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ORIGINAL PAPER

Quantifying high dependency care: a prospective cohort study in Yorkshire (UK)

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Abstract High dependency care (HDC) is a level of care situated between intensive care and usual ward care with its delivery being independent of location. Inadequate definition makes it problematic to determine the number of children receiving HDC, to identify their care setting and therefore to undertake service planning. We aimed to estimate the volume of hospital inpatient HDC in a geographically defined population using a customised measurement tool in four types of paediatric hospital services (1) tertiary specialist wards, (2) tertiary paediatric intensive care units, (3) district general hospitals (DGHs) general wards and (4) wards at a major acute general hospital. A region-wide prospective cohort study during 2005 collected data to develop a 36-item HDC measurement tool, which then identified children receiving HDC by day and night. The cohort identified 1,763 children as receiving HDC during an admission to 1 of 36 hospital wards in 14 hospitals. HDC was delivered during 9,077 shift periods of 12 h or 4,538 bed days. The volume of care and patient profiles varied by hospital type, within hospital by ward type and by age and season. Tertiary specialist wards and ICUs provided 72% of HDC, with the remainder delivered at the DGHs and the major acute general hospital. The volume of admissions to tertiary specialist wards showed little seasonality and children tended to be older (26% were aged 10–15 years). By comparison, admissions to DGHs were younger with an excess during the winter months. This is the first UK study to quantify HDC from empirical data encompassing all hospital and ward types within a large clinical network. A lack of HDC-designated beds across the region resulted in HDC delivery on all types of hospital wards. The study size and representativeness makes the estimated number of HDC bed days per head of population likely to reflect the wider UK population.

Keywords High dependency care · Cohort study · Measurement tool · Paediatric intensive care · Long-term domiciliary ventilation

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Introduction

Critical care is a term used to describe intensive care and high dependency care (HDC) [6, 15]. In the UK, children requiring paediatric intensive care (PIC) require support for one or more organ failures. PIC patients are usually cared for in designated intensive care units (ICUs) staffed by specialist medical and nursing personnel. Although PIC may be initiated in other settings such as the operating theatre or emergency care unit, usually PIC takes place in the ICU. The same cannot be said for HDC where HDC is not synonymous with a dedicated high dependency unit (HDU). Children requiring HDC may be very sick and require a high level of medical and nursing intervention but this level of care is provided by a diversity of healthcare personnel in many hospitals and hospital wards.

The lack of a clear definition makes it difficult to describe HDC. Few attempts have been made to quantify HDC in the UK possibly because of the loose criteria that allow individual healthcare professionals to subjectively assign patients to this level of complex care [4, 11, 24]. As a consequence of inadequate definitions and the heterogeneity of HDC in paediatric secondary and tertiary care, there is a lack of information on the various locations and volume of HDC delivered in the UK.

To inform service planning the Paediatric Critical Care Network of the Yorkshire and Humber Strategic Health Authority in West, North and East Yorkshire commissioned a project. The aim was to produce a working definition of HDC to allow the systematic assessment of the volume of HDC inpatient activity in hospitals and wards in the region. We report on the development of a measurement tool and its application to measure the volume of HDC by shift period, children and bed days, over time and by ward area.

Methods

A prospective cohort study collected inpatient activity data for children of all ages, assessed as receiving HDC [21]. Demographic and basic diagnostic information was collected for all children receiving HDC (Table 1). The 580 paediatric inpatient beds available in the region were spread between 36 hospital wards and 14 hospitals; these hospitals were administered by ten National Health Service (NHS) Trusts. National census data provides populations by 5-year age groups for children 0–14 years; the childhood population (0–14 years) of the study area in 2005 was 629,100 (7%) of the English population [17].

The measurement tool data collection form was piloted for the period of one month (2004) on 36 hospital wards aiming to establish the tool was capturing children receiving HDC [21]. Initially, the data collection form itemised fifty clinical interventions each derived from one or all of the following, therapeutic intervention scoring systems (TISS) [13], Department of Health guidelines [6, 7], interviews with nursing staff from each ward involved in the study, and regional multidisciplinary group workshops. Children were eligible for form completion if they had received one or more of the 50 interventions grouped under seven headings; 1; airway, 2; breathing, 3; circulation, 4; renal, 5; neurological, 6; IV fluids/infusions and 7; other. Analysis of over 5,000 forms submitted over a month period showed that the tool was capturing a proportion of children not deemed not to be receiving HDC by an expert group of consultants and nurses; during this exercise, the experts were blind to any demographic information or the hospital of treatment. As a result, the number of clinical interventions on the form was reduced to 42 for the main study data collection exercise where the additional outcome measure was added for the staff completing the form comprising the question ‘in your opinion is this child in need of HDC’?

The main study collected data from January 1st to December 31st 2005 from 36 hospital wards in four types of tertiary and secondary services as described by the Department of Health [6, 7]:

- Tertiary specialist wards.
- PICUs in tertiary hospitals.
- General wards at District General Hospitals (DGHs).
- Wards at a major acute general hospital.

The tertiary and secondary services were configured as follows: 14 specialist wards at two tertiary hospitals, and one regional burns unit located at a DGH provided HDC to support tertiary specialties. Three PICUs with 17 beds served the 15 specialist hospital wards and the 11 DGHs. Only six designated HDC beds were available, two on one tertiary specialist ward and four on a High Dependency Unit (HDU) at the major acute general hospital. All hospitals were expected to stabilise, intubate and ventilate a critically ill child and provide short-term PIC until the retrieval team arrived to transport the child to one of the three PICUs in two tertiary hospitals, hence the inclusion of the criteria ‘intubation and connection to a mechanical ventilator’. Acutely ill children receiving mechanical

Table 1 Demographic and diagnostic criteria requested for children receiving high dependency care in West, North and East Yorkshire in 2005

Demographic criteria	Diagnostic criteria	
Name	Asthma	Post cardiac surgery
Date of birth	Bacterial meningitis	Respiratory illness/croup
Sex	Bone marrow transplant	Sepsis
Hospital unit number	Diabetic ketoacidosis	Shock
NHS number	Diarrhoea/vomiting	Surgical problem
Postcode	Fits/reduced conscious level	Trauma
Hospital and ward	Meningococcal septicaemia	Other
Shift start date	Metabolic disorder	
Shift period day/night	Poisoning/substance misuse	

ventilation on the PICUs were excluded because the definition of PIC 'intubation and subsequent care of the ventilated child' was set by the Department of Health [6]. However, those children in a PICU not receiving mechanical ventilation but requiring 'greater observation and monitoring', the UK definition for HDC [6] for example children with severe asthma, septic shock and diabetic ketoacidosis, were included.

As in the pilot, data were captured by bedside nurses for any child receiving one or more of the itemised 42 interventions delivered during two shift periods (day and night shift) every 24 h. Guidance notes with severity parameters accompanied the data collection forms to prevent nurses from using subjective judgement (a copy can be obtained from the lead author).

Data was also collected by nurses on each ward for daily ward admissions, discharges and transfers in May and November. Data quality was continuously monitored with systematic checks for missing, out-of-range data values and inconsistencies [2]. Monthly data quality reports were returned to each hospital ward to facilitate a constant review of the data by nursing staff. Hospital visits were made to assess data accuracy by checking a random sample of patient data collection forms against case notes. Data were analysed in SPSS V15 [22].

Complex analysis of concordance/agreement between the intervention data (both for individual items and their multiple combinations) and the outcome measure for over 12,000 forms (50% of dataset) demonstrated that removal of a further six individual interventions improved levels of agreement [21]. Validating the reduced 36-item tool (Fig. 1) on the remaining independent half of the dataset (over 12,000 forms) found moderate levels of agreement between the tool and the outcome measure (nursing opinion) using the Kappa statistic [3].

Thus the final HDC measurement tool comprised 36 clinical interventions which might occur singly or in various combinations (Fig. 1). Each mutually exclusive intervention was weighted according to its level of dependency and listed in three hierarchical groupings labelled A, B and C on the data collection form. The 14 interventions in group A were assigned a score of six; the 15 interventions in group B were assigned a score of four and the seven interventions in group C, a score of two. To score whether a child required HDC for a defined shift period a nurse completed the form and added the scores. A child scoring six or more was assessed as requiring HDC, less than six, usual ward care. This final tool was applied to the data collected in the main study.

Ethics approval was obtained from the Riverside London Ethics Committee and all Local Research and Development Departments from each of the 10 NHS Hospital Trusts. The Patient Information Advisory Group Approval now the National Information Governance Board [16] granted permission for the collection of individual identifiable data.

Results

The 36-item measurement tool captured 9,077 shift periods of HDC, corresponding to 4,538 bed days for 1,763 children of all ages within the Yorkshire region (Table 2). During the study period 1,433/629,100 (0.2%) children aged 0–14 with West, North and East Yorkshire postcodes received 3,325 bed days of HDC. The majority (n=967, 55%) of children requiring HDC were male. Table 2 shows the breakdown of children requiring HDC by age.

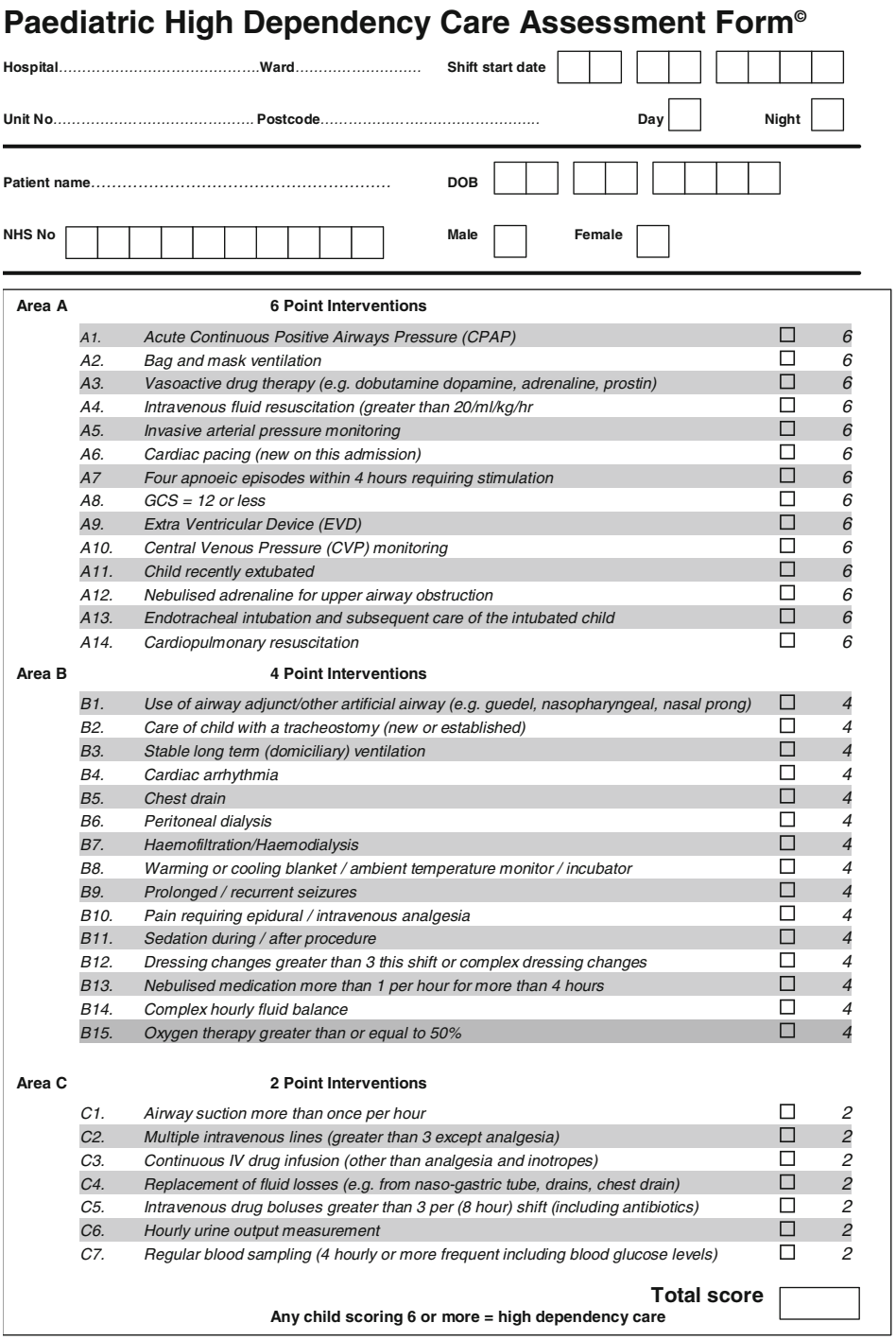
By hospital ward, more (1,466, 16%) HDC was delivered on one of three PICUs than on any other hospital ward. Slightly more HDC was provided for the day shift (n=4,627; 51%). There was a continual demand for HDC throughout the year, November was the busiest month for HDC (n=897, 10%) and June was the least busy (n=623, 7%). Just over one quarter of children requiring HDC were admitted with a surgical problem. Scores obtained using the HDC measurement tool are broken down in Table 2. Although the following three interventions occurred most commonly for children requiring HDC, they occurred in combination with one or more interventions because singly they did not score 6 (Table 3); (i) complex hourly fluid balance, (ii) continuous IV drug infusion other than analgesia and inotropes and (iii) pain requiring epidural or intravenous analgesia. HDC defined by a single intervention, i.e. an intervention with a maximum score of 6 accounted for 877 (10%) shift periods.

Tertiary specialist wards

Of the 3,805 shift periods of HDC, 751 (20%) were for children from outside of the region. Just over one quarter of children were in the 10–15 age group (Table 2) and 299 (44%) children were admitted with a surgical problem. These hospital wards experienced large volumes of activity all year with peaks in HDC in February, April, August and November (Fig. 2). Forty percent of shift periods received an HDC score of 6 (Table 2). Invasive pressure monitoring (arterial and central venous) was performed on two wards, the burns unit and the ward with two designated HDC beds (Table 2).

A total of 346 children required analgesia during 2,108 (69%) shift periods of HDC. Children most commonly admitted to the regional burns unit for HDC were aged 1 to 4 years (n=16, 36%), one quarter (n=11) of which were for children with a Leeds postcode.

Fig. 1 The high dependency care measurement tool



Paediatric High Dependency Care Assessment Form©

Hospital.....Ward..... Shift start date ☐☐ ☐☐ ☐☐☐☐

Unit No..... Postcode..... Day ☐ Night ☐

Patient name..... DOB ☐☐ ☐☐ ☐☐☐☐

NHS No ☐☐☐☐☐☐☐☐☐☐ Male ☐ Female ☐

Area A	**6 Point Interventions**			
	A1.	Acute Continuous Positive Airways Pressure (CPAP)	☐	6
	A2.	Bag and mask ventilation	☐	6
	A3.	Vasoactive drug therapy (e.g. dobutamine dopamine, adrenaline, prostin)	☐	6
	A4.	Intravenous fluid resuscitation (greater than 20/ml/kg/hr	☐	6
	A5.	Invasive arterial pressure monitoring	☐	6
	A6.	Cardiac pacing (new on this admission)	☐	6
	A7	Four apnoeic episodes within 4 hours requiring stimulation	☐	6
	A8.	GCS = 12 or less	☐	6
	A9.	Extra Ventricular Device (EVD)	☐	6
	A10.	Central Venous Pressure (CVP) monitoring	☐	6
	A11.	Child recently extubated	☐	6
	A12.	Nebulised adrenaline for upper airway obstruction	☐	6
	A13.	Endotracheal intubation and subsequent care of the intubated child	☐	6
	A14.	Cardiopulmonary resuscitation	☐	6
Area B	**4 Point Interventions**			
	B1.	Use of airway adjunct/other artificial airway (e.g. guedel, nasopharyngeal, nasal prong)	☐	4
	B2.	Care of child with a tracheostomy (new or established)	☐	4
	B3.	Stable long term (domiciliary) ventilation	☐	4
	B4.	Cardiac arrhythmia	☐	4
	B5.	Chest drain	☐	4
	B6.	Peritoneal dialysis	☐	4
	B7.	Haemofiltration/Haemodialysis	☐	4
	B8.	Warming or cooling blanket / ambient temperature monitor / incubator	☐	4
	B9.	Prolonged / recurrent seizures	☐	4
	B10.	Pain requiring epidural / intravenous analgesia	☐	4
	B11.	Sedation during / after procedure	☐	4
	B12.	Dressing changes greater than 3 this shift or complex dressing changes	☐	4
	B13.	Nebulised medication more than 1 per hour for more than 4 hours	☐	4
	B14.	Complex hourly fluid balance	☐	4
	B15.	Oxygen therapy greater than or equal to 50%	☐	4
Area C	**2 Point Interventions**			
	C1.	Airway suction more than once per hour	☐	2
	C2.	Multiple intravenous lines (greater than 3 except analgesia)	☐	2
	C3.	Continuous IV drug infusion (other than analgesia and inotropes)	☐	2
	C4.	Replacement of fluid losses (e.g. from naso-gastric tube, drains, chest drain)	☐	2
	C5.	Intravenous drug boluses greater than 3 per (8 hour) shift (including antibiotics)	☐	2
	C6.	Hourly urine output measurement	☐	2
	C7.	Regular blood sampling (4 hourly or more frequent including blood glucose levels)	☐	2

Total score ☐

Any child scoring 6 or more = high dependency care

Kay Rushforth Paediatric High Dependency Care Assessment Form V5 The University of Leeds and WY + NEYNEL PCT ©

High dependency care in the paediatric intensive care units in tertiary hospitals

PICUs at the lead centre provided 2,745 (30%) periods of HDC for 608 (34%) children. PICUs accounted for 44% (n=2,745) of all HDC provided in the tertiary centre (Table 2). In the PICUs, 57% (n=344) of children were male and 30% (n=181) were infants. Admission following cardiac surgery was the reason for more children (181, 30%) receiving HDC. HDC scores ranged from 6–72 using the HDC measurement tool, 11% (n=297) of shift periods scored 6 and 68% scored 16 or less. Details of interventions performed for HDC frequently in the PICU are found in Table 2. Of the shift periods of HDC for children requiring stable long-term domiciliary ventilation (LTV) with a tracheostomy, 693 (89%) shift periods or 347

Table 2 Hospitals, wards, shift periods, length of stay and sores for children receiving high dependency care by tertiary and secondary service in West, North and East Yorkshire in 2005

Service	Tertiary				Secondary				Total	
Number of hospitals	2				12				14	
					DGHs (n=11)		Major acute general hospital (n=1)			
Hospital ward type (n)	Specialist (15)		PICs(3)		General (14)		General/HDU (4)		36	
Number of shift periods of HDC (%) (range per ward)	3,805 (42) (15–535)		2,745 (30) (476–1,466)		1,866 (21) (8–397)		661 (7) (10–505)		9,077 (100) 8–1,466	
Median length of HDC stay in days (range)	1 (1–25)		2 (1–34)		1 (1–125)		1 (1–12)		1 (1–125)	
Number of children receiving HDC by age group	n	%	n	%	n	%	n	%	n	%
Neonate (0–28 days)	24	3.5	55	9.0	54	9.2	8	4.8	141	6.9
Infant (29 days to 364 days)	137	20.0	181	29.8	157	26.6	41	24.7	516	25.2
1–4 years	149	21.8	139	22.9	146	24.8	35	21.1	469	23.0
5–9 years	116	16.9	74	12.2	69	11.7	31	18.7	290	14.1
10–15 years	176	25.7	96	15.7	134	22.8	41	24.7	447	21.8
16 years and over	46	6.7	11	1.8	16	2.7	5	3.0	78	3.8
[a]Missing	37	5.4	52	8.6	13	2.2	5	3.0	107	5.2
Total	685	100.0	608	100.0	589	100.0	166	100.0	[b]2048	100.0
Total score for HDC using the HDC measurement tool by shift period										
6	1,518	39.9	297	10.8	941	50.4	211	31.9	2967	32.7
8	828	21.8	676	24.6	290	15.5	132	20.0	1926	21.2
10–19	1,311	34.4	1,005	36.6	496	26.6	287	43.4	3,099	34.1
20–39	144	3.8	646	23.5	114	6.1	28	4.2	932	10.3
40–59	4	0.1	114	4.2	22	1.2	3	0.5	143	1.6
60–72	0	0.0	7	0.3	3	0.2	0	0.0	10	0.1
Total	3,805	100.0	2,745	100.0	1,866	100.0	661	100.0	9,077	100.0

[a] Age not calculated: shift date for care missing (not date of birth)

[b] Total number of children receiving HDC (n=1,763). Children were duplicated by hospital and ward type (n=2,048)

bed days for 16 children were provided on one PICU. Over 14 children were responsible for 37% of the total LTV activity on PICU.

Of the 851 admissions to the three PICUs, 34% (n=290) of children were never intubated; this varied between the three PICUs from 19–60%, these children required observation and intervention other than intubation. During 2005, 151 children were refused admission to one of the three PICUs because the units were full to capacity.

High dependency care on the general wards at district general hospitals

Eleven DGHs and 14 hospital wards provided HDC for 1,866 (21%) shift periods for 589 (33%) children. The majority of children were male (323, 55%) and the largest group were infants (n=157, 27%). Nearly a quarter of children were admitted with a respiratory illness/croup (n=134, 23%). There was a peak in activity during October, November and December (Fig. 2). Scores for HDC ranged from 6 to 62, half (n=941, 50%) of which scored 6 (Table 2). HDC for children receiving stable LTV was provided for 77 (10%) of all regional shift periods of HDC for nine children at six DGHs (Table 2). Invasive pressure monitoring was only provided for children receiving PIC stabilisation before transfer to a PICU (Table 2). Of the 2,690 children admitted to a DGH in May, and 2,718 in November, 8% (n=215) and 12% (n=326) required HDC, respectively.

Wards at the major acute general hospital

The majority (99, 60%) of children admitted for HDC were male and one quarter were infants. Surgical problem was the most common (n=45, 27%) reason for children receiving HDC throughout the hospital. Within the HDU, 47% (n=236) of shift periods scored 8 or less (Table 2). HDC for LTV was provided on the HDU (Table 2). Nearly one quarter (n=156, 24%) of all HDC shift periods were outside of the dedicated HDU provided at this hospital where 60% (n=31) of children received HDC for a surgical problem.

Table 3 Type, number and scores for the 36 clinical interventions using the HDC measurement tool (per shift period) by tertiary and secondary service in West, North and East Yorkshire in 2005

Clinical intervention		Number of clinical interventions per shift period by tertiary/secondary service			
		Tertiary specialist wards (n=15)	PICUs in tertiary hospitals (n=3)	General wards at DGHs (n=14)	Wards at a major acute general hospital (n=4)
Acute CPAP	6-point interventions meet with HDC singly	86	471	77	86
Bag and mask ventilation		36	135	124	22
Vasoactive drug therapy		350	282	28	17
Intravenous fluid resuscitation		92	29	214	31
Invasive arterial pressure monitoring		65	778	19	42
Cardiac pacing (new on admission)		41	35	0	0
Four apnoeas within 4 h		14	42	73	23
Glasgow coma score 12 or less		91	56	194	35
External ventricular device		181	15	0	0
Central venous pressure monitoring		81	600	3	22
Child recently extubated		75	693	74	26
Nebulised adrenaline		17	54	21	6
Endotracheal intubation		16	90	88	6
Cardiopulmonary resuscitation		4	17	30	3
Use of airway adjunct	4-point interventions requires other intervention to meet with HDC	56	286	70	17
Care of the child with a tracheostomy		182	848	622	23
Stable long-term domiciliary ventilation (LTV)		0	693	77	7
Cardiac arrhythmia		5	16	3	2
Chest drain		263	318	9	0
Peritoneal dialysis		14	15	0	0
Haemofiltration/haemodialysis		11	45	0	0
Warming or cooling blanket/incubator		109	188	148	10
Prolonged/recurrent seizure		48	27	103	134
Pain requiring analgesia		1,454	388	107	159
Sedation during/after procedure		197	168	43	7
Dressing changes		320	19	6	13
Nebulised medication		38	24	100	12
Complex hourly fluid balance	2-point interventions requires one or more interventions to meet with HDC	1,874	915	392	246
Oxygen therapy≥50%		338	379	507	195
Airway suction more than once per hour		184	194	619	115
Multiple intravenous lines		375	202	65	29
Continuous IV drug infusion		1,057	540	358	192
Replacement of fluid losses		925	175	114	137
Intravenous drug boluses		1,007	408	284	92
Hourly urine output measurement		651	1,060	175	150
Regular blood sampling		290	366	185	59

A score of 6 denotes high dependency care, less than 6 usual ward care

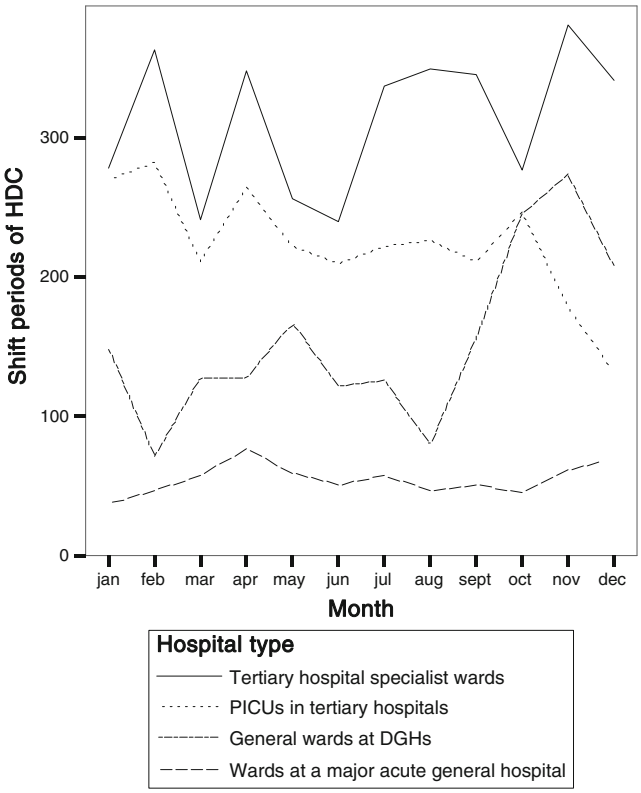


Fig. 2 Shift periods of HDC by month and hospital type in West, North and East Yorkshire in 2005

Discussion

New information on the volume of paediatric HDC delivered in a demographically representative region of England is presented. Our empirical study collected a comprehensive dataset from children admitted to four different types of hospital representing all major specialties. The results report the level of HDC occurring on all ward types and clearly demonstrate the delivery of HDC was not restricted to any specific location of care and took place in varying amounts on all wards in the region.

Assessment of HDC activity in DGHs in May and November found that 8% and 12%, respectively, of all children required HDC, a level consistent with the English Department of Health [7] who estimated that 5–15% of children admitted to a DGH required HDC. PIC is well-described nationally [18] and includes information on HDC delivered in PICU. In 2009, it was reported that 76 (24%) of PIC beds were designated for HDC in 17 (53%) PICUs, an increase from 33 (13%) beds in 13 (42%) PICUs in 2005 [18, 19]. Despite the proportion of designated HDC beds, 28% of admissions to PICU did not require invasive ventilation (associated with PIC). Evidence from PIC and our study confirms that HDC is frequently delivered on PICUs. The centralisation of paediatric intensive care delivered in designated beds and units has improved outcomes for critically ill children [20]. Evidence for similar successes for HDC appears to be lacking, potentially as a consequence of the absence of clear definitions and the diverse locations of care. This study has taken the first step in attempting to address the issue of centralisation in HDC by investigating the feasibility of definitions and quantifying and describing the settings where HDC is delivered. This provides a stepping stone for future studies examining potential benefits of centralised care. In the UK, a Paediatric Critical Care Minimum Data Set [10] of clinical interventions is being developed by a team of medical and nursing experts using information from this study to gather details of each child's admission to provide a systematic basis for economic costing; ultimately, these data will reflect the true identity of HDC occurring in PICU and hospital wards nationally. It is possible therefore that payment for HDC in the future will only be made for delivery of HDC in a centralised location where staff have the skills to care for such children.

Although the location of provision of HDC is dependent upon the local service model, the overall numbers of children requiring HDC is independent of location. The study was commissioned in the Yorkshire region by a proactive clinical network with a view to provision of results that could be employed both locally and nationally. The Yorkshire region is representative of England in terms of population demography and socioeconomic status [9]; therefore, assuming that healthcare services and inpatient profiles are also equivalent, our results are generalisable to England. Applying our results to a national population, the requirement for children aged 0–14 years would be 63,434 national HDC inpatient bed days.

There were variations in the volume of HDC by age and between hospital wards. Although the large amount of HDC provided for infants possibly reflected health problems associated with immature physiological development, the majority of HDC was provided by the tertiary specialist wards, where more HDC was delivered to children aged 10–15 years and where 20% percent of the total shift periods of HDC were for children from outside of the region, which reflected the sheer volume of complex work. One possible explanation for the different age profiles between the tertiary specialist wards compared to other settings was their case mix, including young people with complex, chronic conditions which required HDC level of care often repeatedly during frequent admissions. Specific factors contributing to children triggering the HDC criteria on the tertiary specialist wards (Table 3) include:

- the use of post operative intravenous/epidural analgesia in surgical patients;
- delivery of inotropic agents prescribed to children on the cardiac/cardiology ward;

- chest drain usage for both general and cardiac surgical patients;
- complex fluid balance (measurement of three fluids in and two bodily fluids out) particularly in nephrology, haematology, oncology and hepatology patients;
- continuous intravenous drug infusion (excluding analgesia and inotropic support) in nephrology, haematology, oncology and hepatology patients;
- multiple intravenous drug boluses (four drug boluses in 12 h) in nephrology, haematology, oncology and hepatology patients.

Admission criteria for PIC vary across the UK; however, the three PICUs in Yorkshire delivered surgical HDC for children aged 0–16 years. The absence of dedicated HDC capacity in the tertiary centres resulted in the use of PIC beds for HDC. In addition, the lack of an LTV facility where children could be nursed with a domiciliary ventilator and associated tracheostomy also compelled children to stay on the PICU; both factors displaced acute admissions from the PICU and contributed to a high refusal rate. Although children were entered into the study up to the point of intubation (intubated children were not included), 2005 was representative of other PIC years (2003–2009) for admission rates (825–921, mean 871) and refusals (109–161, mean 130); therefore, our data expose well-recognised deficits in local provision.

The prospective cohort method was chosen to assess the incidence of HDC over a specified period of time and to capture a large study population over a wide geographical area [5]. The study sample was non-random but geographically defined and included all hospitals and wards where children were admitted and, therefore, potentially captured a total population. Owing to the heterogeneous locations across a large geographical region, institutional selection bias was reduced making the findings potentially generalisable to other geographical areas of service delivery. One limitation which may have contributed to a systematic bias in the data collected was the inability of the researcher to check the number of shift periods and children potentially missed during the data collection period. The consequences of this were a possible underestimation of the population requiring HDC. However, it was unlikely that a substantial underestimation occurred because of the large quantity of data returned each month over the year with little fluctuation. Collection of data was a nursing responsibility for which nurses were enthusiastically supportive for a measurement tool to ultimately assess their unrecognised HDC workload.

Although systematic biases are not easy to detect [12, 14], potential systematic biases may have been introduced by senior nurses underestimating HDC and junior nurses overestimating HDC. It would not have been practical to limit completion of the forms to one level of nurse only as junior on one ward may equate to senior on another ward. For future studies tests of consistency of opinion should be performed across locations and between nurses to inform of potential systematic biases.

Establishing the criteria to identify HDC was hampered by a lack of available literature, but this was offset by the knowledge of clinical staff and recommendations from the DH [6, 7] which were exploited to produce data collection forms and the subsequent measurement tool. The only practical way to determine if the period of care was HDC was to ask nurses at the time and although the level of agreement between nursing opinion and the tool represented 50% (overall) of the potentially achievable agreement beyond chance or ‘moderate agreement’, this level has been generally acceptable in this type of research [8].

Although the receiver operator characteristic method is one approach to establish optimal cut points, no gold standard or equivalent tool existed in the UK for external reference or validation with which to assist in the calculation of the sensitivity and specificity for each cut point [1, 23]. The final tool was underpinned by limited published data at the time of its development and evaluation [23] and therefore employed a weighted scoring system to accommodate for the opinions of nurses and clinicians involved in its development who agreed that HDC could be defined by a single intervention or various combinations of multiple interventions. The assignment of a value (2, 4 or 6) to each intervention was a pragmatic process which provided good discrimination between the three categories and produced scores which were clear and understandable to the assessors.

Conclusion

Without detailed information from national registries it is difficult to compare HDC services between networks in the UK and further between countries. Systematic information concerning need, appropriateness, skills of staff and methods for costing paediatric critical care has the potential to assist with evaluation of care and to differentiate between need and demand across all European countries. This is the first UK study to quantify the volume of HDC from within a clinical network and may be applicable to other counties because although the configuration of services has developed with minimal support from dedicated HDC beds and HDUs and may not be typical of services in other regions, it has developed a starting point for understanding how and where children present and remain for their period of HDC. From this study, essential information on the volume of HDC being delivered across the region was provided to commissioners, hospital managers and clinical staff and has provided a base for organisational and strategic planning of

HDC. With PIC established, the definition of HDC and where care is delivered must become clearer to enable the sickest children to gain timely access to the correct level of care provision.

Conflict of interest None.

References

1. Altman DG (1991) Practical statistics for medical research. Chapman and Hall, London
2. Arts DGT, de Keizer NF, Scheffer G (2002) Defining and improving data quality in medical registries: a literature review, case study and generic framework. J Am Med Informat Assoc 9:600–611
3. Cohen JA (1960) A co-efficient for agreement for nominal scales. Educ Psychol 20:37–46
4. Crabtree I (2001) A bridge to the future: impact on high dependency and intensive care. J Child Health Care 5(4):150–154
5. Crombie IK, Davies HTO (1997) Research in health care. Design conduct and interpretation of health services research. John Wiley and Sons, Chichester
6. Department of Health (1997) A framework for the future. DH, London
7. Department of Health (2001) High dependency care for children—report of an expert advisory group for Department of Health. http://www.dh.gov.uk/en/PublicationsAndStatistics/Publications/PublicationsPolicyAndGuidance/DH_4089100.htm. Accessed 12 Sept 2003
8. dos Santos Silva I (1999) Cancer epidemiology: principles and methods. International Agency for Research on Cancer, France
9. Feltbower R, Lewis IJ, Picton S et al (2004) Diagnosing childhood cancer in primary care—a realistic expectation? Br J Cancer 90(10):1882–1884
10. Information centre for health and social care (2007) Paediatric critical care MDS. User guidance. http://www.ic.nhs.uk/services/the-case mix-service/using-this-service/reference/archive/paediatric-and-neonatal-critical-care-mds-user-guidance.htm. Accessed 6 May 2008
11. Maybloom B, Chapple J, Davidson LL (2002) Admissions for critically ill children: where and why? Intensive Crit Care Nurs 18:151–161
12. Meininger JC (1998) Epidemiologic designs. In: Brink PJ, Wood MJ (eds) Advanced Design in Nursing Research. Sage Publications, London
13. Miranda DR, de Rijk A, Schaufeli W (1996) Simplified therapeutic intervention scoring system. The TISS-28 items-result from a multicentre study. Crit Care Med 24(1):64–73
14. Mishel MH (1998) Methodological studies: instrument development. In: Brink PJ, Wood MJ (eds) Advanced Design in Nursing Research. Sage Publications, London
15. Munro R (1999) Critical to success. Nurs Times 95(43):12–13
16. National Information Governance Board. http://www.nigb.nhs.uk/ Accessed 7 Jan 2011
17. Office of National Statistics (2006) Table 9. Mid-2005 population estimates: quinary age groups and sex for local authorities in the UK. http://www.statistics.gov.uk/statbase/Expodata/Spreadsheets/D9666.xls. Accessed 10 Mar 2007
18. Paediatric Intensive Care Audit Network (PICANet) (2007) National Report of the Paediatric Intensive Care Audit Network 2004–2006. Universities of Leeds, Leicester and Sheffield. ISBN 78 0 85316 264 3
19. Paediatric Intensive Care Audit Network. (PICANet) (2009) National Report of the Paediatric Intensive Care Audit Network 2006–2008 Universities of Leeds Leicester and Sheffield. Available online. http://www.picanet.org.uk/Documents/General/Annual%20report_2009/PICANet%20Report%202006%20-%202008_new.pdf. Accessed 15 Jan 2010
20. Pollack MM, Alexander SR, Clarke N, Ruttimann UE, Tesselaar HM, Bachulis AC (1991) Improved outcomes from tertiary care pediatric intensive care. A state wide comparison of tertiary and non tertiary care facilities. Crit Care Med 19(2):150–159
21. Rushforth K (2008) Paediatric High dependency Care in West, North and East Yorkshire. http://etheses.whiterose.ac.uk. Accessed 31 March 2011
22. SPSS Inc. (2006) SPSS for windows Rel15.0.1. SPSS Inc, Chicago
23. Streiner DL, Norman GR (2001) Health measurement scales: a practical guide to their development and use. Oxford University Press, Oxford
24. Wade KJ (2002) Paediatric high dependency provision: a case for urgent review in the United Kingdom. Intensive Crit Care Nurs 18:109–117