not to lose the learning of the value of working as a collaborative system.

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References

1. McCannon CJ, Perla RJ. Learning networks for sustainable, large scale improvement. *The Joint Commission on Accreditation of Healthcare Organizations* 2009;35:286-291.
2. Conway PH, Clancy C. Transformation of health care at the front line. *JAMA* 2009;301:763-765.
3. Carley S, Horner D, Body R, et al. Evidence-based medicine and COVID-19: what to believe and when to change. *EMJ* 2020;37:572-575.
4. Charles A & Ewbank L, 2021, The road to renewal: five priorities for health and care, King's Fund, <https://www.kingsfund.org.uk/publications/covid-19-road-renewal-health-and-care> , [Accessed 3 Nov 2021]
5. Williams I, Essue B, Nouvet E, et al. Priority setting during the COVID-19 pandemic: going beyond vaccines, *BMJ Glob Health* 2021;6:e004686.
6. Wenger, E (2010) Communities of Practice and social learning systems: The career of a concept. In: Blackmore, C (ed.) *Social Learning Systems and Communities of Practice*. London: Springer Verlag and the Open University, 179–198.
7. Wenger EC, Snyder WM. Communities of practice: the organizational frontier. *Harvard Bus Rev*. 2000, 78: 139.
8. le May A: *Introducing communities of practice. Communities of practice in health and social care*. Edited by: le May A. 2009, Wiley-Blackwell, 3-16.
9. Li LC, Grimshaw JM, Nielsen C, Judd M, Coyte PC, Graham ID: Evolution of Wenger's concept of community of practice. *Implement Sci*. 2009, 4.
10. Ranmuthugala, G., Plumb, J.J., Cunningham, F.C. et al. How and why are communities of practice established in the healthcare sector? A systematic review of the literature. *BMC Health Serv Res* 11, 273 (2011). <https://doi.org/10.1186/1472-6963-11-273>
11. Bibby J. Using clinical communities to improve quality: Ten lessons for getting the clinical community approach to work in practice. The Health Foundation. <file:///C:/Users/sidhums/Downloads/UsingClinicalCommunitiesToImproveQuality.pdf> [Accessed 30 May 2022].
12. Gabbay J, le May A. *Practice-Based evidence for healthcare: clinical mindlines*. London: Routledge, 2011.
13. Kislov, R., Harvey, G. & Walshe, K. Collaborations for Leadership in Applied Health Research and Care: lessons from the theory of communities of practice. *Implementation Sci* 6, 64 (2011). <https://doi.org/10.1186/1748-5908-6-64>
14. C Friedman, J Rubin, J Brown, et al. Toward a science of learning systems: a research agenda for the high-functioning Learning Health System, *Journal of the American Medical Informatics Association*, Volume 22, Issue 1, January 2015, Pages 43–50, <https://doi.org/10.1136/amiajnl-2014-002977>
15. Bertone, M.P., Meessen, B., Clarysse, G. et al. Assessing communities of practice in health policy: a conceptual framework as a first step towards empirical research. *Health Res Policy Sys* 11, 39 (2013). <https://doi.org/10.1186/1478-4505-11-39>
16. Tobin MJ, Jubran A & Laghi L. Noninvasive strategies in COVID-19: epistemology, randomised trials, guidelines, physiology, *Eur Respir J* Feb 2021, 57 (2) 2004247; DOI: 10.1183/13993003.04247-2020.
17. Montgomery M, Rehill N, Camporota L, et al. COVID-19: UK frontline intensivists' emerging learning. *Journal of the Intensive Care Society*. 2021 Aug;22(3):211-213. doi: 10.1177/1751143720931731.Epub 2020 Jun 12.

18. Greenhalgh T, Knight M, Inada-Kim M, et al. Remote management of covid-19 using home pulse oximetry and virtual ward support *BMJ* 2021; 372 :n677 doi:10.1136/bmj.n677
19. Vindrola-Padros, C, Singh, K, Sidhu, et al. NJ 2021, 'Remote home monitoring (virtual wards) for confirmed or suspected COVID-19 patients: a rapid systematic review', *EClinicalMedicine*, vol. 37, 100965. <https://doi.org/10.1016/j.eclinm.2021.100965>
20. Vindrola-Padros C, Sidhu M, Georghiou T, et al. N 2021, 'The implementation of remote home monitoring models during the COVID-19 pandemic in England', *EClinicalMedicine*, vol. 34, 100799. <https://doi.org/10.1016/j.eclinm.2021.100799>
21. Georghiou, T, Sherlaw-Johnson, C, Massou, E, Morris, S, Crellin, N, Herlitz, L, Sidhu, M, Tomini, S, Vindrola-Padros, C, Walton, H & Fulop, N 2022, 'The impact of post-hospital remote monitoring of COVID-19 patients using pulse oximetry: a national observational study using hospital activity data', *EClinicalMedicine*, vol. 48, 101441. <https://doi.org/10.1016/j.eclinm.2022.101441>
22. Sherlaw-Johnson, C, Georghiou, T, Morris, S, Crellin, N, Litchfield, I, Massou, E, Sidhu, M, Tomini, S, Vindrola-Padros, C, Watson, H & Fulop, N 2022, 'The impact of remote home monitoring of people with COVID-19 using pulse oximetry: a national population and observational study', *EClinicalMedicine*, vol. 45, 101318. <https://doi.org/10.1016/j.eclinm.2022.101318>
23. NHS England & Improvement, COVID Oximetry @home programme, <https://www.england.nhs.uk/nhs-at-home/covid-oximetry-at-home/> [Accessed 21st November 2021]
24. British Association of Stroke Physicians, Adapting stroke services during the COVID-19 pandemic: An implementation guide- Resource Hub, <https://www.basp.org/supporting-stroke-services-during-the-covid-19-pandemic/adapting-stroke-services/resource-hub/> [Accessed 3 Nov 2021]
25. Ford GA, Hargroves D, Lowe D, et al. Restoration and recovery of stroke services during the COVID-19 pandemic, 2020, Getting It Right First Time (GRIFT) and Oxford Academic Health Science Network (AHSN) <https://www.oxfordahsn.org/wp-content/uploads/2020/07/Restoration-and-recovery-of-stroke-services-during-the-COVID-19-pandemic-July-2020-1.pdf> [Accessed 25 Nov 2021]
26. Ramsay A, Ledger J, Tomini SM, et al. Pre-hospital specialist triage of potential stroke patients using digital technology: A rapid service evaluation to capture learning and impact of innovations prompted by the COVID-19 pandemic <https://www.nuffieldtrust.org.uk/project/pre-hospital-specialist-triage-of-potential-stroke-patients-using-digital-technology> [Accessed 25 Nov 2021]
27. Wenger E, McDermott R, Snyder WM: *Cultivating Communities of Practice: A Guide to Managing Knowledge*. Boston, MA: Harvard Business School Press; 2002.
28. Le May A: *Communities of Practice in Health and Social Care*. Oxford, UK: Wiley-Blackwell; 2009.
29. Kerno SJ. Limitations of communities of practice: a consideration of unresolved issues and difficulties in the approach. *J Leadership Organ Studies* 2008, 15:69–78
30. Lamont T, Barber N, de Pury J, et al. Beyond the ivory tower: New approaches to evaluating complex health and care systems. *BMJ* 2016; 352:i154.
31. Health Innovation Manchester. COVID-19: Research to address the pandemic: Manchester's COVID-19 research rapid response group. <https://healthinnovationmanchester.com/our-work/covid-19-research-rapid-response-group/> [Accessed 1 June 2022]
32. Rehill N, Stevenson F & Rojas-Garcia A. The London Evaluation Cell: Uniting clinical and academic leaders across London to evaluate changes in care, NIHR ARC North Thames,

- <https://www.arc-nt.nihr.ac.uk/research/projects/the-london-evaluation-cell/> , [Accessed 3 Nov 2021]
33. NHS England & Improvement, National Patient Safety Programmes, <https://www.england.nhs.uk/patient-safety/patient-safety-improvement-programmes/> [Accessed 26 Jul 2022]
 34. Kern SJ. Limitations of communities of practice: a consideration of unresolved issues and difficulties in the approach. *J Leadership Organ Studies* 2008, 15:69–78
 35. Graham ID, McCutcheon C & Kothari A. Exploring the frontiers of research co-production: the Integrated Knowledge Translation Research Network concept papers. *Health Res Policy Sys* 17, 88 (2019). <https://doi.org/10.1186/s12961-019-0501-7>
 36. NHS Commissioning Board. Strategic clinical network single operating framework. Nov 2012 <https://www.england.nhs.uk/wp-content/uploads/2012/11/scn-sof.pdf> [accessed 7 Jan 2022]
 37. Addicott R, McGivern G & Ferlie E. The distortion of managerial Technique? The case of clinical networks in UK Health Care. *Br J Management* 2007 18:93-105.
 38. McCannon C.J., et al.: Saving 100,000 lives in US hospitals. *BMJ*. 332:1328–1330, Jun. 3, 2006
 39. McCannon C.J., Schall M.W., Perla R.J. Planning for Scale: A Guide for Designing Large-Scale Improvement Initiatives. IHI Innovation Series white paper. Cambridge, MA: Institute for Healthcare Improvement, 2008.
<http://www.ihio.org/IHI/Results/WhitePapers/PlanningforScaleWhitePaper.htm> [last accessed 8 August 2022].
 40. McCannon, C. Joseph, and Rocco J. Perla. "Learning networks for sustainable, large-scale improvement." *Joint Commission journal on quality and patient safety* 35.5 (2009): 286-291.
 41. US Department of Veteran Affairs, Office of Research and Development, <https://www.research.va.gov/default.cfm>, [Accessed 3 Nov 2021]
 42. Kaiser Permanente Washington Health Institute, <https://www.kpwashingtongresearch.org/> , [Accessed 3 Nov 2021]
 43. UK Clinical Research Collaboration on behalf of the Medical Research Council, UK Health Research Analysis, 2018, <https://hrcsonline.net/reports/analysis-reports/uk-health-research-analysis-2018> [Accessed 3 Nov 2021]
 44. Covid-19 Inquiry Terms of Reference, <https://covid19.public-inquiry.uk/wp-content/uploads/2022/06/Covid-19-Inquiry-Terms-of-Reference-Final.pdf> [Accessed 26 Jul 2022]