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What Cannot be Covered by Insurance? The Inequality of Trauma Care Under a Single-payer Universal Coverage System in Taiwan

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<u>Title</u>

"What Cannot be Covered by Insurance? The Inequality of Trauma Care Under a Single-payer Universal Coverage System in Taiwan."

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e str LW Kuo and CT Cheng conceived and designed the study. CA Liao and SY Wang were in charge of the data collection. CH Liao, SW Chen and CH Hsieh provided statistical analysis of the data and contributed to the tables and figures. LW Kuo and CY Fu drafted the manuscript and critical discussion was made with CA Liao, CH Liao, SY Wang, SW Chen, and CH Hsieh. CT Cheng takes responsibility for the study as a whole, and all authors read and approved the final manuscript.

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This study did not involve any human or animal subjects, and the NHIRD is a nontracible, 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, and interpretation of data and in writing the manuscript.

Data Availability Statements

This study was based on data from the NHIRD provided by the National Health Insurance Administration, Ministry of Health and Welfare of Taiwan, which is managed by the National Health Research Institutes of Taiwan. De-identified data of the NHI insurers can be available when requests were reviewed and granted by the NHIRD review board. However, the interpretation and conclusions contained in this paper do not represent those of the National Health Insurance Administration, Ministry of Health and Welfare of Taiwan, or the National Health Research Institutes of Taiwan.

Conflict of Interest Statement

The authors whose names are listed immediately below certify that they have NO affiliations with or involvement in any organization or entity with any financial interest (such as honoraria; educational grants; participation in speakers' bureaus; membership, employment, consultancies, stock ownership, or other equity interest;

and expert testimony or patent-licensing arrangements), or non-financial interest (such as personal or professional relationships, affiliations, knowledge or beliefs) in the subject matter or materials discussed in this manuscript.

<u>Keywords</u>

 Trauma; inequality; national health insurance; Taiwan; relative poverty

Strengths and limitations of this study

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

Abstract

Objectives:

To discuss the impact of lower socioeconomic status (SES) on the outcome major torso trauma patients under the single-payer system by the National Health

Insurance (NHI) in Taiwan.

Design:

A nationwide, retrograde cohort study.

Setting:

An observational study from the NHI research database, involving all the insurer of the NHI.

Participants:

Patient of major torso trauma (injury severity score \geq 16) from 2003 to 2013 in Taiwan. ICD-9-CM code was used to identify trauma patients. 64,721 patients were initially identified from the NHIRD. After applying 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 analyzed patients with different income levels and geographic regions. Multiple logistic regression was used to control for confounding variables.

<u>Results:</u>

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 low income level remained an independent risk factor for increased in-hospital mortality (p<0.001).

Conclusion:

Even with 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

Manuscript

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).

Taiwan is a country that has universal health insurance coverage for its citizens and inhabitants. Initiated in 1995, the National Health Insurance (NHI) program is run by the government and is a universal single-payer insurance system with mandatory enrollment. Currently, more than 99% of Taiwan's population (approximately 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 aggravated to 99.39(8). Evidence has shown that even the National Health Insurance (NHI) system does not change the disparity in health outcomes experienced by people of different SES(9). More interestingly, while the NHI has provided universal financial support for patients, the difference in the existing infrastructure between

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regions remains substantial, with 7 of the country's 19 medical centers located in Taipei city, the country's capital and only one located in the country's eastern region (Fig. 1).

Trauma has stayed in the top six common causes of death in Taiwan for over a decade, which accounted for approximately 30 deaths per 100,000 population annually(10). However, there are still no budget designated to trauma up to this date in Taiwan, and no research had been done regarding the relationship between SES and trauma outcomes under the current NHI system. The purpose of this study was to analyze the data from the NHI research database (NHIRD) and to discuss whether income level and geographic disparities in infrastructure influence in-hospital mortality for major trauma patients, in order to raise the emphasis on trauma care for the stakeholders in policy making.

Materials and Methods

Data

Data regarding the medical services provided by the program are collected by the National Health Insurance Administration and entered in the National Health Insurance Research Database (NHIRD). This database comprises all claims pertaining to visits, procedures, and prescription medications and includes anonymous eligibility and enrollment information. In this study, all admission records from 2003 to 2013 in the database were analyzed.

Study Cohort

This retrospective, observational study included all patients with major torso

trauma in Taiwan from 2003 to 2013. The definition of major trauma was an injury with an injury severity score (ISS) \geq 16. It is important to note that the NHIRD does not record the ISS, but all patients with $ISSs \ge 16$ are eligible to receive a Major Illness Certificate, which provides copayment exemptions for any medical expenses related to the original trauma, including outpatient clinic visits, emergency department 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 Major Illness Certificate. Therefore, the Major Illness Certificates is an accurate guide to 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 pneumohemothorax; 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; 820 and 821 for femoral fractures. Patients with isolated traumatic brain injuries were excluded because the variable outcomes of traumatic brain injury could interfere with the analysis(11). Lastly, only patients older than 18 years were included in the cohort.

Variables and outcome

This study was intended to discuss the outcomes experienced by patients with different income levels and in different geographic regions. Two independent subgroupings were performed. For income level, we used the NHI payroll brackets,

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which are defined by the annual household income, and divided the patients into the following four groups according to income level: dependent, unemployed, under the relative poverty line, and above the relative poverty line. The dependent group was defined as those patients who had no source of income and were insured under other family members; those who lacked both income and family support were insured under the auspices of the local government and constituted the unemployed group. For the patients who had regular sources of income, we divided them into two groups based on the relative poverty (RP) line, which is 60% of the median income(12). In 2013, the RP line was 19,279 NTD/month (approximately equal to 624.5 USD)(13), and we used this line to separate our third and fourth income groups. Patient 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. To create the geographic subgroups, number of trauma centers per square kilometers, instead of per population was used as a measurement of disparity of medical resource, because geospatial factors, i.e. transport distance and time, are significant predictors for trauma mortalities(14-16). We separated the country into three zones (Fig. 1). Zone one included the administrative areas that have the most abundant medical resources, with more than one level one trauma center per 1000 km². Zone two included the administrative areas that have intermediate levels of medical resources, with fewer than one trauma center per 1000 km², and zone three included the administrative areas that are poor in medical resources, with no trauma centers. After categorization, we compared the subgroups with regard to basic demographic characteristics, injury types, complications, and in-hospital mortality rates. For the

statistical analysis, we used Chi-square 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, Version 22.0. (Armonk, NY: IBM Corp.)

Patient and public involvement

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

<u>Results</u>

In the study cohort, 64,721 patients were initially identified from the NHIRD. After excluding those with missing data (n=134), the earlier data from the time (1996-2002) when the Major Illness Certificate for major trauma was not popularized (n=1670), those with isolated head injuries (n=41551), 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 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. When the patients were divided by region, the same heterogeneity was noted among patient characteristics, and the inhospital mortality rate was still significantly different (Table 2).

To determine which factors influence in-hospital mortality, a multivariate analysis was conducted (Table 3). All income status below the RP line remained an

independent risk factor associated with increased in-hospital mortality rates (Dependent: OR= 1.287, 95% C.I.= 1.130- 1.465; Unemployed: OR= 1.304; 95% C.I.= 1.139- 1.492; Below RP: OR= 1.213; 95% C.I.= 1.074- 1.370; p< 0.001), but the geographic disparity in infrastructure was no longer significant (p=0.125). The number of preexisting chronic conditions was also not significantly associated with increased in-hospital mortality. Other independent risk factors included age (OR= 1.013, 95% C.I.= 1.011- 1.016), head (OR= 3.646, 95% C.I.= 3.295- 4.034), lung (OR= 1.323, 95% C.I.= 1.175- 1.490) and gastrointestinal injuries (OR= 1.348, 95% C.I.=1.127- 1.163); and the complications of renal failure (OR= 9.420, 95% C.I.=7.732-11.477) and stroke (OR= 1.677, 95% C.I.=1.190- 2.364).

Discussion

This is the first study investigating 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 singlepayer 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(17, 18). The shortage of nursing workforce is a 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 NHPPD is 6

hours for medical and surgical wards nurses(19, 20). According to another more intuitive measurement, the patient-nurse ratio, the average in Taiwan is approximately 9 patients to 1 nurse(21), but the ratio mandated by California legislation is no more than 5 medical or surgical patients per nurse(22). Additionally, the NHI does not cover adjunctive systems for the clinical care of patients, such as licensed practical nurses (LPN) and nursing assistants (NA) in the United States. A personal caregiver would cost more than 2,000 NTD (approximately 65 USD) for each patient per day, which might lead to financial pressure on each family(23). Under these circumstances, much of the care of the patient relies solely on the family support system. Confusions on patient caring and complications are not uncommon(24, 25), 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 2nd decile of monthly income (22,471 NTD/month)(12), indicating that less than 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(26-28). Perhaps another urgent issue is the development of trauma prevention strategies for the lower SES groups.

The presence of geographic disparity of medical resource density was associated with a significant difference in trauma outcomes in the univariate study but not the multivariate analysis. One possible explanation is that the low income status in zone

3 overwhelmed the medical resource shortage. 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 (Table 4), which is contrary to our assumption that the unemployment rate is high in economically disadvantaged regions. However, this is compatible with a previous sociology study in Taiwan, which found that the unemployment rates were higher in metropolitan areas than in rural areas(29).

Inequity of trauma care under a single-payer healthcare system is not a very commonly discussed topic. Most literature emphasize on the impact of different insurance levels in the private insurance systems. In a single payer system with universal coverage, the impact of poverty may be diminished, but the gap could not be completely closed. Canada is a great 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 counterpart in the United States (RR= 1.14, 95% C.I.= 1.13-1.15). However, within-country comparison in Canada still suggested that patients from low-income areas had a slight survival disadvantage when compared with patient from the highest income areas (RR= 0.94, 95% C.I.= 0.93- 0.95)(30). As for trauma patients, this phenomenon also stands true. In 2015, Moore and colleagues discovered that patients admitted for traumatic injury who suffer from high social and/or material deprivation have longer acute care length of stay, and have higher risk of unplanned rehospitalization due to complications of injury in the 30 days following discharge(31, 32). These literatures are compatible with our findings, that SES can still effect outcome for 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: 3.295-4.034). Several previous studies have demonstrated the interaction between head injuries and injuries of other organ systems(33-35). Other injuries that were poor prognostic factors in this study include injuries of the GI tract (OR=1.348, 95% CI: 1.127-1.613) and lung (OR=1.323, 95% CI: 1.175-1.490). 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(36). Compared with patients without pulmonary contusion, those with pulmonary contusions have been reported to have a higher risk for posttraumatic acute respiratory distress syndrome (ARDS)(37), and even minor pulmonary injuries can be related to a higher mortality rate(38). These data were compatible with our findings.

Preexisting chronic conditions and acquired complications during admission also affect the outcome of trauma patients. Among the complications, acute kidney failure with hemodialysis was identified as a strong independent risk factor for mortality (OR=9.420, 95% CI: 7.732-11.477). Stroke (OR=1.677, 95% CI: 1.190-2.364) was also associated with increased mortality. Our findings are very similar to those in the current published literature(39-42). However, the number of preexisting chronic conditions failed to demonstrate a significant relationship with mortality in this study.

Limitations

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Our study had several limitations. First, the NHIRD lacks clinical details such as physiologic parameters, laboratory data, and severity. 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 of minor trauma. Another benefit from the NHIRD is the nation-wide nature. All the residents in Taiwan during the study period were included in this study, therefore the large sample size should eliminate potential selection bias. We also acknowledge that the NHIRD income sectors were linked directly to the national taxation bureau of Taiwan, so any under-the-table income would be overlooked.

Time frame is another issue. Our study period located at 2003 to 2013, which did not include the complete and up-to-date data. Before 2003, major trauma was not eligible for Major Illness Certificate application, so there was no way to identify major trauma patients from the NHIRD. After 2013, a new project was brought in to reinforce the medical resource of the despaired area. In 2012, the amendment of Emergency Medical Services Act required health authority to adopt rewarding measures for the areas in short of emergency medical services resources to balance the emergency medical services (43). Thus, Quality Improvement Project for the Rural and Short of Medical Resource Regions was introduced in 2014, which allowed 80 million NTD (approximately 2.55 million USD) subsidies for the emergency medicine network annually(44). We expect such financial aid would improve the quality of care for trauma patients, and we decided to separate this ear and 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 emergency department and out-of-hospital cardiac arrest (OHCA) patients, which might also interfere with interpretation.

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, 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.

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		Incon	ne Level		_
	Dependent	Unemployed	Below RP Line	Above RP Line	
Variable	(N=4887)	(N=3915)	(N=6930)	(N=4277)	P Value
Age, 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
Pneumohemothorax	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

rectaristics of major torso trau natients in different inc ne level Table 1 Cha

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Table 2. Characteristics of major torso trauma patients in different income levels.

		Region		-
Variable	Zone 1 (N=8629)	Zone 2 (N=7432)	Zone 3 (N=3948)	P Value
Age, 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

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Variable	Odds Ratio	95% C.I.	P Value
Sex (Male)	1.100	0.999- 1.212	0.053
Age	1.013	1.011- 1.016	< 0.001
Number of Underlying Conditions			0 456
(Compared to 0)			0.456
1-2	0.955	0.852-1.070	0.426
≥3	0.869	0.679- 1.113	0.266
Injury Type			
Head	3.646	3.295-4.034	< 0.001
Cardiac	1.444	.998- 2.091	0.051
Lung	1.323	1.175- 1.490	< 0.001
Pneumohemothorax	.733	0.662- 0.812	< 0.001
GI Tract	1.348	1.127- 1.613	0.001
Spleen	.772	0.662-0.900	0.001
Liver	.951	0.832-1.086	0.456
Kidney	.681	0.534- 0.869	0.002
Pelvic Organ	.807	0.561-1.162	0.249
Pelvic Fracture	.758	0.658- 0.865	< 0.001
Spine	.738	0.652-0.835	< 0.001
Femoral Fracture	.612	0.542- 0.692	< 0.001
Complication	Ľ	7	
Dialysis	9.420	7.732- 11.477	< 0.001
ACS	.895	0.322- 2.490	0.832
Pneumonia	.378	0.316- 0.453	< 0.001
Sepsis	.586	0.320- 1.072	0.083
Stroke	1.677	1.190-2.364	0.003
GI Bleeding	.872	0.641-1.185	0.381
Region (Compared to Zone 1)			0.125
Zone 2	.932	0.847-1.026	0.150
Zone 3	1.046	0.935-1.69	0.432
Income Level (Compared to Above			< 0.001
the RP Line)			~0.001
Dependent	1.287	1.130- 1.465	< 0.00
Unemployed	1.304	1.139- 1.492	< 0.001
Below the RP Line	1.213	1.074- 1.370	0.002

Table 1	Distribustion	ofIncome	I arrala in	Each Darian
Table 4.	DISTRIBUTION	i of income	Levels in	Each Region

			Region	
		Zone 1	Zone 2	Zone 3
	Dependent	2202 (25.5%)	1828 (24.6%)	857 (21.7%)
	Unemployed	1800 (20.9%)	1408 (18.9%)	707 (17.9%)
Level	Below the RP Line	2739 (31.7%)	2575 (34.6%)	1616 (40.9%)
	Above the RP Line	1888 (21.9%)	1621 (21.8%)	768 (19.5%)

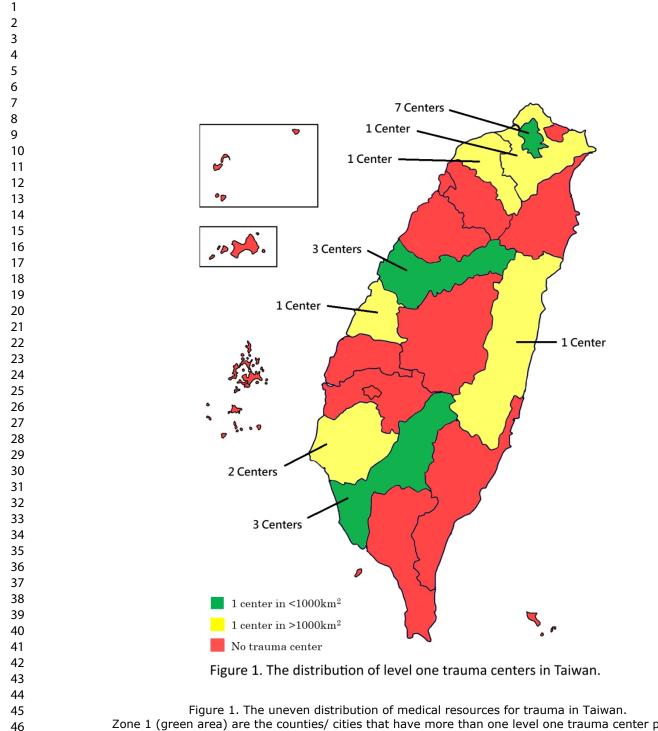
Figure Legends

Figure 1. The uneven distribution of medical resources for trauma in Taiwan.

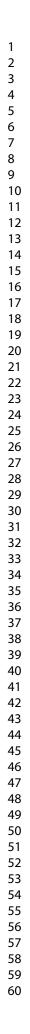
Zone 1 (green area) are the counties/ cities that have more than one level one trauma center per 1000 km². Zone 2 (yellow area) are the counties/ cities that have fewer than one trauma center per 1000 km², and zone 3 (red area) are the counties/ cities that have no trauma centers within its territory.

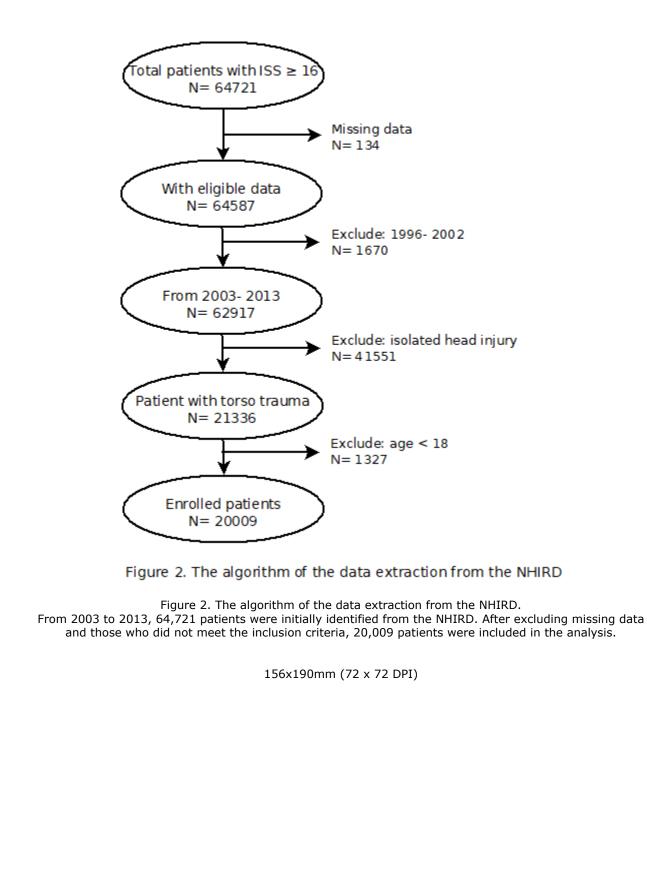
Figure 2. The algorithm of the data extraction from the NHIRD.

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.



Zone 1 (green area) are the counties/ cities that have more than one level one trauma center per 1000 km2. Zone 2 (yellow area) are the counties/ cities that have fewer than one trauma center per 1000 km2, and zone 3 (red area) are the counties/ cities that have no trauma centers within its territory.





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1 2 3 4 5	Reporting checklist for cohort study.						
6 7 8 9	Based on the STROBE cohort guidelines.						
10 11 12	Instructions to authors						
13 14	Complete this chec	klist by	entering the page numbers from your manuscript where readers	will find			
15 16 17	each of the items li	sted be	low.				
18 19 20	Your article may no	ot curre	ntly address all the items on the checklist. Please modify your tex	kt to			
21 22	include the missing	inform	ation. If you are certain that an item does not apply, please write	"n/a" and			
23 24 25	provide a short exp	olanatio	n.				
26 27 28	Upload your compl	eted ch	ecklist as an extra file when you submit to a journal.				
29 30 31	In your methods se	ection, s	ay that you used the STROBE cohortreporting guidelines, and ci	te them			
32 33 34	as:						
34 35 36	von Elm E, Altman	DG, Eg	gger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Stren	gthening			
37 38	the Reporting of OI	oservat	ional Studies in Epidemiology (STROBE) Statement: guidelines f	or			
39 40	reporting observation	onal stu	idies.				
41 42 43				Page			
44 45 46			Reporting Item	Number			
47 48 49	Title and abstract						
50 51 52	Title	<u>#1a</u>	Indicate the study's design with a commonly used term in the	1			
53 54 55			title or the abstract				
55 56 57 58	Abstract	<u>#1b</u>	Provide in the abstract an informative and balanced summary	4-5			
59 60		For pe	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml				

1 2			of what was done and what was found	
3 4 5	Introduction			
6 7	Background /	<u>#2</u>	Explain the scientific background and rationale for the	5-6
8 9 10 11	rationale		investigation being reported	
12 13	Objectives	<u>#3</u>	State specific objectives, including any prespecified	6
14 15			hypotheses	
16 17 18 19	Methods			
20 21 22	Study design	<u>#4</u>	Present key elements of study design early in the paper	6-9
23 24 25	Setting	<u>#5</u>	Describe the setting, locations, and relevant dates, including	6-7
26 27			periods of recruitment, exposure, follow-up, and data collection	
28 29 30	Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of	7
31 32			selection of participants. Describe methods of follow-up.	
33 34 35	Eligibility criteria	#6b	For matched studies, give matching criteria and number of	7
35 36 37			exposed and unexposed	
38 39				
40 41	Variables	<u>#7</u>	Clearly define all outcomes, exposures, predictors, potential	7-8
42 43			confounders, and effect modifiers. Give diagnostic criteria, if	
44 45			applicable	
46 47 48	Data sources /	<u>#8</u>	For each variable of interest give sources of data and details of	8-9
49 50	measurement		methods of assessment (measurement). Describe	
51 52 53			comparability of assessment methods if there is more than one	
54 55			group. Give information separately for for exposed and	
56 57 58			unexposed groups if applicable.	
59 60		For pe	eer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Bias	<u>#9</u>	Describe any efforts to address potential sources of bias	14-15
4 5 6	Study size	<u>#10</u>	Explain how the study size was arrived at	9
7 8	Quantitative	<u>#11</u>	Explain how quantitative variables were handled in the	9
9 10 11	variables		analyses. If applicable, describe which groupings were chosen,	
12 13			and why	
14 15 16	Statistical	<u>#12a</u>	Describe all statistical methods, including those used to control	9
17 18	methods		for confounding	
19 20 21	Statistical	<u>#12b</u>	Describe any methods used to examine subgroups and	9
22 23	methods		interactions	
24 25 26	Statistical	#12c	Explain how missing data were addressed	9
27 28	methods	<u></u>		C
29 30				
31 32 33	Statistical	<u>#12d</u>	If applicable, explain how loss to follow-up was addressed	nil
34 35	methods			
36 37 38	Statistical	<u>#12e</u>	Describe any sensitivity analyses	9
38 39 40	methods			
41 42 43	Results			
44 45 46	Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg	9-10
47 48			numbers potentially eligible, examined for eligibility, confirmed	
49 50			eligible, included in the study, completing follow-up, and	
51 52 53			analysed. Give information separately for for exposed and	
55 54 55			unexposed groups if applicable.	
56 57 58	Participants	<u>#13b</u>	Give reasons for non-participation at each stage	9
59 60		For pe	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Participants	<u>#13c</u>	Consider use of a flow diagram	9
4 5	Descriptive data	<u>#14a</u>	Give characteristics of study participants (eg demographic,	9
6 7			clinical, social) and information on exposures and potential	
8 9 10			confounders. Give information separately for exposed and	
11 12			unexposed groups if applicable.	
13 14 15	Descriptive data	<u>#14b</u>	Indicate number of participants with missing data for each	9
16 17			variable of interest	
18 19 20 21	Descriptive data	<u>#14c</u>	Summarise follow-up time (eg, average and total amount)	nil
22 23 24	Outcome data	<u>#15</u>	Report numbers of outcome events or summary measures	9
25 26			over time. Give information separately for exposed and	
27 28 29			unexposed groups if applicable.	
30 31	Main results	<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-	9
32 33			adjusted estimates and their precision (eg, 95% confidence	
34 35 36			interval). Make clear which confounders were adjusted for and	
37 38			why they were included	
39 40 41	Main results	<u>#16b</u>	Report category boundaries when continuous variables were	10
42 43			categorized	
44 45 46	Main results	#16c	If relevant, consider translating estimates of relative risk into	10
47 48			absolute risk for a meaningful time period	
49 50				
51 52	Other analyses	<u>#17</u>	Report other analyses done—e.g., analyses of subgroups and	10
53 54 55			interactions, and sensitivity analyses	
56 57 58	Discussion			
59 60		For pe	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Key results	<u>#18</u>	Summarise key results with reference to study objectives	10-13
4 5	Limitations	<u>#19</u>	Discuss limitations of the study, taking into account sources of	14-15
6 7 8			potential bias or imprecision. Discuss both direction and	
9 10 11			magnitude of any potential bias.	
12 13	Interpretation	<u>#20</u>	Give a cautious overall interpretation considering objectives,	10-13
14 15			limitations, multiplicity of analyses, results from similar studies,	
16 17			and other relevant evidence.	
18 19 20	Generalisability	#21	Discuss the generalisability (external validity) of the study	nil
20 21 22		<u></u>	results	
23 24				
25 26	Other Information			
27 28 29	Funding	<u>#22</u>	Give the source of funding and the role of the funders for the	3
30 31			present study and, if applicable, for the original study on which	
32 33 34			the present article is based	
35 36 37	None The STROBE	E check	list is distributed under the terms of the Creative Commons Attribu	tion
37 38 39	License CC-BY. Th	is chec	klist can be completed online using <u>https://www.goodreports.org/</u> ,	a tool
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BMJ Open

What Cannot be Covered by Insurance? The Inequality of Trauma Care Under a Single-payer Universal Coverage System in Taiwan

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1 2		
3 4 5	1	Title
6 7	2	"What Cannot be Covered by Insurance? The Inequality of Trauma Care Under a
8 9 10	3	Single-payer Universal Coverage System in Taiwan."
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34 Authors' contributions:

LW Kuo and CT Cheng conceived and designed the study. CA Liao and SY Wang
were in charge of the data collection. CH Liao, SW Chen and CH Hsieh provided
statistical analysis of the data and contributed to the tables and figures. LW Kuo and
CY Fu drafted the manuscript and critical discussion was made with CA Liao, CH Liao,
SY Wang, SW Chen, and CH Hsieh. CT Cheng takes responsibility for the study as a
whole, and all authors read and approved the final manuscript.

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7	42	3786
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11		
12 13	44	This study did not involve any human or animal subjects, and the NHIRD is a non-
14		
15 16	45	tracible, anonymous database. Therefore, this study was exempt from full review by
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27	50	This study was based on data from the NHIRD provided by the National Health
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30 31	51	Insurance Administration, Ministry of Health and Welfare of Taiwan, which is
32	52	managed by the National Health Research Institutes of Taiwan. De-identified data of
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34 35	53	the NHI insurers can be available when requests were reviewed and granted by the
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37 38	54	NHIRD review board. However, the interpretation and conclusions contained in this
39	55	paper do not represent those of the National Health Insurance Administration,
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41 42	56	Ministry of Health and Welfare of Taiwan, or the National Health Research Institutes
43	57	of Taiwan.
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45 46	го	Conflict of Interest Statement
47	58	Conflict of Interest Statement
48 49		
49 50	59	The authors whose names are listed immediately below certify that they have NO
51	60	affiliations with or involvement in any organization or entity with any financial
52 53		
54	61	interest (such as honoraria; educational grants; participation in speakers' bureaus;
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56 57	62	membership, employment, consultancies, stock ownership, or other equity interest;
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63 and expert testimony or patent-licensing arrangements), or non-financial interest

- 64 (such as personal or professional relationships, affiliations, knowledge or beliefs) in
- 65 the subject matter or materials discussed in this manuscript.

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- 68 commercial or not-for-profit sectors.

69 Keywords

70 Trauma; inequality; national health insurance; Taiwan; relative poverty

71 Strengths and limitations of this study

- 72 This is the first study to discuss the relationship between socioeconomic factors
- and the outcome of major trauma patients under the single-payer, universal
- 74 coverage NHI system in Taiwan.
 - 75 This study includes all the major torso trauma patients under the NHI system,
 - 76 which covers more than 99% of Taiwan's residents.
 - 77 The NHI's payroll bracket was based on the income level from the National
- 78 Taxation Bureau. Therefore, the income level was clearly defined in this study.
 - 79 NHIRD did not provide clinical details such as physiologic parameters,
 - 80 laboratory data, and severity.
 - Only the data between 2003-2013 were included in this study due to policy
 - 82 augmentation. Future study is needed to investigate more recent outcomes.

83 Abstract

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84 **Objectives**:

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

88 <u>Design:</u>

89 A nationwide, retrograde cohort study.

90 <u>Setting:</u>

91 An observational study from the NHI research database, involving all the insurer of 92 the NHI.

93 *Participants:*

- Patient of major torso trauma (injury severity score ≥ 16) from 2003 to 2013 in
- 95 Taiwan. ICD-9-CM code was used to identify trauma patients. 64,721 patients were
- 96 initially identified from the NHIRD. After applying exclusion criteria, 20,009 patients
 - 97 were included in our statistical analysis
 - 98 Primary and secondary outcome measures
 - 99 The primary outcome measure was in-hospital mortality, and we analyzed
- 100 patients with different income levels and geographic regions. Multiple logistic
- 101 regression was used to control for confounding variables.

102 *Results:*

- 103 In univariate analysis, geographic disparities and low income level were both risk
- 104 factors for in-hospital mortality for patients with major torso trauma (p=0.002 and

<0.001, respectively). However, in multivariate analysis, only low income level remained an independent risk factor for increased in-hospital mortality (p<0.001). Conclusion: Even with 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 Manuscript 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). Taiwan is a country that has universal health insurance coverage for its citizens and inhabitants. Initiated in 1995, the National Health Insurance (NHI) program is run by the government and is a universal single-payer insurance system with mandatory enrollment. Currently, more than 99% of Taiwan's population (approximately 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

aggravated to 99.39(8). Evidence has shown that even the National Health Insurance
(NHI) system does not change the disparity in health outcomes experienced by
people of different SES(9). More interestingly, 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 centers located in
Taipei city, the country's capital and only one located in the country's eastern region
(Fig. 1).

Trauma has stayed in the top six common causes of death in Taiwan for over a decade, which accounted for approximately 30 deaths per 100,000 population annually(10). However, there is still no budget designated to trauma care up to this date in Taiwan, and no research had been done regarding the relationship between SES and trauma outcomes under the current NHI system. The purpose of this study was to analyze the data from the NHI research database (NHIRD) and to discuss whether income level and geographic disparities in infrastructure influence in-hospital mortality for major trauma patients, in order to raise the emphasis on trauma care for the stakeholders in policy making.

Materials and Methods

144 Data

Data regarding the medical services provided by the program are collected by the
National Health Insurance Administration and entered in the National Health
Insurance Research Database (NHIRD). This database comprises all claims pertaining
to visits, procedures, and prescription medications and includes anonymous
eligibility and enrollment information. In this study, all admission records from 2003

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to 2013 in the database were analyzed. The records from the emergency

department (ED) were in a separated data set, and was not included in this study.

152 Study Cohort

This retrospective, observational study included all patients with major torso trauma in Taiwan from 2003 to 2013. Major trauma has been eligible for Major Illness Certificate application since the beginning of 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 brought in to reinforce the medical resource of the despaired area. In 2012, the amendment of Emergency Medical Services Act required health authority to adopt rewarding measures for the areas in short of emergency medical services resources to balance the emergency medical services resources and elevate the quality and efficiency of the emergency medical services(11). Thus, Quality Improvement Project for the Rural and Short of Medical Resource Regions was introduced in 2014, which allowed 80 million NTD (approximately 2.55 million USD) 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) \geq 16. It is important to note that the NHIRD does not record the ISS, but all patients with ISSs \geq 16 are eligible to receive a Major Illness Certificate, which provides copayment exemptions for any medical expenses related to the original trauma, including outpatient clinic visits, emergency department 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 Major Illness Certificate.

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173	Therefore, the Major Illness Certificates is an accurate guide to identifying
174	appropriate patients. We identified torso trauma patients according to their
175	International Classification of Disease, Ninth Revision, Clinical Modification (ICD-9-
176	CM) codes. The codes we used for specific injuries were as follows: 800-804, 850.3-
177	850.5, 850.9, and 851-854 for head injuries; 861.0 and 861.1 for cardiac injuries;
178	861.2 and 861.3 for lung injuries; 860 for pneumohemothorax; 863 for
179	gastrointestinal (GI) injuries; 865 for splenic injuries; 864 for liver injuries; 866 for
180	kidney injuries; 867 for pelvic organ injuries; 808 for pelvic fractures; 805 and 806 for
181	spinal injuries; 820 and 821 for femoral fractures. Patients with isolated traumatic
182	brain injuries (TBI) were excluded because the natural course of TBIs were quite
183	different from torso injuries. Preventable deaths were less common with TBIs(13,
184	14), suggesting treatment options and SES factors might have less potential
185	interference with the mortality. Lastly, only patients older than 18 years were
186	included in the cohort.
187	Variables and outcome
188	This study was intended to discuss the outcomes experienced by patients with
189	different income levels and in different geographic regions. Three independent
190	subgroupings were performed. The subgrouping for income level was extracted from
191	the data of the NHI payroll brackets. The payroll bracket can be divided by a few
192	groups of population(15). The first group is the people who have registered sources
193	of incomes, including all the employees, the employers, self-employed workers who
194	belongs in occupational unions, and self-cultivating farmers, fishermen, etc., who

belongs in agricultural associations. For this group of population, the persons'

income would be equivalent to the insurance amount, which would be 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 624.5 USD)(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 income, including their spouse, parents or grandparents, and children or grandchildren who are under 20 years of age, with no registered income, are defined as the dependent group. The insurance amount of this group would be the same as the depended insurer, but the dependent itself would not have to pay. The insurance fee would be defrayed by the depended insurer, the employer of the dependent insurer, and the government, in different proportion. For those who lacked both income and family support were insured under the auspices of the local government. The insurance amount of this group would be a minimal fee from 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 centers per square kilometers, instead of per population was used as a measurement of disparity of medical resource, because geospatial factors, i.e. transport distance and time, are significant predictors for trauma mortalities(18-20). We separated the country into three zones (Fig. 1). Zone one included the administrative areas that have the most abundant medical resources, with more than one level one trauma center per 1000

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220	km ² . Zone two included the administrative areas that have intermediate levels of
221	medical resources, with fewer than one trauma center per 1000 km ² , and zone three
222	included the administrative areas that are poor in medical resources, with no trauma
223	centers. Considering the possible impact of different level of hospitals, independent
224	from the influence of regional difference, we also created an analysis by divided the
225	patients by whether they initially received treatment from a trauma center or a non-
226	center hospital. After categorization, we compared the subgroups with regard to
227	basic demographic characteristics, injury types, complications, and in-hospital
228	mortality rates. For the statistical analysis, we used Chi-square tests and Kruskal-
229	Wallis tests, as appropriate. Multivariate logistic regression was performed to
230	determine the factors that independently affect in-hospital mortality. We performed
231	the statistical analyses with IBM [®] SPSS [®] Statistics for Windows, Version 22.0.
232	(Armonk, NY: IBM Corp.)
233	Patient and public involvement
234	Due to the retrospective and database nature of this study, patients and public
235	were not involved in the making of this study.
236	<u>Results</u>
237	In the study cohort, 64,721 patients were initially identified from the NHIRD. After
238	excluding those with missing data (n=134), the earlier data from the time (1996-
239	2002) when the Major Illness Certificate for major trauma was not popularized
240	(n=1670), those with isolated head injuries (n=41551), and those under 18 years of
241	age (n=1327), 20,009 patients were included in our statistical analysis (Figure 2).
242	Table 1 shows the basic demographics, injury types, complications, and in-hospital 11

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243	mortality rates in the patients classified by income level. Considerable heterogeneity
244	in these characteristics existed between each income level; the in-hospital mortality
245	rate was significantly lower in the above the RP line group than in the other three
246	groups of patients with inferior income levels (p<0.001). When the patients were
247	divided by region and hospital levels, the same heterogeneity was noted among
248	patient characteristics. The in-hospital mortality rate was significantly different by
249	regions (p=0.002), with Zone 3 claiming the highest mortality (Table 2). Different
250	hospital level showed significant influence on in-hospital mortality as well (Table 3).
251	Patients who were initially treated in a non-trauma center revealed higher mortality
252	than those treated in a trauma center. (15.3% vs 12.7%, p<0.001)
253	To determine which factors influence in-hospital mortality, a multivariate analysis
254	was conducted (Table 4). All income status below the RP line remained an
255	independent risk factor associated with increased in-hospital mortality rates
256	(Dependent: OR= 1.290, 95% C.I.= 1.133- 1.469; Unemployed: OR= 1.307; 95% C.I.=
257	1.142- 1.496; Below RP: OR= 1.209; 95% C.I.= 1.070- 1.366; p< 0.001). The
258	geographic disparity in infrastructure was no longer significant (p=0.676), but the
259	true risk lies in the difference of hospital levels, with being treated in a non-center
260	setting significantly increased the risk of in-hospital mortality (OR= 1.209; 95% C.I.=
261	1.096- 1.334; p< 0.001). The number of preexisting chronic conditions was also not
262	significantly associated with increased in-hospital mortality. Other independent risk
263	factors included age (OR= 1.013, 95% C.I.= 1.011- 1.016), head (OR= 3.637, 95% C.I.=
264	3.287- 4.025), heart (OR= 1.475, 95% C.I.= 1.019- 2.137), lung (OR= 1.337, 95% C.I.=
265	1.187- 1.506) and gastrointestinal injuries (OR= 1.351, 95% C.I.=1.130- 1.616); and
266	the complications of renal failure (OR= 9.532, 95% C.I.=7.823- 11.615) and stroke 12

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268 Discussion

269 This is the first study investigating the correlation of SES and the outcomes of 270 trauma under the NHI system. In our study, we demonstrated that any income status 271 below the RP line is an independent risk factor for in-hospital mortality among major 272 torso trauma patients. Theoretically, a difference in patient management should not 273 exist in the single-payer system provided by NHI because the same quality of 274 treatment is provided to patients of all economic statuses. We postulated that the 275 care from the family support system is different in each level of income. One 276 notorious disadvantage of the NHIRD is the exploitation of medical professionals, 277 which leads to high burnout rates, especially among nursing staff(21, 22). The 278 shortage of nursing workforce is constant in Taiwan. When measured by nursing 279 hours per patient day (NHPPD), Taiwan averages 5.19 hours, which is very likely to 280 be overestimated, whereas the American Nurses Association suggests that the 281 minimal requirement for NHPPD is 6 hours for medical and surgical wards nurses(23, 282 24). According to another more intuitive measurement, the patient-nurse ratio, the 283 average in Taiwan is approximately 9 patients to 1 nurse(25), but the ratio mandated 284 by California legislation is no more than 5 medical or surgical patients per nurse(26). 285 Additionally, the NHI does not cover adjunctive systems for the clinical care of 286 patients, such as licensed practical nurses (LPN) and nursing assistants (NA) in the 287 United States. A personal caregiver would cost more than 2,000 NTD (approximately 288 65 USD) for each patient per day, which might lead to financial pressure on each 289 family(27). Under these circumstances, much of the care of the patient relies solely

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on the family support system. Confusions on patient caring 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 2nd decile of monthly income (22,471 NTD/month)(16), indicating that less than 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 disparity of medical resource density was associated with a significant difference in trauma outcomes in the univariate study but not the multivariate analysis. In fact, the low income status overwhelmed the potential influence of medical resource shortage in zone two and three. When focusing on each region separately, patients with financial disadvantages were still presented with inferior outcomes, indicating they did not benefit from the resource-abundance in Zone one and two (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 disadvantaged regions. However, this is compatible with a previous sociology study in Taiwan, which found that the unemployment rates were higher in metropolitan areas than in rural areas(33).

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313	Despite regional difference failed to demonstrate statistically significant results on
314	survival, it is still inappropriate to conclude that disparity in medical resources has no
315	negative effect on severe torso trauma patients. In our study, being treated in a non-
316	center setting appeared to be an independent risk factor for in-hospital mortality in
317	multivariate analysis. We surmise that having zero trauma center could be
318	responsible for the poor outcome in zone three. Trauma centers with high-volume of
319	severe trauma have demonstrated survival benefits for patients across different
320	countries and systems(34-36). Similar results can be found in the NHI system in
321	Taiwan. Liao et al. have reported that trauma centers in Taiwan had a higher ratio of
322	splenic injuries treated with non-operative manner, and had a better improvement
323	of outcome in one decade(37). The outcomes of our study were compatible with
324	these articles, suggesting being treated in a trauma center is a favorable prognostic
325	factor.

326 The inequity of trauma care under a single-payer healthcare system is not a very 327 commonly discussed topic. Most literature emphasize the impact of different 328 insurance levels in private insurance systems. In a single-payer system with universal 329 coverage, the impact of poverty may be diminished, but the gap could not be 330 completely closed. Canada is a great example of a single-payer system with universal 331 coverage. In 2009, a meta-analysis by Gorey demonstrated that breast cancer 332 patients from low-income areas in Canada held a better survival advantage when 333 compared with their counterpart in the United States (RR= 1.14, 95% C.I.= 1.13-334 1.15). However, within-country comparison in Canada still suggested that patients 335 from low-income areas had a slight survival disadvantage when compared with 336 patient from the highest income areas (RR= 0.94, 95% C.I.= 0.93- 0.95)(38). As for 15

trauma patients, this phenomenon also stands true. In 2015, Moore and colleagues
discovered that patients admitted for traumatic injury who suffer from high social
and/or material deprivation have longer acute care length of stay, and have higher
risk of unplanned rehospitalization due to complications of injury in the 30 days
following discharge(39, 40). These literatures 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: 3.295-4.034). Several previous studies have demonstrated the interaction between head injuries and injuries of other organ systems(41-43). Other injuries that were poor prognostic factors in this study include injuries of the GI tract (OR=1.348, 95% CI: 1.127-1.613), heart (OR= 1.475, 95% C.I.= 1.019- 2.137), and lung (OR=1.323, 95% CI: 1.175-1.490). 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). Compared with patients without pulmonary contusion, those with pulmonary contusions have been reported to have a higher risk for posttraumatic acute respiratory distress syndrome (ARDS)(47), and even minor pulmonary injuries can be related to a higher mortality rate(48). These data were compatible with our findings. In contrast, some of the injuries were found

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361	to be protective in our study, including pneumohemothoraces (OR=0.735, 95%
362	C.I.=0.663- 0.814), splenic injuries (OR=0.776, 95% C.I.=0.665- 0.905), kidney injuries
363	(OR=0.685, 95% C.I.=0.537- 0.874), pelvic fractures (OR=0.761, 95% C.I.=0.664-
364	0.873), spinal cord injuries (OR=0.744, 95% C.I.=0.657- 0.842), and femoral fractures
365	(OR=0.613, 95% C.I.=0.542- 0.693). Some of these are quite understandable, like
366	spinal cord injuries and femoral fractures are mostly not life-threatening, as reported
367	in previous literatures(49, 50). Other injuries like splenic injuries, kidney injuries, and
368	pelvic fractures might associate with devastating hemorrhage events. However, due
369	to the advancement of angioembolization, a great proportion of these patients can
370	be managed in a non-operative manner, with dramatically improved survival(51-53).
371	Pneumohemothoraces could be presented in a wide variety of chest injuries,
372	however, they can be readily diagnosed by sonography and can be quickly treated,
373	therefore, the general outcome can be satisfying for majority of patients in modern
374	day practice(54). The result from our current study are consistent with the findings
375	of published literatures.
376	Preexisting chronic conditions and acquired complications during admission also
377	affect the outcome of trauma patients. Among the complications, acute kidney
378	failure with hemodialysis was identified as a strong independent risk factor for
379	mortality (OR=9.420, 95% CI: 7.732-11.477). Stroke (OR=1.677, 95% CI: 1.190-2.364)
380	was also associated with increased mortality. Our findings are very similar to those in
381	the current published literature(55-58). However, the number of preexisting chronic
382	conditions failed to demonstrate a significant relationship with mortality in this
383	study.
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Limitations

Our study had several limitations. First, the NHIRD lacks clinical details such as physiologic parameters, laboratory data, and 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 of minor trauma. Another benefit from the NHIRD is the nation-wide nature. All the 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 either. The NHIRD register trauma mechanism with ICD-9 E code, and we could also identify blunt or penetration injury, yet the E code was not mandatory for the NHI registry, and was only available in 21.6% in our dataset, making analysis for trauma mechanism impossible in the current study. However, most of the injuries in Taiwan were blunt trauma, and the incidence of penetrating injuries can be as low as 5%(59). Therefore, the potential effect of different trauma mechanism had limited influence on our analysis.

We need to acknowledge that the NHIRD income sectors were in cooperation with the National Taxation Bureau (NTB) of Taiwan, so any unregistered income would be overlooked. Also, income could be underreported by individuals who deliberately evade insurance fee. This would not be problematic for the employees, since the organization they worked for were required to declare the wages to the NTB and the NHI simultaneously, but for the employers and the self-employed professionals, it is possible to mi-declare their actual income to the NHI. However, the NHI was entitled

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3 4 5	407	to assess the NTB database, and could impose penalty fine to the insurance fee
6 7	408	evaders when needed. Also, a person who belonged in the below RP group might not
8 9	409	be completely economically disadvantaged, as far as household income is
10 11	410	concerned. This might lead to misclassifying high SES individuals to the low SES
12 13 14	411	group. The same concept applies to the insurance dependents. Patients belonged in
15 16	412	the dependent group were financially dependent, but they might not necessarily be
17 18	413	financially challenged. However, being financially dependent might lead to social
19 20	414	segregation and less accessibility to medical resources, which can result in
21 22 23	415	suboptimal health outcomes, especially in the minority groups like women, elderly,
24 25	416	or immigrants(60-62). Thus, the dependent group in this study not exactly implies
26 27	417	having a tight budget, but a broader status of underprivileged.
28 29 30	418	Time frame is another issue. The dataset for our current study was not updated.
31 32	419	The current status of the geographically disadvantaged regions after the quality
33 34 35	420	Improvement Project for the Rural and Short of Medical Resource Regions was
36 37	421	introduced in 2014 is unknown in this study. We expect such financial aid would
38 39	422	improve the quality of care for trauma patients, and we wish to conduct a decadal
40 41 42	423	study to examine the outcome of this amendment in later years.
43 44	424	Finally, another drawback is that these data did not include the deaths at the
45 46	425	emergency department and out-of-hospital cardiac arrest (OHCA) patients, which
47 48 49	426	might also interfere with interpretation. However, in the trimodal trauma death
50 51	427	model, immediate and early deaths that occur in the first few hours are affected
52 53	428	mainly by the severity of the injuries(63), which is less relevant to the discussion of
54 55	429	this study. Therefore, the interference is somehow limited.
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Conclusion

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Table 1. Characteristics of major tors	to trauma patients in different income levels.

		Incor	ne Level		
	Dependent	Unemployed	Below RP Line	Above RP Line	_
Variable	(N=4887)	(N=3915)	(N=6930)	(N=4277)	P Value
Age, 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%)	
<u>≥3</u>	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*
Pneumohemothorax	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*

Note: *=p< 0.05; RP= relative poverty; GI= gastrointestinal; ACS= acute coronary syndrome

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		Region		
Variable	Zone 1 (N=8629)	Zone 2 (N=7432)	Zone 3 (N=3948)	- P Value
Age, 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^{*}
Note: *=p< 0.05; GI= ga	strointestinal; ACS=	acute coronary synd		

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Table 3. Characteristics of	of major torso trauma patier	its in different hospital leve	els.	
	Hospital Level			
Variable	Non-Center (N=10227)	Trauma center (N=9782)	P Value	
Age, 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%)		
<u>≥3</u>	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*	
Pneumohemothorax	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*	

 Table 4. Multivariate Analysis of the Factors Affecting In-hospital Mortality

Note: *=p< 0.05; GI= gastrointestinal; ACS= acute coronary syndrome

Variable	Odds Ratio	95% C.I.	P Valu
Sex (Male)	1.100	0.999- 1.212	0.052
Age	1.013	1.011- 1.016	< 0.001
Number of Underlying Conditions			0 450
(Compared to 0)			0.458
1-2	0.951	0.848- 1.066	0.385
≥3	0.875	0.683- 1.120	0.290
Injury Type			
Head	3.637	3.287- 4.025	< 0.001
Cardiac	1.475	1.019-2.137	0.040*
Lung	1.337	1.187- 1.506	< 0.001
Pneumohemothorax	0.735	0.663- 0.814	< 0.001
GI Tract	1.351	1.130- 1.616	0.001*
Spleen	0.776	0.665-0.905	0.001*
Liver	0.957	0.837-1.093	0.513
Kidney	0.685	0.537-0.874	0.002
Pelvic Organ	0.804	0.558- 1.157	0.240
Pelvic Fracture	0.761	0.664- 0.873	< 0.001
Spine	0.744	0.657-0.842	< 0.001
Femoral Fracture	0.613	0.542- 0.693	< 0.001
Complication			
Dialysis	9.532	7.823-11.615	< 0.001
ACS	0.891	0.321-2.467	0.832
Pneumonia	0.377	0.315- 0.451	< 0.001
Sepsis	0.581	0.317-1.064	0.079
Stroke	1.687	1.197-2.378	0.003
GI Bleeding	0.857	0.631-1.165	0.325
Region (Compared to Zone 1)			0.676
Zone 2	0.969	0.897-1.068	0.523
Zone 3	0.954	0.846- 1.077	0.447
Income Level (Compared to Above			<0.001
the RP Line)			~0.001
Dependent	1.290	1.133- 1.469	< 0.001
Unemployed	1.307	1.142- 1.496	< 0.001
Below the RP Line	1.209	1.070- 1.366	0.002*

1.096-1.334 <0.001*

Note: *=p< 0.05; RP= relative poverty; GI= gastrointestinal; ACS= acute coronary syndrome

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

			Income Level				
		Dependent	Unemployed	Below RP	Above RP	P Value	
	Zone 1 (n)	2202	1800	2739	1888	0.016*	
	Mortality (%)	304 (13.8%)	273 (15.2%)	421 (15.4%)	232 (12.3%)	0.010	
Dogion	Zone 2 (n)	1828	1408	2575	1621	0.006*	
Region	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%)		

Note: *=p< 0.05; RP= relative poverty

Figure Legends

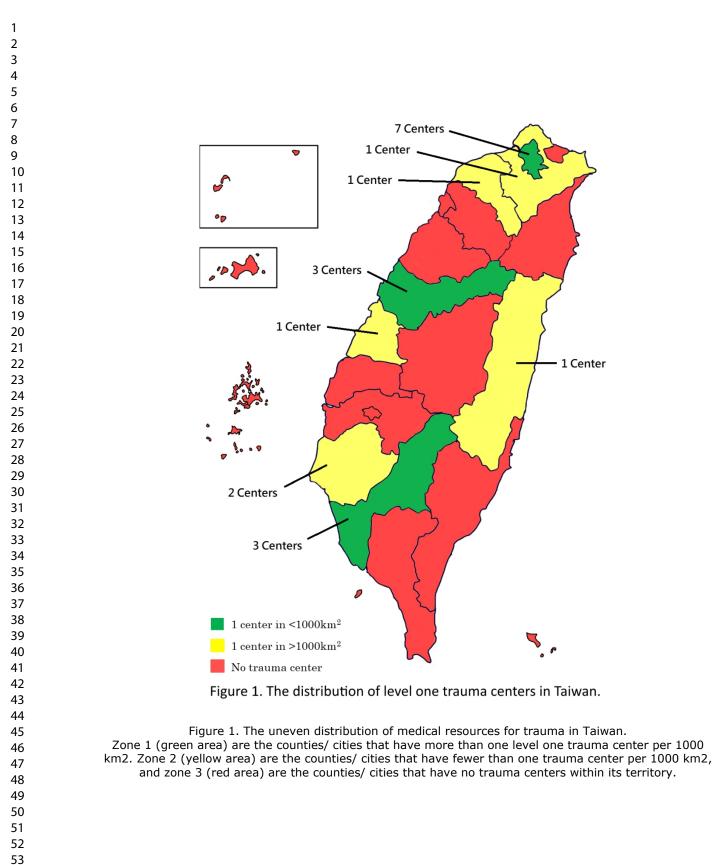
Figure 1. The uneven distribution of medical resources for trauma in Taiwan.

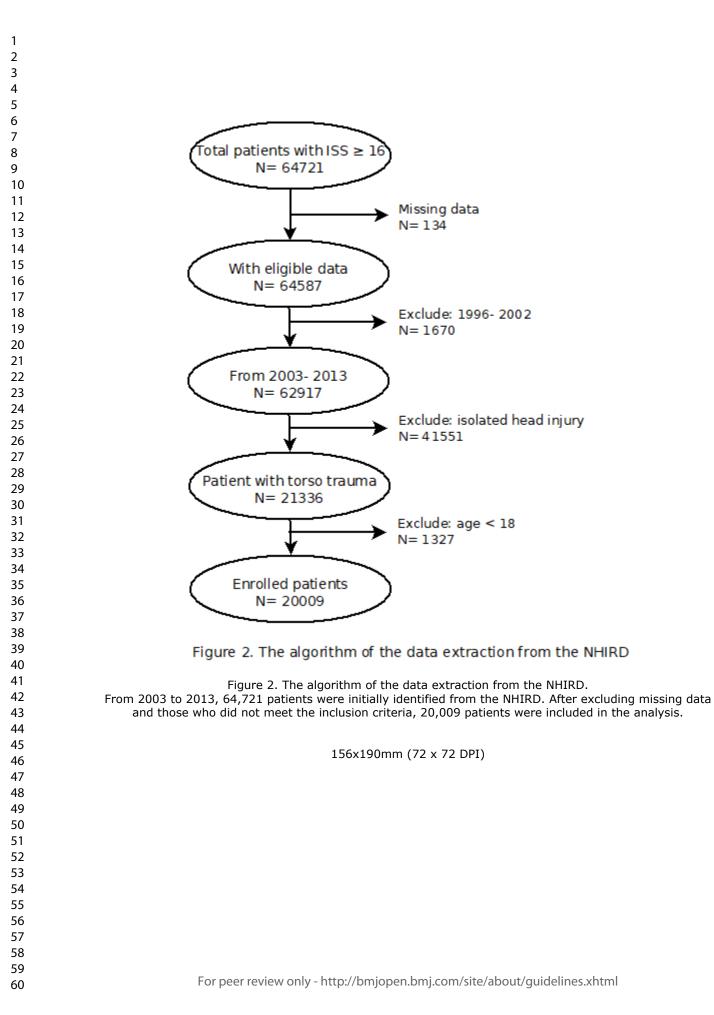
Zone 1 (green area) are the counties/ cities that have more than one level one trauma center per 1000 km². Zone 2 (yellow area) are the counties/ cities that have fewer than one trauma center per 1000 km², and zone 3 (red area) are the counties/ cities that have no trauma centers within its territory.

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.

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Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below. Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation. Upload your completed checklist as an extra file when you submit to a journal. In your methods section, say that you used the STROBE cohortreporting guidelines, and cite them as: von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

Title and abstract

Title#1aIndicate the study's design with a commonly used term in the1title or the abstract

Abstract <u>#1b</u> Provide in the abstract an informative and balanced summary 4-5

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1 2			of what was done and what was found	
3 4 5 6 7 8	Introduction			
	Background /	<u>#2</u>	Explain the scientific background and rationale for the	5-6
8 9 10 11	rationale		investigation being reported	
12 13	Objectives	<u>#3</u>	State specific objectives, including any prespecified	6
14 15			hypotheses	
16 17 18 19	Methods			
20 21 22	Study design	<u>#4</u>	Present key elements of study design early in the paper	6-9
23 24 25	Setting	<u>#5</u>	Describe the setting, locations, and relevant dates, including	6-7
25 26 27 28			periods of recruitment, exposure, follow-up, and data collection	
29 30	Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of	7
31 32 33			selection of participants. Describe methods of follow-up.	
34 35	Eligibility criteria	<u>#6b</u>	For matched studies, give matching criteria and number of	7
36 37 38 39			exposed and unexposed	
40 41	Variables	<u>#7</u>	Clearly define all outcomes, exposures, predictors, potential	7-8
42 43			confounders, and effect modifiers. Give diagnostic criteria, if	
44 45 46			applicable	
47 48	Data sources /	<u>#8</u>	For each variable of interest give sources of data and details of	8-9
49 50	measurement		methods of assessment (measurement). Describe	
51 52 53			comparability of assessment methods if there is more than one	
54 55			group. Give information separately for for exposed and	
56 57 58			unexposed groups if applicable.	
59 60		For pe	eer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Bias	<u>#9</u>	Describe any efforts to address potential sources of bias	14-15
4 5 6	Study size	<u>#10</u>	Explain how the study size was arrived at	9
7 8 9	Quantitative	<u>#11</u>	Explain how quantitative variables were handled in the	9
10 11	variables		analyses. If applicable, describe which groupings were chosen,	
12 13 14			and why	
15 16	Statistical	<u>#12a</u>	Describe all statistical methods, including those used to control	9
17 18 19	methods		for confounding	
20 21 22	Statistical	<u>#12b</u>	Describe any methods used to examine subgroups and	9
23 24	methods		interactions	
25 26 27	Statistical	<u>#12c</u>	Explain how missing data were addressed	9
28 29	methods			
30 31 32	Statistical	<u>#12d</u>	If applicable, explain how loss to follow-up was addressed	nil
33 34 35	methods			
36 37	Statistical	<u>#12e</u>		9
38 39 40	methods			
41 42 43	Results			
44 45 46	Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg	9-10
47 48			numbers potentially eligible, examined for eligibility, confirmed	
49 50			eligible, included in the study, completing follow-up, and	
51 52 53			analysed. Give information separately for for exposed and	
54 55			unexposed groups if applicable.	
56 57 58	Participants	<u>#13b</u>	Give reasons for non-participation at each stage	9
59 60		For pe	eer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Participants	<u>#13c</u>	Consider use of a flow diagram	9
4 5 7 8 9 10 11 12	Descriptive data	<u>#14a</u>	Give characteristics of study participants (eg demographic,	9
			clinical, social) and information on exposures and potential	
			confounders. Give information separately for exposed and	
			unexposed groups if applicable.	
13 14	Descriptive data	#14b	Indicate number of participants with missing data for each	9
15 16 17			variable of interest	-
17 18 19			0	
20 21	Descriptive data	<u>#14c</u>	Summarise follow-up time (eg, average and total amount)	nil
22 23	Outcome data	<u>#15</u>	Report numbers of outcome events or summary measures	9
24 25 26			over time. Give information separately for exposed and	
27 28			unexposed groups if applicable.	
29 30	Main regulta	#160	Cive upediveted estimates and if applicable, confounder	0
31 32	Main results	<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-	9
33 34			adjusted estimates and their precision (eg, 95% confidence	
35 36			interval). Make clear which confounders were adjusted for and	
37 38			why they were included	
39 40 41	Main results	<u>#16b</u>	Report category boundaries when continuous variables were	10
42 43			categorized	
44 45				
46 47	Main results	<u>#16c</u>	If relevant, consider translating estimates of relative risk into	10
48 49			absolute risk for a meaningful time period	
50 51 52	Other analyses	<u>#17</u>	Report other analyses done—e.g., analyses of subgroups and	10
53 54			interactions, and sensitivity analyses	
55 56	Discussion			
57 58	D1900991011			
59 60		For pe	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Key results	<u>#18</u>	Summarise key results with reference to study objectives	10-13
4 5	Limitations	<u>#19</u>	Discuss limitations of the study, taking into account sources of	14-15
6 7			potential bias or imprecision. Discuss both direction and	
8 9 10			magnitude of any potential bias.	
11 12 13	Interpretation	<u>#20</u>	Give a cautious overall interpretation considering objectives,	10-13
14 15			limitations, multiplicity of analyses, results from similar studies,	
16 17 18			and other relevant evidence.	
19 20	Generalisability	<u>#21</u>	Discuss the generalisability (external validity) of the study	nil
21 22 23			results	
24 25 26	Other Information			
27 28 29	Funding	<u>#22</u>	Give the source of funding and the role of the funders for the	3
30 31			present study and, if applicable, for the original study on which	
32 33 34			the present article is based	
35 36 27	None The STROB	E checł	dist is distributed under the terms of the Creative Commons Attributed	ution
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The Inequality of Trauma Care Under a Single-payer Universal Coverage System in Taiwan: A Nation-wide Cohort Study from the National Health Insurance Research Database.

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1 2		
3 4 5	1	<u>Title</u>
6 7 8	2	The Inequality of Trauma Care Under a Single-payer Universal Coverage System in
8 9 10	3	Taiwan: A Nation-wide Cohort Study from the National Health Insurance Research
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35 Authors' contributions:

- 36 LW Kuo and CT Cheng conceived of and designed the study. CA Liao and SY Wang
- 37 were in charge of the data collection. CH Liao, SW Chen and CH Hsieh provided the
- 38 statistical analysis of the data and contributed to the tables and figures. LW Kuo and
- 39 CY Fu drafted the manuscript, and critical discussions involved CA Liao, CH Liao, SY

40	Wang, SW Chen, and CH Hsieh. CT Cheng takes responsibility for the study as a
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46	tracible, anonymous database. Therefore, this study was exempt from full review by
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49	the manuscript.
50	Data Availability Statements
51	This study was based on data from the NHIRD provided by the National Health
52	Insurance Administration, Ministry of Health and Welfare of Taiwan, which is
53	managed by the National Health Research Institutes of Taiwan. De-identified data of
54	the NHI insurers can be available when requests are reviewed and granted by the
55	NHIRD review board. However, the interpretation and conclusions contained in this
56	paper do not represent those of the National Health Insurance Administration,
57	Ministry of Health and Welfare of Taiwan, or the National Health Research Institutes
58	of Taiwan.
59	Conflict of Interest Statement
60	All the authors, including Ling-Wei Kuo, Chih-Yuan Fu, Chien-An Liao, Chien-Hung
61	Liao, Chi-Hsun Hsieh, Shang-Yu Wang, Shao-Wei Chen, and Chi-Tung Cheng, certify 3

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62 that they have NO affiliations with or involvement in any organization or entity with

- 63 any financial interest (such as honoraria; educational grants; participation in
- 64 speakers' bureaus; membership, employment, consultancies, stock ownership, or
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71 Keywords

- 72 Trauma; inequality; national health insurance; Taiwan; relative poverty
- 73 Abstract

74 Objectives:

75 To discuss the impact of lower socioeconomic status (SES) on the outcome of

N. N.

- 76 major torso trauma patients under the single-payer system by the National Health
- 77 Insurance (NHI) in Taiwan.

78 <u>Design:</u>

79 A nationwide, retrospective cohort study.

80 <u>Setting:</u>

81 An observational study from the NHI research database, involving all the insurees

82 in the NHI.

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83 Participants:

Patients with major torso trauma (injury severity score ≥ 16) from 2003 to 2013 in
Taiwan were included. ICD-9-CM codes were used to identify trauma patients. A

total of 64,721 patients were initially identified in the NHIRD. After applying the

87 exclusion criteria, 20,009 patients were included in our statistical analysis.

88 Primary and secondary outcome measures

89 The primary outcome measure was in-hospital mortality, and we analyzed

90 patients with different income levels and geographic regions. Multiple logistic

91 regression was used to control for confounding variables.

92 <u>Results:</u>

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).

97 **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

101 Strengths and limitations of this study

102 • This is the first study to discuss the relationship between socioeconomic factors

and the outcome of major trauma patients under the single-payer, universal

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3 4 5	104	coverage NHI system in Taiwan.
6 7 8	105	• This study includes all major torso trauma patients under the NHI system, which
9 10	106	covers more than 99% of Taiwan's residents.
11 12 13	107	• The NHI's payroll bracket was based on the income level from the National
14 15	108	Taxation Bureau. Therefore, the income level was clearly defined in this study.
16 17 18	109	• The NHIRD did not provide clinical details, such as physiologic parameters,
19 20 21	110	laboratory data, and severity.
22 23	111	• Only the data between 2003 and 2013 were included in this study due to policy
24 25 26	112	augmentation. Future studies are needed to investigate more recent outcomes.
27 28 29	113	
30 31 32	114	Manuscript
33 34	115	Introduction
35 36 37	116	Multiple socioeconomic status (SES) factors, including race, insurance status, rural
38 39	117	geographic location, and low income level, have been reported to impact the
40 41 42	118	epidemiology and outcomes of trauma events (1-4). However, these SES factors
43 44	119	often interact with each other, making it difficult to define the extent of the
45 46 47	120	influence of each factor (5).
48 49	121	Taiwan is a country that has universal health insurance coverage for its citizens
50 51 52	122	and inhabitants. Initiated in 1995, the National Health Insurance (NHI) program is
52 53 54	123	run by the government and is a universal single-payer insurance system with
55 56 57	124	mandatory enrollment. Currently, more than 99% of Taiwan's population

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125	(approximately 23 million residents) receive medical care through the NHI (6).
126	Theoretically, the universal coverage of the NHI should have partially eliminated the
127	negative effect of low SES on health outcomes. However, Taiwan is also a country
128	with rapidly escalating wealth inequity (7). In 1998, the household income of the top
129	5% was 32.74 times as much as the income of the lowest 5%. In 2013, this ratio
130	changed to 99.39 (8). Evidence has shown that even the NHI system does not change
131	the disparity in health outcomes experienced by people of different SESs (9). More
132	interestingly, while the NHI has provided universal financial support for patients, the
133	difference in the existing infrastructure between regions remains substantial, with 7
134	of the country's 19 medical centers located in Taipei city, the country's capital, and
135	only one is located in the country's eastern region (Fig. 1).

136 Trauma has remained in the top six common causes of death in Taiwan for over a 137 decade, accounting for approximately 30 deaths per 100,000 population annually 138 (10). However, there is still no budget designated for trauma care in Taiwan, and no 139 research has been conducted regarding the relationship between SES and trauma 140 outcomes under the current NHI system. The purpose of this study was to analyze 141 the data from the NHI research database (NHIRD) and to discuss whether income 142 levels and geographic disparities in infrastructure influence in-hospital mortality for 143 major trauma patients to draw attention to trauma care from stakeholders in policy 144 making.

145 Materials and Methods

146 Data

147 Data regarding the medical services provided by the program 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 enrollment information. In this study, all admission records from 2003 to 2013 in the database were analyzed. The records from the emergency department (ED) were in a separate data set and were not included in this study.

154 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 NTD (approximately 2.55 million USD) 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) \geq 16. It is important to note that the NHIRD does not record the ISS, but all patients with ISSs \geq 16 are eligible to receive a catastrophic illness certificate, which

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provides copayment exemptions for any medical expenses related to the original trauma, including outpatient clinic visits, emergency department 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 pneumohemothorax; 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.

189 Variables and outcome

190 This study was intended to discuss the outcomes experienced by patients with 191 different income levels and in different geographic regions. Three independent 192 subgroupings were generated. The subgrouping for income level was extracted from 193 the data of the NHI payroll brackets. The payroll bracket can be divided into a few

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194	groups (15). The first group is the people who have registered sources of incomes,
195	including all the employees, employers, self-employed workers who belong in
196	occupational unions, and self-employed farmers, fishermen, etc. who belong to
197	agricultural associations. For this population group, the income is equivalent to the
198	insurance amount, which is paid to the NHI by the insurer, the employer, and the
199	government, in different proportions. We divided patients from this category into
200	two groups based on the relative poverty (RP) line, which is 60% of the median
201	income (16). In 2013, the RP line was 19,279 NTD/month (approximately equal to
202	624.5 USD) (17). Patients with income levels below this line were assigned to the
203	under the RP line group, and those with incomes greater than the RP line were
204	assigned to the above the RP line group. The first degree and direct second degree
205	relatives of people with registered incomes, including their spouse, parents or
206	grandparents, and children or grandchildren who are under 20 years of age, with no
207	registered incomes, were defined as the dependent group. The insurance amount in
208	this group is the same as that of the insured, but the dependent does not have to
209	pay. The insurance fee is defrayed by the insurer, the employer of the insurer, and
210	the government in different proportions. Those who lack both income and family
211	support are insured under the auspices of the local government. The insurance
212	amount of this group is a minimal fee based on the actuarial analysis by the NHI,
213	which is 100% paid by the government. Patients from this population constituted the
214	unemployed group in our analysis.
215	To create the geographic subgroups, the number of trauma centers per square
216	kilometers, instead of per population, was used as a measurement of the disparity of

217 medical resources because geospatial factors, i.e. transport distance and time, are 10 Page 11 of 38

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218	significant predictors of mortality from trauma (18-20). We separated the country
219	into three zones (Fig. 1). Zone one included the administrative areas that have the
220	most abundant medical resources, with more than one level one trauma center per
221	1000 km ² . Zone two included the administrative areas that have intermediate levels
222	of medical resources, with fewer than one trauma center per 1000 km ² , and zone
223	three included the administrative areas that are lacking in medical resources, with
224	no trauma centers. Considering the possible impact of different levels of hospitals,
225	independent of the influence of regional differences, we divided the patients
226	according to whether they initially received treatment from a trauma center or a
227	non-trauma center hospital. After categorization, we compared the subgroups with
228	regard to basic demographic characteristics, injury types, complications, and in-
229	hospital mortality rates. For the statistical analysis, we used chi-square tests and
230	Kruskal-Wallis tests, as appropriate. Multivariate logistic regression was performed
231	to determine the factors that independently affect in-hospital mortality. We
232	performed the statistical analyses with IBM® SPSS® Statistics for Windows, Version
233	22.0. (Armonk, NY: IBM Corp.)
234	Patient and public involvement
235	Due to the retrospective and database-based nature of this study, patients and
236	the public were not involved.
237	<u>Results</u>
238	In the study cohort, 64,721 patients were initially identified from the NHIRD. After
239	excluding those with missing data (n=134), data from the time (1996-2002) when the
240	catastrophic illness certificate for major trauma had not been popularized (n=1670), 11

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2 3		
4 5	241	those with isolated head injuries (n=41551), and those under 18 years of age
6 7 8 9 10 11 12 13 14 15 16 17 18	242	(n=1327), 20,009 patients were included in our statistical analysis (Figure 2). Table 1
	243	shows the basic demographics, injury types, complications, and in-hospital mortality
	244	rates in the patients classified by income level. Considerable heterogeneity in these
	245	characteristics existed between each income level; the in-hospital mortality rate was
	246	significantly lower in the above the RP line group than in the other three groups of
	247	patients with inferior income levels (p<0.001). When the patients were divided by
19 20	248	region and hospital levels, the same heterogeneity was noted among patient
21 22 23	249	characteristics. The in-hospital mortality rate significantly differed by region
24 25	250	(p=0.002), with Zone 3 having the highest mortality rate (Table 2). Different hospital
26 27	251	levels also had a significant influence on in-hospital mortality (Table 3). Patients who
28 29 30 31 32	252	were initially treated in a non-trauma center had a higher mortality rate than those
	253	treated in a trauma center (15.3% vs 12.7%, p<0.001).
33		
34 35	254	To determine which factors influence in-hospital mortality, a multivariate analysis
36 37	255	was conducted (Table 4). An income status below the RP line remained an
38 39	256	independent risk factor associated with increased in-hospital mortality rates
40 41 42	257	(dependent: OR= 1.290, 95% C.I.= 1.133- 1.469; unemployed: OR= 1.307; 95% C.I.=
42 43 44	258	1.142- 1.496; below RP: OR= 1.209; 95% C.I.= 1.070- 1.366; p< 0.001). The
45 46	259	geographic disparity in infrastructure was no longer significant (p=0.676), but
47 48	260	hospital level remained significant, with treatment in a non-trauma center setting
49 50 51 52 53 54 55	261	significantly increasing the risk of in-hospital mortality (OR= 1.209; 95% C.I.= 1.096-
	262	1.334; p< 0.001). The number of preexisting chronic conditions was also not
	263	significantly associated with increased in-hospital mortality. Other independent risk
56 57 58 59 60	264	factors included age (OR= 1.013, 95% C.I.= 1.011- 1.016); head (OR= 3.637, 95% C.I.= 12

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5 4 5	265	3.287- 4.025), heart (OR= 1.475, 95% C.I.= 1.019- 2.137), lung (OR= 1.337, 95% C.I.=
6 7 8 9 10 11 12	266	1.187- 1.506) and gastrointestinal injuries (OR= 1.351, 95% C.I.=1.130- 1.616); and
	267	the complications of renal failure (OR= 9.532, 95% C.I.=7.823- 11.615) and stroke
	268	(OR= 1.687, 95% C.I.=1.197- 2.378).
13 14 15	269	Discussion
16 17	270	This is the first study investigating the correlation of SES and the outcomes of
18 19 20	271	trauma under the NHI system. In our study, we demonstrated that any income status
21 22	272	below the RP line is an independent risk factor for in-hospital mortality among major
23 24	273	torso trauma patients. Theoretically, a difference in patient management should not
25 26 27 28 29 30 31 32 33	274	exist in the single-payer system provided by NHI because the same quality of
	275	treatment is provided to patients of all economic statuses. We postulated that the
	276	care from the family support system is different in each level of income. One
	277	notorious disadvantage of the NHIRD is the exploitation of medical professionals,
34 35	278	which leads to high burnout rates, especially among nursing staff (21, 22). The
36 37	279	shortage of the nursing workforce is constant in Taiwan. When measured by nursing
38 39 40	280	hours per patient day (NHPPD), Taiwan averages 5.19 hours, which is very likely to
41 42	281	be overestimated, whereas the American Nurses Association suggests that the
43 44 45 46 47 48 49 50 51 52 53	282	minimal requirement for the NHPPD is 6 hours for medical and surgical ward nurses
	283	(23, 24). According to another more intuitive measurement, the patient-nurse ratio,
	284	the average in Taiwan is approximately 9 patients to 1 nurse (25), but the ratio
	285	mandated by California legislation is no more than 5 medical or surgical patients per
	286	nurse (26). Additionally, the NHI does not cover adjunctive systems for the clinical
54 55 56	287	care of patients, such as licensed practical nurses (LPNs) and nursing assistants
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288	(NAs), as in the United States. A personal caregiver would cost more than 2,000 NTD
289	(approximately 65 USD) for each patient per day, which might lead to financial
290	pressure on each family (27). Under these circumstances, much of the care of the
291	patient relies solely on the family support system. Confusions regarding patient care
292	and complications are not uncommon (28, 29), and these adverse incidences might
293	ultimately result in different levels of quality of care and different outcomes.
294	Moreover, the incidence of major torso trauma is extremely high among the lower
295	income groups. The dependent, unemployed, and below the RP line groups
296	accounted for 78.6% of all the enrolled patients, and the 2013 RP line (19,279
297	NTD/month) was already below the 2nd decile of monthly income (22,471
298	NTD/month) (16), indicating that less than 20% of the population produced more
299	than 3/4 of the major torso trauma patients. Poverty is associated with increased
300	trauma incidence and increased mortality (30-32). Perhaps another urgent issue is
301	the development of trauma prevention strategies for the lower SES groups.
302	The presence of geographic disparities in medical resource density was associated
303	with a significant difference in trauma outcomes in the univariate analysis but not
304	the multivariate analysis. In fact, a low income status overwhelmed the potential

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influence of medical resource shortages in zones two and three. 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 one and two (Table 5). Interestingly, compared with the other two zones,

dependent and unemployed patients, which is contrary to our assumption that the

zone 3 had fewer patients with incomes above the RP line, but it also had fewer

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311 unemployment rate is high in economically disadvantaged regions. However, this is 312 compatible with a previous sociological study in Taiwan, which found that the 313 unemployment rates were higher in metropolitan areas than in rural areas (33). 314 Although regional differences failed to demonstrate statistically significant results 315 regarding survival, it is still inappropriate to conclude that the disparity in medical 316 resources has no negative effect on severe torso trauma patients. In our study, being 317 treated in a non-trauma center setting appeared to be an independent risk factor for 318 in-hospital mortality in multivariate analysis. We surmise that having zero trauma 319 centers could be responsible for the poor outcome in zone three. Trauma centers 320 with a high volume of severe trauma patients have demonstrated survival benefits 321 for patients across different countries and systems (34-36). Similar results can be 322 found in the NHI system in Taiwan. Liao et al. reported that trauma centers in Taiwan 323 had a higher ratio of splenic injuries treated in a non-operative manner and had a 324 better improvement in the outcome in one decade (37). The outcomes of our study 325 were compatible with the findings of these articles, suggesting that being treated in 326 a trauma center is a favorable prognostic factor.

The inequity of trauma care under a single-payer healthcare system is not a very commonly discussed topic. Most studies emphasize 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 lowincome areas in Canada held a better survival advantage when compared with their

 counterparts in the United States (RR= 1.14, 95% C.I.= 1.13-1.15). 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% C.I.= 0.93- 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 rehospitalization 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: 3.295-4.034). 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: 1.127-1.613), heart (OR= 1.475, 95% C.I.= 1.019- 2.137), and lung (OR=1.323, 95% CI: 1.175-1.490). 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). Compared with patients

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3 4 5	358	without pulmonary contusions, those with pulmonary contusions have been
6 7	359	reported to have a higher risk for posttraumatic acute respiratory distress syndrome
8 9	360	(ARDS) (47), and even minor pulmonary injuries are associated with a higher
10 11	361	mortality rate (48). These data were compatible with our findings. In contrast, some
12 13 14	362	of the injuries were found to be protective in our study, including
15 16	363	pneumohemothoraces (OR=0.735, 95% C.I.=0.663- 0.814), splenic injuries
17 18	364	(OR=0.776, 95% C.I.=0.665- 0.905), kidney injuries (OR=0.685, 95% C.I.=0.537-
19 20 21	365	0.874), pelvic fractures (OR=0.761, 95% C.I.=0.664- 0.873), spinal cord injuries
21 22 23	366	(OR=0.744, 95% C.I.=0.657- 0.842), and femoral fractures (OR=0.613, 95% C.I.=0.542-
24 25	367	0.693). Some of these are quite understandable, as spinal cord injuries and femoral
26 27	368	fractures are mostly not life-threatening, as reported in previous studies (49, 50).
28 29 30	369	Other injuries, such as splenic injuries, kidney injuries, and pelvic fractures, might be
31 32	370	associated with devastating hemorrhagic events. However, due to the advancement
33 34	371	of angioembolization, a substantial proportion of these patients can be managed in a
35 36	372	non-operative manner, with dramatically improved survival (51-53).
37 38 39	373	Pneumohemothoraces could be present in a wide variety of chest injuries. However,
40 41	374	they can be readily diagnosed by sonography and can be quickly treated; therefore,
42 43	375	the outcome is generally satisfactory for the majority of patients in modern clinical
44 45	376	practice (54). The results from our current study are consistent with the findings in
46 47 48	377	the published literature.
49 50	378	Preexisting chronic conditions and acquired complications during admission also
51 52 53	379	affect the outcome of trauma patients. Among these complications, acute kidney
53 54 55	380	failure with hemodialysis was identified as a strong independent risk factor for
56 57 58 59 60	381	mortality (OR=9.420, 95% CI: 7.732-11.477). Stroke (OR=1.677, 95% CI: 1.190-2.364) 17

was also associated with increased mortality. Our findings are very similar to those in
the current published literature (55-58). However, the number of preexisting 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 physiologic 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

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405	who deliberately evade insurance fees. This would not be problematic for employees
406	because the organizations they work for are required to declare the wages to the
407	NTB and the NHI simultaneously, but for employers and self-employed professionals,
408	it is possible to falsify their income reported to the NHI. However, the NHI is entitled
409	to assess the NTB database and can impose fines on insurance fee evaders when
410	needed. Also, a person who was classified in the below the RP group might not be
411	completely economically disadvantaged as far as household income is concerned.
412	This might lead to misclassifying high SES individuals in the low SES group. The same
413	concept applies to insurance dependents. Patients belonging to the dependent
414	group were financially dependent, but they might not necessarily be financially
415	challenged. However, being financially dependent might lead to social segregation
416	and less accessibility to medical resources, which can result in suboptimal health
417	outcomes, especially in minority groups such as women, elderly individuals, or
418	immigrants (60-62). Thus, the dependent group in this study does not precisely
419	indicate an economic disadvantage but rather a broader status of being
420	underprivileged.
421	Time frame is another issue. The dataset for our current study was not current.
422	The current status of the geographically disadvantaged regions after the quality
423	Improvement Project for the Rural and Short of Medical Resource Regions was
424	introduced in 2014 was not considered in this study. We expect such financial aid to
425	have improved the quality of care for trauma patients, and we wish to conduct a

426 decadal study to examine the outcome of this amendment in later years.

427 Finally, another drawback is that these data did not include the deaths at the

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emergency department and out-of-hospital cardiac arrest (OHCA) 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.

433 *Conclusion*

434	Although Taiwan's NHI has reduced the financial barriers to medical care,
435	disparities in trauma care remain. An income level below the RP line is an
436	independent risk factor for in-hospital mortality for major torso trauma patients,
437	despite universal insurance coverage. Geographic disparities in infrastructure
438	were associated with increased in-hospital mortality in the univariate analysis but
439	not the multivariate analysis. Concomitant head, GI, heart, and lung injuries were
440	also associated with increased in-hospital mortality among major torso trauma
441	patients. Public health and welfare policies must continue to focus their attention
442	on this vulnerable population to eliminate inequality in trauma care.
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Table 1. Characteristics of major torso trauma patients with different income levels.

		Income Level				
	Dependent	Unemployed	Below RP Line	Above RP Line	_	
Variable	(N=4887)	(N=3915)	(N=6930)	(N=4277)	P Value	
Age, years, Median					< 0.001*	
(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%)		
<u>≥</u> 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*	
Pneumohemothorax	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*	

Note: *=p< 0.05; RP= relative poverty; GI= gastrointestinal; ACS= acute coronary syndrome

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		Table 2. Characteristics of major torso trauma patients in different geographic regions.
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		Region		-
Variable	Zone 1 (N=8629)	Zone 2 (N=7432)	Zone 3 (N=3948)	P Value
Age, years, Median				<0.001*
(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*

Note: *=p< 0.05; GI= gastrointestinal; ACS= acute coronary syndrome

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	Hospital Level			
	Non-Trauma Center			
Variable	(N=10227)	Trauma Center (N=9782)	P Value	
Age, years, Median			< 0.001*	
(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*	
Pneumohemothorax	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*	

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

Note: *=p< 0.05; GI= gastrointestinal; ACS= acute coronary syndrome

Variable	Odds Ratio	95% C.I.	P Value
Sex (Male)	1.100	0.999- 1.212	0.052
Age	1.013	1.011- 1.016	< 0.001
Number of Underlying Conditions			0.459
(Compared to 0)			0.458
1-2	0.951	0.848- 1.066	0.385
≥3	0.875	0.683- 1.120	0.290
Injury Type			
Head	3.637	3.287-4.025	< 0.001
Cardiac	1.475	1.019-2.137	0.040*
Lung	1.337	1.187- 1.506	< 0.001
Pneumohemothorax	0.735	0.663- 0.814	< 0.001
GI Tract	1.351	1.130- 1.616	0.001*
Spleen	0.776	0.665- 0.905	0.001*
Liver	0.957	0.837-1.093	0.513
Kidney	0.685	0.537- 0.874	0.002*
Pelvic Organ	0.804	0.558- 1.157	0.240
Pelvic Fracture	0.761	0.664- 0.873	< 0.001
Spine	0.744	0.657-0.842	< 0.001
Femoral Fracture	0.613	0.542- 0.693	< 0.001
Complication	. 7	7	
Dialysis	9.532	7.823- 11.615	< 0.001
ACS	0.891	0.321-2.467	0.832
Pneumonia	0.377	0.315- 0.451	< 0.001
Sepsis	0.581	0.317- 1.064	0.079
Stroke	1.687	1.197-2.378	0.003*
GI Bleeding	0.857	0.631-1.165	0.325
Region (Compared to Zone 1)			0.676
Zone 2	0.969	0.897-1.068	0.523
Zone 3	0.954	0.846- 1.077	0.447
Income Level (Compared to Above			<0.001
the RP Line)			< 0.001
Dependent	1.290	1.133- 1.469	< 0.001
Unemployed	1.307	1.142- 1.496	< 0.001
Below the RP Line	1.209	1.070- 1.366	0.002*

Treated in Non-Trauma Center 1.20	09 1.096-1.334	< 0.001*
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Note: *=p< 0.05; RP= relative poverty; GI= gastrointestinal; ACS= acute coronary syndrome

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

		Income Level				
		Dependent	Unemployed	Below RP	Above RP	P Value
	Zone 1 (n)	2202	1800	2739	1888	0.016*
	Mortality (%)	304 (13.8%)	273 (15.2%)	421 (15.4%)	232 (12.3%)	0.010
Dogion	Zone 2 (n)	1828	1408	2575	1621	0.006*
Region	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%)	

Note: *=p< 0.05; RP= relative poverty

Figure Legends

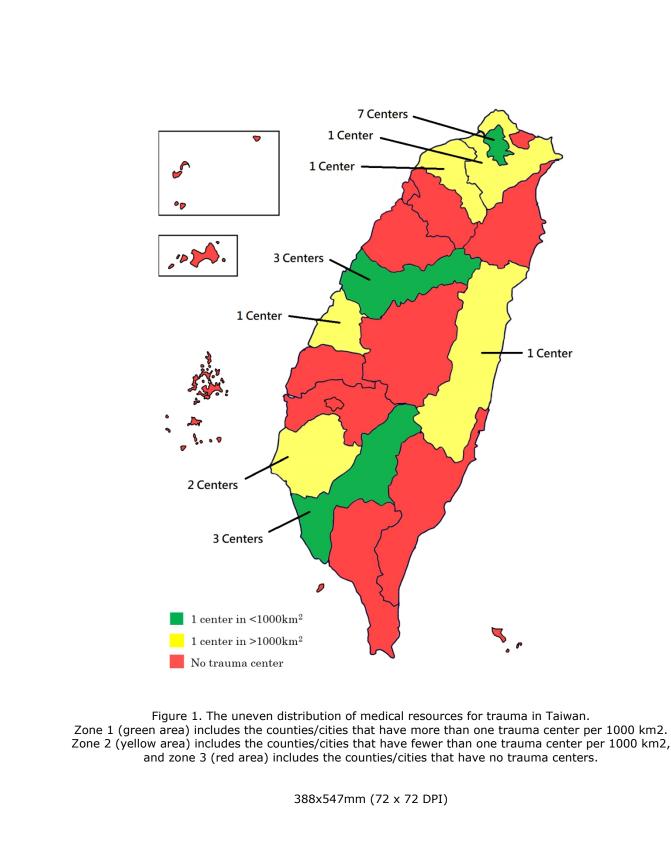
Figure 1. The uneven distribution of medical resources for trauma in Taiwan.

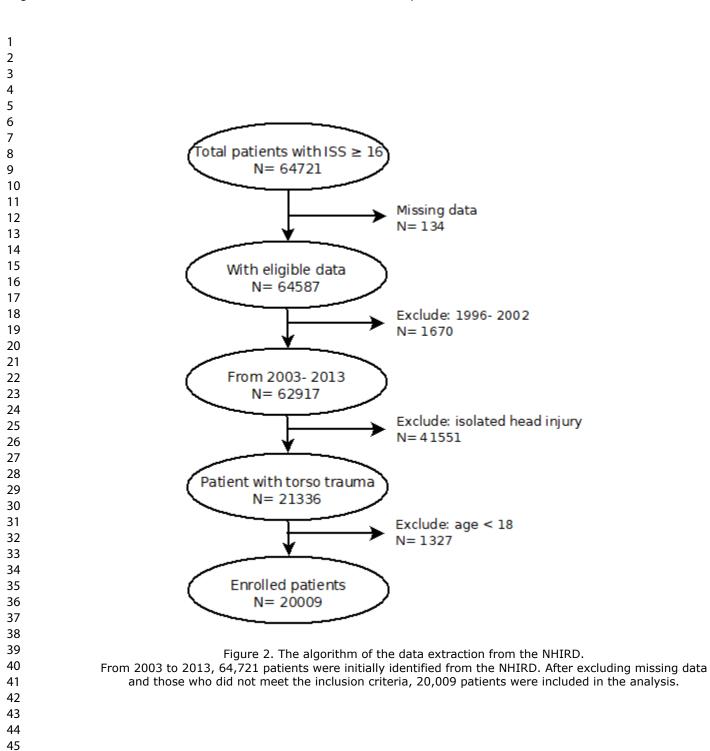
Zone 1 (green area) includes the counties/cities that have more than one trauma center per 1000 km². Zone 2 (yellow area) includes the counties/cities that have fewer than one trauma center per 1000 km², and zone 3 (red area) includes the counties/cities that have no trauma centers.

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.

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Reporting checklist for cohort study.

Based on the STROBE cohort guidelines.

Instructions to authors

Complete this checklist by entering the page numbers from your manuscript where readers will find each of the items listed below. Your article may not currently address all the items on the checklist. Please modify your text to include the missing information. If you are certain that an item does not apply, please write "n/a" and provide a short explanation. Upload your completed checklist as an extra file when you submit to a journal. In your methods section, say that you used the STROBE cohortreporting guidelines, and cite them as: von Elm E, Altman DG, Egger M, Pocock SJ, Gotzsche PC, Vandenbroucke JP. The Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) Statement: guidelines for reporting observational studies.

Title and abstract

Title#1aIndicate the study's design with a commonly used term in the1title or the abstract

Abstract <u>#1b</u> Provide in the abstract an informative and balanced summary 4-5

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1 2			of what was done and what was found	
3 4 5	Introduction			
6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35 36	Background /	<u>#2</u>	Explain the scientific background and rationale for the	5-6
	rationale		investigation being reported	
	Objectives #		State specific objectives, including any prespecified	6
			hypotheses	
	Methods			
	Study design #4		Present key elements of study design early in the paper	6-9
	Setting	<u>#5</u>	Describe the setting, locations, and relevant dates, including	6-7
			periods of recruitment, exposure, follow-up, and data collection	
	Eligibility criteria	<u>#6a</u>	Give the eligibility criteria, and the sources and methods of	7
			selection of participants. Describe methods of follow-up.	
	Eligibility criteria	<u>#6b</u>	For matched studies, give matching criteria and number of	7
37 38			exposed and unexposed	
39 40 41	Variables	<u>#7</u>	Clearly define all outcomes, exposures, predictors, potential	7-8
42 43			confounders, and effect modifiers. Give diagnostic criteria, if	
44 45 46			applicable	
47 48	Data sources /	<u>#8</u>	For each variable of interest give sources of data and details of	8-9
49 50	measurement		methods of assessment (measurement). Describe	
51 52 53			comparability of assessment methods if there is more than one	
54 55			group. Give information separately for for exposed and	
56 57 58			unexposed groups if applicable.	
59 60		For pe	eer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16	Bias	<u>#9</u>	Describe any efforts to address potential sources of bias	14-15
	Study size	<u>#10</u>	Explain how the study size was arrived at	9
	Quantitative	<u>#11</u>	Explain how quantitative variables were handled in the	9
	variables		analyses. If applicable, describe which groupings were chosen,	
			and why	
	Statistical	<u>#12a</u>	Describe all statistical methods, including those used to control	9
17 18 19	methods		for confounding	
20 21	Statistical	<u>#12b</u>	Describe any methods used to examine subgroups and	9
22 23 24	methods		interactions	
25 26 27	Statistical	<u>#12c</u>	Explain how missing data were addressed	9
28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 9 50 51 52 53 54 55 56 57 58	methods			
	Statistical	<u>#12d</u>	If applicable, explain how loss to follow-up was addressed	nil
	methods			
	Statistical	<u>#12e</u>		9
	methods			
	Results			
	Participants	<u>#13a</u>	Report numbers of individuals at each stage of study—eg	9-10
			numbers potentially eligible, examined for eligibility, confirmed	
			eligible, included in the study, completing follow-up, and	
			analysed. Give information separately for for exposed and	
			unexposed groups if applicable.	
	Participants	<u>#13b</u>	Give reasons for non-participation at each stage	9
59 60		For pe	eer review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3 4 5 6 7 8 9 10 11 12 13 14	Participants	<u>#13c</u>	Consider use of a flow diagram	9
	Descriptive data	<u>#14a</u>	Give characteristics of study participants (eg demographic,	9
			clinical, social) and information on exposures and potential	
			confounders. Give information separately for exposed and	
			unexposed groups if applicable.	
	Descriptive data	#14b	Indicate number of participants with missing data for each	9
15 16 17			variable of interest	-
18			0	
19 20 21 22 23 24 25 26	Descriptive data	<u>#14c</u>	Summarise follow-up time (eg, average and total amount)	nil
	Outcome data	<u>#15</u>	Report numbers of outcome events or summary measures	9
			over time. Give information separately for exposed and	
27 28			unexposed groups if applicable.	
29 30 31 32 33 34 35 36 37 38	Main results	#160	Give upadiusted estimates and if applicable, confounder	9
	Main results	<u>#16a</u>	Give unadjusted estimates and, if applicable, confounder-	9
			adjusted estimates and their precision (eg, 95% confidence	
			interval). Make clear which confounders were adjusted for and	
			why they were included	
39 40 41	Main results	<u>#16b</u>	Report category boundaries when continuous variables were	10
41 42 43			categorized	
44 45				
46 47	Main results	<u>#16c</u>	If relevant, consider translating estimates of relative risk into	10
48 49 50 51 52 53 54 55 56			absolute risk for a meaningful time period	
	Other analyses	<u>#17</u>	Report other analyses done—e.g., analyses of subgroups and	10
			interactions, and sensitivity analyses	
	Discussion			
57 58	DISCUSSION			
59 60		For pe	er review only - http://bmjopen.bmj.com/site/about/guidelines.xhtml	

1 2 3	Key results	<u>#18</u>	Summarise key results with reference to study objectives	10-13			
4 5	Limitations	<u>#19</u>	Discuss limitations of the study, taking into account sources of	14-15			
6 7			potential bias or imprecision. Discuss both direction and				
8 9 10			magnitude of any potential bias.				
11 12 13	Interpretation	<u>#20</u>	Give a cautious overall interpretation considering objectives,	10-13			
14 15			limitations, multiplicity of analyses, results from similar studies,				
16 17 18			and other relevant evidence.				
19 20	Generalisability	<u>#21</u>	Discuss the generalisability (external validity) of the study	nil			
21 22 23			results				
24 25 26	Other Information						
27 28 29	Funding	<u>#22</u>	Give the source of funding and the role of the funders for the	3			
30 31			present study and, if applicable, for the original study on which				
32 33 34			the present article is based				
35 36	None The STROBE checklist is distributed under the terms of the Creative Commons Attribution						
37 38 39	License CC-BY. Th	nis cheo	klist can be completed online using <u>https://www.goodreports.org/</u> ,	a tool			
40 41	made by the EQUATOR Network in collaboration with Penelope.ai						
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