Learning networks in the pandemic

Sidhu, Manni; Ford, Gary ; Fulop, Naomi; Roberts, Michael

[Link to publication on Research at Birmingham portal](#)

Analysis

Learning Networks in the pandemic:
Mobilising evidence for improvement

Manbinder S. Sidhu[1]
Gary A. Ford[2]
Naomi J. Fulop[3]
C. Michael Roberts[4]

[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

Word count: 2990 words
References: 44 references

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

39

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

44

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

48

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

53

54

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

60

61 **Conflicts of Interest**
62 *We have read and understood BMJ policy on declaration of interests and have the following interests*
63 *to declare. Note: where a competing interest exists that might disqualify an author from*
64 *contributing, it is wise to discuss it with a BMJ editor before writing the article.*
65 C Michael Roberts was previous managing Director of UCLPartners (August 2021).
66 Manbinder S Sidhu has no conflict of interest to declare.
67 Naomi J Fulop has the following interests: NIHR Senior Investigator, non-executive director of
68 Whittington Health NHS Trust and trustee of Health Services Research UK. She is a non-executive
69 director of the organisation COVID-19 Bereaved Families for Justice and has legal representation in
70 the UK COVID-19 Inquiry.
71 Gary A Ford the following interests: Personal financial interest: Non-Executive Director NICE Board,
72 CSL Behring consultancy stroke trial design. Personal non-financial interest: Trustee Picker Institute;
73 NIHR Strategy Board member; Health Services Research UK Trustee; Accelerated Access
74 Collaborative Board member; Chair Pfizer/Bristol Myers Squibb independent atrial fibrillation
75 detection improvement grants panel; Chair Cardiovascular Healthcare Systems Strategic Forum,
76 Novartis funded; Bristol Myers Squibb/PwC Life Sciences 2030 Cancer Moonshot Roundtable; He is
77 Chief Executive Officer of the Oxford Academic Health Science Network, which has multiple joint
78 working agreements and medical education grants with industry partners that are contracts with
79 Oxford University Hospitals NHS Trust the host organisation for the Oxford AHSN.

80

81 **Licence**
82 The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of
83 all authors, an exclusive licence (or non-exclusive for government employees) on a worldwide basis
84 to the BMJ Publishing Group Ltd ("BMJ"), and its Licensees to permit this article (if accepted) to be
85 published in The BMJ's editions and any other BMJ products and to exploit all subsidiary rights, as
86 set out in The BMJ's licence.

87

88

3

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.

101 **Introduction**

102 The challenges of embedding a range of evidence into practice are well known in relation to clinical

103 practice, service organisation, and delivery. Less discussed is an effective mechanism to both

104 generate and implement evidence rapidly into clinical practice at scale. The COVID-19 pandemic

105 presented a unique challenge where clinical practice needed to develop and spread 'emerging novel

106 practice' to both manage COVID-19 patients in the absence of research evidence and adapt existing

107 models of care that were safe for non-COVID-19 patients.

108 In this paper we discuss how clinicians and researchers came together organically to develop

109 learning networks, in the absence of national or regional co-ordination. We narrate how these

110 networks came to share evidence. At the onset of the pandemic this was reliant on personal

111 relationships and individual leadership but was eventually supported by regional and national NHS

112 systems to facilitate evaluation. We describe three cases where clinically led innovation generated

113 communities of practice which evolved into 'clinical learning networks (CLN)'[1,2] and produced rapid

114 change at scale to meet the needs of the health system.

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

116 **pandemic**

117 COVID-19 was a new disease and in the absence of specific evidence-based guidance for treatment.

118 Clinicians initially extrapolated from existing evidence of other viral respiratory diseases, but it

119 became rapidly clear previous guidance on SARS-2 infections lacked understanding of the

120 complexities of COVID-19. In this evidence vacuum, clinicians began to share emerging knowledge

121 nationally and then internationally in real time[3].

122 UK Research funders responded to the pandemic by mobilising rolling rapid research calls from

123 February 2020. In parallel, several national and regional groups emerged to develop innovations in

124 practice during the early stages of the pandemic[4, 5]. Such collaborations `of shared purpose' are

125 described as communities of practice (CoP)[6]. CoPs provide a mechanism for those working across

126 health services to share tacit knowledge leading to innovative practice and new learning based on a

127 common interest[7,8]. CoPs move beyond the acquisition of knowledge and centre on three key

128 domains: 1) joint enterprise (what it is about); mutual engagement (the interactions that lead to the

129 shared meaning); and a shared repertoire (of resources such as techniques, tools, experiences or

130 process and practice)[9-11]. CoPs allow people to come together to solve complex problems with

131 common goals using knowledge-in-practice-in-context mechanisms, and support for formal and

132 informal interaction between members with resultant learning and knowledge sharing[12,13].

133   A key characteristic of CoPs is the facilitation of communication amongst individuals across networks

134   to promote the uptake of new knowledge in health care settings[9]. We argue this key characteristic

135   forms the essential element of a CLN that can support clinicians with knowledge generation

136   processes and decision-making. Defined elements of a CLN are 1) the structured exchange of

137   information and learning, with members 2) the sharing of practical insights of adaption and adoption

138   of evidence-based protocols, and 3) using innovation to overcome deficiencies in care[1,6,7].

139   During the early pandemic there were no evidence-based protocols, or national data sharing to front

140   line staff nor a national programme of innovative service evaluation. What ensued was a model that

141   shared knowledge of "what works best" back to clinicians in real-time in the absence of robust data

142   or research evidence[14]. As the pandemic unfolded these networks were supported, to incorporate

143   data and emerging evidence whilst also generating new evidence, through partnerships with

144   Academic Health Science Networks (AHSNs), NHS Regional Offices, National Institute for Health

145   Research (NIHR) Applied Research Collaboratives (ARCs) and Rapid Research and Evaluation centres.

146   **Learning from new care models during the COVID-19 pandemic**

147   In the following section we refer to examples of new care models and draw out lessons on their

148   approach. We have used a conceptual framework developed by Bertone et al. [15] to assess the

149   impact of CoPs and CLNs.

150   *Case 1: An ICU clinical learning network, that drew in medical specialties, generating real time*

151   *knowledge changing practice across continents*

152   In March 2020, robust evidence from randomised controlled trials regarding ICU management of

153   COVID-19 was lacking[16]. As a pragmatic response, clinicians applied National Institute for Clinical

154   Evidence (NICE) guidance for management of acute respiratory distress syndrome, but adoption was

155   associated with high mortality. The Intensive Care Society (ICSo) approached UCLPartners, an

156   academic health science system including an AHSN, to form a collaboration to share emerging

157   clinical experience (e.g. insights from key experts, front line key workers, and patients) between

158   intensivists across the UK. A weekly series of webinars for ICS members was established at which

159   emerging experience was shared including the value of proning and the early recognition of

160   thromboembolic disease.[17] The sessions were recorded, and thematic analysis was undertaken by

161   the AHSN team. Within 24 hours analyses were distributed via email to ICS members. Applied health

162   researchers (NIHR North Thames ARC) supported the group with evidence searches of rapid

163   publication trial data where relevant. Within the first week members had begun to disseminate the

164   summary, via multiple media channels to over 5000 intensivists worldwide. As this shared learning

165 revealed COVID-19 to be a multisystem disease, experts in renal medicine, haematology, respiratory

166 and cardiology were drawn into the learning network.

167

168 *Case 2: Development of national remote home monitoring using pulse oximetry of COVID-19 patients*

169 *using shared learning and research evaluation*

170

171 This was an example where there was greater alignment of national and regional NHS and NIHR

172 resources to evaluate and to spread practice at scale and pace. This evaluation, completed in two

173 months by the two NIHR rapid evaluation teams (Rapid Service Evaluation Team (RSET) and

174 Birmingham, RAND, And Cambridge Evaluation (BRACE) Centre), provided evidence of how remote

175 home monitoring models (also referred to as *virtual wards*) were implemented during the first

176 wave[18], together with a rapid systematic review[19] , provided lessons for preparation for the second

177 wave and the national roll out of these services[20-22]. Findings from the evaluation were rapidly

178 disseminated during autumn 2020 through networks which had been established to share best

179 practice, resources and learnings including the COVID-19 Oximetry Community of Practice Group,

180 the National Learning Network and its regional forum-based equivalents facilitated by AHSN Patient

181 Safety Collaboratives, supported by the NHS Futures Platform (a network of NHS staff who want to

182 connect with each other to accelerate their work). Some COPs were established from scratch while

183 others built on established networks such as the National Deterioration Forum, but all brought

184 together clinicians from primary, community and secondary care settings. As a result, a national roll

185 out of this programme across the whole of England was achieved within a matter of weeks in late

186 2020[23].

187 *Case 3: Adapting non-COVID pathways to the virtual first approach for transient ischaemic attack*

188 *(TIA) and stroke care*

189 In parallel, the consequence of researchers and clinicians pivoting to focus on managing the

190 pandemic had a significant impact (or lack of) on building the evidence for the provision of services

191 for non-COVID-19 health conditions. Oxford AHSN and programmes such as Getting It Right First

192 Time adopted a learning network approach rapidly producing guidance and resource hubs to

193 support clinicians and health system planners organise non-COVID-19 services during the pandemic

194 synthesising *available* evidence on remote evaluation and management of conditions along with

195 drawing on the early experiences of sites (e.g. guidance on the organisation of stroke and TIA

196 services)[24]. In some instances, this supported the rapid roll out of service models that had been

197 tested in a non-pandemic context e.g. remote assessment by senior clinicians of acute stroke for

198 reperfusion therapies[25]. In other instances, e.g. remote assessment of suspected TIA and stroke

199   more generally[25,26], recommendations were based on clinical experience and reasoning without

200   drawing upon a research evidence base as apparent in case studies 1 & 2.

201   **What can be learnt from the cases we present?**

202   The three cases described evolved differently but all show how CLNs established in the absence of

203   evidence and delivered change at pace when facilitated by an administrative infrastructure. CLNs

204   also had the ability to bring together researchers, evaluative/academic organisations, and funders to

205   incorporate emerging evidence. Specifically, there were several mechanisms which enabled CLNs to

206   produce real time 'evidence' in the absence of robust methodological evaluation. First, CLNs

207   generated new learning through collaborative and interdisciplinary working. For example, gathering

208   both evidence-based and tacit knowledge from key experts, front-line clinicians, and patients, which

209   led to the development of new learning applicable to different clinical contexts to treat COVID-19.

210   Secondly, both evaluation and research were grounded in service need whereby clinical innovation

211   drove the research agenda across CLNs. Notably, it was widely acknowledged by CLNs that

212   transferable learning can be obtained from rapid service evaluation and not just formal research.

213   Lastly, electronic media offered an unrealised opportunity in forming CLNs and then in disseminating

214   learning. This was observed both in the formal use of new media e.g. Microsoft Teams and Zoom to

215   facilitate organised meetings but also informally by the personal use of WhatsApp and Twitter by

216   those with a shared interest. This can be a particularly effective mechanism for spreading learning at

217   scale and pace across clinical specialities as demonstrated in case studies 1 & 2. Electronic media

218   was most effective in CLNs which achieved a high level of trust amongst its members and those

219   which had a clear collective commitment under a common purpose[27,28].

220   **What worked well?**

221   A key strength of CLNs was clinicians stepping up and focusing on a clinical priority that brought

222   large numbers of multi-disciplinary experts together in a common cause as part of a shared

223   community of purpose. As part of this community, it was important for those clinicians to be honest

224   about the challenges they faced (and expected) when establishing relationships that grew

225   organically as part of CLNs. For example, CLNs were proactive in getting the 'right' people (i.e. active

226   practitioners and key leaders who were able to share current and lived experiences that are relevant

227   and valuable to others involved) to share knowledge. In part, this may explain why CLNs that

228   emerged during the pandemic were novel in their collaborative and hierarchical structures[29].

229   What also worked well was the engagement between applied health researchers and CLNs which

230   was vital to the speed of knowledge dissemination, as generated by the networks[30]. A key

231 component to achieving this engagement was the role of knowledge brokers i.e. people with hybrid

232 professional roles who have membership across several CLNs and CoPs and facilitated interaction

233 and co-ordination[13].

234 As the pandemic progressed, regional NHS services provided leadership as part of joined up working

235 with ARCs and AHSNs to support system wide service change. Such co-ordination was absent prior to

236 the pandemic and the risk is that such collaborations will diminish as the health sector returns to

237 business as usual. Yet, there are examples of good practice that go against this trend. The National

238 Patient Safety Collaborative[33] has operated pre-pandemic with support from the AHSN network. The

239 [Manchester Academic Health Science Centre](#) operates across regionally based research and

240 innovation organisations to provide a Rapid Research Response Group[31]. Others evolved during the

241 pandemic including the London Evaluation Cell[32] that brought together the NHS Regional Team with

242 three regional NIHR ARCs and three AHSNs to collectively agree pandemic related service changes

243 prioritised for research grade evaluation. Importantly, none of these initiatives had central oversight.

244 **What were the challenges?**

245 First, there was an apparent lack of national planning for or co-ordination of real time clinical

246 learning and service innovation at the onset of the pandemic. In parallel, there was no national plan

247 to use existing administrative structures to support emerging clinical networks. All were initially

248 hampered by the lack of a supportive infrastructure at national and regional level that may have

249 provided access to clinical data, research organisations for rapid evaluation, and planned rather than

250 opportunistic support from AHSNs. As a result none systematically incorporated patient and carer

251 co-design and there was a lack of consideration of health inequities as key drivers, with case 2 being

252 the exception. Many of the CLNs developed during the pandemic to address COVID-19 have now

253 discontinued rather than continue with revised goals through lack of ongoing national or regional

254 NHS support and direction[34].

255

256 Finally, there was a shortage of capable service evaluation staff who could support rapid evaluation

257 of front-line innovation during the pandemic. The lack of national alignment of the NIHR

258 infrastructure was a result of a pre-existing failure to systematically address the competing pressures

259 from academic and policy worlds whilst many staff were deployed to respond to the national

260 research agendas[35].

261

262 **What barriers existed to shared learning and how were they overcome, where they were? Can we**

263 **learn from experiences elsewhere?**

264 Across our three cases we identified several barriers. Shared learning was largely limited to

265 members of CLNs whereby disseminating learning in real-time to front-line practitioners took time

266 and constant refinement to ensure messages were clear. Further, traditional dissemination

267 strategies to share learning were paused e.g. suspension of conferences, roundtable discussions, and

268 rapid peer review of academic publications. However, other much faster routes of dissemination

269 were developed e.g. electronic media (WhatsApp, Twitter) as well as NIHR rapid evaluation teams

270 working closely with CLNs to share formative feedback on findings using slide decks and online

271 workshops. National alignment of CLNs with NICE when it occurred helped facilitate shared learning

272 and dissemination but was limited as well as unsystematic.

273 The presence of organically developed CLNs during pandemic provided an opportunity for an

274 alternative paradigm in knowledge generation linked to rapid implementation compared to the

275 traditional generation of knowledge through research methodology. The NHS has run clinical

276 networks previously and last made major policy changes to these in 2013[36]; the year that AHSNs

277 were established. The opportunity to formally link the two was however neglected. These previous

278 iterations established effective knowledge sharing, but their impact on bottom-up service

279 transformation was ultimately diminished by top-down government demands[37] and an absence of a

280 formal implementation partner. NHS clinical networks lacked the linkage to the academic research

281 and evaluation community and ultimately relevant and contemporary data so never meeting the

282 criteria of a true clinical learning network.

283 In contrast there are examples of successful CLNs in other countries, including in the United States

284 (100 000 lives)[38], Denmark (operation LIFE)[39], and Japan (Partners campaign)[39]. These sought to

285 design and construct a sustainable national learning network for improving health care whose

286 usefulness outlives a time-bounded improvement initiative[40]. Common to all were CLNs that support

287 knowledge generation and exchange: the need to have clear aims and leadership alongside

288 brokering relationships with a range of stakeholders, rapid dissemination of learning to frontline

289 practitioners using web-based applications, and encouraging critique and reflection[40].

290 Nationally, common interests broke down silos between specialties and across secondary and

291 primary care. Supported by regional structures including the AHSNs and NHS Regional Offices, CoPs

292 were empowered to develop and deliver innovations at scale and pace with an emphasis on learning

293 from each other in close to real time so forming clinical learning networks. Relationships developed

294 with the research community that highlighted the need for rapid evidence generation through

295 evaluation and research so binding clinicians and academics to an aligned purpose. Most

296 importantly, collaborative knowledge production and mobilisation, as part of CLNs, during a

297 pandemic required health system improvisation and collective leadership to drive forward an

298 agenda in the absence of evidence.

299 However there also remains a tension between promulgating 'best practice' prior to robust evidence

300 being available which could result in implementing a clinical practice later proven to be ineffective or

301 harmful. Determining what is 'good enough' evidence to support 'best practice' is an on-going

302 challenge: whether clinicians believe available evidence is sufficiently reliable and relevant to

303 support service change and if further, more robust evidence will be generated. There is a need for a

304 collaborative relationship between CLNs with academics to undertake evaluation rapidly but also to

305 provide research evidence in a format that supports the implementation of evidence into practice.

306 We suggest that alignment of rapid evaluation and applied health research generated by CLNs is

307 essential in creating CLNs based on robust evidence addressing relevant questions for the NHS (e.g.

308 impact on workforce and workflow) so optimising translation at scale and pace.

309 This approach has been used successfully overseas with strategic partnerships between academic

310 researchers and clinical services such as the United States Veterans Administration's Office of

311 Research & Development[41] and Kaiser Permanente's Health Research Institute[42]. Others have

312 embedded academic researchers within the health system[3] to promote research priorities driven by

313 the needs of the health system. Yet, to promote an effective clinician-academic alliance, change is

314 also required throughout the academic research system. A recent analysis of UK research showed

315 that half of all funding is spent on 'underpinning' (understanding normal biological, psychological

316 and socioeconomic processes which forms the basis for subsequent research) and 'aetiology' (the

317 risks, causes and development of disease)[43]. In comparison just 5.6% of funds were allocated to

318 health service research[43] which is further compounded by the very limited capacity within NHS non-

319 research budgets for evaluation.

320 A summary of the questions we pose for the English government's inquiry into the COVID-19

321 pandemic are summarised in Box 1., aligned with the COVID-19 Inquiry Terms of Reference[44].

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?

322

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

334

335

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 Jl* 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,

434 https://www.arc-nt.nihr.ac.uk/research/projects/the-london-evaluation-cell/ , [Accessed 3
435 Nov 2021]
436 33. NHS England & Improvement, National Patient Safety Programmes,
437   https://www.england.nhs.uk/patient-safety/patient-safety-improvement-programmes/
438   [Accessed 26 Jul 2022]
439 34. Kerno SJ. Limitations of communities of practice: a consideration of unresolved issues and
440   difficulties in the approach. J Leadership Organ Studies 2008, 15:69–78
441 35. Graham ID, McCutcheon C & Kothari A. Exploring the frontiers of research co-production:
442   the Integrated Knowledge Translation Research Network concept papers. *Health Res Policy*
443   *Sys* 17, 88 (2019). https://doi.org/10.1186/s12961-019-0501-7
444 36. NHS Commissioning Board. Strategic clinical network single operating framework. Nov 2012
445   https://www.england.nhs.uk/wp-content/uploads/2012/11/scn-sof.pdf [accessed 7 Jan
446   2022]
447 37. Addicott R, McGivern G & Ferlie E. The distortion of managerial Technique? The case of
448   clinical networks in UK Health Care. Br J Management 2007 18:93-105.
449 38. McCannon C.J., et al.: Saving 100,000 lives in US hospitals. BMJ. 332:1328–1330, Jun. 3, 2006
450 39. McCannon C.J., Schall M.W., Perla R.J. Planning for Scale: A Guide for Designing Large-Scale
451   Improvement Initiatives. IHI Innovation Series white paper. Cambridge, MA: Institute for
452   Healthcare Improvement, 2008.
453   http://www.ihi.org/IHI/Results/WhitePapers/PlanningforScaleWhitePaper.htm [last
454   accessed 8 August 2022].
455 40. McCannon, C. Joseph, and Rocco J. Perla. "Learning networks for sustainable, large-scale
456   improvement." Joint Commission journal on quality and patient safety 35.5 (2009): 286-291.
457 41. US Department of Veteran Affairs, Office of Research and Development,
458   https://www.research.va.gov/default.cfm, [Accessed 3 Nov 2021]
459 42. Kaiser Permanente Washington Health Institute, https://www.kpwashingtonresearch.org/ ,
460   [Accessed 3 Nov 2021]
461 43. UK Clinical Research Collaboration on behalf of the Medical Research Council, UK Health
462   Research Analysis, 2018, https://hrcsonline.net/reports/analysis-reports/uk-health-research-
463   analysis-2018 [Accessed 3 Nov 2021]
464 44. Covid-19 Inquiry Terms of Reference, https://covid19.public-inquiry.uk/wp-
465   content/uploads/2022/06/Covid-19-Inquiry-Terms-of-Reference-Final.pdf [Accessed 26 Jul
466   2022]
467
468
469
470
471
472
473
474