Article:
Sinha, R, Aramburo, A, Deep, A et al. (13 more authors) (2021) Caring for critically ill adults in paediatric intensive care units in England during the COVID-19 pandemic: planning, implementation and lessons for the future. Archives of Disease in Childhood, 106 (6). pp. 548-557. ISSN 0003-9888

https://doi.org/10.1136/archdischild-2020-320962

Caring for critically ill adults in paediatric intensive care units in England during the COVID-19 pandemic: planning, implementation and lessons for the future

Ruchi Sinha[1], Angela Aramburo[2], Akash Deep[3], Emma-Jane Bould[4], Hannah Buckley[5,] Elizabeth Draper[6], Richard Feltbower[5], Rebecca Mitting[1], Sarah Mahoney[7], John Alexander[8], Stephen Playfor[9], Amy Chan-Dominy[2,10], Simon Nadel[1], Ganesh Suntharalingam[11,12], James Fraser[13,14], Padmanabhan Ramnarayan[1,14,15]

Affiliations:

1. Paediatric Intensive Care Unit, St Mary's Hospital, Imperial College Healthcare NHS Trust, London
2. Paediatric Intensive Care Unit, Royal Brompton and Harefield NHS Trust, London
3. Paediatric Intensive Care Unit, King's College Hospital NHS Foundation Trust, London
4. Paediatric Intensive Care Unit, Royal London Hospital, Barts Health NHS Trust, London
5. Paediatric Intensive Care Audit Network (PICANet), Leeds Institute for Data Analytics, University of Leeds, Leeds
6. Paediatric Intensive Care Audit Network (PICANet), Department of Health Sciences, University of Leicester, Leicester
7. Paediatric Intensive Care Unit, Alder Hey NHS Trust, Liverpool
8. Paediatric Intensive Care Unit, Royal Stoke Hospital, University Hospital of North Midlands, Stoke-on-Trent
9. Paediatric Intensive Care Unit, Royal Manchester Children's Hospital, Manchester
10. Adult Intensive Care Unit, Royal Brompton and Harefield NHS Trust, London
11. Adult Intensive Care Unit, North West London Hospitals NHS Trust, London
12. Intensive Care Society, London
13. Paediatric Intensive Care Unit, Bristol Children's Hospital, Bristol
14. Paediatric Intensive Care Society, London
15. Children's Acute Transport Service, Great Ormond Street Hospital NHS Foundation Trust and NIHR Biomedical Research Centre, London

Corresponding author:

Padmanabhan Ramnarayan

26-27 Boswell Street

London, WC1N 3JZ

Email: pramnarayan@nhs.net

Word count: Abstract (250 words); Main manuscript (2394 words)

Take Home message: *During the COVID-19 pandemic in England, many children's intensive care teams cared for critically ill adults. In this article, we describe the success of this experience and highlight valuable lessons learnt, including insights relevant to future waves of the pandemic.*

SUMMARY BOXES

Section 1: What is already known on this topic

- During the first wave of the COVID-19 pandemic in England, there was a significant demand for adult critical care beds.
- Surge critical care beds were created in theatres and recovery areas and respiratory wards, and in some parts of the country, in paediatric intensive care units.
- There is a lack of national data on the extent to which paediatric intensive care units were transformed to manage adult patients and how critical care services for children were maintained nationally.

Section 2: What this study adds

- Seven paediatric intensive care units in England repurposed their space, equipment and staff to care for 145 critically ill adults during the first wave of the pandemic.
- Modelling based on historic national clinical audit data was used to predict national demand for paediatric intensive care beds to maintain adequate provision for critically ill children in other units.
- Repurposed paediatric intensive care units cared for nearly 1 in 5 adults needing critical care within their own hospitals.

ABSTRACT

Objective: To describe the experience of paediatric intensive care units (PICUs) in England that repurposed their units, equipment and staff to care for critically ill adults during the first wave of the COVID-19 pandemic.

Design: Descriptive study.

Setting: Seven paediatric intensive care units (PICUs) in England.

Interventions: None.

Main outcome measures: 1) Modelling using historical Paediatric Intensive Care Audit Network (PICANet) data; 2) space, staff, equipment, clinical care, communication, and governance considerations during repurposing of PICUs; 3) characteristics, interventions and outcomes of adults cared for in repurposed PICUs.

Results: Seven English PICUs, accounting for 137 beds, repurposed their space, staff and equipment to admit critically ill adults. Neighbouring PICUs increased their bed capacity to maintain overall bed numbers for children, which was informed by historical data modelling (median 280-307 PICU beds were required in England from March to June). A total of 145 adult patients (median age 50-62 years) were cared for in repurposed PICUs (1553 bed-days). The vast majority of patients had COVID-19 (109/145, 75%); the majority required invasive ventilation (91/109, 85%). Nearly a third of patients (42/145, 29%) underwent a tracheostomy. Renal replacement therapy was provided in 20/145 (14%) patients. Twenty adults died in PICU (14%).

Conclusion: In a rapid and unprecedented effort during the first wave of the COVID-19 pandemic, seven PICUs in England were repurposed to care for adult patients. The success of this effort was underpinned by extensive local preparation, close collaboration with adult intensivists and careful national planning to safeguard paediatric critical care capacity.

INTRODUCTION

On March 11th 2020, the World Health Organisation (WHO) declared the Coronavirus disease-2019 (COVID-19) outbreak a pandemic (1). Experience from China and Italy indicated that 98% of all infections were in adults, and at least 5% of infected adults required critical care admission. Only 2% of infections were in children, of whom just 1-2% required paediatric intensive care unit (PICU) admission (2-5).

National and international modelling together with early clinical experience, indicated that the demand for adult intensive care unit (AICU) beds during the pandemic was likely to rapidly outstrip bed capacity several-fold (6-9). Increasing AICU surge capacity during pandemics and other mass-casualty disasters has been the subject of much discussion (10-12). Since there are far fewer critical care beds for children than for adults, the use of AICU beds for critically ill/injured children has been an important consideration in pandemic plans (including during the H1N1 influenza pandemic in 2009), whereas the opposite scenario (utilisation of PICU beds for critically ill adults) has not featured heavily (13, 14).

In England, paediatric intensive care is a centralised, nationally commissioned service, comprising PICUs based in tertiary hospitals and associated specialist retrieval teams (15). Prior to the COVID-19 pandemic, there were 312 PICU beds in 22 hospitals (2.7 beds per 100,000 children aged <18 years), compared to 4,123 AICU beds in over 150 hospitals (9 beds per 100,000 adults) (16, 17). English PICUs admit around 15,000 children each year, nearly 10,000 of them being unplanned admissions (18). Importantly, demand for PICU beds follows a seasonal pattern, with a 30% increase in unplanned respiratory admissions over winter (19). While many PICUs supported adult critical care expansion through loan of space and equipment during the COVID-19 pandemic, single-centre reports from Europe and the United States (US) describe how they repurposed their entire PICUs, including staff, to care for critically ill adults (20, 21); however, there is a dearth of national data on this topic.

The National Health Service (NHS) declared a Level 4 incident in early March 2020 (22). Plans to rapidly increase AICU bed capacity were implemented initially by cancelling elective surgery, then creation of additional critical care beds outside AICU areas through step-wise escalation - high dependency units, operating theatres and recovery areas, followed by other acute wards and finally, the newly built Nightingale hospitals (23, 24). Since surge planning occurred at a regional and individual hospital level, plans to utilise PICU beds to care for adult patients featured in some regions and not in others. In this article, we describe how seven PICUs in England repurposed their units, equipment and staff to look after adult patients during the first wave of the COVID-19 pandemic; how regional and national level planning maintained overall PICU bed capacity for critically ill children; the characteristics, interventions and outcomes of adult patients cared for in repurposed PICUs; and lessons learnt for future waves of the pandemic.

METHODS

NATIONAL PLANNING

Paediatric intensive care has a limited number of units configured in long-established 'hub-and-spoke' networks with dedicated transport teams (25). To support adult critical care demands on paediatric critical care, the UK Paediatric Intensive Care Society (PICS) co-ordinated national planning and support for all PICUs through: a) weekly web conferences for clinicians from individual PICUs to jointly discuss their bed capacity and regional surge arrangements, allowing for a 'birds-eye' view of national PICU capacity; and b) rapid national clinical guidance to cover various 'hot' topics relevant to these clinical teams.

MODELLING PICU DEMAND

If some PICUs were being repurposed to care for adults, plans for maintaining adequate capacity for critically ill children in England crucially depended on estimation of anticipated demand for PICU beds at a regional and national level. In late March 2020, we analysed routine audit data from the Paediatric Intensive Care Audit Network (PICANet) database, a high-quality clinical database to which all UK PICUs submit data, to estimate the average (and minimum) demand for PICU beds nationally and regionally in England from March through to June. Historical data from November 2018 to June 2019 were used for modelling. Since over 60% of PICU admissions are unplanned, and even planned admissions for major complex surgery (e.g. congenital heart disease) cannot safely be postponed for longer than a few weeks, 500 scenarios were simulated for each month and region with 10% of planned admissions randomly removed without replacement. Summary statistics for the number of bed days estimated to be required should 10% of planned workload be removed for each month in 2019-2020 were then calculated at regional level based on these simulated datasets.

REPURPOSING PICU

In line with recent guidance (26-28) the challenges for the repurposed units were broadly categorised into: space, staff, equipment, clinical care, communication and governance. Details regarding how PICUs were repurposed along these principles, as well as how they were adapted to local requirements, were collected from the individual units. Repurposed PICUs also collected data on the clinical characteristics, interventions performed and outcomes of adults cared for in their units, as well as numbers of children cared for at the same time (if any) and transfers out of children from their hospital to other PICUs. Summary data was pooled by the lead author from all units for descriptive analysis.

ETHICS

Since only the treating teams were involved in data collection, and only anonymised aggregated data were pooled for central analysis, ethics committee approval was not required.

RESULTS

From 19 March to 2 June 2020, 13 national web conferences were organised by PICS, with representation from all PICUs in England. In anticipation of significant demand for adult critical

care beds, PICS and their adult counterpart, the ICS, published a joint position statement in early March supporting the flexible use of PICU beds for specific cohorts of young adults (29). However, it became rapidly obvious that the majority of critically ill adults were older than 40 years, therefore significant redeployment of PICU staff and equipment to adult ICUs was needed to support critical care expansion (30).

Data modelling

Figure 1 shows the seasonal demand for PICU beds in the UK, with the number of unplanned admissions lowest in summer, followed by a 20% rise in demand over winter. In Table 1, the mean and median bed activity data for each region in the UK is summarised by month covering the period from November 2018 to June 2019. The median bed activity in the pandemic months (March-June) in England was estimated from historical data to be 280 to 307, with a minimum of 251 beds. These numbers accounted for the cancellation of planned surgery. The median bed activity in winter months was estimated to be a median of 310 to 338, with a minimum estimate of 266. The COVID-19 pandemic occurred during spring/summer months, when demand for unplanned admissions to PICU was nearly 20% lower than in winter months.

Repurposing PICUs

Seven PICUs in England admitted critically ill adults to their fully repurposed units. As shown in Tables 2a and b, they accounted for a total of 83 PICU and 54 high-dependency care beds prior to the pandemic. Staff redeployment affected almost all UK PICUs; however, the choices around whether to maintain familiarity (keeping the teams together in their usual environment), or to redeploy staff to help adult services, involved making complex decisions at a time of great stress, and these seven units chose to keep their teams together in their usual environment. In most cases, staff had never been trained to care for adults or had not looked after adults for many years.

Considerations during repurposing included:1) Space: The re-organisation of the physical PICU space to identify “green” and “red” areas with donning and doffing facilities for personal protective equipment (PPE).

2) Staffing (skills): The rapid credentialing of paediatric-trained staff to identify those with recent ICU experience, redeployment and training on the basics of management of critically ill adults (including those with COVID-19), via remote, face-to-face and simulated educational sessions.

3) Staffing models: The overhaul of medical and nursing rotas to provide for additional layers of cover in the context of COVID-19 related illness and/or quarantine requirements. Some units needed to rapidly implement full shift, resident consultant rotas.

4) Equipment: The re-stocking of storerooms with adult appropriate equipment such as renal replacement filters, endotracheal tubes, intravenous access catheters and pharmacy stores. Many units needed both adult and paediatric resuscitation and difficult airway trolleys that were easily distinguishable.

5) Clinical care: The development of adult-specific clinical guidance, including bespoke checklists, quick guides and common drug doses. These were rapidly disseminated and frequently updated as new guidance emerged via critical care networks and the Intensive Care Society (ICS). Regular multidisciplinary team (MDT) meetings with adult medical and critical care colleagues, pharmacists, and allied healthcare professionals supported patient flow, clinical decision making, and dealing with resource limitations. Task specific teams were developed to streamline workload in ICU areas (31).

6) Communication: Information and technology resources including bedside webcams, hand-held devices for point-of-care ultrasound and professional online collaboration platforms such as Microsoft Teams were used to aid communication with families and within clinical teams.

7) Governance: A Joint Statement from Statutory Regulators of Heath and Care Professionals provided some reassurance to the paediatric nurses and doctors that working cooperatively with adult specialists and using the best available evidence in these challenging circumstances was acceptable to their respective regulatory bodies (32).

Tables 3a and b summarise how the above challenges were approached by each PICU. Although all seven units broadly adopted similar processes within a short time frame to meet the challenges of accommodating adult patients, local factors also played an important role in determining how beds were configured. Some PICUs needed to ring-fence a few PICU beds for highly specialised paediatric services such as liver transplant and trauma/neurosurgery, and for children presenting to their own emergency department or those acutely deteriorating on the paediatric wards. Hence in all but 2 units a small number of critically ill children were cared for alongside critically ill adults. PICU staff usually managed adult patients in close consultation with AICU teams, although frontline-staffing models varied.

Table 4 shows the numbers of adult patients cared for by the seven PICUs. Overall, 145 critically ill adults were cared for in these PICUs, accounting for a total of 1553 bed-days. Notably, the 6 PICUs that were co-located with AICUs admitted nearly 1 out of 5 adults cared for in those hospitals. Overall mortality on PICU was 14%. Table 4 also shows how many children were cared for in the same period in these PICUs. One PICU retrieval team in London set up an additional team staffed by paediatric anaesthetists to undertake 12 inter-hospital transfers of adult COVID-19 patients during the peak of the surge.

Other PICUs followed different models: stand-alone children's hospitals increased their capacity to absorb critically ill children diverted from repurposed units, some PICUs relocated to other wards to give up their space and equipment for adults, and others adopted a hybrid approach, admitting both paediatric and adult patients. PICU retrieval teams decanted existing paediatric inpatients from PICUs repurposed for adults, including those on advanced life support such as extra-corporeal membrane oxygenation (ECMO), and over the ensuing weeks, functioned in a co-ordinated fashion to divert emergency admissions to 'ring-fenced' PICU beds in other units.

DISCUSSION

Many lessons were learnt by the PICU community in England as a result of this extraordinary healthcare response to the COVID-19 pandemic. This transformation into adult ICUs was based on well-described principles (28, 30) applied to local requirements, allowing a proportion of adult critical care demand to be met by PICU teams alone, either by repurposing entire PICUs or by maintaining a hybrid model where adults and children were cared for on the same unit. We found that paediatric teams can deliver excellent care to adults with outcomes comparable to adult ICUs as long as there is strong leadership and effective communication. These PICU teams were performing interventions such as adult cardiopulmonary resuscitation, treating unfamiliar conditions such as fast atrial fibrillation or pulmonary embolism, and prescribing unfamiliar medications. The physical size of the patients, as well as the fact that they needed to be proned for prolonged periods of time, also introduced new challenges (33). Extended lengths of stay and the slow pace of recovery in adults with COVID-19 were in stark contrast to the short length of stay seen in critically ill children in general (median length of PICU stay 3.2 days). Mortality in adults with COVID-19 was also much higher compared to the usual PICU patients (14% versus 5.1%) (18, 34). Supporting staff wellbeing in the face of these challenges was crucial in maintaining team morale and achieving optimal outcomes. Particularly challenging was looking after children as well as adults on the same unit, necessitating a frequent reset of mental models of care.

Our modelling demonstrated that compared to March/April, an additional 20-25% PICU capacity is required in November/December to satisfy winter demand for emergency paediatric admissions in England. Plans for adult critical care expansion in case of future COVID-19 waves need to take this into account – each year, PICU's "winter surge" is managed by cancellation of elective complex surgery, *ad hoc* and temporary relaxation of PICS standards for staffing ratios (35), and redeployment of non-clinical staff to the frontline. Children are often transferred to distant units due to lack of regional PICU beds, an issue that is frequently highlighted in the press (36, 37). Replicating the previous PICU response during further COVID-19 surges will be challenging during winter. In addition, since the majority of planned complex surgery in children cannot be postponed for long (e.g. cardiac surgery), longer-term outcome data are crucial to support the ethical and legal implications of denying children access to such surgery by using PICU beds for adult patients in future waves.

This unique experience has highlighted the need in future waves to maintain up to date records of staff training and credentials, mechanisms to swiftly develop and communicate guidance in the face of rapidly accumulating experience, systems for responsive rostering to adapt to changing demands, closer liaison between adult and paediatric ICU teams in general, adoption of techniques for positioning heavy patients, greater emphasis on delirium prevention and management, and embedding wellbeing interventions into routine practice to support staff.

PICU staff recognised the challenges of working outside their normal practice with close cooperation with adult teams working to the best available evidence: this was feasible, safe and supported by regulatory bodies. Had children been predominantly more affected than adults, it is arguable whether transformation of AICUs would have been as rapidly achievable.

The dedicated task-specific teams used were usually led by adult anaesthetists, some with little experience of managing critically ill children, highlighting the importance of shared training and professional development for the future.

The strengths of this study are the inclusion of all seven PICUs who repurposed their entire units (providing a national picture) and availability of detailed data on how the units were repurposed and the characteristics and outcomes of adults treated on these units. We were however limited by the unavailability of activity data from other PICUs during the same period to indicate the impact of these changes and outcome data for adults discharged from the PICUs to other areas (providing a lower mortality rate than expected from adult ICUs).

CONCLUSIONS

In an unprecedented transformative effort, seven PICU teams in England repurposed to manage critically ill adults in spring 2020. We contributed significantly to the national expansion effort for adult critical care. This effort was supported by national-level planning within the PICU community, ensuring that critically ill children continued to have access to PICU beds.

Table 1. Modelling predicted demand for paediatric intensive care beds in England utilising historical data from November 2018 through to June 2019

		England	North	Midlands and East	London	South
Nov-18	**Mean (SD)**	**341.6 (21.9)**	98.0 (6.2)	77.5 (4.6)	127.0 (9.8)	43.4 (3.8)
	Med (Min-Max)	**338.5 (300, 388)**	97.1 (82, 120)	77.3 (63, 90)	125.8 (97, 156)	43.5 (32, 54)
	IQR	**327 - 356**	93.7 - 101.6	73.8 - 81.5	120.3 - 132.2	40.7 - 45.7
Dec-18	**Mean (SD)**	**324.7 (30.4)**	93.6 (8.7)	71.8 (5.1)	121.4 (12.1)	39.3 (7.8)
	Med (Min-Max)	**332.0 (266, 370)**	94.4 (64, 113)	72.3 (56, 85)	122.0 (92, 152)	41.6 (18, 54)
	IQR	**305 - 350**	87.7 - 100.8	67.8 - 75.4	110.6 - 132.1	33.7 - 45.0
Jan-19	**Mean (SD)**	**307.4 (15.3)**	90.7 (6.3)	71.4 (4.3)	109.5 (6.8)	37.3 (4.9)
	Med (Min-Max)	**311.0 (273, 328)**	91.2 (72, 112)	71.5 (56, 83)	109.8 (89, 131)	36.8 (25, 50)
	IQR	**295 - 320**	86.7 - 94.5	68.8 - 74.9	104.9 - 114.2	33.0 - 41.7
Feb-19	**Mean (SD)**	**308.6 (14.2)**	91.1 (5.4)	69.0 (5.4)	105.9 (6.9)	42.0 (2.7)
	Med (Min-Max)	**310.5 (268, 328)**	91.5 (71, 109)	69.5 (48, 83)	105.6 (84, 125)	42.2 (33, 51)
	IQR	**304 - 318.5**	88.4 - 94.4	66.3 - 72.6	101.3 - 111.3	40.3 - 43.7
Mar-19	**Mean (SD)**	**296.0 (17.3)**	79.3 (5.3)	66.5 (5.6)	108.7 (6.8)	38.7 (4.4)
	Med (Min-Max)	**296.0 (264, 327)**	78.9 (64, 96)	66.0 (51, 83)	108.6 (85, 129)	39.0 (27, 50)
	IQR	**281.0 - 311.0**	75.5 - 82.6	62.4 - 70.0	104.1 - 114.1	35.7 - 41.4

Apr-19	**Mean (SD)**	**301.2 (17.4)**	77.8 (8.2)	68.2 (5.7)	110.4 (8.0)	43.1 (3.0)
	Med (Min-Max)	**307.0 (258, 325)**	79.0 (51, 97)	68.4 (53, 84)	110.8 (88, 131)	42.9 (35, 52)
	IQR	**291.0 - 315.0**	72.1 - 84.2	63.6 - 72.0	104.6 - 116.5	40.9 - 45.3
May-19	**Mean (SD)**	**293.1 (15.7)**	80.1 (6.9)	64.8 (4.5)	105.0 (6.5)	39.2 (4.5)
	Med (Min-Max)	**293.0 (262, 316)**	80.1 (62, 100)	64.9 (50, 80)	105.8 (82, 124)	38.7 (27, 51)
	IQR	**281.0 - 307.0**	74.2 - 86.0	61.5 - 67.8	100.7 - 109.9	36.1 - 42.6
Jun-19	**Mean (SD)**	**278.7 (15.8)**	73.9 (6.1)	60.8 (5.6)	103.2 (6.4)	35.5 (3.6)
	Med (Min-Max)	**280.5 (251, 304)**	73.9 (56, 91)	61.0 (46, 78)	102.3 (84, 122)	35.5 (24, 45)
	IQR	**264.0 - 292.0**	69.4 - 78.3	56.6 - 64.9	97.9 - 108.6	32.9 - 38.0

Table 2a. Pre-pandemic characteristics of seven repurposed PICUs in England

Hospitals	St Mary's Hospital	Royal Brompton Hospital	Royal London Hospital	Alder Hey Children's Hospital	Royal Manchester Children's Hospital	King's College Hospital	Royal Stoke University Hospital	Total
Region	Northwest London	Northwest London	Northeast London	Northwest England	Northwest England	Southeast London	North Midlands	
<u>Hospital characteristics</u>								
Paediatric Emergency Department	Yes	No	Yes	Yes	Yes	Yes	Yes	
Retrieval Service	No	Yes (adult ECMO)	Yes (London Air Ambulance HEMS)	Yes	Yes	No	No	
<u>Critical care characteristics</u>								
Paediatric (level 3)*	11	16	6	21	15	8	6	83
Paediatric (level 2)**	4	8	4	14	12	8	4	54
Paediatric ECMO	No	Yes	No	Yes	No	No	No	
Adult (level 2 and 3)	32	42	44	0	56	69	52	295
<u>PICU characteristics</u>								
Annual admissions	412	569	369	951	1133	642	277	4353

External admission sources	CATS and STRS	CATS and STRS	CATS and STRS	NWTS	NWTS	STRS and CATS	KIDS and NWTS	
Usual PICU case-mix	Medical-surgical	Cardiorespiratory	Medical-surgical	Medical-surgical and cardiac	Medical-surgical	Medical-surgical	Medical-surgical	
Specialist Services	Paediatric Major Trauma centre Paediatric HCID-A centre Non-oncological bone marrow transplant centre	Congenital Heart Surgery (all ages) Long-term ventilation (all ages) Adult unit is one of 5 centrally funded ECMO centres for acute respiratory failure	Major Trauma centre (all ages) National referral centre for bone marrow failure syndromes, Tertiary gastroenterology and endocrinology	Paediatric Major Trauma centre Paediatric ECMO centre (cardiac and respiratory) Congenital Heart Surgery Paediatric HCID-A centre Designated Vein of Galen centre	Metabolic service Bone Marrow Transplant Service	Major Trauma centre Tertiary gastroenterolgy National Liver Transplant Centre Neurosciences		

CATS = Children's Acute Transport Service; ECMO = extracorporeal membrane oxygenation; HEMS = Helicopter Emergency Medical Service; KIDS = Kids Intensive Care and Decision Support; STRS = South Thames Retrieval Service

* Level 3 critical care defined as invasive organ support (intensive care) ** Level 2 critical care defined as high dependency care

Table 2b. Plans for expanding critical care capacity to look after adults using repurposed PICU space and staff

Hospitals	St Mary's Hospital	Royal Brompton Hospital	Royal London Hospital	Alder Hey Children's Hospital	Royal Manchester Children's Hospital	King's College Hospital	Royal Stoke University Hospital
Ring-fenced arrangements for paediatric critical care patients	2 bed-spaces for internal emergency	1 bed-space for internal emergency on a separate ward	2 bed-spaces for internal emergency	Bed-spaces for ECMO service and emergency cardiac surgery.	15 bed-spaces for internal emergency Accept external time-critical admissions and specialist local service referrals	4 bed-spaces for internal emergency, mainly liver and neurosciences Accept external admissions for neurosurgery and liver referrals	No bed-spaces
Diversion Arrangements	Divert CATS admissions to GOSH/ELCH	Divert CATS /STRS admissions to GOSH/ELCH	Divert CATS /STRS admissions to GOSH/ELCH	None	Divert referrals	Diverts all CATS/STRS admissions to GOSH/ELCH	Divert KIDS admissions to BCH
Alternative provision				Paediatric HDU relocated to a general ward. Burns Unit relocated.	Satellite level 2 paediatric critical care facility on general ward		

Admission capacity for level 2-3 adult critical care	15 COVID	18 COVID, including ECMO	12 non-COVID and COVID	19 non-COVID and COVID	21 COVID	12 non-COVID	10 COVID

BCH= Birmingham Children's Hospital; CATS= Children Acute Transport Service; ELCH = Evelina London Children's Hospital; GOSH = Great Ormond Street Hospital; KIDS = Kids Intensive Care and Decision Support; STRS = South Thames Retrieval Service

Table 3a. Logistics involved in repurposing seven PICUs to care for critically ill adults – Space, Staff and Equipment

Hospitals	St Mary's Hospital	Royal Brompton Hospital	Royal London Hospital	Alder Hey Children's Hospital	Royal Manchester Children's Hospital	Kings College Hospital	Royal Stoke University Hospital
Space management	Entire PICU designated as COVID "red" clinical zone. Designated green zone for breaks and meetings to meet social distancing guidelines Internal Paediatric emergencies needing critical care admitted to 2 negative-pressure cubicles	Entire PICU designated as COVID "red" clinical zone, and reorganisation of PICU/entrance to accommodate doffing. Paediatric Sleep Unit converted as "green" command-control centre and staff donning area. Virtual handover and rounds allow maximising of the limited "green" clinical space, so staff could join remotely.	2 cubicles kept for sole paediatric use. Space around entrance and cubicles kept green. Designated areas for Donning and AITU equipment created. New adult CD cupboard installed. Two 5 bedded bays increased to 6 beds each for covid positive adult patients. Towards end of the surge newly expanded adult itu was created to take covid positive adults, then PICU bays were used for green AITU patients. Parent bedrooms converted to staff showering facitilites.	Entire PICU + HDU as COVID "red" clinical zone. Designated green zones for breaks and meetings. Reconfigurated entrance and exit, and desginated donning-doffing areas. PICU handovers in seminar room, AICU handovers in PPE in COVID pods.	Original PICU designated as COVID "red" zone, primarily for adults, but one paediatric COVID case also cared for in this area. Original PHDU refitted to accommodate 15 bed-spaces ring-fenced for PICU patients. Burns Unit closed to allow for separation of Covid Zone staff for changing & refreshments, and donning/doffing. Two separate handovers took place; a	Entire PICU as only "green" zone that provided level 3 care for COVID-negative Adult patients. New King's Critical care Centre started functioning ahead of schedule provided space for 29 beds	Entire PICU as COVID "red" clinical zone

			Well being space created. Designated green areas for staff breaks and handover.		'COVID' handover and a 'Non-COVID' handover for the critically ill children now being cared for in the original PHDU.		
Staffing Medical: Senior Tier	Led by PICU consultants on resident rota AICU consultants available on phone for advice	Led by PICU consultants on resident rota; Day supporting rota of paediatric respiratory and cardiology consultants Senior AICU middle grade and consultants available for advice Middle- and junior-grade paediatric trainees from PICU,	Led by PICU consultants AICU consultants available for support, and anaesthetic consultants ad hoc	Led by PICU consultants on resident rota; Rota of seconded paediatric anaesthetic consultants AICU consultants available for phone advice Usual PICU rota plus 3 seconded	PICU and AICU consultants jointly led till peak. After peak, PICU consultants solely cared for paediatric patients, whilst AICU consultants and paediatric anaesthetists shared rota to care for adult patients. Resident rota of PICU staff included ANPs,	Led by PICU consultants Supporting anaesthetists and AICU middle grade with twice daily adult consultant support rounds	Led by PICU consultants on resident rota, supported by AICU consultants and general paediatricians.

Medical: Middle and Junior Tiers Nursing	PICU staff, mostly general paediatric trainees PICU nursing pool (some with previous AICU experience)	supplemented from cardiology and respiratory PICU and AICU nursing pool, including some from recovery; Paediatric ward nurses trained to supervise PPE donning and doffing stations.	PICU staff rota, included redeployed SHOs, neonatal fellows, surgical trainees Adult patients: AICU nurses supported by ODP and PICU nurses; whilst PICU nurses were redeployed to AICU	paediatric SpRs and 1 anaesthetic fellow PICU nurses, operating theatre staff and previous staff with PICU experience	fellows, adult ICU and emergency medicine trainees, redeployed neonatal fellows and paediatric SHOs. Adult trainees worked mainly in the COVID zone allowing paediatric and neonatal trainees to manage the non COVID critically ill children in the repurposed PHDU PICU nurses assisted by theatre-recovery staff. Past PICU nurses redeployed from community and research roles	PICU staff and AICU trainees who previously rotated in PICU	Middle-grade paediatric trainees PICU nursing pool, supplemented from paediatric HDU and general paediatric

			Paediatric patients: PICU nurses			Dual-trained nursing pool, working alongside PICU nurses. Paediatric Clinical Nurse Specialists redeployed to PICU	
Education and Training	Webinars by AICU team Simulation training with anaesthetists and PICU multi-disciplines AICU learning package: "ICU for non-adult intensivists"	Simulation training within the paediatric department led by the education teams; Co-training with the adult team led by the anaesthetic department.	Pre surge training seminar Daily updates from AITU team via whatsapp Access to AITU guidelines and protocols, daily check list	AICU visit by Matron and PICU Consultants Simulation and OSCE-style teaching by PICU nurses /ANPs Regional AICU guidelines, new regional and	Online resources Simulation sessions in paediatric theatres for PICU/PHDU staff Shift rotation of PICU staff onto adult COVID areas prior to use of PICU for admission of adult patients	Simulation and virtual training sessions to upskill non-AICU staff Daily clinical and non-management updates from local trust and international societies	Simulation training by AICU team. Training on AICU patient data management system with access to all adult guidelines.

	Daily support from regional adult critical care network	"How to ICU" portal access for protocol training	Support from adult regional critical care network as needed AICU nurses supporting PICU nurses on the job	national COVID guidelines National and international webinars Daily support from adult regional critical care network	Daily support from adult regional critical care network		
Equipment							
Challenges	Medicines Dialysis fluids Imaging Airway management Ventilators PPE	Ventilators PPE Dialysis fluids Airway management	Ventilators initially loaned to AITU RRT Adult equipment storage Storage of medications	PPE Ventilators	Medicines PPE	Ventilators Dialysis fluids and RRT admissions Medicines Staffing	Infusion pumps Airway management PPE
Solutions	-Regular discussions with pharmacy and AICU	-NIV ventilators repurposed for use	Maintenance of sufficient supply of	- Specific donners and	-AnaConDa product to save on syringe	-Plans to repurpose neonatal ventilators and transport	-Reprogrammed Pumps for adult volume

	-Network approach to transfer to another centre for RRT -2 additional hand-held USS probes -adult trolleys including McGrath blades	-London Fashion School staff tailored theatre drapes to gowns -RRT planning or collaboration with regional dialysis centre at Northwick Park Hospital -reorganised paediatric airway trolley with adult equipment	ventilators for paediatric admissions New CD cupboard Adult airways trolleys and central line trolleys -Transfer to original AICU or RLH dialysis centre	doffers for all pods - PICU consultant shifts changed from 24-h shift pattern to 13-h resident shifts. - Changed all ventilators from anaesthetic machines to Draeger in adult pod.	drivers and intravenous drugs.	ventilators if necessary -Leadership updates and planning for alternatives when in short supply -occupational health involvement to get directives on who and when to return to work Extra RRT machines sourced from industry and the fluids from the private sector	-Difficult airway trolley from AICU

*ANP – advanced nurse practitioners

Table 3b. Clinical care delivery in seven repurposed PICUs to care for critically ill adults

Hospitals	St Mary's Hospital	Royal Brompton Hospital	Royal London Hospital	Alder Hey Children's Hospital	Royal Manchester Children's Hospital	Kings College Hospital	Royal Stoke University Hospital
Procedure- Specific Teams: MERIT (Mobile Emergency Rapid Intubating Team) Vascular Access Proning Other	Anaesthetists-led MERIT Vascular access teams set up but not needed - procedures performed by PICU teams. Proning teams included paediatric physiotherapists Dedicated tracheostomy lists	Anaesthetists-led Adult and paediatric respiratory nurse specialists led on tracheostomy safety rounds	Airway team- Anaesthetists-led, with staff rota Vascular access teams- MDT staff including surgical and transplant consultants Proning teams MDT staff Weekly dedicated tracheostomy theatre list Adult ID ward round Clinical psychologists, medical and nursing	Anaesthetist-led, with staff rota including consultant paediatric surgeons.	Task Teams set up, but was not required.	Anaesthetists-led	AICU staff-led

Family liaison	Non-critical care consultants led on MDT and existing PICU family liaison nurses	Non-critical care consultants (adults and paediatric directorate) led on MDT and family liaison	staff family liaison teams	Consultant Paediatric surgeon led with staff rota of paediatric respiratory consultants, PICU nurse consultants and non-PICU consultants.	Existing PICU Family Care Team of Band 6 and Band 7 nurses	Existing PICU family liaison nurses	PICU Medical and nursing staff
Clinical resources developed for adult patients	-COVID daily ward round template (appendix) -Quick nursing guides (appendix) -Quick reference guide to common AICU medications	-Ward Round template as per AICU -Handover operational checklist -Common Medicines Quick Guide (appendix) -Extubation algorithm (appendix)	-COVID checklists for daily plans Research guide including patient selection and contacts	-AICU admission sheet -Daily documentation adapted into PICU EPR, including all communication and procedures. - Nursing documentation added to electronic medical records	- Electronic patient information system integrated with adult documentation including a simplified specific COVID Daily Ward Round template "Idiot's Guide to COVID Intensive Care" developed by AICU team PICM and AICM trainees developed a	-Adult guidelines app -Same Clinical Information system for adults as for PICU -Admission and discharge on EPR	-Patient Data Management System as per AICU to access all adult guidelines. -Paediatric bedside charts for fluid balance

		-Tracheostomy referral form			"Differences between PICU and AICU" guide		
Communications	Daily AICU/ PICU/ anaesthetics meetings to clarify operational logistics Daily management leadership dial-in updates on latest operational issues 3 times per week respiratory/ ICU MDT Dedicated mobile phones for referrals, investigation requests and family communications. Microsoft Teams for communication between "red" and "green" zones.	Daily respiratory, radiology, pharmacy, family liaison rounds Regular visiting consults from microbiology, haematology, pulmonary hypertension, neurology, nephrology Webcam on all bed spaces Microsoft Teams for full range of virtual rounds (including education, and governance) across all 3 operational critical care areas.	Co-ordinating AICU consultant on every shift Joint MDT decision-making for complex patients and end-of-life discussions WhatsApp and email between AICU and PICU. Daily calls to updates families and access to video calling 'Walkie talkies' and dedicated phone lines to cubicles and bays, wipeable white boards	Daily tactical leadership teleconference with local adult CCN to identify operational issues and potential patient transfers. Twice daily nurse huddles and medical handovers; Daily micro/ID consults and family liaison rounds Liaise with adult colleagues on challenging or end-of-life decisions. Microsoft Teams for communications	Twice daily Silver Command meetings Reverted to historic numerical assignment of the wards instead of naming as "PICU" during the mixed board of adult and paediatric patients Well-being hubs Microsoft Teams for twice weekly Infectious Diseases Rounds	Daily tactical leadership updates to clarify operational issues Well-being hubs Pharmacy, procurement, and HR included in leadership updates Microsoft teams in use	Twice daily ward round by paediatric staff including adult pharmacist Twice daily ward round by AICU consultant Daily/twice daily medical and nursing team huddle to provide mutual support.

				across all critical care pods			

*MDT= multidisciplinary team *RRT = renal replacement therapy

Table 4. Characteristics, interventions and outcomes of patients admitted to the seven PICUs repurposed to care for adults

Hospitals	St Mary's Hospital	Royal Brompton Hospital	Royal London Hospital	Alder Hey Children's Hospital	Royal Manchester Children's Hospital	King's College Hospital	Royal Stoke University Hospital	Total
Period during which PICU was repurposed	9 weeks (20th March -22nd May)	6 weeks (3rd April -13th May)	7 weeks (23rd March –12th May)	3 weeks (6th April – 1st May)	6 weeks (8th March –21st April)	6 weeks (27th March –10th May)	5 weeks (30th March –6th May)	
Total number of patients in adult critical care (COVID and non-COVID) in the same hospital during the same time period	118	110	187	11	115	101	70	712
Repurposed PICU activity for adults								

Number of non-COVID patients IMV HFNC	5 5 0	0 0 0	8 6 2	0 0 0	0 0 0	23 23 0	0 0 0	36 34 2
Total number of COVID patients ECMO IMV NIV HFNC	23 1 22 0 0	29 5 24 0 0	26 0 8 10 8	11 0 11 0 0	9 0 9 0 0	0 0 0 0 0	11 0 11 0 0	109 6 85 10 8
Patient-bed days	434	324	197	169	81	229	119	1553
Median age in years (range)	57 (32-76)	50 years (36-77)	57 (19-78)	62 (44-72)	60 (50-70)	53 (19-77)	55 (20-73)	
<u>Interventions</u> ECMO RRT	 1 6	 5 9	 0 0	 0 4	 0 0	 0 0	 0 1	 6 20

CPR	2	1	0	1	1	2	0	7
Tracheostomy	9	14	0	0	6	10	3	42
Outcome								
Died in PICU	8	2	3	4	1	0	2	20
Discharged from PICU	20	27	31	7	8	23	9	125
Repurposed PICU activity for children								
Bed capacity	2	1	2	43	15	4	0	67
Non-COVID children	24	0	8	34	59	21	0	146
COVID children	5	0	1	2 (1 on ECMO)	1	4	0	13
Refusals/Transfers out	6	0	1	0	0	8	0	15

CPR = cardiopulmonary resuscitation; ECMO= extracorporeal membrane oxygenation; RRT = renal replacement therapy; IMV = invasive mechanical ventilation; NIV = non-invasive ventilation; HFNC: high flow nasal cannula therapy

CONFLICT OF INTEREST

All authors have completed the ICMJE uniform disclosure form and declare: no support from any organisation for the submitted work; no financial relationships with any organisations that might have an interest in the submitted work in the previous three years, no other relationships or activities that could appear to have influenced the submitted work.

EXCLUSIVE LICENSE

The Corresponding Author has the right to grant on behalf of all authors and does grant on behalf of all authors, a worldwide licence (http://www.bmj.com/sites/default/files/BMJ%20Author%20Licence%20March%202013.doc) to the Publishers and its licensees in perpetuity, in all forms, formats and media (whether known now or created in the future), to i) publish, reproduce, distribute, display and store the Contribution, ii) translate the Contribution into other languages, create adaptations, reprints, include within collections and create summaries, extracts and/or, abstracts of the Contribution and convert or allow conversion into any format including without limitation audio, iii) create any other derivative work(s) based in whole or part on the on the Contribution, iv) to exploit all subsidiary rights to exploit all subsidiary rights that currently exist or as may exist in the future in the Contribution, v) the inclusion of electronic links from the Contribution to third party material where-ever it may be located; and, vi) licence any third party to do any or all of the above. All research articles will be made available on an open access basis (with authors being asked to pay an open access fee—see http://www.bmj.com/about-bmj/resources-authors/forms-policies-and-checklists/copyright-open-access-and-permission-reuse). The terms of such open access shall be governed by a Creative Commons licence—details as to which Creative Commons licence will apply to the research article are set out in our worldwide licence referred to above.

CONTRIBUTORSHIP

Conception of study: RS, AA, AC-D and PR. Data analysis and modelling: HB, ESD and RF. Data collection and analysis: RS, AA, AC-D, AD, E-JB, SP, SM, RM, SN and JA. Data interpretation: GS and JF. PR acts as guarantor for the data. All authors were involved in drafting the manuscript, and all authors approved the final submitted version.

TRANSPARENCY STATEMENT

The senior author affirms that the manuscript is an honest, accurate, and transparent account of the study being reported, no important aspects of the study have been omitted, and any discrepancies from the study as originally planned (and, if relevant, registered) have been explained.

FUNDING SOURCE

None.

DATA SHARING

Reasonable requests to share study data can be made to the corresponding author.

DISSEMINATION

Dissemination to patient/public groups is not applicable.

REFERENCES:

1. World Health Organization E. WHO announces COVID-19 outbreak a pandemic. 2020, 12th March [updated 2020, 8 July. Available from: https://www.euro.who.int/en/health-topics/health-emergencies/coronavirus-covid-19/news/news/2020/3/who-announces-covid-19-outbreak-a-pandemic.
2. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical Characteristics of Coronavirus Disease 2019 in China. N Engl J Med. 2020;382(18):1708-20.
3. Wu Z, McGoogan JM. Characteristics of and Important Lessons From the Coronavirus Disease 2019 (COVID-19) Outbreak in China: Summary of a Report of 72314 Cases From the Chinese Center for Disease Control and Prevention. JAMA. 2020.
4. Livingston E, Bucher K. Coronavirus Disease 2019 (COVID-19) in Italy. JAMA. 2020.
5. Dong Y, Mo X, Hu Y, Qi X, Jiang F, Jiang Z, et al. Epidemiology of COVID-19 Among Children in China. Pediatrics. 2020;145(6).
6. Xie J, Tong Z, Guan X, Du B, Qiu H, Slutsky AS. Critical care crisis and some recommendations during the COVID-19 epidemic in China. Intensive Care Med. 2020;46(5):837-40.
7. Grasselli G, Pesenti A, Cecconi M. Critical Care Utilization for the COVID-19 Outbreak in Lombardy, Italy: Early Experience and Forecast During an Emergency Response. JAMA. 2020.
8. Ministerios Sanidad y Consumo GdE. Actualización nº 52. Enfermedad por el coronavirus (covid-19) 2020, 21st March [Available from: https://www.mscbs.gob.es/profesionales/saludPublica/ccayes/alertasActual/nCov-China/documentos/Actualizacion_52_COVID-19.pdf.
9. Imperial College London. Report 9 - Impact of non-pharmaceutical interventions (NPIs) to reduce COVID-19 mortality and healthcare demand 2020, 16th March [Available from: https://www.imperial.ac.uk/mrc-global-infectious-disease-analysis/covid-19/report-9-impact-of-npis-on-covid-19/.
10. Einav S, Hick JL, Hanfling D, Erstad BL, Toner ES, Branson RD, et al. Surge capacity logistics: care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. Chest. 2014;146(4 Suppl):e17S-43S.
11. Maves RC, Jamros CM, Smith AG. Intensive Care Unit Preparedness During Pandemics and Other Biological Threats. Crit Care Clin. 2019;35(4):609-18.
12. Hick JL, Einav S, Hanfling D, Kissoon N, Dichter JR, Devereaux AV, et al. Surge capacity principles: care of the critically ill and injured during pandemics and disasters: CHEST consensus statement. Chest. 2014;146(4 Suppl):e1S-e16S.
13. Barfield WD, Krug SE, Kanter RK, Gausche-Hill M, Brantley MD, Chung S, et al. Neonatal and pediatric regionalized systems in pediatric emergency mass critical care. Pediatr Crit Care Med. 2011;12(6 Suppl):S128-34.
14. Christian MD, Kissoon N. Caring for Critically Ill Adults in PICUs Is Not "Child's Play". Pediatr Crit Care Med. 2020;21(7):679-81.
15. Ramnarayan P, Thiru K, Parslow RC, Harrison DA, Draper ES, Rowan KM. Effect of specialist retrieval teams on outcomes in children admitted to paediatric intensive care units in England and Wales: a retrospective cohort study. Lancet. 2010;376(9742):698-704.
16. NHS England and NHS Improvement. Paediatric intensive care surge standard operating procedure. 2019, 13th Dec [Available from: https://www.england.nhs.uk/publication/paediatric-intensive-care-surge-sop/.
17. Anandaciva S. Critical care services in the English NHS. 2020, 07th April. [Available from: https://www.kingsfund.org.uk/publications/critical-care-services-nhs - the-number-of-beds-.

18. Paediatric Intensive Care Audit Network (PICANet). PICANet 2019 Annual Report. 2019, 13th Dec [Available from: https://www.picanet.org.uk/annual-reporting-and-publications/.
19. O'Donnell DR, Parslow RC, Draper ES. Deprivation, ethnicity and prematurity in infant respiratory failure in PICU in the UK. Acta Paediatr. 2010;99(8):1186-91.
20. Kneyber MCJ, Engels B, van der Voort PHJ. Paediatric and adult critical care medicine: joining forces against Covid-19. Crit Care. 2020;24(1):350.
21. Yager PH, Whalen KA, Cummings BM. Repurposing a Pediatric ICU for Adults. N Engl J Med. 2020;382(22):e80.
22. NHS England. Incident Response Plan (National). 2017, 21st July [updated 2019, 8th July. Available from: https://www.england.nhs.uk/ourwork/eprr/gf/ - eprr.
23. NHS England. Management of surge and escalation in critical care services: standard operating procedure for adult critical care. 2013, 14th November [Available from: https://www.england.nhs.uk/commissioning/ccs/.
24. Barts Health NT. NHS Nightingale London Hospital 2020 [Available from: https://www.bartshealth.nhs.uk/nightingale.
25. NHS England. Paediatric critical care and surgery in children review: Summary report 2019, 5th Nov [Available from: https://www.england.nhs.uk/publication/paediatric-critical-care-and-surgery-in-children-review-summary-report/.
26. Aziz S, Arabi YM, Alhazzani W, Evans L, Citerio G, Fischkoff K, et al. Managing ICU surge during the COVID-19 crisis: rapid guidelines. Intensive Care Med. 2020;46(7):1303-25.
27. Goh KJ, Wong J, Tien JC, Ng SY, Duu Wen S, Phua GC, et al. Preparing your intensive care unit for the COVID-19 pandemic: practical considerations and strategies. Crit Care. 2020;24(1):215.
28. Remy KE, Verhoef PA, Malone JR, Ruppe MD, Kaselitz TB, Lodeserto F, et al. Caring for Critically Ill Adults With Coronavirus Disease 2019 in a PICU: Recommendations by Dual Trained Intensivists. Pediatr Crit Care Med. 2020;21(7):607-19.
29. Paediatric Intensive Care Society. PICS and ICS joint position statement. 2020, 12 March [Available from: https://picsociety.uk/news/pics-and-ics-joint-position-statement-12-mar-2020/.
30. Docherty AB, Harrison EM, Green CA, Hardwick HE, Pius R, Norman L, et al. Features of 20 133 UK patients in hospital with covid-19 using the ISARIC WHO Clinical Characterisation Protocol: prospective observational cohort study. BMJ. 2020;369:m1985.
31. NHS England and NHS Improvement. Clinical guide to adult critical care during the coronavirus pandemic: Staffing framework 2020, 3rd April [Available from: https://www.england.nhs.uk/coronavirus/workforce/.
32. General Medical Council. How we will continue to regulate in light of novel coronavirus (COVID-19) 2020, 3th March [Available from: https://www.gmc-uk.org/news/news-archive/how-we-will-continue-to-regulate-in-light-of-novel-coronavirus.
33. NHS England and NHS Improvement coronavirus. Management of critical care patients. Clinical guide for the management of critical care for adults with COVID-19 during the coronavirus pandemic 2020, 8th April [Available from: https://www.england.nhs.uk/coronavirus/secondary-care/other-resources/specialty-guides/ - adult-critical-care.
34. ICNARC (Intensive Care National Audit & Research Centre). Icnarc report on covid-19 in critical care. 2020, 3rd July [Available from: https://www.icnarc.org/Our-Audit/Audits/Cmp/Reports.

35. Paediatric Intensive Care Society (PICS). PICS Quality Standards for the Care of Critically Ill Children (5th Edition). 2015 [Available from: https://picsociety.uk/about-pics/pics-standards/.
36. Denis Campbell. 'Breaking point': fears over lack of intensive care beds for children. 2019, 29th Dec [Available from: https://www.theguardian.com/society/2019/dec/29/nhs-picu-shortage-intensive-care-beds-critically-ill-children.
37. Shaun Lintern. Lack of care available to country's sickest children forces NHS to restore beds to local hospitals 2019, 11th Nov [Available from: https://www.independent.co.uk/news/health/nhs-intensive-care-children-england-paediatric-bed-shortage-winter-a9198201.html.

ACKNOWLEDGEMENTS

We would like to thank Katherine Brown and Peter Davis (clinical input into PICANet data analysis), and all clinical staff on all PICUs in England who contributed data to PICANet and cared for critically ill adults during the COVID-19 pandemic.

PICANet is commissioned by the Healthcare Quality Improvement Partnership (HQIP) as part of the National Clinical Audit and Patient Outcomes Programme (NCAPOP). HQIP is led by a consortium of the Academy of Medical Royal Colleges, the Royal College of Nursing, and National Voices. Its aim is to promote quality improvement in patient outcomes, and in particular, to increase the impact that clinical audit, outcome review programmes and registries have on healthcare quality in England and Wales. HQIP holds the contract to commission, manage, and develop the National Clinical Audit and Patient Outcomes Programme (NCAPOP), comprising around 40 projects covering care provided to people with a wide range of medical, surgical and mental health conditions. The programme is funded by NHS England, the Welsh Government and, with some individual projects, other devolved administrations and crown dependencies www.hqip.org.uk/national-programmes.