


BMJ Open Inequality of trauma care under a single-payer universal coverage system in Taiwan: a nationwide cohort study from the National Health Insurance Research Database

Ling-wei Kuo ¹, Chih-Yuan Fu,¹ Chien-An Liao,¹ Chien-Hung Liao,¹ Chi-Hsun Hsieh,¹ Shang-Yu Wang,¹ Shao-Wei Chen,² Chi-Tung Cheng¹

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¹Trauma and Critical Care Center, Chang Gung Memorial Hospital Linkou Main Branch, Taoyuan, Taiwan

²Division of Thoracic and Cardiovascular Surgery, Department of Surgery, Chang Gung Memorial Hospital Linkou Branch, Taoyuan, Taiwan

Correspondence to

Dr Chi-Tung Cheng;
atong89130@gmail.com

ABSTRACT

Objectives To assess the impact of lower socioeconomic status on the outcome of major torso trauma patients under the single-payer system by the National Health Insurance (NHI) in Taiwan.

Design A nationwide, retrospective cohort study.

Setting An observational study from the NHI Research Database (NHIRD), involving all the insurees in the NHI.

Participants Patients with major torso trauma (injury severity score ≥ 16) from 2003 to 2013 in Taiwan were included. International Classification of Disease, Ninth Revision, Clinical Modification codes were used to identify trauma patients. A total of 64 721 patients were initially identified in the NHIRD. After applying the exclusion criteria, 20 009 patients were included in our statistical analysis.

Primary and secondary outcome measures The primary outcome measure was in-hospital mortality, and we analysed patients with different income levels and geographic regions. Multiple logistic regression was used to control for confounding variables.

Results In univariate analysis, geographic disparities and low-income level were both risk factors for in-hospital mortality for patients with major torso trauma ($p=0.002$ and <0.001 , respectively). However, in multivariate analysis, only a low-income level remained an independent risk factor for increased in-hospital mortality ($p<0.001$).

Conclusion Even with the NHI, wealth inequity still led to different outcomes for major torso trauma in Taiwan. Health policies must focus on this vulnerable group to eliminate inequality in trauma care.

INTRODUCTION

Multiple socioeconomic status (SES) factors, including race, insurance status, rural geographic location and low-income level, have been reported to impact the epidemiology and outcomes of trauma events.^{1–4} However, these SES factors often interact with each other, making it difficult to define the extent of the influence of each factor.⁵

Strengths and limitations of this study

- This is the first study to assess the relationship between socioeconomic factors and the outcome of major trauma patients under the single-payer, universal coverage National Health Insurance (NHI) system in Taiwan.
- This study includes all major torso trauma patients under the NHI system, which covers >99% of Taiwan's residents.
- The NHI's payroll bracket was based on the income level from the National Taxation Bureau. Therefore, the income level was clearly defined in this study.
- The NHI Research Database did not provide clinical details, such as physiological parameters, laboratory data and severity.
- Only the data between 2003 and 2013 were included in this study due to policy augmentation. Future studies are needed to investigate more recent outcomes.

Taiwan is a country that has universal health insurance coverage for its citizens and inhabitants. Initiated in 1995, the National Health Insurance (NHI) programme is run by the government and is a universal single-payer insurance system with mandatory enrolment. Currently, >99% of Taiwan's population (~23 million residents) receive medical care through the NHI.⁶ Theoretically, the universal coverage of the NHI should have partially eliminated the negative effect of low SES on health outcomes. However, Taiwan is also a country with rapidly escalating wealth inequity.⁷ In 1998, the household income of the top 5% was 32.74 times as much as the income of the lowest 5%. In 2013, this ratio changed to 99.39.⁸ Evidence has shown that even the NHI system does not change the disparity in health outcomes experienced by people of different SESs.⁹ More interestingly,

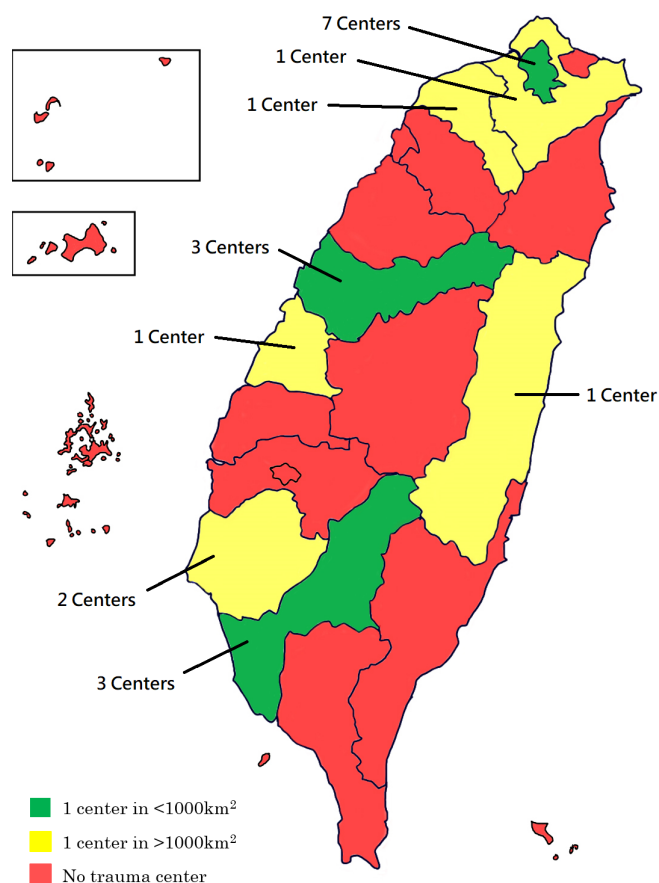


Figure 1 The uneven distribution of medical resources for trauma in Taiwan. Zone 1 (green area) includes the counties/cities that have more than one trauma centre per 1000 km². Zone 2 (yellow area) includes the counties/cities that have fewer than one trauma centre per 1000 km², and zone 3 (red area) includes the counties/cities that have no trauma centres.

while the NHI has provided universal financial support for patients, the difference in the existing infrastructure between regions remains substantial, with 7 of the country's 19 medical centres located in Taipei city, the country's capital, and only one is located in the country's eastern region (figure 1).

Trauma has remained in the top six common causes of death in Taiwan for over a decade, accounting for ~30 deaths per 100 000 population annually.¹⁰ However, there is still no budget designated for trauma care in Taiwan, and no research has been conducted regarding the relationship between SES and trauma outcomes under the current NHI system. The purpose of this study was to analyse the data from the NHI Research Database (NHIRD) and to assess whether income levels and geographic disparities in infrastructure influence in-hospital mortality for major trauma patients to draw attention to trauma care from stakeholders in policymaking.

MATERIALS AND METHODS

Data

Data regarding the medical services provided by the programme are collected by the National Health Insurance Administration and entered into the NHIRD. This database comprises all claims pertaining to visits, procedures and prescription medications and includes anonymous eligibility and enrolment information. In this study, all admission records from 2003 to 2013 in the database were analysed. The records from the emergency department (ED) were in a separate dataset and were not included in this study.

Study cohort

This retrospective, observational study included all patients with major torso trauma in Taiwan from 2003 to 2013. Major trauma has been an eligibility criterion for the catastrophic illness certificate since the beginning of the NHI, but before 2003, there was no unique coding for such patients, so there was no way to identify them from the NHIRD. After 2013, a new project was implemented to reinforce medical resources in disadvantaged areas. In 2012, the amendment of the Emergency Medical Services Act required health authorities to adopt a system of rewards for areas lacking emergency medical service resources to balance these resources and improve the quality and efficiency of emergency medical services in disadvantaged regions.¹¹ Thus, the Quality Improvement Project for the Rural and Short of Medical Resource Regions was introduced in 2014, which allocated 80 million New Taiwan Dollar (NTD) (~US\$2.55 million) in subsidies for the emergency medicine network annually.¹² Therefore, we focused only on the 2003–2013 era in this study. The definition of major trauma was an injury with an injury severity score (ISS) ≥ 16 . It is important to note that the NHIRD does not record the ISS, but all patients with ISSs ≥ 16 are eligible to receive a catastrophic illness certificate, which provides copayment exemptions for any medical expenses related to the original trauma, including outpatient clinic visits, ED visits or hospital admissions. To prevent unnecessary compensation and extra expenses for the NHI, strict chart reviews are performed by the NHI before issuing a catastrophic illness certificate. Therefore, the catastrophic illness certificates serve as an accurate guide for identifying appropriate patients. We identified torso trauma patients according to their International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-CM) codes. The codes we used for specific injuries were as follows: 800–804, 850.3–850.5, 850.9 and 851–854 for head injuries; 861.0 and 861.1 for cardiac injuries; 861.2 and 861.3 for lung injuries; 860 for pneumothorax; 863 for gastrointestinal (GI) injuries; 865 for splenic injuries; 864 for liver injuries; 866 for kidney injuries; 867 for pelvic organ injuries; 808 for pelvic fractures; 805 and 806 for spinal injuries; and 820 and 821 for femoral fractures. Patients with isolated traumatic brain injury (TBI) were excluded because the natural course of TBIs is quite different from that of

from torso injuries. Preventable deaths are less common with TBIs,^{13 14} suggesting that treatment options and SES factors might have less potential influence on mortality. Last, only patients older than 18 years were included in the cohort.

Variables and outcome

This study was intended to assess the outcomes experienced by patients with different income levels and in different geographic regions. Three independent subgroupings were generated. The subgrouping for income level was extracted from the data of the NHI payroll brackets. The payroll bracket can be divided into a few groups.¹⁵ The first group is the people who have registered sources of incomes, including all the employees, employers, self-employed workers who belong in occupational unions, and self-employed farmers, fishermen and so on who belong to agricultural associations. For this population group, the income is equivalent to the insurance amount, which is paid to the NHI by the insurer, the employer and the government, in different proportions. We divided patients from this category into two groups based on the relative poverty (RP) line, which is 60% of the median income.¹⁶ In 2013, the RP line was 19 279 NTD/month (approximately equal to US\$624.5).¹⁷ Patients with income levels below this line were assigned to the under the RP line group, and those with incomes greater than the RP line were assigned to the above the RP line group. The first degree and direct second degree relatives of people with registered incomes, including their spouse, parents or grandparents, and children or grandchildren who are under 20 years of age, with no registered incomes, were defined as the dependent group. The insurance amount in this group is the same as that of the insured, but the dependent does not have to pay. The insurance fee is defrayed by the insurer, the employer of the insurer and the government in different proportions. Those who lack both income and family support are insured under the auspices of the local government. The insurance amount of this group is a minimal fee based on the actuarial analysis by the NHI, which is 100% paid by the government. Patients from this population constituted the unemployed group in our analysis.

To create the geographic subgroups, the number of trauma centres per square kilometres, instead of per population, was used as a measurement of the disparity of medical resources because geospatial factors, that is, transport distance and time, are significant predictors of mortality from trauma.^{18–20} We separated the country into three zones (figure 1). Zone 1 included the administrative areas that have the most abundant medical resources, with more than one level one trauma centre per 1000 km². Zone 2 included the administrative areas that have intermediate levels of medical resources, with fewer than one trauma centre per 1000 km², and zone 3 included the administrative areas that are lacking in medical resources, with no trauma centres. Considering the possible impact of different levels of hospitals, independent of the

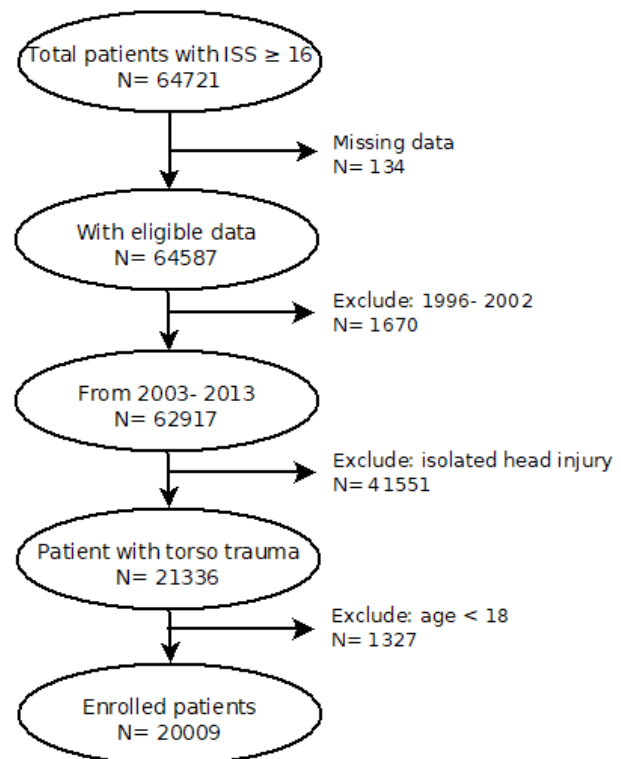


Figure 2 The algorithm of the data extraction from the NHIRD. From 2003 to 2013, 64 721 patients were initially identified from the NHIRD. After excluding missing data and those who did not meet the inclusion criteria, 20 009 patients were included in the analysis. ISS, injury severity score; NHIRD, NHI Research Database.

influence of regional differences, we divided the patients according to whether they initially received treatment from a trauma centre or a non-trauma centre hospital. After categorisation, we compared the subgroups with regard to basic demographic characteristics, injury types, complications and in-hospital mortality rates. For the statistical analysis, we used χ^2 tests and Kruskal-Wallis tests, as appropriate. Multivariate logistic regression was performed to determine the factors that independently affect in-hospital mortality. We performed the statistical analyses with IBM SPSS Statistics for Windows V.22.0.

Patient and public involvement

Due to the retrospective and database-based nature of this study, patients and the public were not involved.

RESULTS

In the study cohort, 64 721 patients were initially identified from the NHIRD. After excluding those with missing data (n=134), data from the time (1996–2002) when the catastrophic illness certificate for major trauma had not been popularised (n=1670), those with isolated head injuries (n=41 551) and those under 18 years of age (n=1327), 20 009 patients were included in our statistical analysis (figure 2). Table 1 shows the basic demographics, injury types, complications and in-hospital mortality rates in the

Table 1 Characteristics of major torso trauma patients with different income levels

Variable	Income level				P value
	Dependent (n=4887)	Unemployed (n=3915)	Below RP line (n=6930)	Above RP line (n=4277)	
Age, years, median (IQR)	36 (20–65)	42 (31–56)	50 (35–63)	43 (31–53)	<0.001*
Chronic condition, no					<0.001*
0	3807 (77.9%)	3026 (77.3%)	5131 (74.0%)	3551 (83.0%)	
1–2	916 (18.7%)	763 (19.5%)	1584 (22.9%)	663 (15.5%)	
≥3	164 (3.4%)	126 (3.2%)	215 (3.1%)	63 (1.5%)	
Sex (male, ratio)	3109 (63.6%)	3074 (78.5%)	4940 (71.3%)	3249 (76.0%)	<0.001*
Injury type					
Head	2646 (54.1%)	2098 (53.6%)	3610 (52.1%)	2135 (49.9%)	<0.001*
Cardiac	58 (1.2%)	37 (0.9%)	63 (0.9%)	65 (1.5%)	0.016*
Pneumothorax	1719 (35.2%)	1515 (38.7%)	2935 (42.4%)	1808 (42.3%)	<0.001*
Lung	733 (15.0%)	552 (14.1%)	933 (13.5%)	679 (15.9%)	0.003*
GI tract	282 (5.8%)	237 (6.1%)	458 (6.6%)	287 (6.7%)	0.169
Spleen	704 (14.4%)	434 (11.1%)	775 (11.2%)	490 (11.5%)	<0.001*
Liver	787 (16.1%)	570 (14.6%)	912 (13.2%)	670 (15.7%)	<0.001*
Kidney	281 (5.7%)	188 (4.8%)	287 (4.1%)	220 (5.1%)	0.001*
Pelvic organ	84 (1.7%)	70 (1.8%)	130 (1.9%)	97 (2.3%)	0.237
Pelvic fracture	764 (15.6%)	526 (13.4%)	973 (14.0%)	632 (14.8%)	0.018*
Spine	1023 (20.9%)	1009 (25.8%)	1649 (23.8%)	1003 (23.5%)	<0.001*
Femoral fracture	1239 (25.4%)	823 (21.0%)	1422 (20.5%)	814 (19.0%)	<0.001*
Complication					
Dialysis	128 (2.6%)	89 (2.3%)	192 (2.8%)	109 (2.5%)	0.476
ACS	11 (0.2%)	7 (0.2%)	16 (0.2%)	3 (0.1%)	0.002*
Pneumonia	439 (9.0%)	386 (9.9%)	732 (10.6%)	313 (7.3%)	<0.001*
Sepsis	31 (0.6%)	30 (0.8%)	62 (0.9%)	19 (0.4%)	0.042*
Stroke	62 (1.3%)	49 (1.3%)	58 (0.8%)	36 (0.8%)	0.034*
GI bleeding	88 (1.8%)	92 (2.3%)	192 (2.8%)	86 (2.0%)	0.003*
In-hospital mortality	706 (14.4%)	585 (14.9%)	1010 (14.6%)	503 (11.8%)	<0.001*

*p<0.05

ACS, acute coronary syndrome; GI, gastrointestinal; RP, relative poverty.

patients classified by income level. Considerable heterogeneity in these characteristics existed between each income level; the in-hospital mortality rate was significantly lower in the above the RP line group than in the other three groups of patients with inferior income levels ($p<0.001$). When the patients were divided by region and hospital levels, the same heterogeneity was noted among patient characteristics. The in-hospital mortality rate significantly differed by region ($p=0.002$), with zone 3 having the highest mortality rate (table 2). Different hospital levels also had a significant influence on in-hospital mortality (table 3). Patients who were initially treated in a non-trauma centre had a higher mortality rate than those treated in a trauma centre (15.3% vs 12.7%, $p<0.001$).

To determine which factors influence in-hospital mortality, a multivariate analysis was conducted (table 4).

An income status below the RP line remained an independent risk factor associated with increased in-hospital mortality rates (dependent: OR=1.290, 95% CI 1.133 to 1.469; unemployed: OR=1.307; 95% CI 1.142 to 1.496; below RP: OR=1.209; 95% CI 1.070 to 1.366; $p<0.001$). The geographic disparity in infrastructure was no longer significant ($p=0.676$), but hospital level remained significant, with treatment in a non-trauma centre setting significantly increasing the risk of in-hospital mortality (OR=1.209; 95% CI 1.096 to 1.334; $p<0.001$). The number of pre-existing chronic conditions was also not significantly associated with increased in-hospital mortality. Other independent risk factors included age (OR=1.013, 95% CI 1.011 to 1.016); head (OR=3.637, 95% CI 3.287 to 4.025), heart (OR=1.475, 95% CI 1.019 to 2.137), lung (OR=1.337, 95% CI 1.187 to 1.506) and GI injuries

Table 2 Characteristics of major torso trauma patients in different geographic regions

Variable	Region			P value
	Zone 1 (n=8629)	Zone 2 (n=7432)	Zone 3 (n=3948)	
Age, years, median (IQR)	43 (28–57)	44 (29–59)	48 (32–63)	<0.001*
Chronic condition, no				<0.001*
0	6776 (78.5%)	5842 (78.6%)	2897 (73.4%)	
1–2	1629 (18.9%)	1381 (18.6%)	916 (23.2%)	
≥3	224 (2.6%)	209 (2.8%)	135 (3.4%)	
Sex (male, ratio)	6201 (71.9%)	5373 (72.3%)	2798 (70.9%)	0.273
Injury type				
Head	4610 (53.4%)	3644 (49.0%)	2235 (56.6%)	<0.001*
Cardiac	96 (1.1%)	94 (1.3%)	33 (0.8%)	0.116
Pneumohemothorax	3328 (38.6%)	2937 (39.5%)	1712 (43.4%)	<0.001*
Lung	1200 (13.9%)	1200 (16.1%)	497 (12.6%)	<0.001*
GI tract	491 (5.7%)	488 (6.6%)	285 (7.2%)	0.003*
Spleen	986 (11.4%)	909 (12.2%)	508 (12.9%)	0.053
Liver	1255 (14.5%)	1198 (16.1%)	486 (12.3%)	<0.001*
Kidney	425 (4.9%)	374 (5.0%)	177 (4.5%)	0.417
Pelvic organ	170 (2.0%)	161 (2.2%)	50 (1.3%)	0.003*
Pelvic fracture	1367 (15.8%)	1051 (14.1%)	477 (12.1%)	<0.001*
Spine	2110 (24.5%)	1721 (23.2%)	853 (21.6%)	0.002*
Femoral fracture	1900 (22.0%)	1566 (21.1%)	832 (21.1%)	0.271
Complication				
Dialysis	240 (2.8%)	182 (2.4%)	96 (2.4%)	0.328
ACS	10 (0.1%)	19 (0.3%)	8 (0.2%)	0.116
Pneumonia	705 (8.2%)	706 (9.5%)	459 (11.6%)	<0.001*
Sepsis	53 (0.6%)	55 (0.7%)	34 (0.9%)	0.287
Stroke	82 (1.0%)	71 (1.0%)	52 (1.3%)	0.125
GI bleeding	222 (2.6%)	128 (1.7%)	108 (2.7%)	<0.001*
In-hospital mortality	1230 (14.3%)	967 (13.0%)	607 (15.4%)	0.002*

*p<0.05.

ACS, acute coronary syndrome; GI, gastrointestinal.

(OR=1.351, 95% CI 1.130 to 1.616); and the complications of renal failure (OR=9.532, 95% CI 7.823 to 11.615) and stroke (OR=1.687, 95% CI 1.197 to 2.378).

DISCUSSION

This is the first study investigating the correlation of SES and the outcomes of trauma under the NHI system. In our study, we demonstrated that any income status below the RP line is an independent risk factor for in-hospital mortality among major torso trauma patients. Theoretically, a difference in patient management should not exist in the single-payer system provided by NHI because the same quality of treatment is provided to patients of all economic statuses. We postulated that the care from the family support system is different in each level of income. One notorious disadvantage of the NHIRD is the exploitation of medical professionals, which leads to high

burnout rates, especially among nursing staff.^{21 22} The shortage of the nursing workforce is constant in Taiwan. When measured by nursing hours per patient day (NHPPD), Taiwan averages 5.19 hours, which is very likely to be overestimated, whereas the American Nurses Association suggests that the minimal requirement for the NHPPD is 6 hours for medical and surgical ward nurses.^{23 24} According to another more intuitive measurement, the patient–nurse ratio, the average in Taiwan is approximately nine patients to one nurse,²⁵ but the ratio mandated by California legislation is no more than five medical or surgical patients per nurse.²⁶ Additionally, the NHI does not cover adjunctive systems for the clinical care of patients, such as licensed practical nurses and nursing assistants, as in the USA. A personal caregiver would cost >2000 NTD (~US\$65) for each patient per day, which might lead to financial pressure on each

Table 3 Characteristics of major torso trauma patients stratified by hospital level

Variable	Hospital level		P value
	Non-trauma centre (n=10227)	Trauma centre (n=9782)	
Age, years, median (IQR)	47 (31–61)	43 (27–57)	<0.001*
Chronic condition, no			<0.001*
0	7692 (75.2%)	7823 (79.97%)	
1–2	916 (21.9%)	763 (17.27%)	
≥3	164 (2.9%)	126 (2.76%)	
Sex (male, ratio)	7330 (71.7%)	7042 (72.0%)	0.619
Injury type			
Head	5664 (55.4%)	4825 (49.3%)	<0.001*
Cardiac	82 (0.8%)	141 (1.4%)	<0.001*
Pneumothorax	4178 (40.9%)	3799 (38.8%)	0.004*
Lung	1308 (12.8%)	1589 (16.2%)	<0.001*
GI tract	656 (6.4%)	608 (6.2%)	0.563
Spleen	1203 (11.8%)	1200 (12.3%)	0.273
Liver	1339 (13.1%)	1600 (16.4%)	<0.001*
Kidney	443 (4.3%)	533 (5.4%)	<0.001*
Pelvic organ	170 (1.7%)	211 (2.2%)	0.010*
Pelvic fracture	1332 (13.0%)	1563 (16.0%)	<0.001*
Spine	2288 (22.4%)	2396 (24.5%)	<0.001*
Femoral fracture	2239 (21.9%)	2059 (21.0%)	0.146
Complication			
Dialysis	238 (2.3%)	280 (2.9%)	0.017*
ACS	21 (0.2%)	16 (0.2%)	0.492
Pneumonia	1045 (10.2%)	825 (8.4%)	<0.001*
Sepsis	84 (0.8%)	58 (0.6%)	0.054
Stroke	110 (1.1%)	95 (1.0%)	0.463
GI bleeding	289 (2.8%)	169 (1.7%)	<0.001*
In-hospital mortality	1564 (15.3%)	1240 (12.7%)	<0.001*

*p<0.05.

ACS, acute coronary syndrome; GI, gastrointestinal.

family.²⁷ Under these circumstances, much of the care of the patient relies solely on the family support system. Confusions regarding patient care and complications are not uncommon,^{28 29} and these adverse incidences might ultimately result in different levels of quality of care and different outcomes.

Moreover, the incidence of major torso trauma is extremely high among the lower income groups. The dependent, unemployed and below the RP line groups accounted for 78.6% of all the enrolled patients, and the 2013 RP line (19 279 NTD/month) was already below the second decile of monthly income (22 471 NTD/month),¹⁶ indicating that <20% of the population produced more than 3/4 of the major torso trauma patients. Poverty is associated with increased trauma incidence and increased mortality.^{30–32} Perhaps another urgent issue is

the development of trauma prevention strategies for the lower SES groups.

The presence of geographic disparities in medical resource density was associated with a significant difference in trauma outcomes in the univariate analysis but not the multivariate analysis. In fact, a low-income status overwhelmed the potential influence of medical resource shortages in zones 2 and 3. When focusing on each region separately, patients with financial disadvantages still presented with inferior outcomes, indicating that they did not benefit from the resource abundance in zones 1 and 2 (table 5). Interestingly, compared with the other two zones, zone 3 had fewer patients with incomes above the RP line, but it also had fewer dependent and unemployed patients, which is contrary to our assumption that the unemployment rate is high in economically

Table 4 Multivariate analysis of the factors affecting In-hospital mortality

Variable	OR	95% CI	P value
Sex (male)	1.100	0.999 to 1.212	0.052
Age	1.013	1.011 to 1.016	<0.001*
No of underlying conditions (compared with 0)			0.458
1–2	0.951	0.848 to 1.066	0.385
≥3	0.875	0.683 to 1.120	0.290
Injury type			
Head	3.637	3.287 to 4.025	<0.001*
Cardiac	1.475	1.019 to 2.137	0.040*
Lung	1.337	1.187 to 1.506	<0.001*
Pneumohemothorax	0.735	0.663 to 0.814	<0.001*
GI tract	1.351	1.130 to 1.616	0.001*
Spleen	0.776	0.665 to 0.905	0.001*
Liver	0.957	0.837 to 1.093	0.513
Kidney	0.685	0.537 to 0.874	0.002*
Pelvic organ	0.804	0.558 to 1.157	0.240
Pelvic fracture	0.761	0.664 to 0.873	<0.001*
Spine	0.744	0.657 to 0.842	<0.001*
Femoral fracture	0.613	0.542 to 0.693	<0.001*
Complication			
Dialysis	9.532	7.823 to 11.615	<0.001*
ACS	0.891	0.321 to 2.467	0.832
Pneumonia	0.377	0.315 to 0.451	<0.001*
Sepsis	0.581	0.317 to 1.064	0.079
Stroke	1.687	1.197 to 2.378	0.003*
GI bleeding	0.857	0.631 to 1.165	0.325
Region (compared with zone 1)			0.676
Zone 2	0.969	0.897 to 1.068	0.523
Zone 3	0.954	0.846 to 1.077	0.447
Income level (compared with above the RP line)			<0.001*
Dependent	1.290	1.133 to 1.469	<0.001*
Unemployed	1.307	1.142 to 1.496	<0.001*
Below the RP line	1.209	1.070 to 1.366	0.002*
Treated in non-trauma centre	1.209	1.096 to 1.334	<0.001*

*p<0.05.

ACS, acute coronary syndrome; GI, gastrointestinal; RP, relative poverty.

disadvantaged regions. However, this is compatible with a previous sociological study in Taiwan, which found that the unemployment rates were higher in metropolitan areas than in rural areas.³³

Although regional differences failed to demonstrate statistically significant results regarding survival, it is still inappropriate to conclude that the disparity in medical resources has no negative effect on severe torso trauma patients. In our study, being treated in a non-trauma centre setting appeared to be an independent risk factor for

in-hospital mortality in multivariate analysis. We surmise that having zero trauma centres could be responsible for the poor outcome in zone 3. Trauma centres with a high volume of severe trauma patients have demonstrated survival benefits for patients across different countries and systems.^{34–36} Similar results can be found in the NHI system in Taiwan. Liao *et al* reported that trauma centres in Taiwan had a higher ratio of splenic injuries treated in a non-operative manner and had a better improvement in the outcome in one decade.³⁷ The outcomes of our study were compatible with the findings of these articles, suggesting that being treated in a trauma centre is a favourable prognostic factor.

The inequity of trauma care under a single-payer healthcare system is not a very commonly discussed topic. Most studies emphasise the impact of different insurance levels in private insurance systems. In a single-payer system with universal coverage, the impact of poverty may be diminished, but the gap cannot be completely closed. Canada is an excellent example of a single-payer system with universal coverage. In 2009, a meta-analysis by Gorey demonstrated that breast cancer patients from low-income areas in Canada held a better survival advantage when compared with their counterparts in the USA (RR=1.14, 95% CI 1.13 to 1.15). However, a within-country comparison in Canada still suggested that patients from low-income areas had a slight survival disadvantage when compared with patients from the highest income areas (RR=0.94, 95% CI 0.93 to 0.95).³⁸ With regard to trauma patients, this phenomenon also holds true. In 2015, Moore and colleagues discovered that patients admitted for traumatic injury who suffered from extreme social and/or material deprivation had longer acute care lengths of stay and a higher risk of unplanned rehospitalisation due to complications of the injury in the 30 days following discharge.^{39 40} These studies are compatible with our findings that SES can still affect the outcomes of trauma patients, even under a single-payer system with universal coverage.

Aside from SES, injury types influence the outcomes. In our study, head injuries played a crucial role in in-hospital mortality (OR=3.646, 95% CI 3.295 to 4.034). Several previous studies have demonstrated the interaction between head injuries and injuries of other organ systems.^{41–43} Other injuries that were factors leading to a poor prognosis in this study included injuries to the GI tract (OR=1.348, 95% CI 1.127 to 1.613), heart (OR=1.475, 95% CI 1.019 to 2.137) and lung (OR=1.323, 95% CI 1.175 to 1.490). A possible explanation for the higher mortality among patients with GI tract injuries than among those with other injuries may be that GI tract injuries are often latent, and delayed or missed diagnoses are not infrequent.⁴⁴ Assessing traumatic cardiac injury is often challenging, and the presentation of injured myocardium can range from asymptomatic to cardiogenic or hypovolemic shock or both. Mortality secondary to blunt or penetrating cardiac trauma remains high despite improvements in diagnostic technologies.^{45 46}

Table 5 The interaction between income level and regions, regarding in-hospital mortality

Region	Income level				P value
	Dependent	Unemployed	Below RP	Above RP	
Zone 1 (n)	2202	1800	2739	1888	0.016*
Mortality (%)	304 (13.8%)	273 (15.2%)	421 (15.4%)	232 (12.3%)	
Zone 2 (n)	1828	1408	2575	1621	0.006*
Mortality (%)	262 (14.3%)	195 (13.8%)	339 (13.2%)	171 (10.5%)	
Zone 3 (n)	857	707	1616	768	0.200
Mortality (%)	140 (16.3%)	117 (16.5%)	250 (15.5%)	100 (13.0%)	

*p<0.05.

RP, relative poverty.

Compared with patients without pulmonary contusions, those with pulmonary contusions have been reported to have a higher risk for post-traumatic acute respiratory distress syndrome,⁴⁷ and even minor pulmonary injuries are associated with a higher mortality rate.⁴⁸ These data were compatible with our findings. In contrast, some of the injuries were found to be protective in our study, including pneumothoraces (OR=0.735, 95% CI 0.663 to 0.814), splenic injuries (OR=0.776, 95% CI 0.665 to 0.905), kidney injuries (OR=0.685, 95% CI 0.537 to 0.874), pelvic fractures (OR=0.761, 95% CI 0.664 to 0.873), spinal cord injuries (OR=0.744, 95% CI 0.657 to 0.842) and femoral fractures (OR=0.613, 95% CI 0.542 to 0.693). Some of these are quite understandable, as spinal cord injuries and femoral fractures are mostly not life-threatening, as reported in previous studies.^{49 50} Other injuries, such as splenic injuries, kidney injuries and pelvic fractures, might be associated with devastating haemorrhagic events. However, due to the advancement of angiobolisation, a substantial proportion of these patients can be managed in a non-operative manner, with dramatically improved survival.⁵¹⁻⁵³ Pneumothoraces could be present in a wide variety of chest injuries. However, they can be readily diagnosed by sonography and can be quickly treated; therefore, the outcome is generally satisfactory for the majority of patients in modern clinical practice.⁵⁴ The results from our current study are consistent with the findings in the published literature.

Pre-existing chronic conditions and acquired complications during admission also affect the outcome of trauma patients. Among these complications, acute kidney failure with haemodialysis was identified as a strong independent risk factor for mortality (OR=9.420, 95% CI 7.732 to 11.477). Stroke (OR=1.677, 95% CI 1.190 to 2.364) was also associated with increased mortality. Our findings are very similar to those in the current published literature.⁵⁵⁻⁵⁸ However, the number of pre-existing chronic conditions failed to demonstrate a significant relationship with mortality in this study.

Limitations

Our study had several limitations. First, the NHIRD lacks clinical details such as physiological parameters,

laboratory data and the ISS. However, the NHIRD is the only available database that includes all medical activities in Taiwan. By limiting the cohort to patients with ISSs \geq 16, we could focus on major torso trauma patients and avoid interference from minor trauma. Another benefit of the NHIRD is its nationwide nature. All residents in Taiwan during the study period were included in this study; therefore, the large sample size should eliminate potential selection bias. The potential effect of trauma mechanism was not evaluated in our study. The NHIRD registers trauma mechanism with ICD-9 E code, and we could also identify whether it was a blunt or penetrating injury, yet the E code is not mandatory in the NHI registry and was only available in 21.6% in our dataset, making the analysis of trauma mechanism impossible in the current study. However, most of the injuries in Taiwan are blunt trauma, and the incidence of penetrating injuries can be as low as 5%.⁵⁹ Therefore, the potential effect of different trauma mechanisms had limited influence on our analysis.

We need to acknowledge that the NHIRD income sectors were generated based on data from the National Taxation Bureau (NTB) of Taiwan, so any unregistered income was overlooked. Additionally, income could be underreported by individuals who deliberately evade insurance fees. This would not be problematic for employees because the organisations they work for are required to declare the wages to the NTB and the NHI simultaneously, but for employers and self-employed professionals, it is possible to falsify their income reported to the NHI. However, the NHI is entitled to assess the NTB database and can impose fines on insurance fee evaders when needed. Also, a person who was classified in the below the RP group might not be completely economically disadvantaged as far as household income is concerned. This might lead to misclassifying high SES individuals in the low SES group. The same concept applies to insurance dependents. Patients belonging to the dependent group were financially dependent, but they might not necessarily be financially challenged. However, being financially dependent might lead to social segregation and less accessibility to medical resources, which can result in suboptimal health outcomes, especially in minority groups such as women,

elderly individuals or immigrants.^{60–62} Thus, the dependent group in this study does not precisely indicate an economic disadvantage but rather a broader status of being underprivileged.

Time frame is another issue. The dataset for our current study was not current. The current status of the geographically disadvantaged regions after the quality Improvement Project for the Rural and Short of Medical Resource Regions was introduced in 2014 was not considered in this study. We expect such financial aid to have improved the quality of care for trauma patients, and we wish to conduct a decadal study to examine the outcome of this amendment in later years.

Finally, another drawback is that these data did not include the deaths at the ED and out-of-hospital cardiac arrest patients, which might also interfere with the interpretation. However, in the trimodal trauma death model, immediate and early deaths that occur in the first few hours are affected mainly by the severity of the injuries,⁶³ which is less relevant to the discussion in this study. Therefore, the interference is somewhat limited.

CONCLUSION

Although Taiwan's NHI has reduced the financial barriers to medical care, disparities in trauma care remain. An income level below the RP line is an independent risk factor for in-hospital mortality for major torso trauma patients, despite universal insurance coverage. Geographic disparities in infrastructure were associated with increased in-hospital mortality in the univariate analysis but not the multivariate analysis. Concomitant head, GI, heart and lung injuries were also associated with increased in-hospital mortality among major torso trauma patients. Public health and welfare policies must continue to focus their attention on this vulnerable population to eliminate inequality in trauma care.

Acknowledgements This study did not involve any human or animal subjects, and the NHIRD is a non-tracible, anonymous database. Therefore, this study was exempt from full review by the Ethics Institutional Review Board of Chang Gung Memorial Hospital. No funding was received during the collection, analysis, or interpretation of data or in writing the manuscript.

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ORCID iD

Ling-wei Kuo <http://orcid.org/0000-0001-6489-3723>

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