

# Health Disparities of Critically Ill Children in Poverty: A Nationwide Population-Based Study

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## Research

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# Abstract

**Background:** There is a lack of nationwide studies on health disparity of critically ill patients under the National Health Insurance (NHI) System. We aim to evaluate health disparities in intensive care unit (ICU) admission, outcomes, and readmission after ICU discharge in an impoverished pediatric population.

**Methods:** We conducted a retrospective cohort study using a national database of claims submitted to the Korean NHI and Medical Aid Program (MAP). MAP provides support for the population whose household income is lower than 40% of the median Korean household income, and we defined poverty as being a MAP beneficiary. Patients between 28 days and 18 years old who were admitted to the ICU between August 1, 2010 and September 30, 2013, were included. Demographic characteristics, procedures, admission rates, and clinical outcomes were compared between the poverty and reference groups. Logistic regression model used to analyze hospital mortality and readmission with adjustment for patient characteristics, hospital type, and management procedures.

**Results:** Out of 17,893 patients, 1,153 (6.4%) patients were in poverty. The age-standardized ICU admission rate was higher in the poverty group (126.9 vs. 80.2 per 100,000 person-years). There were more deaths among impoverished patients who were admitted to the ICU (11.8 vs. 4.3 per 100,000 person-years). Patients in the poverty group had a similar risk of adjusted in-hospital mortality to those not in the poverty group (odds ratio: 1.15, confidence interval [CI]: 0.84–1.55) but a higher readmission rate (hazard ratio 1.25, CI 1.09–1.42).

**Conclusion:** Pediatric patients in poverty were more likely to die in association with ICU admission. A high ICU admission rate rather than the high in-hospital mortality rate may cause the disparity in deaths. Further policies and studies are required to improve the health status of pediatric patients in poverty to decrease ICU admission.

**Trial registration:** retrospectively registered

## Introduction

Health disparity is a preventable risk factor for morbidity and mortality [1]. Health disparities might come from disparities in pre-hospital health status or in-hospital healthcare [2]. Poor health status of impoverished people is associated with an increased incidence of severe sepsis [3]. In-hospital mortality rate could be affected by inadequate resource uses related to the poverty of patients in the intensive care unit (ICU) [4, 5]. Children are more likely to stay in ICUs at the end of life than adults do [6]. For treatment of critically ill children, health disparity related to poverty is important to consider at ICU admission.

Previous research on health disparities in impoverished people has focused on a few specific critical conditions [7–10]. Few studies have reported on health disparities of critically ill patients in a whole ICU system [4, 11]. In addition, there was a lack of studies conducted under the National Health Insurance (NHI) system in which barriers of medical access are low. A nationwide study on health disparity of

impoverished children is required to identify the incidence of ICU admission, healthcare outcomes during ICU admission, and health status after ICU discharge in this population without selection bias of hospitals, where the ratio of impoverished people might differ.

Therefore, we sought to evaluate health disparities among all Korean pediatric patients in the ICU. Our study aims were to evaluate differences in (1) the incidence of ICU admission, (2) ICU management outcomes, and (3) readmission rates after ICU discharge between those who were in poverty and those who were not.

## Methods

### Study population and design

We conducted a retrospective cohort study using the national database from Health Insurance Review and Assessment (HIRA), which is a central office in the Korean Ministry of Health. Korea has a single-payer national health system. The Korean NHI covers approximately 97% of Koreans, and the remaining 3% of Koreans who cannot afford national insurance are covered by the Medical Aid Program (MAP) [12]. MAP is a public assistance program to protect socially disadvantaged or low-income family whose household income is lower than 40% of the median Korean household income (example: for 1-person family  $< 0.4 \times \$1302 = \$521$  per month and for 4-person family  $< 0.4 \times \$3519 = \$1407$  per month). In this study, we defined the poverty group as the MAP beneficiaries. Claims submitted for reimbursement to Korean NHI and MAP are reviewed by the HIRA service. Therefore, the HIRA database includes virtually all ICU admissions (including private hospitals) of all patients  $< 18$  years of age in Korea between August 1, 2009, and September 30, 2014.

From this cohort, we identified ICU patients between 28 days and 18 years of age who had first ICU admission. We did not enroll patients admitted in the first study year (from August 2009 to July 2010) to limit participants to only new admissions within at least 1 year. We also excluded hospital discharges during the last study year (from October 2013 to September 2014) since we could not determine if the patients were re-admitted within 1 year or not. Then we excluded patients who changed insurance status during ICU admission ( $n = 34$ ). The final sample size was 17,893 patients who admitted between August 1, 2010, and September 30, 2013 (**Additional file 1: Supplementary Fig. 1**). The study was reviewed by the Institutional Review Board of Samsung Medical Center (# 2019-07-114) and informed consent was waived because we only accessed de-identified administrative data that had been previously collected. Detailed information regarding this study can be found elsewhere [13].

### Study variables

We identified ICU admissions using the claim codes that hospitals submit for cost claims for ICU management of in-hospital stays to HIRA (codes AJ100-AJ590900). We considered ICU stays during the same hospitalization as a single ICU admission. Similarly, we considered the claim codes of hospital stay separated by same or less than 1 day as the same hospital admission. Diagnostic codes are based on

the Korean Classification of Diseases 6th edition, which is the modified version of the International Classification of Diseases 10th revision adapted for use in the Korean health system [14].

Study outcomes were in-hospital mortality, hospital readmission, readmission to the ICU and emergency room (ER) visit within three months after discharge. In-hospital mortality was defined as death prior to discharge. To obtain readmission information, we linked study participants' personal identification numbers to the 2010–2014 inpatient databases.

Information on procedures, prescriptions, and demographic characteristics was based on claim codes. Procedures of interest were mechanical ventilation (Korean NHI procedure codes M5857, M5858, M5860), transplantation (Q8040-Q8050, Q8140-Q8150, Q8080, Q8101-Q8103, and R3280), hemodialysis (O7020, O7062, O7051-7054), and extracorporeal membrane oxygenation (O1901-O1904). We identified the use of vasopressor drugs such as dobutamine, dopamine, epinephrine, and norepinephrine for more than two days using Korea drug and anatomical therapeutic chemical codes (148201BIJ, 38900BIJ, 148701BIJ, 148702BIJ, 429500BIJ, 152601BIJ, and 203101BIJ) [15].

Hospitals were classified according to their capacity based on the number of hospital beds and the number of specialties as defined by the Korean Health Law [16]. A hospital is defined as a healthcare institution with more than 30 inpatient beds. A general hospital is a hospital with more than 100 beds and more than seven specialty departments including Internal Medicine, Surgery, Pediatrics, Obstetrics and Gynecology, Anesthesiology, Pathology, and Laboratory Medicine. A tertiary hospital is a general hospital with more than 20 specialty departments that serves as a teaching hospital for medical students and nurses. Data on ICU length of stay, hospital length of stay, and total cost of hospitalization were also collected.

## Statistical analysis

We obtained population estimates for each year of age, sex, and calendar year from the NHI Service based on our definition of poverty. All analyses were conducted separately for the poverty and non-poverty groups. We calculated standardized rates of ICU admission and mortality by the direct method [17] using the Korean standard population from 2010 to 2013 [18]. Mean and standard deviation or median and interquartile range were used to describe the distribution of continuous variables. We used the chi-square test and Student's t-tests to compare categorical and continuous variables, respectively.

We used multivariable logistic regression analysis to compare the risk of in-hospital mortality between groups. Odds ratios with 95% confidence intervals (CI) were estimated using the model. We adjusted for age, gender, primary diagnosis, vasopressor, extracorporeal membrane oxygenation and mechanical ventilation. Since patients could be clustered by hospital, we used hospital as a stratification factor in the logistic regression model. We estimated hazard ratios (HRs) with 95% CI for the cumulative incidence of readmission, readmission to the ICU, and ER visits associated with poverty after adjusting for other risk factors. We conducted subgroup analysis according to use of mechanical ventilation to evaluate the

poverty effect in subgroups with different mortality rates. In the subgroup analysis, the same logistic regression model was used except adjustment of mechanical ventilation.

We considered a p-value < 0.05 to be significant. Statistical analyses were performed using SAS® Visual Analytics (SAS Institute Inc., USA) and STATA version 14 (StataCorp LP, College Station, TX, USA).

## Results

The mean (standard deviation) age of study patients was 7.3 (6.1) years, and 57.9% were male. Among 17,893 patients, 1,153 patients (6.4%) were in poverty (Table 1). From August 2010 to September 2013, the age-standardized ICU admission rate was 82.4 per 100,000 person-years (80.2 per 100,000 person-years in non-poverty patients vs. 126.9 per 100,000 person-years in poverty patients). Poverty patients had higher rates of ICU hospitalization at all ages, and rates were especially high among younger patients (Fig. 1). Compared to non-poverty patients, those who were in poverty were older and more likely to be male (57.7% vs. 59.9%) (Table 1). Patients in the poverty group were more likely to be admitted with injuries (22.9% vs. 17.8%), neoplasms (13.8% vs. 9.3%), neurologic diseases (10.7% vs. 9.1%), and infectious diseases (3.0% vs. 2.3%) than the non-poverty group. While 39.8% and 67.4% of ICU admissions occurred in tertiary hospitals among the poverty and non-poverty groups, respectively, and rates of mechanical ventilation and vasopressor use were higher in the non-poverty group than the poverty group (Table 1).

Table 1  
 Characteristics of pediatric patients in intensive care units according to poverty status.

<b>Variables</b>	<b>Overall</b>	<b>Non-poverty</b>	<b>Poverty</b>	<b>P-value</b>
	<b>(N = 17,893)</b>	<b>(n = 16,740)</b>	<b>(n = 1,153)</b>	
<b>Age (years)</b>	7.3 (6.1)	7.1 (6.1)	10.9 (5.4)	< .001
<b>Age groups</b>				< .001
Infants, < 1 year	4,571 (25.5)	4,476 (26.7)	95 (8.2)	
Children, 1–11 years	7,283 (40.7)	6,894 (41.2)	389 (33.7)	
Adolescents, 12–17 years	6,039 (33.8)	5,370 (32.1)	669 (58.0)	
<b>Sex</b>				0.145
Male	10,357 (57.9)	9,666 (57.7)	691 (59.9)	
Female	7,536 (42.1)	7,074 (42.3)	462 (40.1)	
<b>Type of hospital</b>				< 0.001
Tertiary hospital	11,747 (65.7)	11,288 (67.4)	459 (39.8)	
General hospital	5,975 (33.4)	5,300 (31.7)	675 (58.5)	
Other	171 (1.0)	152 (0.9)	19 (1.6)	
<b>Hospital admission type<sup>¶</sup></b>				0.002
ER	8,218 (45.9)	7,638 (45.6)	580 (50.3)	
OPD	9,673 (54.1)	9,100 (54.4)	573 (49.7)	
<b>Department*</b>				< 0.001
Medical	7,481 (41.8)	6,919 (41.3)	562 (48.7)	
Surgical	10,412 (58.2)	9,821 (58.7)	591 (51.3)	
<b>Primary diagnosis</b>				< 0.001
Congenital anomalies	5,082 (28.4)	4,872 (29.1)	210 (18.2)	
Injury	3,246 (18.1)	2,982 (17.8)	264 (22.9)	
Respiratory disease	1,945 (10.9)	1,862 (11.1)	83 (7.2)	
Neoplasms	1,715 (9.6)	1,556 (9.3)	159 (13.8)	
Neurologic disease	1,648 (9.2)	1,525 (9.1)	123 (10.7)	
Circulatory disease	1,531 (8.6)	1,446 (8.6)	85 (7.4)	

Variables	Overall	Non-poverty	Poverty	P-value
	(N = 17,893)	(n = 16,740)	(n = 1,153)	
NEC (not elsewhere classified)	622 (3.5)	556 (3.3)	66 (5.7)	
Gastrointestinal disease	464 (2.6)	439 (2.6)	25 (2.2)	
Infectious disease	426 (2.4)	391 (2.3)	35 (3.0)	
Others	1,214 (6.8)	1,111 (6.6)	103 (8.9)	
<b>Region**</b>				< 0.001
Seoul	8,368 (46.8)	7,973 (47.6)	395 (34.3)	
Metropolitan areas	3,650 (20.4)	3,312 (19.8)	338 (29.3)	
Rural areas	5,875 (32.8)	5,455 (32.6)	420 (36.4)	
<b>Management procedures</b>				
Mechanical ventilation*	7,624 (42.6)	7,214 (43.1)	410 (35.6)	< 0.001
Vasopressors	2,788 (15.6)	2,646 (15.8)	142 (12.3)	0.002
CPR	835 (4.7)	770 (4.6)	65 (5.6)	0.106
Transplantation	52 (0.3)	49 (0.3)	3 (0.3)	1
Hemodialysis	456 (2.5)	423 (2.5)	33 (2.9)	0.485
ECMO	158 (0.9)	147 (0.9)	11 (1.0)	0.790
Values in the table are number (%), except for age (mean and SD).				
ER: Emergency room; OPD: Outpatient department; ECMO: Extracorporeal membrane oxygenation, CPR: Cardiopulmonary resuscitation, IQR: Interquartile range.				
* Medical admissions included Pediatrics, Internal Medicine, Neurology, Neuropsychiatry, Dermatology, Rehabilitation Medicine, General, Radiology, Family Medicine, and Emergency Medicine. Surgical admissions included General Surgery, Orthopedic Surgery, Neurosurgery, Thoracic and Cardiovascular Surgery, Plastic Surgery, Ophthalmology, Otorhinolaryngology, Urology, Oral Surgery, Anesthesiology, and Obstetrics and Gynecology.				
** Regions were grouped as Seoul, metropolitan areas (Busan, Incheon, Daegu, Gwangju, Daejeon and Ulsan) and rural areas (Gyeonggi, Kangwon, Chungbuk, Chungnam, Jeonbuk, Jeonnam, Gyeongbuk, Gyeongnam, Jeju and Sejong).				
¶ 6 (0.02%) admissions were missing in the hospital admission type.				

The overall in-hospital mortality was 5.1% (6.0% in poverty patients and 5.1% in non-poverty patients;  $p = 0.223$ ). The overall mortality of the subgroup with mechanical ventilation was 10.8%, while that of the subgroup without mechanical ventilation was 0.9%. There were 4.5 ICU deaths per 100,000 Koreans per year (4.3 deaths per 100,000 person-years in non-poverty patients vs. 11.8 deaths per 100,000 person-

years in poverty patients; Fig. 1). Multivariable analysis showed that the two groups had a similar risk of in-hospital mortality (adjusted odds ratio, 1.15; 95% CI, 0.84–1.55;  $p = 0.38$ ; Table 2). In the both subgroups with and without mechanical ventilation, the adjusted risk of in-hospital mortality was not statistically different between poverty and non-poverty group. Among patients who survived ( $n = 17,360$ ), those in the poverty group were more likely to be re-admitted (adjusted HR 1.25; 95% CI 1.09–1.42) and visit the ER (adjusted HR 1.31; 95% CI 1.06–1.62) within three months after discharge than those in the non-poverty group were (Table 3).

Table 2  
In-hospital mortality of pediatric patients in intensive care units according to poverty status.

In-hospital mortality	No. of patients	No. of death	Adjusted OR (95% CI)	p-value
<b>Overall</b>				
Non-poverty	16,740	850 (5.1)	<i>Reference</i>	
Poverty	1,153	69 (6.0)	1.15 (0.84–1.55)	0.384
<b>Non-mechanical ventilation</b>				
Non-poverty	9526	88 (0.9)	<i>Reference</i>	
Poverty	743	9 (1.2)	1.71 (0.83–3.52)	0.145
<b>Mechanical ventilation</b>				
Non-poverty	7214	762 (10.6)	<i>Reference</i>	
Poverty	410	60 (14.6)	1.05 (0.75–1.47)	0.776
Model was adjusted for age, gender, primary diagnosis (congenital anomalies, injury, respiratory disease, neoplasms, neurologic disease, circulatory disease, NEC(not elsewhere classified), gastrointestinal disease and infectious disease), vasopressor, extracorporeal membrane oxygenation and mechanical ventilation (adjusted only overall group)				
p-for interaction was 0.588.				

Table 3  
Post-ICU discharge outcomes according to poverty status (N = 17,360)

3 months after ICU discharge	Adjusted	
	OR (95% CI)	p-value
<b>Overall</b>		
Re-admission	<b>1.25 (1.09–1.42)</b>	<b>&lt; .001</b>
Re-admission to the ICU	1.31 (0.98–1.74)	0.06
Emergency room visit	<b>1.31 (1.06–1.62)</b>	<b>0.011</b>
<b>Non-mechanical ventilation</b>		
Re-admission	1.13 (0.96–1.33)	0.134
Re-admission to the ICU	1.30 (0.94–1.80)	0.119
Emergency room visit	<b>1.26 (1.00-1.59)</b>	<b>0.048</b>
<b>Mechanical ventilation</b>		
Re-admission	<b>1.42 (1.17–1.73)</b>	<b>&lt; .001</b>
Re-admission to the ICU	1.31 (0.86–1.98)	0.21
Emergency room visit	<b>1.35 (1.00-1.83)</b>	<b>0.049</b>
Model was adjusted for age, gender, cause of admission (congenital anomalies, injury, respiratory disease, neoplasms, neurologic disease, circulatory disease, NEC (not elsewhere classified), gastrointestinal disease and infectious disease), vasopressor, extracorporeal membrane oxygenation and mechanical ventilation (adjusted only overall group)		
P-for interaction 0.002, 0.48, and 0.40 with re-admission, re-admission to ICU, and emergency room visit		

## Discussion

In this representative population-base cohort, we showed that the age-standardized population-based ICU admission rate of children in poverty (income of their household < 0.4 × median household income of Korea) was 1.6 (126.9/80.2) times higher than that of children not in poverty. The age-standardized population-based mortality rate of children in poverty was 2.7 (11.8/4.3) times higher than that of children not in poverty. The adjusted in-hospital mortality of critically ill children admitted to the ICU was not different between the poverty and non-poverty groups.

The high age-standardized mortality in the impoverished population highlights a critical public health issue (Fig. 1). A child in an impoverished family has a high risk of death. Once children were admitted, the crude in-hospital mortality of children in poverty was not statistically different from that of the non-poverty group (6.0% vs. 5.1%,  $p = 0.223$ ). In addition, the difference in mortality rates between the two

groups was not significant when we adjusted for demographics, hospital factors, and management procedures. The result of adjusted analysis was similar in the high mortality subgroup (mechanical ventilation) and low mortality subgroup (non-mechanical ventilation). It may suggest that there is no disparity in healthcare outcomes in ICU according to poverty. However, the admission rate was high in the poverty group across all age groups. Therefore, the age-standardized mortality of the impoverished population is likely due to high admission rate of the group rather than from high in-hospital mortality rate. We could not identify the cause of high admission rate in the poverty group, but poor pre-hospital health status could be an explanation. In previous studies, the severity scores of patients at ICU admission were higher in uninsured patients [5, 11], which implies worse health status of them at ICU admission. Previous studies conducted at select hospitals were not able to identify disparities in admission rate and population-based mortality because of selection bias [8, 11, 19]. Utilization of high-volume or top-ranked (low mortality) hospitals differed according to poverty status [20, 21], and data from these renowned hospitals could bias admission rates of low-income patients. In our study, we included all hospitals where pediatric patients are admitted to the ICU, except for rare possible administrative losses of insurance claims.

Disparity in resource use was suspected as one of the causes of disparity in healthcare outcomes [5]. The low incidence of mechanical ventilation (35.6% vs. 43.1) and vasopressor use (12.3% vs. 15.8%) in the poverty group might raise suspicion of a passive attitude toward treating patients in poverty. However, the rates of mechanical ventilation and vasopressor uses were different by age group in our previous study [13]. The age distribution of the poverty group was different from that of the overall population, possibly due to the different age distribution of parents under MAP from the general population. When we stratified age into 3 groups (infant, children, adolescent), there were no statistically significant differences in the incidence of mechanical ventilation and vasopressors according to poverty status (Additional file 2: Table S1). In addition, the incidence of other resource-heavy procedures such as transplantation, extracorporeal membrane oxygenation, and hemodialysis was similar between the poverty and non-poverty groups in an NHI system (Table 1) (Additional file 2: Table S1). These findings are contrary to the reported socioeconomic disparities in transplantation [22–24]. The difference might originate from the different health insurance systems.

Low socioeconomic status (SES) could affect pre-hospital health status in various ways. Difficulties in access to care and preventive health services may contribute to the high severity of illness and organ failure on hospital presentation [2]. Other factors such as inadequate health behaviors, lack of parental education, unhealthy environmental factors, and low vaccination rates may contribute to the worse health status of the low SES population [2, 25]. In our study, ER visits and readmission rates after ICU discharge were higher in patients in poverty. Previous studies reported that the increased rate of ER visits in low SES patients is associated with differences in health status rather than health behaviors [26]. Low SES is also associated with a high readmission rate [27, 28]. We suspect that the high ER visit and readmission rate among patients in poverty imply poor health status. Policies to improve the health status of patients in poverty might be required to decrease population-based mortality associated with ICU admission.

The adjusted in-hospital mortality, in this study, was similar between the two groups, which might imply that healthcare resources and services were easily accessible during ICU admission without disparity. However, one needs to be cautious in saying there were no healthcare disparities in the ICU. The overall in-hospital mortality rate of children might be too low to identify a disparity compared to adult patients [13, 29]. Furthermore, healthcare disparities might exist in some subgroups of ICU patients.

There are some limitations to this study. First, this study was conducted in a single country where a National Healthcare Insurance System covers the impoverished with a MAP, thus virtually no one is uninsured population. Our findings are more likely to apply to countries with a National Health Insurance system and may yield different results according to insurance status. Second, we could not use physiologic parameters or laboratory findings to evaluate the severity of illness. However, we adjusted for illness severity using the different mortality rates for the primary diagnosis, hospital factors, and treatment requirements, according to a previous study [13]. Despite these limitations, we included virtually all pediatric patients admitted to the ICU, which allowed us to calculate the population-based admission rate and mortality rate without selection bias associated with particular hospitals.

Our findings also have implications for reducing disparities in mortality in patients living in poverty. The National Health Insurance System with a single-payer might work well to provide healthcare in the ICU to impoverished patients without disparity, but policies to improve the health status of patients in poverty are required to decrease ICU admission and improve population-based mortality.

## Conclusion

Pediatric patients in poverty were more likely to die in association with ICU admission. A high ICU admission rate rather than the high in-hospital mortality rate may cause the disparity in deaths. Further policies and studies are required to improve the health status of pediatric patients in poverty to decrease ICU admission.

### Supplementary information

**Additional file 1.** Figure S1: Flow chart of Patient selection with inclusion and exclusion

**Additional file 2.** Table S1: Characteristics of pediatric patients in intensive care units according to poverty status by age groups.

## Abbreviations

ICU

intensive care unit; NHI:National Health Insurance; MAP:Medical Aid Program; HIRA:Health Insurance Review and Assessment; ER:emergency room; CI:confidence interval; HR:hazard ratio; SES:socioeconomic status

## Declarations

**Ethical approval and consent to participate:** This study was approved by the research ethics committee from Samsung Medical Center (Seoul, Korea) and informed consent was exempted because we only accessed de-identified previously collected data.

**Consent for publication:** not applicable

### Availability of data and materials

The researchers can access on the intranet of Korean Health Insurance Review & Assessment Service through the URL <http://opendata.hira.or.kr/home.do> after approval of the request. The researchers can request the same periods, terms and items (claim codes) as done in this study. The authors did not have any special access privileges that others would not have.

**Conflicts of interest:** All authors declare no support from any organization for the submitted work; no financial relationships with any organization that might have an interest in the submitted work in the previous three years; and no other relationships or activities that could appear to have influenced the submitted work.

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**Authors' contributions:** EP, HP, JC conceived the study idea. EP, HP, JC, GYS, KJ, CRC, JHY, JC2 and EG designed the study. JC2, HP, DK were responsible for collection data. JC2, HP, DK and EG provided statistical expertise. EP and HP wrote the first draft of the manuscript. EG, JC2, and JC made critical revisions of the manuscript content. All the authors contributed to the interpretation of the results and approved the final version of the manuscript.

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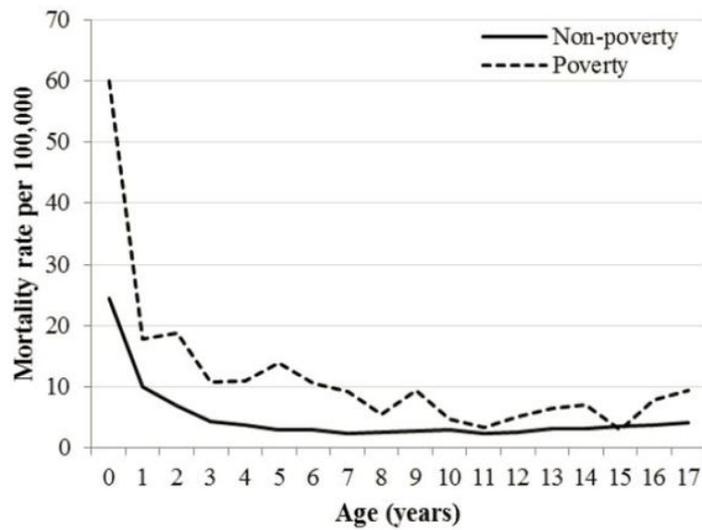
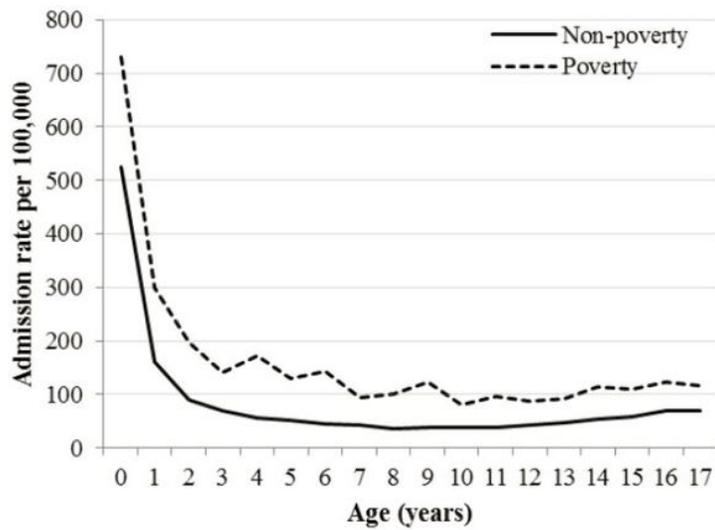
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## Figures



**Figure 1**

Age-standardized rates of admission to intensive care units (left) and mortality (right) according to poverty status by age.

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