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## The influence of chronic health conditions on susceptibility to severe acute illness of children treated in PICU

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**Abstract** *Objectives:* Our study aimed to assess differences in the susceptibility to severe acute illness in children with and without chronic health conditions treated in a pediatric intensive care unit (PICU). *Patients and methods:* Data on age, gender, need for ventilator support, length of stay, as well as other parameters for the Paediatric Index of Mortality (PIM2) score were collected. Data were analyzed and compared across three patient groups: those with a neurodevelopmental disability, those with a chronic condition other than a neurodevelopmental disability, and those with no chronic condition. Reasons for admission of patients were classified according to the Australia and New Zealand Paediatric Intensive Care Registry (ANZPIC Registry) diagnostic codes. In the multidisciplinary, seven-bed, level I PICU of the Split University Hospital, the admission data were collected prospectively for 591 consecutively admitted patients aged  $\leq 18$  years. *Results:* Patients with a neurodevelopmental disability had a significantly higher rate of respiratory-related admissions compared to patients with other chronic health conditions and those with no chronic condition ( $\chi^2=33.72$ ,  $P<0.001$ ). There was a significant difference in the age at admission ( $f=6.04$ ,  $P=0.003$ ), median length of stay ( $f=7.94$ ,  $P<0.001$ ), need for ventilation during the first hour of admission ( $\chi^2=14.74$ ,  $P<0.001$ ) and PICU mortality ( $\chi^2=9.91$ ,  $P=0.007$ ) of patients with neurodevelopmental disabilities, compared to the other two groups of patients. *Conclusion:* Children with neurodevelopmental disabilities are more susceptible to acute illness compared to children with other chronic health conditions and those with no chronic condition.

**Keywords** Child · Intensive care · Chronic disease · Severity of disease · Scoring system

### Introduction

Chronic health conditions are a significant cause of pediatric hospital admissions and contribute greatly to childhood morbidity and mortality. Children with chronic health conditions are hospitalized three times more often than children without chronic health conditions [14], and the majority of children who die in a hospital have at least one chronic health condition [7]. Children with chronic health conditions also form a significant fraction of children treated in pediatric intensive care units (PICU) [8, 17]. It is likely that there are several reasons for this. Chronically ill children may have an increased risk of severe acute illness [5], or PICU admissions may follow scheduled hospitalizations for the treatment of complications of the chronic illness [9]. We hypothesized that susceptibility to severe acute illness would differ between children with and without chronic health conditions, and therefore the present study aims to evaluate the influence of chronic health conditions on the susceptibility to acute severe illness.

### Materials and methods

Split University Hospital is a public, university-affiliated hospital that serves a population of approximately 1,000,000 people from southern Croatia. The Pediatric Department has 120 beds, with an average of 3,100 admissions per year, and a separate neonatal ICU (NICU), where inborn patients are treated. The PICU is a seven-bed, multidisciplinary unit with three additional step-down beds, where children who need chronic ventilation are monitored (not included in the present study). The unit admits all children from newborns up to and including children 18 years of age. All medical and surgical (including trauma and burn) patients and newborns

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transported by “two-way transport” from outside of Split are admitted to the unit. Cardiac surgery is not available in the area serviced by Split hospital, and children with congenital heart diseases are transported to other centers. With the exception of extracorporeal membrane oxygenation, all other modes of management are available in the unit, including conventional ventilation, high-frequency oscillatory ventilation, NO therapy, peritoneal dialysis, venovenous hemodiafiltration, and invasive pressure monitoring. The unit is staffed by full time pediatric intensive care consultants and pediatricians of other subspecialties dedicated to intensive care.

Between June 2002 and July 2004, data were obtained prospectively from 591 consecutively admitted patients aged  $\leq 18$  years, but excluding preterm infants. Repeat admissions for an individual patient were considered as independent admissions. Chronic health conditions were defined as ongoing physical, developmental, behavioral, or emotional conditions that required health and related services of a type and amount in excess of that which is usually required by children [12]. Neurodevelopmental disabilities were defined according to the adaptation of Crocker’s categorization of developmental disabilities and mental retardation [4]. These disorders may result from genetic abnormalities, abnormalities of embryonic development or other antenatal or perinatal problems. However, in some patients, no underlying cause may be found [9].

The study protocol was approved by the Hospital’s Ethics Committee. Demographic data, such as age, gender, need for ventilator support and length of stay, were collected. Parameters for the determination of the Paediatric Index of Mortality (PIM2) score were recorded during the first hour of admission, and mortality risk for each patient was calculated according to the equations developed and published by the PIM Study Group [22]. Each patient’s principal reason for PICU admission was recorded as one of six diagnostic categories, in accordance with the Australia and New Zealand Paediatric Intensive Care Registry (ANZPIC Registry) of diagnostic codes [21].

The chi-squared test and ANOVA with the Tukey post-hoc test, together with Kruskal-Wallis test and Mann-

Whitney test were used in statistical analysis, with results considered significant at 95% ( $P < 0.05$ ).

## Results

During the study period, 528 children accounted for 591 admissions to the PICU. Thirty-five children died in PICU. Since repeat admissions were considered as independent admissions, there were 248 (42%) patients with chronic health conditions and 343 (58%) patients with no chronic condition. Two admissions of children on long-term ventilation were not included in the study, since they stayed in the step-down unit. No noninvasive modes of ventilation were used in our patients.

For analysis, patients were divided into three groups: no chronic condition, neurodevelopmental disability, and other chronic condition. Table 1 lists the main reasons for PICU admission for each of the three groups. The most common reason for admission to the PICU for those with chronic illnesses (including neurodevelopmental disability) was a respiratory-related illness. However, patients with a neurodevelopmental disability had a significantly higher rate of respiratory-related admissions compared to patients of the other two groups.

Demographic and mortality data of the three groups of patients are shown in Table 2. The majority of admissions to PICU were unscheduled. Children with a chronic condition other than neurodevelopmental disability had a significantly higher percentage of elective admissions compared to children in the other two groups. The duration of PICU stay, number of patients ventilated during the first hour of admission, and observed PICU mortality were all significantly greater in patients with a neurodevelopmental disability compared with patients with other or no chronic condition. Patients with a neurodevelopmental disability were significantly younger at admission than other patients. Bronchopneumonia was the main cause of death.

**Table 1** Patients with chronic health conditions in diagnostic groups defined by the reasons most directly responsible for PICU admission

Diagnostic group	No. of patients (%)		
	No chronic condition	Neurodevelopmental disability	Other chronic condition
Total	343	129	119
Respiratory <sup>a</sup>	66 (19.2)	58 (45.0)	26 (21.8)
Miscellaneous	55 (16.0)	22 (17.0)	26 (21.8)
Neurological	49 (14.3)	26 (20.2)	9 (7.6)
Postoperative (noncardiac)	39 (11.4)	10 (7.7)	22 (18.5)
Cardiac	2 (0.6)	9 (7.0)	17 (14.3)
Injury	116 (33.8)	1 (0.7)	1 (0.8)
Diabetes mellitus			10 (8.4)
Procedures (CVC insertion, laryngobronchoscopy)	16 (4.7)	3 (2.4)	8 (6.7)

<sup>a</sup> $P < 0.001$  between patients with neurodevelopmental disability and no chronic condition and between patients with neurodevelopmental disability and other chronic condition

**Table 2** Demographic and mortality data of patients with no chronic condition, neurodevelopmental disability, and other chronic condition

	No chronic condition	Neurodevelopmental disability	Other chronic condition	
No. of patients (%)	343 (58)	129 (21.9)	119 (20.1)	
Median age in months (range) <sup>a</sup>	33 (0.033–216)	16 (0.033–216)	42 (0.033–216)	<i>P</i> =0.027
No. of elective admissions (%) <sup>b</sup>	50 (14.5)	12 (9.3)	27 (22.7)	<i>P</i> =0.012
Median days of stay (range) <sup>c</sup>	2 (0.5–52)	3 (0.5–52)	1 (0.5–43)	<i>P</i> =0.009
No. of patients ventilated during the 1st hour (%) <sup>d</sup>	86 (25.0)	54 (41.8)	28 (23.5)	<i>P</i> <0.001
No. of PICU mortalities (%) <sup>e</sup>	16 (4.7)	15 (11.6)	4 (3.4)	<i>P</i> =0.007
No. of cases with bronchopneumonia as the cause of death (% of deaths)	1/16 (6.2)	5/15 (33.3)	0/4	<i>P</i> =0.084
Predicted PICU mortality (95%CI)	5.5 (3.9–7.0)	6.6 (4.7–8.5)	4.8 (2.7–6.9)	<i>P</i> =0.544
Repeated admissions <sup>f</sup>	10	38	16	<i>P</i> =0.000

<sup>a</sup>*P*=0.033 between patients with neurodevelopmental disability and no chronic condition and *P*=0.007 between patients with neurodevelopmental disability and other chronic condition

<sup>b</sup>*P*=0.004 between patients with neurodevelopmental disability and other chronic condition and *P*=0.040 between patients with no chronic condition and other chronic condition

<sup>c</sup>*P*=0.004 between patients with neurodevelopmental disability and no chronic condition and *P*=0.010 between patients with neurodevelopmental disability and other chronic condition

<sup>d</sup>*P*<0.001 between patients with neurodevelopmental disability and no chronic condition

<sup>e</sup>*P*=0.006 between patients with neurodevelopmental disability and no chronic condition

<sup>f</sup>*P*<0.001 between patients with neurodevelopmental disability and no chronic condition, *P*<0.001 between patients with no chronic condition and other chronic condition, and *P*=0.002 between patients with neurodevelopmental disability and other chronic condition

## Discussion

Children with chronic health conditions suffer a diverse range of illnesses. This means that the indications for hospitalization, the severity of their illnesses, the level of care they require, and the outcomes from treatment will vary among individuals.

Previous studies have reported different mortality rates for children with chronic neurodevelopmental disabilities. For example, Graham et al. reported a 3% mortality rate in patients with neurodevelopmental disabilities [9], whereas Glass and colleagues reported a 17% mortality rate for patients with chromosomal anomalies and mental retardation [8]. The variations in mortality rates are institutionally dependent, and reflect the differences among the populations of children treated, and the differences in specialties and procedures available at the different units. The majority of admissions from the study of Graham et al. were scheduled postsurgical admissions, whereas the majority of admissions in our study were unscheduled. The mortality of our patients with neurodevelopmental disabilities corresponds better with the survey of Dosa et al. where the mortality of patients with unscheduled admissions that were related to chronic diseases was 10.7% [5].

The evaluation of performance disclosed that the PIM2 scoring system was applicable for the whole population of our patients [13]. The PIM2-predicted mortality did not differ significantly among the three groups in this study. That lack of significance points to the consistency in application of the ICU admission criteria for all our patients. However, the observed mortality was significantly higher in patients with neurodevelopmental disabilities. The difference between the predicted and the observed mortality indicates the higher susceptibility for physiologic

instability provoked by the acute insult in this group of children. The principal reason for this high susceptibility is likely the children's inclination for overwhelming pulmonary infections. Respiratory problems reduce life expectancy and are the main cause of death in children with neurological impairment [16, 18]. They are multifactorial, numerous, and difficult to cope with [19]. Our patients with a neurodevelopmental disability were significantly more susceptible to severe respiratory illness than patients with other or no chronic disease. Moreover, bronchopneumonia was the commonest cause of death in this group. The significantly longer stay, the younger age at admission, and the greater need for mechanical ventilation compared with the other two groups, fit into the context of the observed morbidity pattern that is dependent on the neurological disability.

Our data set is relatively small, but it indicates that the course and the outcome of critical illness were associated with the existence and type of the underlying chronic condition of the studied groups of patients. Besides the broad range of health-related needs, the particularities and diversities of their needs make children with chronic diseases especially vulnerable [15, 20]. The needs of children with neurodevelopmental disabilities include additional complex services. A substantial proportion of these children are technology-dependent, and repeat admissions for this group at the PICU are more than likely [3, 5].

There were several limitations to our study. The studied population was relatively small. We did not perform a detailed diagnosis classification of our patients. The grade of the resource utilization for the three groups of patients was not evaluated. However, the demographic and mortality data of this study disclosed that patients with

neurodevelopmental disabilities may be more endangered than patients with other or no chronic disease. An organized approach should be aimed at meeting the health-related needs and improving the general health of children with neurodevelopmental disabilities. That approach includes patient-oriented primary care, family support, access to specialty care, planning and monitoring home care, planning the use of emergency care services, and management of respiratory problems [1, 2, 6, 10, 11, 16]. The comprehensive application of these measures aids in reducing the development of life-threatening complications induced by an acute illness and protecting this susceptible population from unfavorable outcomes.

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