BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032062
Article Type:	Research
Date Submitted by the Author:	01-Jun-2019
Complete List of Authors:	Kuo, Ling-wei; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Fu, Chih-Yuan; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Liao, Chien-An; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Liao, Chien-Hung; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Hsieh, Chi-Hsun; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Wang, Shang-Yu; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Chen, Shao-Wei ; Chang Gung Memorial Hospital Linkou Branch, Division of Thoracic and Cardiovascular Surgery, Department of Surgery Cheng, Chi-Tung; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center
Keywords:	ACCIDENT & EMERGENCY MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, SURGERY, TRAUMA MANAGEMENT, EPIDEMIOLOGY

Title

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

Authors

Ling-Wei Kuo[1]

E-mail: m0102@cgmh.org.tw

Chih-Yuan Fu[1]

E-mail: drfu5564@yahoo.com.tw

Chien-An Liao[1]

E-mail: m8407@cgmh.org.tw

Chien-Hung Liao[1]

E-mail: surgymet@gmail.com

Chi-Hsun Hsieh[1]

E-mail: hsieh0818@cgmh.org.tw

Shang-Yu Wang[1]

E-mail: shangyuwang@gmail.com

Shao-Wei Chen[2]

E-mail: josephchen0314@gmail.com

Chi-Tung Cheng*[1]

E-mail: atong89130@gmail.com

Affiliation

1. Chang Gung Memorial Hospital, Linkou, Trauma and Critical Care Center; Taoyuan City, Taiwan

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

Corresponding author:

Chi-Tung Cheng, MD

Chang Gung Memorial Hospital, Linkou, Trauma and Critical Care Center

No.5, Fuxing St., Guishan Dist.

Taoyuan City 333, Taiwan

E-mail: atong89130@gmail.com

TEL: (+886)3-328-1200 Ext. #3651

Fax: (+886) 3-328-9582

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.

Word count:

2708

Acknowledgements

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

Keywords

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 ≥ 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.

Results:

In univariate analysis, geographic disparities and low income level were both risk factors for in-hospital mortality for patients with major torso trauma (p=0.002 and <0.001, respectively). However, in multivariate analysis, only 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 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) ≥ 16. It is important to note that the NHIRD does not record the ISS, but all patients with ISSs ≥ 16 are eligible to receive a 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,

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 km^2. Zone two included the administrative areas that have intermediate levels of medical resources, with fewer than one trauma center per 1000 km^2, 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.

Results

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 in-hospital 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 single-payer system provided by NHI because the same quality of treatment is provided to patients of all economic statuses. We postulated that the care from the family support system is different in each level of income. One notorious disadvantage of the NHIRD is the exploitation of medical professionals, which leads to high burnout rates, especially among nursing staff(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

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 ≥ 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 resources and elevate the quality and efficiency of 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.

References

1. Arthur M, Hedges JR, Newgard CD, Diggs BS, Mullins RJ. Racial disparities in mortality among adults hospitalized after injury. Medical care. 2008;46(2):192-9.
2. Greene WR, Oyetunji TA, Bowers U, Haider AH, Mellman TA, Cornwell EE, et al. Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma. Am J Surg. 2010;199(4):554-7.
3. Hosking J, Ameratunga S, Exeter D, Stewart J, Bell A. Ethnic, socioeconomic and geographical inequalities in road traffic injury rates in the Auckland region. Aust N Z J Public Health. 2013;37(2):162-7.
4. Wesson HK, Boikhutso N, Bachani AM, Hofman KJ, Hyder AA. The cost of injury

and trauma care in low- and middle-income countries: a review of economic evidence. Health Policy Plan. 2014;29(6):795-808.

5. Haider AH, Weygandt PL, Bentley JM, Monn MF, Rehman KA, Zarzaur BL, et al. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. J Trauma Acute Care Surg. 2013;74(5):1195-205.

6. Hsiao F-Y, Yang C-L, Huang Y-T, Huang W-F. Using Taiwan's National Health Insurance Research Databases for Pharmacoepidemiology Research2007. 99-108 p.

7. Hsu M, Chuang Y-C, Chen Y-L. Preliminary Analysis of the Sources of Household Income Inequality in Taiwan. Review of Social Sciences. 2015;9(1):1-31.

8. Yeh YC. The Truth of Wealth Inequity in Taiwan. The Reporter. 2016.

9. Wang JY, Wang CY, Juang SY, Huang KY, Chou P, Chen CW, et al. Low socioeconomic status increases short-term mortality of acute myocardial infarction despite universal health coverage. Int J Cardiol. 2014;172(1):82-7.

10. Ministry of Health and Welfare, Taiwan. Taiwan's Leading Causes of Death in 2016. 2017.

11. Lingsma HF, Roozenbeek B, Li B, Lu J, Weir J, Butcher I, et al. Large between-center differences in outcome after moderate and severe traumatic brain injury in the international mission on prognosis and clinical trial design in traumatic brain injury (IMPACT) study. Neurosurgery. 2011;68(3):601-7; discussion 7-8.

12. National Statistics, Taiwan. Report on the Survey of Family Income and Expenditure, 2013. 2014.

13. Atkinson A, Cantillon B, Marlier E, Nolan B. Social Indicators: The EU and Social Inclusion2002.

14. Rhinehart ZJ, Guyette FX, Sperry JL, Forsythe RM, Murdock A, Alarcon LH, et al. The association between air ambulance distribution and trauma mortality. Ann Surg. 2013;257(6):1147-53.

15. Danne PD. Trauma management in Australia and the tyranny of distance. World J Surg. 2003;27(4):385-9.

16. Cudnik MT, Newgard CD, Wang H, Bangs C, Herrington Rt. Distance impacts mortality in trauma patients with an intubation attempt. Prehosp Emerg Care. 2008;12(4):459-66.

17. Wu SC, Ming MS, Sung SC. Analysis of the Causes of Nurses Working Overtime in a Medical Center of Southern Taiwan. VGH Nursing. 2008;25(1):31-7.

18. Chou LP, Li CY, Hu SC. Job stress and burnout in hospital employees: comparisons of different medical professions in a regional hospital in Taiwan. BMJ Open. 2014;4(2):e004185.

19. Yeh CM, Chao Yu YM, Chen YC, Tien SF. A Study of Nursing Manpower Planning in Taiwan. Formosan Journal of Medicine. 2005;9(2).

20. Chang YC, Yen M, Chang SM, Liu YM. Exploring the relationship between nursing hours per patient day and mortality rate of hospitalised patients in Taiwan. J Nurs Manag. 2017;25(2):85-92.

21. Liang YW, Tsay SF, Chen WY. Effects of nurse staffing ratios on patient mortality in Taiwan acute care hospitals: a longitudinal study. J Nurs Res. 2012;20(1):1-7.

22. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. Jama. 2002;288(16):1987-93.

23. Lin LC, Hsu HY, Sung HC. The Perspectives of Family Caregivers Concerning a Skilled Mixed Care Model in a Hospital: A Qualitative Study. The Journal of Health Sciences. 2011;13(1):38-47.

24. Wu YH, Tseng YH. The Lived Experience of Family Caregivers Caring for Ventilator-Dependent Patients at Home. The Journal of Long-Term Care. 2009;13(2):169-89.

25. Chen CF. Experience Helping a Caregiver Reduce Stressors. The Journal of Nursing. 2010;57(2_S):81-6.

26. Karb RA, Subramanian SV, Fleegler EW. County Poverty Concentration and Disparities in Unintentional Injury Deaths: A Fourteen-Year Analysis of 1.6 Million U.S. Fatalities. PLoS One. 2016;11(5):e0153516.

27. Fritzell J, Rehnberg J, Bacchus Hertzman J, Blomgren J. Absolute or relative? A comparative analysis of the relationship between poverty and mortality. Int J Public Health. 2015;60(1):101-10.

28. Bagher A, Andersson L, Wingren CJ, Ottosson A, Wangefjord S, Acosta S. Socio-economic status and major trauma in a Scandinavian urban city: A population-based case-control study. Scand J Public Health. 2016;44(2):217-23.

29. Jiang F-F, Liu PK-C. A Panel Study of Regional Unemployment in Taiwan: 1987-2001. Journal of Population Studies. 2005;31:1-39.

30. Gorey KM. Breast cancer survival in Canada and the USA: meta-analytic evidence of a Canadian advantage in low-income areas. Int J Epidemiol. 2009;38(6):1543-51.

31. Moore L, Cisse B, Batomen Kuimi BL, Stelfox HT, Turgeon AF, Lauzier F, et al. Impact of socio-economic status on hospital length of stay following injury: a multicenter cohort study. BMC Health Serv Res. 2015;15:285.

32. Cisse B, Moore L, Kuimi BL, Porgo TV, Boutin A, Lavoie A, et al. Impact of socio-economic status on unplanned readmission following injury: A multicenter cohort study. Injury. 2016;47(5):1083-90.
33. Baltas I, Gerogiannis N, Sakellariou P, Matamis D, Prassas A, Fylaktakis M. Outcome in severely head injured patients with and without multiple trauma. Journal of neurosurgical sciences. 1998;42(2):85-8.
34. Lefering R, Paffrath T, Linker R, Bouillon B, Neugebauer EA, Deutsche Gesellschaft fur Unfallchirurgie/German Society for Trauma S. Head injury and outcome--what influence do concomitant injuries have? J Trauma. 2008;65(5):1036-43; discussion 43-4.
35. Collaborators MCT, Perel P, Arango M, Clayton T, Edwards P, Komolafe E, et al. Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients. BMJ. 2008;336(7641):425-9.
36. Fakhry SM, Watts DD, Luchette FA, Group EM-IHVIR. Current diagnostic approaches lack sensitivity in the diagnosis of perforated blunt small bowel injury: analysis from 275,557 trauma admissions from the EAST multi-institutional HVI trial. J Trauma. 2003;54(2):295-306.
37. Watkins TR, Nathens AB, Cooke CR, Psaty BM, Maier RV, Cuschieri J, et al. Acute respiratory distress syndrome after trauma: development and validation of a predictive model. Crit Care Med. 2012;40(8):2295-303.
38. Veysi VT, Nikolaou VS, Paliobeis C, Efstathopoulos N, Giannoudis PV. Prevalence of chest trauma, associated injuries and mortality: a level I trauma centre experience. Int Orthop. 2009;33(5):1425-33.
39. Patel MS, Malinoski DJ, Nguyen XM, Hoyt DB. The impact of select chronic diseases on outcomes after trauma: a study from the National Trauma Data Bank. J Am Coll Surg. 2011;212(1):96-104.
40. Santos PR, Monteiro DL. Acute kidney injury in an intensive care unit of a general hospital with emergency room specializing in trauma: an observational prospective study. BMC Nephrol. 2015;16:30.
41. Eriksson M, Brattstrom O, Martensson J, Larsson E, Oldner A. Acute kidney injury following severe trauma: Risk factors and long-term outcome. J Trauma Acute Care Surg. 2015;79(3):407-12.
42. Alkhawam H, Madanieh R, El-Hunjul M, Madanieh A, Syed U, Ahmad S, et al. Morbidity and Mortality of Congestive Heart Failure in Trauma Patients. Am J Med Sci. 2016;352(2):172-6.
43. Ministry of Health and Welfare, Taiwan. Emergency Medical Services Act,

(2013).

44. National Health Insurance Administration, Taiwan. Quality Improvement Project for the Rural and Short of Medical Resource Regions. 2018.

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

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

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

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

Table 3. Multivariate Analysis of the Factors Affecting In-hospital Mortality

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 (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			
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 the RP Line)			<0.001
Dependent	1.287	1.130- 1.465	<0.001
Unemployed	1.304	1.139- 1.492	<0.001
Below the RP Line	1.213	1.074- 1.370	0.002

Table 4. Distribution of Income Levels in Each Region

		Region		
		Zone 1	Zone 2	Zone 3
Income Level	Dependent	2202 (25.5%)	1828 (24.6%)	857 (21.7%)
	Unemployed	1800 (20.9%)	1408 (18.9%)	707 (17.9%)
	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 km^2. Zone 2 (yellow area) are the counties/ cities that have fewer than one trauma center per 1000 km^2, 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.

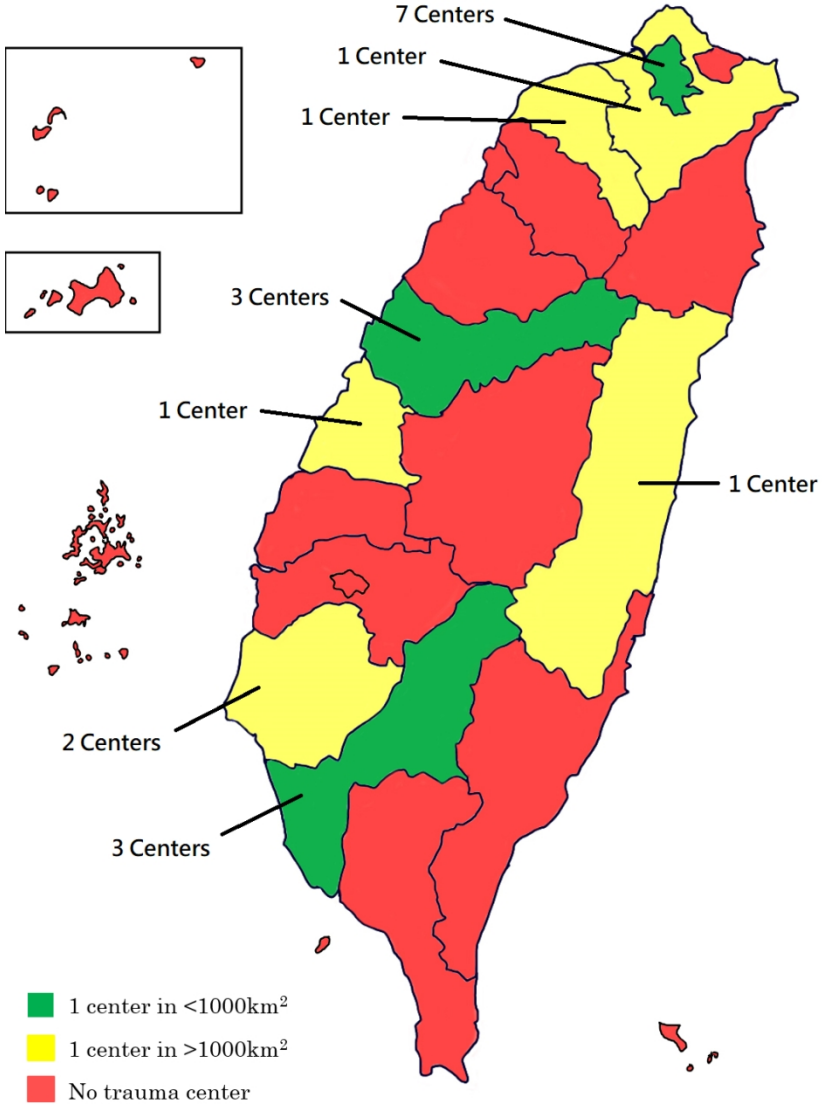

Figure 1. The distribution of level one trauma centers in Taiwan.

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.

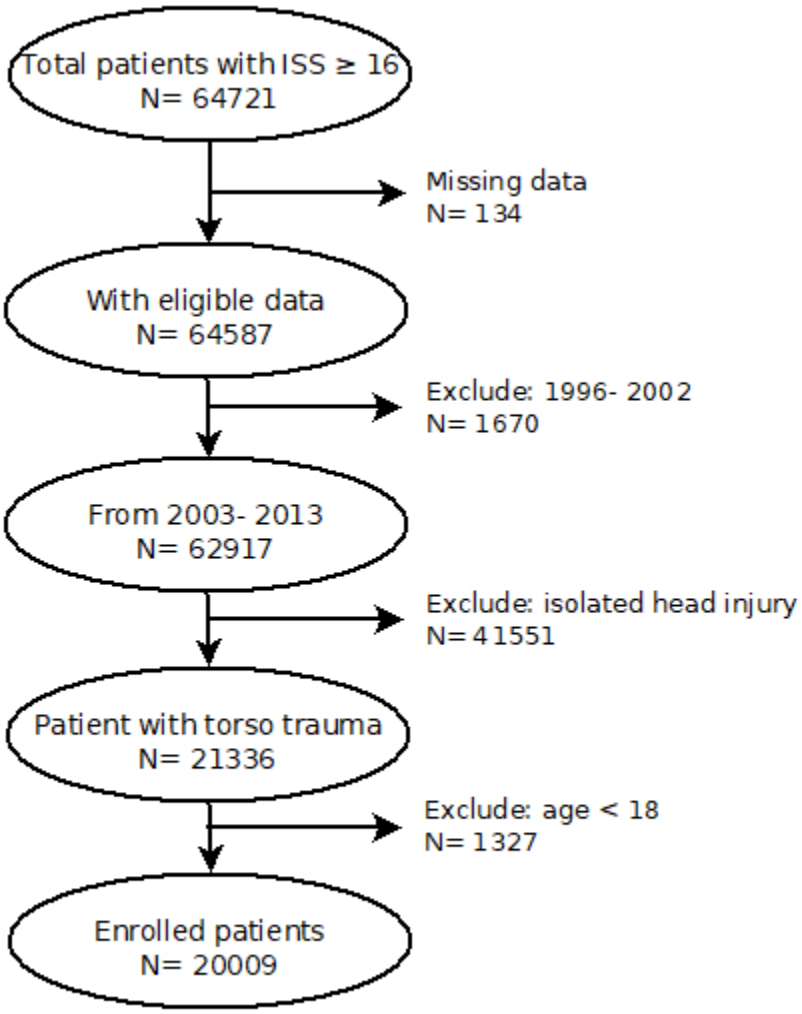

Figure 2. The algorithm of the data extraction from the NHIRD

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.

156x190mm (72 x 72 DPI)

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.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary	4-5

		of what was done and what was found	
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	#4	Present key elements of study design early in the paper	6-9
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	7
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	7
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-9

Bias	#9	Describe any efforts to address potential sources of bias	14-15
Study size	#10	Explain how the study size was arrived at	9
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	9
Statistical methods	#12c	Explain how missing data were addressed	9
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	nil
Statistical methods	#12e	Describe any sensitivity analyses	9
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg 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.	9-10
Participants	#13b	Give reasons for non-participation at each stage	9

Participants	#13c	Consider use of a flow diagram	9
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	9
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	nil
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	9
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
Main results	#16b	Report category boundaries when continuous variables were categorized	10
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10

Discussion

Key results	#18	Summarise key results with reference to study objectives	10-13
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14-15
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	10-13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	nil
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

BMJ Open

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

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032062.R1
Article Type:	Original research
Date Submitted by the Author:	16-Sep-2019
Complete List of Authors:	Kuo, Ling-wei; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Fu, Chih-Yuan; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Liao, Chien-An; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Liao, Chien-Hung; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Hsieh, Chi-Hsun; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Wang, Shang-Yu; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Chen, Shao-Wei ; Chang Gung Memorial Hospital Linkou Branch, Division of Thoracic and Cardiovascular Surgery, Department of Surgery Cheng, Chi-Tung; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center
Primary Subject Heading:	Surgery
Secondary Subject Heading:	Epidemiology, Health policy, Public health, Health economics
Keywords:	ACCIDENT & EMERGENCY MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, SURGERY, TRAUMA MANAGEMENT, EPIDEMIOLOGY

Title

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

Authors

Ling-Wei Kuo[1]

E-mail: m0102@cgmh.org.tw

Chih-Yuan Fu[1]

E-mail: drfu5564@yahoo.com.tw

Chien-An Liao[1]

E-mail: m8407@cgmh.org.tw

Chien-Hung Liao[1]

E-mail: surgymet@gmail.com

Chi-Hsun Hsieh[1]

E-mail: hsieh0818@cgmh.org.tw

Shang-Yu Wang[1]

E-mail: shangyuwang@gmail.com

Shao-Wei Chen[2]

E-mail: josephchen0314@gmail.com

Chi-Tung Cheng*[1]

E-mail: atong89130@gmail.com

Affiliation

1. Chang Gung Memorial Hospital, Linkou, Trauma and Critical Care Center; Taoyuan City, Taiwan

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

Corresponding author:

Chi-Tung Cheng, MD

Chang Gung Memorial Hospital, Linkou, Trauma and Critical Care Center

No.5, Fuxing St., Guishan Dist.

Taoyuan City 333, Taiwan

E-mail: atong89130@gmail.com

TEL: (+886)3-328-1200 Ext. #3651

Fax: (+886) 3-328-9582

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.

Word count:

3786

Acknowledgements

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

Funding Statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Keywords

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, the 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 of 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 ≥ 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.

Results:

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

<0.001, respectively). However, in multivariate analysis, only 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

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. The records from the emergency department (ED) were in a separated data set, and was not included in this study.

Study Cohort

This retrospective, observational study included all patients with major torso trauma in Taiwan from 2003 to 2013. Major trauma has been 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) ≥ 16. It is important to note that the NHIRD does not record the ISS, but all patients with ISSs ≥ 16 are eligible to receive a 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 (TBI) were excluded because the natural course of TBIs were quite different from torso injuries. Preventable deaths were less common with TBIs(13, 14), suggesting treatment options and SES factors might have less potential interference with the mortality. 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. Three independent subgroupings were performed. The subgrouping for income level was extracted from the data of the NHI payroll brackets. The payroll bracket can be divided by a few groups of population(15). The first group is the people who have registered sources of incomes, including all the employees, the employers, self-employed workers who 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

km^2. Zone two included the administrative areas that have intermediate levels of medical resources, with fewer than one trauma center per 1000 km^2, and zone three included the administrative areas that are poor in medical resources, with no trauma centers. Considering the possible impact of different level of hospitals, independent from the influence of regional difference, we also created an analysis by divided the patients by whether they initially received treatment from a trauma center or a non-center hospital. 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.

Results

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 (p<0.001). When the patients were divided by region and hospital levels, the same heterogeneity was noted among patient characteristics. The in-hospital mortality rate was significantly different by regions (p=0.002), with Zone 3 claiming the highest mortality (Table 2). Different hospital level showed significant influence on in-hospital mortality as well (Table 3). Patients who were initially treated in a non-trauma center revealed higher mortality than those treated in a trauma center. (15.3% vs 12.7%, p<0.001)

To determine which factors influence in-hospital mortality, a multivariate analysis was conducted (Table 4). All income status below the RP line remained an independent risk factor associated with increased in-hospital mortality rates (Dependent: OR= 1.290, 95% C.I.= 1.133- 1.469; Unemployed: OR= 1.307; 95% C.I.= 1.142- 1.496; Below RP: OR= 1.209; 95% C.I.= 1.070- 1.366; p< 0.001). The geographic disparity in infrastructure was no longer significant (p=0.676), but the true risk lies in the difference of hospital levels, with being treated in a non-center setting significantly increased the risk of in-hospital mortality (OR= 1.209; 95% C.I.= 1.096- 1.334; p< 0.001). 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= 3.637, 95% C.I.= 3.287- 4.025), heart (OR= 1.475, 95% C.I.= 1.019- 2.137), lung (OR= 1.337, 95% C.I.= 1.187- 1.506) and gastrointestinal injuries (OR= 1.351, 95% C.I.=1.130- 1.616); and the complications of renal failure (OR= 9.532, 95% C.I.=7.823- 11.615) and stroke

(OR= 1.687, 95% C.I.=1.197- 2.378).

Discussion

This is the first study investigating the correlation of SES and the outcomes of trauma under the NHI system. In our study, we demonstrated that any income status below the RP line is an independent risk factor for in-hospital mortality among major torso trauma patients. Theoretically, a difference in patient management should not exist in the single-payer system provided by NHI because the same quality of treatment is provided to patients of all economic statuses. We postulated that the care from the family support system is different in each level of income. One notorious disadvantage of the NHIRD is the exploitation of medical professionals, which leads to high burnout rates, especially among nursing staff(21, 22). The shortage of nursing workforce is constant in Taiwan. When measured by nursing hours per patient day (NHPPD), Taiwan averages 5.19 hours, which is very likely to be overestimated, whereas the American Nurses Association suggests that the minimal requirement for NHPPD is 6 hours for medical and surgical wards nurses(23, 24). According to another more intuitive measurement, the patient-nurse ratio, the average in Taiwan is approximately 9 patients to 1 nurse(25), but the ratio mandated by California legislation is no more than 5 medical or surgical patients per nurse(26). Additionally, the NHI does not cover adjunctive systems for the clinical care of patients, such as licensed practical nurses (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(27). 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(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).

Despite regional difference failed to demonstrate statistically significant results on survival, it is still inappropriate to conclude that disparity in medical resources has no negative effect on severe torso trauma patients. In our study, being treated in a non-center setting appeared to be an independent risk factor for in-hospital mortality in multivariate analysis. We surmise that having zero trauma center could be responsible for the poor outcome in zone three. Trauma centers with high-volume of severe trauma have demonstrated survival benefits for patients across different countries and systems(34-36). Similar results can be found in the NHI system in Taiwan. Liao et al. have reported that trauma centers in Taiwan had a higher ratio of splenic injuries treated with non-operative manner, and had a better improvement of outcome in one decade(37). The outcomes of our study were compatible with these articles, suggesting being treated in 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 literature 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 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)(38). 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(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

to be protective in our study, including pneumohemothoraces (OR=0.735, 95% C.I.=0.663- 0.814), splenic injuries (OR=0.776, 95% C.I.=0.665- 0.905), kidney injuries (OR=0.685, 95% C.I.=0.537- 0.874), pelvic fractures (OR=0.761, 95% C.I.=0.664- 0.873), spinal cord injuries (OR=0.744, 95% C.I.=0.657- 0.842), and femoral fractures (OR=0.613, 95% C.I.=0.542- 0.693). Some of these are quite understandable, like spinal cord injuries and femoral fractures are mostly not life-threatening, as reported in previous literatures(49, 50). Other injuries like splenic injuries, kidney injuries, and pelvic fractures might associate with devastating hemorrhage events. However, due to the advancement of angioembolization, a great proportion of these patients can be managed in a non-operative manner, with dramatically improved survival(51-53). Pneumohemothoraces could be presented in a wide variety of chest injuries, however, they can be readily diagnosed by sonography and can be quickly treated, therefore, the general outcome can be satisfying for majority of patients in modern day practice(54). The result from our current study are consistent with the findings of published literatures.

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(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 ISS. However, the NHIRD is the only available database that includes all medical activities in Taiwan. By limiting the cohort to patients with ISSs ≥ 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

to assess the NTB database, and could impose penalty fine to the insurance fee evaders when needed. Also, a person who belonged in the below RP group might not be completely economically disadvantaged, as far as household income is concerned. This might lead to misclassifying high SES individuals to the low SES group. The same concept applies to the insurance dependents. Patients belonged in the dependent group were financially dependent, but they might not necessarily be financially challenged. However, being financially dependent might lead to social segregation and less accessibility to medical resources, which can result in suboptimal health outcomes, especially in the minority groups like women, elderly, or immigrants(60-62). Thus, the dependent group in this study not exactly implies having a tight budget, but a broader status of underprivileged.

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

Finally, another drawback is that these data did not include the deaths at the emergency department and out-of-hospital cardiac arrest (OHCA) patients, which might also interfere with 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 of this study. Therefore, the interference is somehow limited.

Conclusion

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

References

1. Arthur M, Hedges JR, Newgard CD, Diggs BS, Mullins RJ. Racial disparities in mortality among adults hospitalized after injury. Medical care. 2008;46(2):192-9.
2. Greene WR, Oyetunji TA, Bowers U, Haider AH, Mellman TA, Cornwell EE, et al. Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma. Am J Surg. 2010;199(4):554-7.
3. Hosking J, Ameratunga S, Exeter D, Stewart J, Bell A. Ethnic, socioeconomic and geographical inequalities in road traffic injury rates in the Auckland region. Aust N Z J Public Health. 2013;37(2):162-7.
4. Wesson HK, Boikhutso N, Bachani AM, Hofman KJ, Hyder AA. The cost of injury and trauma care in low- and middle-income countries: a review of economic evidence. Health Policy Plan. 2014;29(6):795-808.
5. Haider AH, Weygandt PL, Bentley JM, Monn MF, Rehman KA, Zarzaur BL, et al. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. J Trauma Acute Care Surg. 2013;74(5):1195-205.

6. Hsiao F-Y, Yang C-L, Huang Y-T, Huang W-F. Using Taiwan's National Health Insurance Research Databases for Pharmacoepidemiology Research2007. 99-108 p.
7. Hsu M, Chuang Y-C, Chen Y-L. Preliminary Analysis of the Sources of Household Income Inequality in Taiwan. Review of Social Sciences. 2015;9(1):1-31.
8. Yeh YC. The Truth of Wealth Inequity in Taiwan. The Reporter. 2016.
9. Wang JY, Wang CY, Juang SY, Huang KY, Chou P, Chen CW, et al. Low socioeconomic status increases short-term mortality of acute myocardial infarction despite universal health coverage. Int J Cardiol. 2014;172(1):82-7.
10. Ministry of Health and Welfare, Taiwan. Taiwan's Leading Causes of Death in 2016. 2017.
11. Ministry of Health and Welfare, Taiwan. Emergency Medical Services Act, 2013.
12. National Health Insurance Administration, Taiwan. Quality Improvement Project for the Rural and Short of Medical Resource Regions. 2018.
13. Montmany S, Pallisera A, Rebasa P, Campos A, Colilles C, Luna A, et al. Preventable deaths and potentially preventable deaths. What are our errors? Injury. 2016;47(3):669-73.
14. Matsumoto S, Jung K, Smith A, Coimbra R. Trauma center maturity measured by an analysis of preventable and potentially preventable deaths: there is always something to be learned. Surgery today. 2018;48(11):1004-10.
15. Ministry of Health and Welfare, Taiwan. National Health Insurance Act, (2017).
16. National Statistics, Taiwan. Report on the Survey of Family Income and Expenditure, 2013. 2014.
17. Atkinson A, Cantillon B, Marlier E, Nolan B. Social Indicators: The EU and Social Inclusion2002.
18. Rhinehart ZJ, Guyette FX, Sperry JL, Forsythe RM, Murdock A, Alarcon LH, et al. The association between air ambulance distribution and trauma mortality. Ann Surg. 2013;257(6):1147-53.
19. Danne PD. Trauma management in Australia and the tyranny of distance. World J Surg. 2003;27(4):385-9.
20. Cudnik MT, Newgard CD, Wang H, Bangs C, Herrington Rt. Distance impacts mortality in trauma patients with an intubation attempt. Prehosp Emerg Care. 2008;12(4):459-66.
21. Wu SC, Ming MS, Sung SC. Analysis of the Causes of Nurses Working Overtime in a Medical Center of Southern Taiwan. VGH Nursing. 2008;25(1):31-7.
22. Chou LP, Li CY, Hu SC. Job stress and burnout in hospital employees: comparisons of different medical professions in a regional hospital in Taiwan. BMJ

Open. 2014;4(2):e004185.
23. Yeh CM, Chao Yu YM, Chen YC, Tien SF. A Study of Nursing Manpower Planning in Taiwan. Formosan Journal of Medicine. 2005;9(2).
24. Chang YC, Yen M, Chang SM, Liu YM. Exploring the relationship between nursing hours per patient day and mortality rate of hospitalised patients in Taiwan. J Nurs Manag. 2017;25(2):85-92.
25. Liang YW, Tsay SF, Chen WY. Effects of nurse staffing ratios on patient mortality in Taiwan acute care hospitals: a longitudinal study. J Nurs Res. 2012;20(1):1-7.
26. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. Jama. 2002;288(16):1987-93.
27. Lin LC, Hsu HY, Sung HC. The Perspectives of Family Caregivers Concerning a Skilled Mixed Care Model in a Hospital: A Qualitative Study. The Journal of Health Sciences. 2011;13(1):38-47.
28. Wu YH, Tseng YH. The Lived Experience of Family Caregivers Caring for Ventilator-Dependent Patients at home. The Journal of Long-Term Care. 2009;13(2):169-89.
29. Chen CF. Experience Helping a Caregiver Reduce Stressors. The Journal of Nursing. 2010;57(2_S):81-6.
30. Karb RA, Subramanian SV, Fleegler EW. County Poverty Concentration and Disparities in Unintentional Injury Deaths: A Fourteen-Year Analysis of 1.6 Million U.S. Fatalities. PLoS One. 2016;11(5):e0153516.
31. Fritzell J, Rehnberg J, Bacchus Hertzman J, Blomgren J. Absolute or relative? A comparative analysis of the relationship between poverty and mortality. Int J Public Health. 2015;60(1):101-10.
32. Bagher A, Andersson L, Wingren CJ, Ottosson A, Wangefjord S, Acosta S. Socio-economic status and major trauma in a Scandinavian urban city: A population-based case-control study. Scand J Public Health. 2016;44(2):217-23.
33. Jiang F-F, Liu PK-C. A Panel Study of Regional Unemployment in Taiwan: 1987-2001. Journal of Population Studies. 2005;31:1-39.
34. Endo A, Shiraishi A, Fushimi K, Murata K, Otomo Y. Increased Severe Trauma Patient Volume is Associated With Survival Benefit and Reduced Total Health Care Costs: A Retrospective Observational Study Using a Japanese Nationwide Administrative Database. Ann Surg. 2018;268(6):1091-6.
35. Zacher MT, Kanz KG, Hanschen M, Haberle S, van Griensven M, Lefering R, et al.

526 Association between volume of severely injured patients and mortality in German
527 trauma hospitals. The British journal of surgery. 2015;102(10):1213-9.
528 36. Fu CY, Bajani F, Tatebe L, Butler C, Starr F, Dennis A, et al. Right hospital, right
529 patients: Penetrating injury patients treated at high-volume penetrating trauma
530 centers have lower mortality. J Trauma Acute Care Surg. 2019;86(6):961-6.
531 37. Liao CA, Wu YT, Liao CH, Wang SY, Fu CY, Hsieh CH, et al. Hospital level
532 variations in the trends and outcomes of the nonoperative management of splenic
533 injuries - a nationwide cohort study. Scandinavian journal of trauma, resuscitation
534 and emergency medicine. 2019;27(1):4.
535 38. Gorey KM. Breast cancer survival in Canada and the USA: meta-analytic
536 evidence of a Canadian advantage in low-income areas. Int J Epidemiol.
537 2009;38(6):1543-51.
538 39. Moore L, Cisse B, Batomen Kuimi BL, Stelfox HT, Turgeon AF, Lauzier F, et al.
539 Impact of socio-economic status on hospital length of stay following injury: a
540 multicenter cohort study. BMC Health Serv Res. 2015;15:285.
541 40. Cisse B, Moore L, Kuimi BL, Porgo TV, Boutin A, Lavoie A, et al. Impact of socio-
542 economic status on unplanned readmission following injury: A multicenter cohort
543 study. Injury. 2016;47(5):1083-90.
544 41. Baltas I, Gerogiannis N, Sakellariou P, Matamis D, Prassas A, Fylaktakis M.
545 Outcome in severely head injured patients with and without multiple trauma.
546 Journal of neurosurgical sciences. 1998;42(2):85-8.
547 42. Lefering R, Paffrath T, Linker R, Bouillon B, Neugebauer EA, Deutsche
548 Gesellschaft fur Unfallchirurgie/German Society for Trauma S. Head injury and
549 outcome--what influence do concomitant injuries have? J Trauma. 2008;65(5):1036-
550 43; discussion 43-4.
551 43. Collaborators MCT, Perel P, Arango M, Clayton T, Edwards P, Komolafe E, et al.
552 Predicting outcome after traumatic brain injury: practical prognostic models based
553 on large cohort of international patients. BMJ. 2008;336(7641):425-9.
554 44. Fakhry SM, Watts DD, Luchette FA, Group EM-IHVIR. Current diagnostic
555 approaches lack sensitivity in the diagnosis of perforated blunt small bowel injury:
556 analysis from 275,557 trauma admissions from the EAST multi-institutional HVI trial.
557 J Trauma. 2003;54(2):295-306.
558 45. Skinner DL, Laing GL, Rodseth RN, Ryan L, Hardcastle TC, Muckart DJ. Blunt
559 cardiac injury in critically ill trauma patients: a single centre experience. Injury.
560 2015;46(1):66-70.
561 46. Gosavi S, Tyroch AH, Mukherjee D. Cardiac Trauma. Angiology.

2016;67(10):896-901.

47. Watkins TR, Nathens AB, Cooke CR, Psaty BM, Maier RV, Cuschieri J, et al. Acute respiratory distress syndrome after trauma: development and validation of a predictive model. Crit Care Med. 2012;40(8):2295-303.

48. Veysi VT, Nikolaou VS, Paliobeis C, Efstathopoulos N, Giannoudis PV. Prevalence of chest trauma, associated injuries and mortality: a level I trauma centre experience. Int Orthop. 2009;33(5):1425-33.

49. Jain NB, Ayers GD, Peterson EN, Harris MB, Morse L, O'Connor KC, et al. Traumatic spinal cord injury in the United States, 1993-2012. Jama. 2015;313(22):2236-43.

50. Cantu RV, Graves SC, Spratt KF. In-hospital mortality from femoral shaft fracture depends on the initial delay to fracture fixation and Injury Severity Score: a retrospective cohort study from the NTDB 2002-2006. J Trauma Acute Care Surg. 2014;76(6):1433-40.

51. El-Matbouly M, Jabbour G, El-Menyar A, Peralta R, Abdelrahman H, Zarour A, et al. Blunt splenic trauma: Assessment, management and outcomes. The surgeon : journal of the Royal Colleges of Surgeons of Edinburgh and Ireland. 2016;14(1):52-8.

52. Fu CY, Chan SY, Wang SY, Hsieh CH, Liao CH, Huang JF, et al. The effect of angioembolization for life-threatening retroperitoneal hemorrhage in patients with pelvic fracture. The American journal of emergency medicine. 2019;37(4):603-7.

53. El-Menyar A, Abdelrahman H, Al-Hassani A, Peralta R, AbdelAziz H, Latifi R, et al. Single Versus Multiple Solid Organ Injuries Following Blunt Abdominal Trauma. World J Surg. 2017;41(11):2689-96.

54. Chrysou K, Halat G, Hoksch B, Schmid RA, Kocher GJ. Lessons from a large trauma center: impact of blunt chest trauma in polytrauma patients-still a relevant problem? Scandinavian journal of trauma, resuscitation and emergency medicine. 2017;25(1):42.

55. Patel MS, Malinoski DJ, Nguyen XM, Hoyt DB. The impact of select chronic diseases on outcomes after trauma: a study from the National Trauma Data Bank. J Am Coll Surg. 2011;212(1):96-104.

56. Santos PR, Monteiro DL. Acute kidney injury in an intensive care unit of a general hospital with emergency room specializing in trauma: an observational prospective study. BMC Nephrol. 2015;16:30.

57. Eriksson M, Brattstrom O, Martensson J, Larsson E, Oldner A. Acute kidney injury following severe trauma: Risk factors and long-term outcome. J Trauma Acute Care Surg. 2015;79(3):407-12.

58. Alkhawam H, Madanieh R, El-Hunjul M, Madanieh A, Syed U, Ahmad S, et al. Morbidity and Mortality of Congestive Heart Failure in Trauma Patients. Am J Med Sci. 2016;352(2):172-6.
59. Hsieh CH, Lai WH, Wu SC, Chen YC, Kuo PJ, Hsu SY, et al. Trauma injury in adult underweight patients: A cross-sectional study based on the trauma registry system of a level I trauma center. Medicine. 2017;96(10):e6272.
60. Lin SL, Hsiao YL. Social Segregation and the Health Care of Female Immigrants in Taiwan. The Journal of Nursing. 2007;54(4):67-72.
61. Luo WX, Xie Y. Socioeconomic Disparities in Health among Chinese Elderly: A Test of the Fundamental Cause Theory. Journal of Population Studies. 2015(50):1-28.
62. Nour NM. Health consequences of child marriage in Africa. Emerging infectious diseases. 2006;12(11):1644-9.
63. American College of Surgeons. Advanced Trauma Life Support (ATLS), 10th edition.2018.

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

Variable	Income Level				P Value
	Dependent (N=4887)	Unemployed (N=3915)	Below RP Line (N=6930)	Above RP Line (N=4277)	
Age, 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*

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

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

Variable	Region			P Value
	Zone 1 (N=8629)	Zone 2 (N=7432)	Zone 3 (N=3948)	
Age, 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= gastrointestinal; ACS= acute coronary syndrome

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

Table 3. Characteristics of major torso trauma patients in different hospital levels.

	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%)	
≥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*

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 (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 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-center	1.209	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
Region	Zone 1 (n)	2202	1800	2739	1888	0.016*
	Mortality (%)	304 (13.8%)	273 (15.2%)	421 (15.4%)	232 (12.3%)	
	Zone 2 (n)	1828	1408	2575	1621	0.006*
	Mortality (%)	262 (14.3%)	195 (13.8%)	339 (13.2%)	171 (10.5%)	
	Zone 3 (n)	857	707	1616	768	0.200
	Mortality (%)	140 (16.3%)	117 (16.5%)	250 (15.5%)	100 (13.0%)	

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 km^2. Zone 2 (yellow area) are the counties/ cities that have fewer than one trauma center per 1000 km^2, 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.

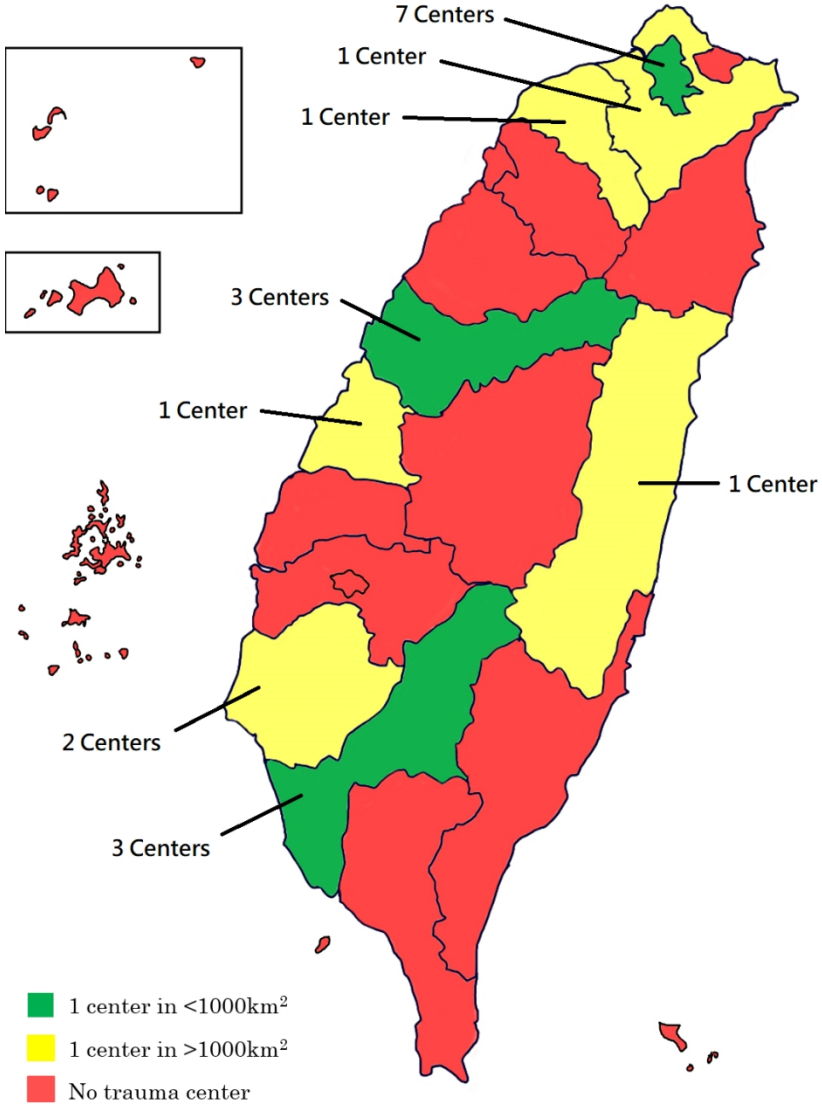

Figure 1. The distribution of level one trauma centers in Taiwan.

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.

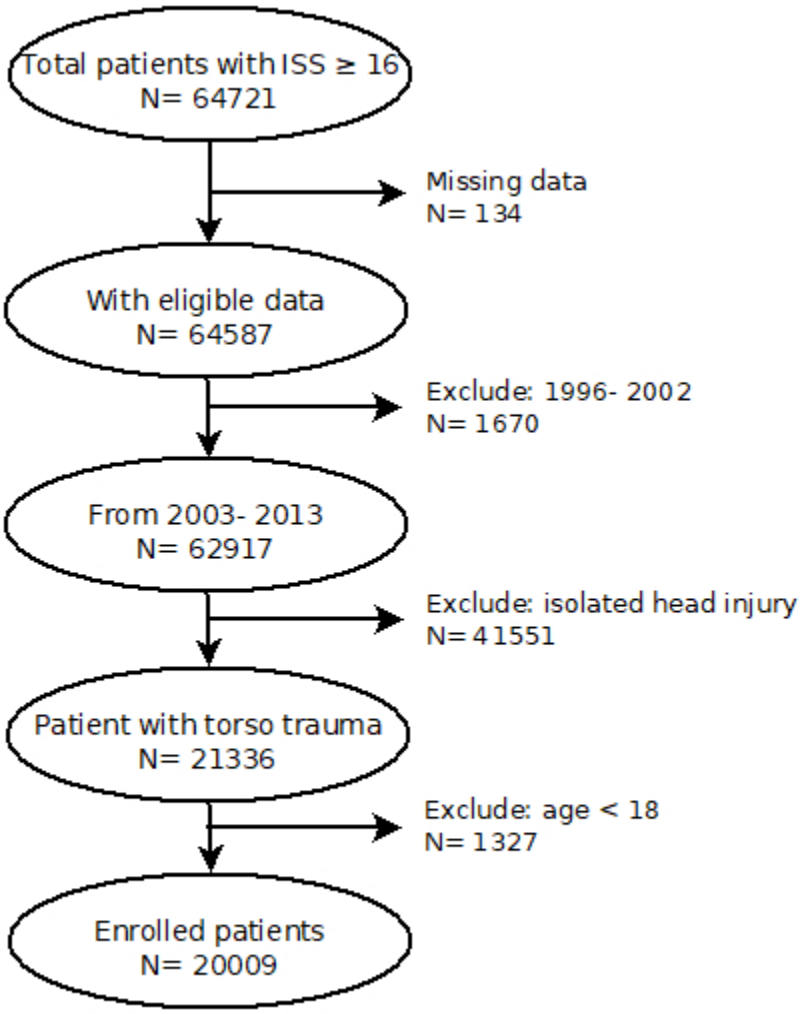

Figure 2. The algorithm of the data extraction from the NHIRD

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.

156x190mm (72 x 72 DPI)

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.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary	4-5

		of what was done and what was found	
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	#4	Present key elements of study design early in the paper	6-9
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	7
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	7
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-9

Bias	#9	Describe any efforts to address potential sources of bias	14-15
Study size	#10	Explain how the study size was arrived at	9
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	9
Statistical methods	#12c	Explain how missing data were addressed	9
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	nil
Statistical methods	#12e	Describe any sensitivity analyses	9
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg 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.	9-10
Participants	#13b	Give reasons for non-participation at each stage	9

Participants	#13c	Consider use of a flow diagram	9
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	9
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	nil
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	9
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
Main results	#16b	Report category boundaries when continuous variables were categorized	10
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10

Discussion

Key results	#18	Summarise key results with reference to study objectives	10-13
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14-15
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	10-13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	nil
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3

BMJ Open

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.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2019-032062.R2
Article Type:	Original research
Date Submitted by the Author:	21-Oct-2019
Complete List of Authors:	Kuo, Ling-wei; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Fu, Chih-Yuan; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Liao, Chien-An; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Liao, Chien-Hung; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Hsieh, Chi-Hsun; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Wang, Shang-Yu; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center Chen, Shao-Wei ; Chang Gung Memorial Hospital Linkou Branch, Division of Thoracic and Cardiovascular Surgery, Department of Surgery Cheng, Chi-Tung; Chang Gung Memorial Hospital Linkou Main Branch, Trauma and Critical Care Center
Primary Subject Heading:	Surgery
Secondary Subject Heading:	Epidemiology, Health policy, Public health, Health economics
Keywords:	ACCIDENT & EMERGENCY MEDICINE, Health policy < HEALTH SERVICES ADMINISTRATION & MANAGEMENT, SURGERY, TRAUMA MANAGEMENT, EPIDEMIOLOGY

Title

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.

Authors

Ling-Wei Kuo[1]

E-mail: m0102@cgmh.org.tw

Chih-Yuan Fu[1]

E-mail: drfu5564@yahoo.com.tw

Chien-An Liao[1]

E-mail: m8407@cgmh.org.tw

Chien-Hung Liao[1]

E-mail: surgymet@gmail.com

Chi-Hsun Hsieh[1]

E-mail: hsieh0818@cgmh.org.tw

Shang-Yu Wang[1]

E-mail: shangyuwang@gmail.com

Shao-Wei Chen[2]

E-mail: josephchen0314@gmail.com

Chi-Tung Cheng*[1]

E-mail: atong89130@gmail.com

Affiliations

1. Chang Gung Memorial Hospital, Linkou, Trauma and Critical Care Center; Taoyuan City, Taiwan

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

Corresponding author:

Chi-Tung Cheng, MD

Chang Gung Memorial Hospital, Linkou, Trauma and Critical Care Center

No.5, Fuxing St., Guishan Dist.

Taoyuan City 333, Taiwan

E-mail: atong89130@gmail.com

TEL: (+886)3-328-1200 Ext. #3651

Fax: (+886) 3-328-9582

Authors' contributions:

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

Word count:

3819

Acknowledgements

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

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 are 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

All the authors, including Ling-Wei Kuo, Chih-Yuan Fu, Chien-An Liao, Chien-Hung Liao, Chi-Hsun Hsieh, Shang-Yu Wang, Shao-Wei Chen, and Chi-Tung Cheng, 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.

Funding Statement

This research received no specific grant from any funding agency in the public, commercial or not-for-profit sectors.

Keywords

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

Abstract

Objectives:

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

Design:

A nationwide, retrospective cohort study.

Setting:

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

Participants:

Patients with major torso trauma (injury severity score ≥ 16) from 2003 to 2013 in Taiwan were included. 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 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.

Results:

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

Conclusion:

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

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 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, the income level was clearly defined in this study.
- The NHIRD did not provide clinical details, such as physiologic parameters, laboratory data, and severity.
- Only the data between 2003 and 2013 were included in this study due to policy augmentation. Future studies are needed to investigate more recent outcomes.

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 changed to 99.39 (8). Evidence has shown that even the NHI system does not change the disparity in health outcomes experienced by people of different SESs (9). More interestingly, 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 is located in the country's eastern region (Fig. 1).

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

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) ≥ 16. It is important to note that the NHIRD does not record the ISS, but all patients with ISSs ≥ 16 are eligible to receive a catastrophic illness certificate, which

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

Variables and outcome

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

groups (15). The first group is the people who have registered sources of incomes, including all the employees, employers, self-employed workers who belong in occupational unions, and self-employed farmers, fishermen, etc. who belong to agricultural associations. For this population group, the income is equivalent to the insurance amount, which is paid to the NHI by the insurer, the employer, and the government, in different proportions. We divided patients from this category into two groups based on the relative poverty (RP) line, which is 60% of the median income (16). In 2013, the RP line was 19,279 NTD/month (approximately equal to 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 incomes, including their spouse, parents or grandparents, and children or grandchildren who are under 20 years of age, with no registered incomes, were defined as the dependent group. The insurance amount in this group is the same as that of the insured, but the dependent does not have to pay. The insurance fee is defrayed by the insurer, the employer of the insurer, and the government in different proportions. Those who lack both income and family support are insured under the auspices of the local government. The insurance amount of this group is a minimal fee based on the actuarial analysis by the NHI, which is 100% paid by the government. Patients from this population constituted the unemployed group in our analysis.

To create the geographic subgroups, the number of trauma centers per square kilometers, instead of per population, was used as a measurement of the disparity of medical resources because geospatial factors, i.e. transport distance and time, are

significant predictors of mortality from trauma (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 km^2. Zone two included the administrative areas that have intermediate levels of medical resources, with fewer than one trauma center per 1000 km^2, and zone three included the administrative areas that are lacking in medical resources, with no trauma centers. Considering the possible impact of different levels of hospitals, independent of the influence of regional differences, we divided the patients according to whether they initially received treatment from a trauma center or a non-trauma center hospital. 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-based nature of this study, patients and the public were not involved.

Results

In the study cohort, 64,721 patients were initially identified from the NHIRD. After excluding those with missing data (n=134), data from the time (1996-2002) when the catastrophic illness certificate for major trauma had not been 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 (p<0.001). When the patients were divided by region and hospital levels, the same heterogeneity was noted among patient characteristics. The in-hospital mortality rate significantly differed by region (p=0.002), with Zone 3 having the highest mortality rate (Table 2). Different hospital levels also had a significant influence on in-hospital mortality (Table 3). Patients who were initially treated in a non-trauma center had a higher mortality rate than those treated in a trauma center (15.3% vs 12.7%, p<0.001).

To determine which factors influence in-hospital mortality, a multivariate analysis was conducted (Table 4). An income status below the RP line remained an independent risk factor associated with increased in-hospital mortality rates (dependent: OR= 1.290, 95% C.I.= 1.133- 1.469; unemployed: OR= 1.307; 95% C.I.= 1.142- 1.496; below RP: OR= 1.209; 95% C.I.= 1.070- 1.366; p< 0.001). The geographic disparity in infrastructure was no longer significant (p=0.676), but hospital level remained significant, with treatment in a non-trauma center setting significantly increasing the risk of in-hospital mortality (OR= 1.209; 95% C.I.= 1.096-1.334; p< 0.001). 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= 3.637, 95% C.I.=

3.287- 4.025), heart (OR= 1.475, 95% C.I.= 1.019- 2.137), lung (OR= 1.337, 95% C.I.= 1.187- 1.506) and gastrointestinal injuries (OR= 1.351, 95% C.I.=1.130- 1.616); and the complications of renal failure (OR= 9.532, 95% C.I.=7.823- 11.615) and stroke (OR= 1.687, 95% C.I.=1.197- 2.378).

Discussion

This is the first study investigating the correlation of SES and the outcomes of trauma under the NHI system. In our study, we demonstrated that any income status below the RP line is an independent risk factor for in-hospital mortality among major torso trauma patients. Theoretically, a difference in patient management should not exist in the single-payer system provided by NHI because the same quality of treatment is provided to patients of all economic statuses. We postulated that the care from the family support system is different in each level of income. One notorious disadvantage of the NHIRD is the exploitation of medical professionals, which leads to high burnout rates, especially among nursing staff (21, 22). The shortage of the nursing workforce is constant in Taiwan. When measured by nursing hours per patient day (NHPPD), Taiwan averages 5.19 hours, which is very likely to be overestimated, whereas the American Nurses Association suggests that the minimal requirement for the NHPPD is 6 hours for medical and surgical ward nurses (23, 24). According to another more intuitive measurement, the patient-nurse ratio, the average in Taiwan is approximately 9 patients to 1 nurse (25), but the ratio mandated by California legislation is no more than 5 medical or surgical patients per nurse (26). Additionally, the NHI does not cover adjunctive systems for the clinical care of patients, such as licensed practical nurses (LPNs) and nursing assistants

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

Moreover, the incidence of major torso trauma is extremely high among the lower income groups. The dependent, unemployed, and below the RP line groups accounted for 78.6% of all the enrolled patients, and the 2013 RP line (19,279 NTD/month) was already below the 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 disparities in medical resource density was associated with a significant difference in trauma outcomes in the univariate analysis but not the multivariate analysis. In fact, a low income status overwhelmed the potential influence of medical resource shortages in zones 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, 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 sociological study in Taiwan, which found that the unemployment rates were higher in metropolitan areas than in rural areas (33).

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

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

Preexisting chronic conditions and acquired complications during admission also affect the outcome of trauma patients. Among these 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 (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 ≥ 16, we could focus on major torso trauma patients and avoid interference from minor trauma. Another benefit of the NHIRD is its nationwide nature. All residents in Taiwan during the study period were included in this study; therefore, the large sample size should eliminate potential selection bias. The potential effect of trauma mechanism was not evaluated in our study. The NHIRD registers trauma mechanism with ICD-9 E code, and we could also identify whether it was a blunt or penetrating injury, yet the E code is not mandatory in the NHI registry and was only available in 21.6% in our dataset, making the analysis of trauma mechanism impossible in the current study. However, most of the injuries in Taiwan are blunt trauma, and the incidence of penetrating injuries can be as low as 5% (59). Therefore, the potential effect of different trauma mechanisms had limited influence on our analysis.

We need to acknowledge that the NHIRD income sectors were generated based on data from the National Taxation Bureau (NTB) of Taiwan, so any unregistered income was overlooked. Additionally, income could be underreported by individuals

who deliberately evade insurance fees. This would not be problematic for employees because the organizations they work for are required to declare the wages to the NTB and the NHI simultaneously, but for employers and self-employed professionals, it is possible to falsify their income reported to the NHI. However, the NHI is entitled to assess the NTB database and can impose fines on insurance fee evaders when needed. Also, a person who was classified in the below the RP group might not be completely economically disadvantaged as far as household income is concerned. This might lead to misclassifying high SES individuals in the low SES group. The same concept applies to insurance dependents. Patients belonging to the dependent group were financially dependent, but they might not necessarily be financially challenged. However, being financially dependent might lead to social segregation and less accessibility to medical resources, which can result in suboptimal health outcomes, especially in minority groups such as women, elderly individuals, or immigrants (60-62). Thus, the dependent group in this study does not precisely indicate an economic disadvantage but rather a broader status of being underprivileged.

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

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

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.

Conclusion

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

References

1. Arthur M, Hedges JR, Newgard CD, Diggs BS, Mullins RJ. Racial disparities in mortality among adults hospitalized after injury. Medical care. 2008;46(2):192-9.
2. Greene WR, Oyetunji TA, Bowers U, Haider AH, Mellman TA, Cornwell EE, et al. Insurance status is a potent predictor of outcomes in both blunt and penetrating trauma. Am J Surg. 2010;199(4):554-7.
3. Hosking J, Ameratunga S, Exeter D, Stewart J, Bell A. Ethnic, socioeconomic and

geographical inequalities in road traffic injury rates in the Auckland region. Aust N Z J Public Health. 2013;37(2):162-7.
4. Wesson HK, Boikhutso N, Bachani AM, Hofman KJ, Hyder AA. The cost of injury and trauma care in low- and middle-income countries: a review of economic evidence. Health Policy Plan. 2014;29(6):795-808.
5. Haider AH, Weygandt PL, Bentley JM, Monn MF, Rehman KA, Zarzaur BL, et al. Disparities in trauma care and outcomes in the United States: a systematic review and meta-analysis. J Trauma Acute Care Surg. 2013;74(5):1195-205.
6. Hsiao F-Y, Yang C-L, Huang Y-T, Huang W-F. Using Taiwan's National Health Insurance Research Databases for Pharmacoepidemiology Research2007. 99-108 p.
7. Hsu M, Chuang Y-C, Chen Y-L. Preliminary Analysis of the Sources of Household Income Inequality in Taiwan. Review of Social Sciences. 2015;9(1):1-31.
8. Yeh YC. The Truth of Wealth Inequity in Taiwan. The Reporter. 2016.
9. Wang JY, Wang CY, Juang SY, Huang KY, Chou P, Chen CW, et al. Low socioeconomic status increases short-term mortality of acute myocardial infarction despite universal health coverage. Int J Cardiol. 2014;172(1):82-7.
10. Ministry of Health and Welfare, Taiwan. Taiwan's Leading Causes of Death in 2016. 2017.
11. Ministry of Health and Welfare, Taiwan. Emergency Medical Services Act, 2013.
12. National Health Insurance Administration, Taiwan. Quality Improvement Project for the Rural and Short of Medical Resource Regions. 2018.
13. Montmany S, Pallisera A, Rebasa P, Campos A, Colilles C, Luna A, et al. Preventable deaths and potentially preventable deaths. What are our errors? Injury. 2016;47(3):669-73.
14. Matsumoto S, Jung K, Smith A, Coimbra R. Trauma center maturity measured by an analysis of preventable and potentially preventable deaths: there is always something to be learned. Surgery today. 2018;48(11):1004-10.
15. Ministry of Health and Welfare, Taiwan. National Health Insurance Act, (2017).
16. National Statistics, Taiwan. Report on the Survey of Family Income and Expenditure, 2013. 2014.
17. Atkinson A, Cantillon B, Marlier E, Nolan B. Social Indicators: The EU and Social Inclusion2002.
18. Rhinehart ZJ, Guyette FX, Sperry JL, Forsythe RM, Murdock A, Alarcon LH, et al. The association between air ambulance distribution and trauma mortality. Ann Surg. 2013;257(6):1147-53.
19. Danne PD. Trauma management in Australia and the tyranny of distance. World

J Surg. 2003;27(4):385-9.

20. Cudnik MT, Newgard CD, Wang H, Bangs C, Herrington Rt. Distance impacts mortality in trauma patients with an intubation attempt. Prehosp Emerg Care. 2008;12(4):459-66.

21. Wu SC, Ming MS, Sung SC. Analysis of the Causes of Nurses Working Overtime in a Medical Center of Southern Taiwan. VGH Nursing. 2008;25(1):31-7.

22. Chou LP, Li CY, Hu SC. Job stress and burnout in hospital employees: comparisons of different medical professions in a regional hospital in Taiwan. BMJ Open. 2014;4(2):e004185.

23. Yeh CM, Chao Yu YM, Chen YC, Tien SF. A Study of Nursing Manpower Planning in Taiwan. Formosan Journal of Medicine. 2005;9(2).

24. Chang YC, Yen M, Chang SM, Liu YM. Exploring the relationship between nursing hours per patient day and mortality rate of hospitalised patients in Taiwan. J Nurs Manag. 2017;25(2):85-92.

25. Liang YW, Tsay SF, Chen WY. Effects of nurse staffing ratios on patient mortality in Taiwan acute care hospitals: a longitudinal study. J Nurs Res. 2012;20(1):1-7.

26. Aiken LH, Clarke SP, Sloane DM, Sochalski J, Silber JH. Hospital nurse staffing and patient mortality, nurse burnout, and job dissatisfaction. Jama. 2002;288(16):1987-93.

27. Lin LC, Hsu HY, Sung HC. The Perspectives of Family Caregivers Concerning a Skilled Mixed Care Model in a Hospital: A Qualitative Study. The Journal of Health Sciences. 2011;13(1):38-47.

28. Wu YH, Tseng YH. The Lived Experience of Family Caregivers Caring for Ventilator-Dependent Patients at home. The Journal of Long-Term Care. 2009;13(2):169-89.

29. Chen CF. Experience Helping a Caregiver Reduce Stressors. The Journal of Nursing. 2010;57(2_S):81-6.

30. Karb RA, Subramanian SV, Fleegler EW. County Poverty Concentration and Disparities in Unintentional Injury Deaths: A Fourteen-Year Analysis of 1.6 Million U.S. Fatalities. PLoS One. 2016;11(5):e0153516.

31. Fritzell J, Rehnberg J, Bacchus Hertzman J, Blomgren J. Absolute or relative? A comparative analysis of the relationship between poverty and mortality. Int J Public Health. 2015;60(1):101-10.

32. Bagher A, Andersson L, Wingren CJ, Ottosson A, Wangefjord S, Acosta S. Socio-economic status and major trauma in a Scandinavian urban city: A population-based

case-control study. Scand J Public Health. 2016;44(2):217-23.
33. Jiang F-F, Liu PK-C. A Panel Study of Regional Unemployment in Taiwan: 1987-2001. Journal of Population Studies. 2005;31:1-39.
34. Endo A, Shiraishi A, Fushimi K, Murata K, Otomo Y. Increased Severe Trauma Patient Volume is Associated With Survival Benefit and Reduced Total Health Care Costs: A Retrospective Observational Study Using a Japanese Nationwide Administrative Database. Ann Surg. 2018;268(6):1091-6.
35. Zacher MT, Kanz KG, Hanschen M, Haberle S, van Griensven M, Lefering R, et al. Association between volume of severely injured patients and mortality in German trauma hospitals. The British journal of surgery. 2015;102(10):1213-9.
36. Fu CY, Bajani F, Tatebe L, Butler C, Starr F, Dennis A, et al. Right hospital, right patients: Penetrating injury patients treated at high-volume penetrating trauma centers have lower mortality. J Trauma Acute Care Surg. 2019;86(6):961-6.
37. Liao CA, Wu YT, Liao CH, Wang SY, Fu CY, Hsieh CH, et al. Hospital level variations in the trends and outcomes of the nonoperative management of splenic injuries - a nationwide cohort study. Scandinavian journal of trauma, resuscitation and emergency medicine. 2019;27(1):4.
38. Gorey KM. Breast cancer survival in Canada and the USA: meta-analytic evidence of a Canadian advantage in low-income areas. Int J Epidemiol. 2009;38(6):1543-51.
39. Moore L, Cisse B, Batomen Kuimi BL, Stelfox HT, Turgeon AF, Lauzier F, et al. Impact of socio-economic status on hospital length of stay following injury: a multicenter cohort study. BMC Health Serv Res. 2015;15:285.
40. Cisse B, Moore L, Kuimi BL, Porgo TV, Boutin A, Lavoie A, et al. Impact of socio-economic status on unplanned readmission following injury: A multicenter cohort study. Injury. 2016;47(5):1083-90.
41. Baltas I, Gerogiannis N, Sakellariou P, Matamis D, Prassas A, Fylaktakis M. Outcome in severely head injured patients with and without multiple trauma. Journal of neurosurgical sciences. 1998;42(2):85-8.
42. Lefering R, Paffrath T, Linker R, Bouillon B, Neugebauer EA, Deutsche Gesellschaft fur Unfallchirurgie/German Society for Trauma S. Head injury and outcome--what influence do concomitant injuries have? J Trauma. 2008;65(5):1036-43; discussion 43-4.
43. Collaborators MCT, Perel P, Arango M, Clayton T, Edwards P, Komolafe E, et al. Predicting outcome after traumatic brain injury: practical prognostic models based on large cohort of international patients. BMJ. 2008;336(7641):425-9.

44. Fakhry SM, Watts DD, Luchette FA, Group EM-IHVIR. Current diagnostic approaches lack sensitivity in the diagnosis of perforated blunt small bowel injury: analysis from 275,557 trauma admissions from the EAST multi-institutional HVI trial. J Trauma. 2003;54(2):295-306.

45. Skinner DL, Laing GL, Rodseth RN, Ryan L, Hardcastle TC, Muckart DJ. Blunt cardiac injury in critically ill trauma patients: a single centre experience. Injury. 2015;46(1):66-70.

46. Gosavi S, Tyroch AH, Mukherjee D. Cardiac Trauma. Angiology. 2016;67(10):896-901.

47. Watkins TR, Nathens AB, Cooke CR, Psaty BM, Maier RV, Cuschieri J, et al. Acute respiratory distress syndrome after trauma: development and validation of a predictive model. Crit Care Med. 2012;40(8):2295-303.

48. Veysi VT, Nikolaou VS, Paliobeis C, Efstathopoulos N, Giannoudis PV. Prevalence of chest trauma, associated injuries and mortality: a level I trauma centre experience. Int Orthop. 2009;33(5):1425-33.

49. Jain NB, Ayers GD, Peterson EN, Harris MB, Morse L, O'Connor KC, et al. Traumatic spinal cord injury in the United States, 1993-2012. Jama. 2015;313(22):2236-43.

50. Cantu RV, Graves SC, Spratt KF. In-hospital mortality from femoral shaft fracture depends on the initial delay to fracture fixation and Injury Severity Score: a retrospective cohort study from the NTDB 2002-2006. J Trauma Acute Care Surg. 2014;76(6):1433-40.

51. El-Matbouly M, Jabbour G, El-Menyar A, Peralta R, Abdelrahman H, Zarour A, et al. Blunt splenic trauma: Assessment, management and outcomes. The surgeon : journal of the Royal Colleges of Surgeons of Edinburgh and Ireland. 2016;14(1):52-8.

52. Fu CY, Chan SY, Wang SY, Hsieh CH, Liao CH, Huang JF, et al. The effect of angioembolization for life-threatening retroperitoneal hemorrhage in patients with pelvic fracture. The American journal of emergency medicine. 2019;37(4):603-7.

53. El-Menyar A, Abdelrahman H, Al-Hassani A, Peralta R, AbdelAziz H, Latifi R, et al. Single Versus Multiple Solid Organ Injuries Following Blunt Abdominal Trauma. World J Surg. 2017;41(11):2689-96.

54. Chrysou K, Halat G, Hoksch B, Schmid RA, Kocher GJ. Lessons from a large trauma center: impact of blunt chest trauma in polytrauma patients-still a relevant problem? Scandinavian journal of trauma, resuscitation and emergency medicine. 2017;25(1):42.

55. Patel MS, Malinoski DJ, Nguyen XM, Hoyt DB. The impact of select chronic

diseases on outcomes after trauma: a study from the National Trauma Data Bank. J Am Coll Surg. 2011;212(1):96-104.

56. Santos PR, Monteiro DL. Acute kidney injury in an intensive care unit of a general hospital with emergency room specializing in trauma: an observational prospective study. BMC Nephrol. 2015;16:30.

57. Eriksson M, Brattstrom O, Martensson J, Larsson E, Oldner A. Acute kidney injury following severe trauma: Risk factors and long-term outcome. J Trauma Acute Care Surg. 2015;79(3):407-12.

58. Alkhawam H, Madanieh R, El-Hunjul M, Madanieh A, Syed U, Ahmad S, et al. Morbidity and Mortality of Congestive Heart Failure in Trauma Patients. Am J Med Sci. 2016;352(2):172-6.

59. Hsieh CH, Lai WH, Wu SC, Chen YC, Kuo PJ, Hsu SY, et al. Trauma injury in adult underweight patients: A cross-sectional study based on the trauma registry system of a level I trauma center. Medicine. 2017;96(10):e6272.

60. Lin SL, Hsiao YL. Social Segregation and the Health Care of Female Immigrants in Taiwan. The Journal of Nursing. 2007;54(4):67-72.

61. Luo WX, Xie Y. Socioeconomic Disparities in Health among Chinese Elderly: A Test of the Fundamental Cause Theory. Journal of Population Studies. 2015(50):1-28.

62. Nour NM. Health consequences of child marriage in Africa. Emerging infectious diseases. 2006;12(11):1644-9.

63. American College of Surgeons. Advanced Trauma Life Support (ATLS), 10th edition.2018.

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

Variable	Income Level: Dependent (N=4887)	Unemployed (N=3915)	Below RP Line (N=6930)	Above RP Line (N=4277)	P Value
Age, years, Median (IQR)	36 (20-65)	42 (31-56)	50 (35-63)	43 (31-53)	<0.001*
Chronic Condition, No.					<0.001*
0	3807 (77.9%)	3026 (77.3%)	5131 (74.0%)	3551 (83.0%)	
1-2	916 (18.7%)	763 (19.5%)	1584 (22.9%)	663 (15.5%)	
≥3	164 (3.4%)	126 (3.2%)	215 (3.1%)	63 (1.5%)	
Sex (Male, Ratio)	3109 (63.6%)	3074 (78.5%)	4940 (71.3%)	3249 (76.0%)	<0.001*
Injury Type					
Head	2646 (54.1%)	2098 (53.6%)	3610 (52.1%)	2135 (49.9%)	<0.001*
Cardiac	58 (1.2%)	37 (0.9%)	63 (0.9%)	65 (1.5%)	0.016*
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

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

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

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

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

	Hospital Level		
Variable	Non-Trauma Center (N=10227)	Trauma Center (N=9782)	P Value
Age, years, Median (IQR)	47 (31-61)	43 (27-57)	<0.001*
Chronic Condition, No.			<0.001*
0	7692 (75.2%)	7823 (79.97%)	
1-2	916 (21.9%)	763 (17.27%)	
≥3	164 (2.9%)	126 (2.76%)	
Sex (Male, Ratio)	7330 (71.7%)	7042 (72.0%)	0.619
Injury Type			
Head	5664 (55.4%)	4825 (49.3%)	<0.001*
Cardiac	82 (0.8%)	141 (1.4%)	<0.001*
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*

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

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

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 (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 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	1.209	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
Region	Zone 1 (n)	2202	1800	2739	1888	0.016*
	Mortality (%)	304 (13.8%)	273 (15.2%)	421 (15.4%)	232 (12.3%)	
	Zone 2 (n)	1828	1408	2575	1621	0.006*
	Mortality (%)	262 (14.3%)	195 (13.8%)	339 (13.2%)	171 (10.5%)	
	Zone 3 (n)	857	707	1616	768	0.200
	Mortality (%)	140 (16.3%)	117 (16.5%)	250 (15.5%)	100 (13.0%)	

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 km^2. Zone 2 (yellow area) includes the counties/cities that have fewer than one trauma center per 1000 km^2, 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.

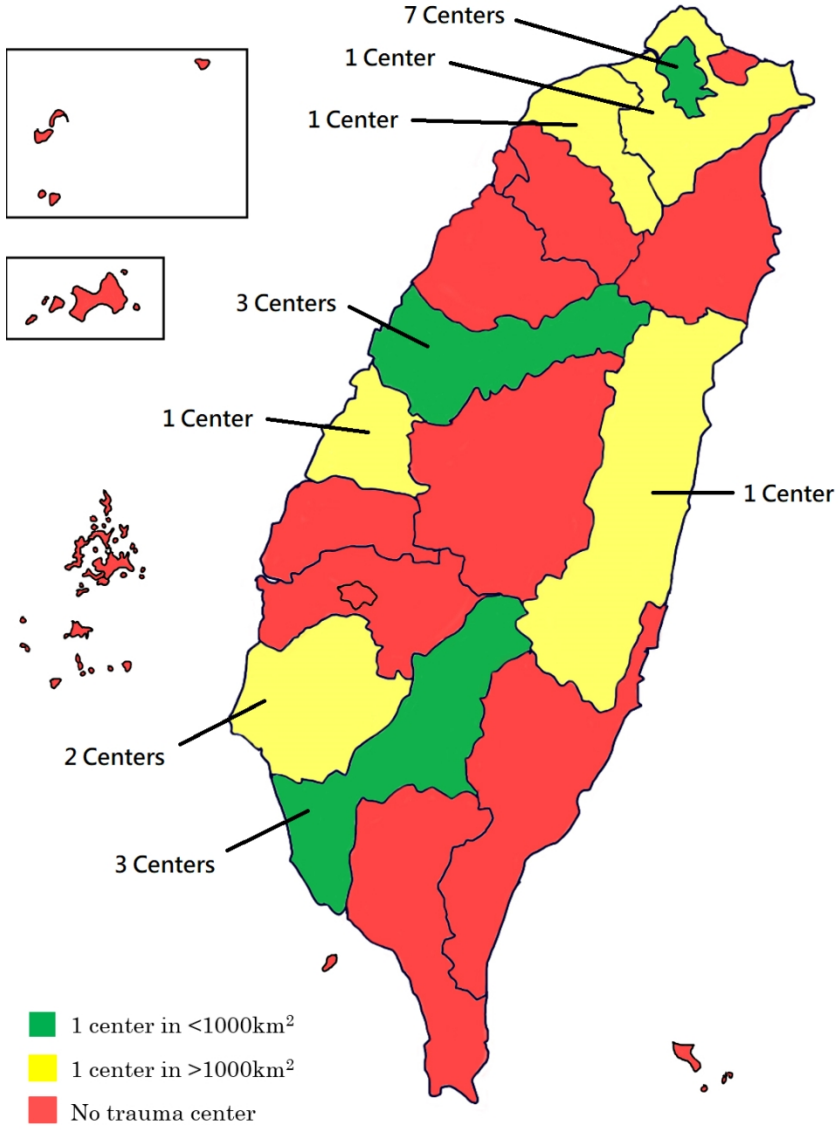

Figure 1. The uneven distribution of medical resources for trauma in Taiwan.
Zone 1 (green area) includes the counties/cities that have more than one trauma center per 1000 km2.
Zone 2 (yellow area) includes the counties/cities that have fewer than one trauma center per 1000 km2,
and zone 3 (red area)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

388x547mm (72 x 72 DPI)

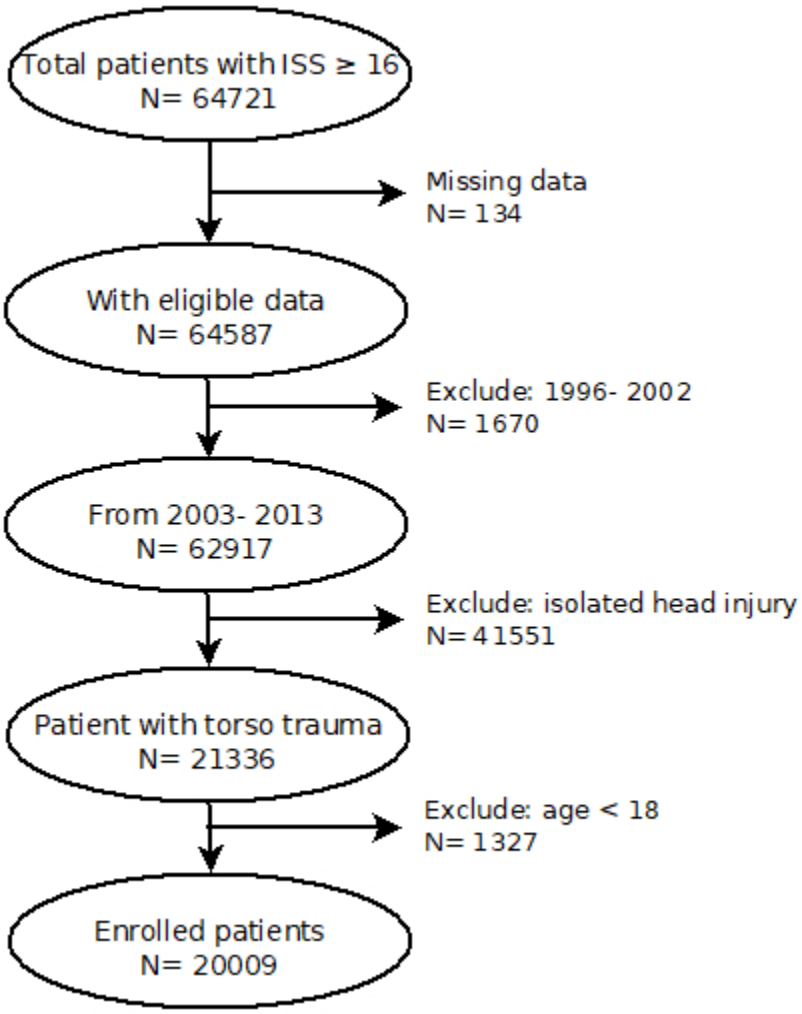

Figure 2. The algorithm of the data extraction from the NHIRD.
From 2003 to 2013, 64,721 patients were initially identified from the NHIRD. After excluding missing data and those who did not meet the inclusion criteria, 20,009 patients were included in the analysis.

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.

		Reporting Item	Page Number
Title and abstract			
Title	#1a	Indicate the study's design with a commonly used term in the title or the abstract	1
Abstract	#1b	Provide in the abstract an informative and balanced summary	4-5

		of what was done and what was found	
Introduction			
Background / rationale	#2	Explain the scientific background and rationale for the investigation being reported	5-6
Objectives	#3	State specific objectives, including any prespecified hypotheses	6
Methods			
Study design	#4	Present key elements of study design early in the paper	6-9
Setting	#5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-7
Eligibility criteria	#6a	Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up.	7
Eligibility criteria	#6b	For matched studies, give matching criteria and number of exposed and unexposed	7
Variables	#7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	7-8
Data sources / measurement	#8	For each variable of interest give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group. Give information separately for for exposed and unexposed groups if applicable.	8-9

Bias	#9	Describe any efforts to address potential sources of bias	14-15
Study size	#10	Explain how the study size was arrived at	9
Quantitative variables	#11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen, and why	9
Statistical methods	#12a	Describe all statistical methods, including those used to control for confounding	9
Statistical methods	#12b	Describe any methods used to examine subgroups and interactions	9
Statistical methods	#12c	Explain how missing data were addressed	9
Statistical methods	#12d	If applicable, explain how loss to follow-up was addressed	nil
Statistical methods	#12e	Describe any sensitivity analyses	9
Results			
Participants	#13a	Report numbers of individuals at each stage of study—eg 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.	9-10
Participants	#13b	Give reasons for non-participation at each stage	9

Participants	#13c	Consider use of a flow diagram	9
Descriptive data	#14a	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders. Give information separately for exposed and unexposed groups if applicable.	9
Descriptive data	#14b	Indicate number of participants with missing data for each variable of interest	9
Descriptive data	#14c	Summarise follow-up time (eg, average and total amount)	nil
Outcome data	#15	Report numbers of outcome events or summary measures over time. Give information separately for exposed and unexposed groups if applicable.	9
Main results	#16a	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9
Main results	#16b	Report category boundaries when continuous variables were categorized	10
Main results	#16c	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	10
Other analyses	#17	Report other analyses done—e.g., analyses of subgroups and interactions, and sensitivity analyses	10

Discussion

Key results	#18	Summarise key results with reference to study objectives	10-13
Limitations	#19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias.	14-15
Interpretation	#20	Give a cautious overall interpretation considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence.	10-13
Generalisability	#21	Discuss the generalisability (external validity) of the study results	nil
Other Information			
Funding	#22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	3