



The relationship between physician case volume and in-hospital mortality of critically ill children with a diagnosis of pneumonia: A cross-sectional observational analytical study



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ABSTRACT

Purpose: The aim of this study is to examine the relationship between physician case volume and the outcomes of critically ill children with pneumonia.

Materials and methods: This is a population-based cohort study analyzed data provided from by the National Health Insurance Research Database of Taiwan, 2006–2009. Children (aged 3 months to 17 years) having records of intensive care unit (ICU) admission and a diagnosis of pneumonia were included. A total of 9754 critically ill children and 1042 attending physicians were enrolled. The children were assigned to 1 of 4 groups based on the physician's pneumonia case volume.

Results: The patients in the very high case volume group had a significantly lower length of hospital stay, in-hospital mortality rate, and hospitalization expenses, and a significantly higher ratio of ICU to hospital stays than the other 3 groups ($P < .001$). The probability of death tended to be lower when the physician's case volume was higher. The risk-adjusted odds ratio for in-hospital mortality of very-high case volume group was 0.48 (95% confidence interval, 0.35–0.65; $P < .001$) compared to low case volume group.

Conclusions: A higher physician's pneumonia case volume is associated with a lower length of hospital stay, lower in-hospital mortality rate, and lower hospitalization expenses among critically ill children with pneumonia.

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1. Introduction

Pneumonia is a common disease among children worldwide, and one of the most common diagnoses of critically ill children admitted to pediatric intensive care units (PICUs). A critically ill child with pneumonia may have complex complications and a poor prognosis, some of which may ultimately result in death. The World Health Organization has stated that pneumonia is the leading cause of death among children [1], even though a significant amount of effort has been undertaken to improve the outcomes of critically ill children with pneumonia. Therefore, identifying factors that are associated with the outcomes of children with pneumonia is crucial to reduce this mortality rate.

Many factors may contribute to quality of care and thus influence the outcomes of patients. The volume-outcome relationship has been investigated across a variety of different fields, especially in those

involving surgical or medical procedures [2–6]. A higher hospital or procedure volume was found to be associated with a reduction in mortality for surgical or medical procedures [2–6], and patient volume has been reported to be an important predictor of outcome in critically ill patients admitted to intensive care units (ICU) [7–11]. In addition, physician case volume has also been reported to be a useful predictor of patient outcomes [12–15]. Therefore, hospital and/or physician case volume may help to predict patient outcomes.

A number of investigations, with regard to pediatric patients, examined the relationship between outcomes and hospital patient volume, and many factors have been reported to influence the outcomes of critically ill children including medication, management, care policies, facilities available at the PICU, and the experience/workload of the caring physicians and team members [7,8,10,16–21]. An attending physician's case volume indicates his or her clinical practice with regard to these cases, so it may also be a useful predictor of patient outcome. However, the relationship between a physician's PICU case volume and patient outcome among critically ill children has not been well investigated to date.

Pneumonia has been one of the top 5 causes of death among children during past years in Taiwan. It has been reported that about

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20 to 24% of critically ill children admitted to a PICU have a diagnosis of pneumonia, and that the mortality rate is approximately 4.2% [22,23]. A population-based study on the volume-outcome relationship may be helpful as a way of potentially improving the outcomes of critically ill children with pneumonia.

We hypothesized that a higher physician PICU pneumonia case volume is likely to result in better outcomes. This study was designed to investigate the volume-outcome relationship among critically ill children who were admitted to a PICU with a diagnosis of pneumonia in relation to the physician's PICU pneumonia case volume using the National Health Insurance Research Database (NHIRD) of Taiwan from 2006 to 2009.

2. Materials and methods

2.1. Data collection

The National Health Insurance (NHI) program was initiated in Taiwan in 1995 and currently has a coverage rate that is greater than 99.5% of the entire population living in Taiwan [24]. The NHIRD is a comprehensive nationwide population-based database that includes data from the NHI program and has been used in a many areas of published research [12–15]. All of the information from the NHIRD is double scrambled to exclude any possibility of identifying any personal or institutional information. This study was approved by the Institutional Review Board of the Taipei Veterans General Hospital (VGHIRB No. 2013-04-010 AC).

2.2. Study population

We used the in-patient data claims of children younger than 18 years from the NHIRD from 2006 to 2009 to identify critically ill children with a diagnosis of pneumonia, which was defined as a record of one or more ICU stays and a discharge diagnosis of pneumonia with *International Classification of Diseases, Ninth Revision, Clinical Modification* codes 480–486 and 487.0. We excluded neonatal patients younger than 3 months and cases who died within 24 hours of admission. We also excluded the patients who had been transferred to or from another hospital to eliminate the possibility that the transfer of sicker patients would artificially enhance physician performance evaluations. Data regarding the enrolled children and their physicians were extracted from the in-patient data claims and then used for analysis. If there was more than one physician caring for the enrolled children during their ICU stays, only the physician that was in-charge until the patient was transferred out of the ICUs or dead was enrolled into the analysis.

The children with long-term ventilator dependence were identified based on a record of catastrophic illness associated with long-term mechanical ventilation. According to the criteria of catastrophic illnesses of the Bureau of NHI, the definition of long-term mechanical ventilation is when a patient requires 21 or more days and more than 6 hours per day of invasive or noninvasive ventilator use [25]. In-hospital mortality was identified if the patients' discharge condition was either that the patient was dead or was discharged against medical advice in a terminally critical condition with no further medical records provided during the following 6 months.

2.3. Physician case volume

The total pneumonia case volume of critically ill children for each attending physician from 2006 to 2009 was calculated using the attending physician identifiers in the claims data. The physician PICU pneumonia case volumes were then sorted in ascending order, and volume cutoff points were determined so that the sample could be classified into four, approximately equal-sized groups [2–4,12].

2.4. Statistical analysis

Data from the NHIRD was retrieved using Microsoft SQL Server 2008 R2 for database decoding, and then SPSS (version 19, SPSS Inc, Chicago, IL, USA) was used for data analysis. Descriptive statistics were used for the patients' and physicians' characteristics. One-way analysis of variance followed by post hoc Student-Newman-Keul test was used to compare the continuous variables, such as length of stay in ICU, total hospital days, and hospitalization expense, and the χ^2 test was used to compare categorical variables and case proportions. Logistic regression modeling was used to analyze the odds ratios (ORs) for association factors in the in-hospital mortality rate among enrolled children. The potential confounders assessed for inclusion in the logistic regression model included hospital category, physician's specialty, pneumonia case volume, age, sex, and clinical experience, and patients' age, sex, and long-term ventilator dependence. The decision threshold for eligibility was $P < .10$ for the model (univariate) and to remain in the model (multivariate). For multiple logistic regressions, the categorical dummy variables included physician case volume groups, physician's specialty, physician's sex, hospital category, patients' age groups, and long-term ventilator dependence. A two-sided P value of less than .05 was used to determine statistical significance.

3. Results

A total of 10 186 children aged 3 months to 17 years were identified as having both a record of ICU admission and a diagnosis of pneumonia from 2006 to 2009. Of these cases, 432 had records that identified patient transfers to or from another hospital or death occurring within 24 hours, and these individuals were excluded. A total of 9754 cases were thus enrolled.

Among the enrolled children, 56.9% were male, and the male-to-female ratio was 1.3. Young children (0–2 years) were the largest population ($n = 3858$, 39.6%), and teenagers (12–17 years) were the lowest population (1049, 10.7%). In total, 66.4% of enrolled children were younger than 6 years. Of the enrolled cases, 31.1% were long-term ventilator dependent (Table 1). Among the non-ventilator dependent children, 26% of them required mechanical ventilation during their ICU stays. The average length of ICU and hospital stay of the enrolled children was 9.7 ± 24.4 and 16.0 ± 21.5 days, respectively, and the hospitalization expenses per case were TWD

Table 1
Characteristics of the critically ill children with a diagnosis of pneumonia, 2006–2009

Variables	Value
Total case, n	9754
Sex	
Male, n (%)	5546 (56.9)
Female, n (%)	4208 (43.1)
Patient's age, mean (SD)	4.7 (4.6)
0–2 y, n (%)	3858 (39.6)
3–5 y, n (%)	2623 (26.9)
6–11 y, n (%)	2046 (21.0)
12–17 y, n (%)	1227 (12.5)
Long-term ventilator dependent, n (%)	3033 (31.1)
Not long-term ventilator dependent, n (%)	6721 (68.9)
≥ 4 d, n (%)	883 (13.1)
1–3 d, n (%)	880 (13.1)
None, n (%)	4958 (73.8)
Length of ICU stay (days), mean (SD)	9.7 (24.4)
Length of hospital stay, mean (SD), d	16.0 (21.5)
Hospitalization expenses, mean (SD), TWD\$/USD\$	174 837(246 548)/5464(7705) ^a
In-hospital mortality, n (%)	487 (4.9)

TWD indicates Taiwan dollar; USD, Unites States dollar.

^a USD\$1 was approximately equal to TWD\$32, 2006–2009.

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