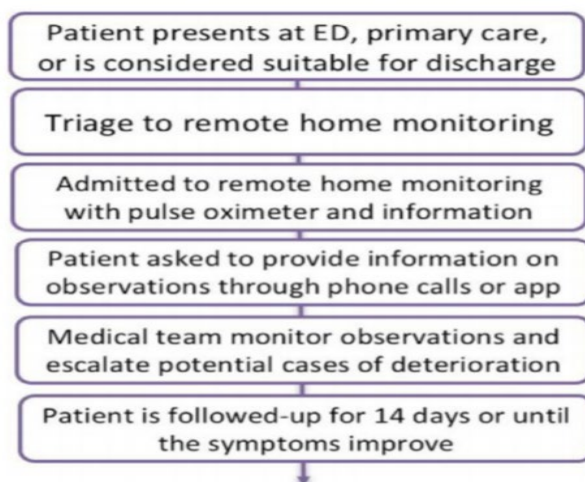# File 1: The study reported here is an extension to a concurrent evaluation of remote home monitoring models during the COVID-19 pandemic in England

In May 2020, the UK government released a COVID-19 care home support package which included a commitment from the NHS to support the introduction and use of key medical equipment, such as pulse oximeters, to enable remote monitoring of COVID-19 patients across primary and secondary care as well as within care homes, both independently and in collaboration [68]. A mixed-methods evaluation of remote home monitoring models including both pre-hospital and early discharge models has been undertaken by the BRACE and RSET NIHR rapid evaluation teams in two phases. Several outputs have been published including a rapid systematic review of remote home monitoring (virtual wards) during the COVID-19 pandemic and an analysis of the implementation of remote home monitoring models during the first wave of the pandemic [34, 35]. It should be noted the rapid systematic review and analysis of the implementation of remote home monitoring models during the first wave of the pandemic did not include care homes undertaking remote monitoring of residents. Therefore, learning from the mixed-methods evaluation helped identify a need for this rapid evaluation and shape research questions. An overview of phase two of the evaluation during the second wave of the pandemic is presented in Box 31.

A number of remote monitoring models of care using pulse oximetry, some of which were pre-hospital and others following early discharge from the hospital, were set up and implemented across primary and secondary care in England during the first wave of the COVID-19 pandemic in the first half of 2020, with many more being developed since the second wave of the pandemic in England in the winter of 2020/2021 [34]. Figure A demonstrates the main steps involved in these models.

Figure A. Main steps involved in remote home monitoring models [35].

Patient presents at ED, primary care, or is considered suitable for discharge

Triage to remote home monitoring

Admitted to remote home monitoring with pulse oximeter and information

Patient asked to provide information on observations through phone calls or app

Medical team monitor observations and escalate potential cases of deterioration

Patient is followed-up for 14 days or until the symptoms improve

Notably, remote home monitoring models for COVID-19 have been categorised by NHS England and Improvement into two distinct categories: COVID Oximetry @Home (November 2020) and COVID Virtual Wards led by primary and secondary care (January 2021). The key characteristics of each model are presented in Figure B) [69]. There are also a number of integrated (combination of primary and secondary led) models across England. By December 2020, 152 sites had been set up in England across primary care and secondary care. A recent study of remote home monitoring models operating during the first wave of the COVID-19 pandemic in England found a wide variety of service set-up processes for implementation across the country, with some pre-hospital models run by primary and secondary care teams working in partnership and some early discharge/step down models led by secondary care NHS Trusts[34].

Figure B. Description of COVID Oximetry @Home and COVID Virtual Wards [69].

	COVID Oximetry @home	COVID virtual ward
WHERE	Primary care supervised	Hospital supervised
WHO	Lower acuity/complexity	Higher acuity/complexity
WHEN	Community diagnosed patients	Emergency hospital patients
AIMS	**Safe admission avoidance**	**Early supported hospital discharge** **Safe admission avoidance**
HOW	Patient self-monitoring/escalation **Earlier deterioration presentation**	More intensive monitoring **Reliable deterioration recognition**
WHAT	Supportive treatments	+/- dexamethasone, low molecular weight heparin, oxygen

The COVID Oximetry @ Home and COVID Virtual Ward models run alongside other possible escalation services including contact with a GP, care homes, or community nursing teams as detailed in NHS standard operating procedure documents. Some general practices and Virtual Wards, either independently or as part of a Primary Care Network (i.e. with each Primary Care Network having a clinical lead for care homes in their area), have introduced the use of pulse oximetry to monitor care homes' residents and provided ongoing support and educational materials to care home staff to encourage the use of pulse oximetry[34].

Box 6. Description of the mixed methods evaluation by the RSET and BRACE rapid evaluation teams of remote home monitoring models during the COVID-19 pandemic in England

Background: Within this study we are studying both pre-hospital and early discharge models. Previous research has explored remote home monitoring for other conditions, but there is a lack of research on the effectiveness and implementation of remote home monitoring models for COVID-19. Social, political and socio-technical theoretical lenses will be used to inform this research project.

Aims and objectives:

1) Explore the effectiveness of COVID Oximetry @home (e.g. in relation to mortality and use of hospital services)
2) Assess the cost-effectiveness of implementing COVID Oximetry @home
3) Analyse processes of implementation of the COVID Oximetry @home service
4) Analyse patients' experiences of, and engagement with the COVID Oximetry @home service
5) Analyse staff' experiences of delivering and implementing COVID Oximetry @home

Methods:

To explore the effectiveness of COVID Oximetry @home, using routinely available data, management information summaries produced by the programme and hospital administrative data to estimate the impact of COVID Oximetry@home on hospitalisations and mortality, including the impact of tech-enabled oximetry.

To identify the costs of implementing COVID Oximetry @home, by conducting a cost analysis of implementing and running the service, and following up those who require treatment followed by a cost-effectiveness analysis to estimate the incremental cost per life saved and the incremental cost per quality-adjusted life year from using COVID Oximetry @home.

a) a national study and b) in-depth case studies. a) To conduct a national survey with patients and carers, and a national survey of staff in approximately 25 NHS sites. The national survey with patients and carers will explore their experiences of receiving COVID Oximetry @home and their engagement with the service. The national survey with staff will explore their experiences delivering COVID Oximetry @home. In addition, to explore different experiences of both three patients and staff with analogue vs digital models. Survey data will be analysed using descriptive statistics and univariate analyses.

b) For the in-depth case studies, to conduct one-to-one interviews with a purposive sample of patients and staff from 14 selected sites. The patient interviews will include patients' experiences of receiving COVID oximetry @home and the barriers and facilitators to engagement, or will explore reasons for withdrawal or declining COVID oximetry @home. In four sites, to ask some of the patients and staff who have used digital solutions to narrate the process of using the technology (think aloud methodology). The staff interviews will include providers' experiences of implementing and/or delivering COVID oximetry @home and the barriers and facilitators to delivery. We will rapidly analyse the data using Rapid Assessment Procedure (RAP) sheets.