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Disparities in mortality among doctors in Taiwan: a 17-year follow-up study of 37 545 doctors

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ABSTRACT

Objectives: The authors used cohort data from the registry of all doctors in Taiwan to determine if the effect of health disparities exists after control of potential confounding by different occupational exposures in different specialties.

Design: Retrospective cohort study, 1990–2006.

Settings: The Taiwan Medical Association.

Participants: A total of 37 545 doctors from the registry of the doctor file maintained by the Taiwan Medical Association. The registry has been required by the governmental regulation for verification of credentials of all practicing doctors.

Main outcome measures: Cause-specific standardised mortality ratios for surgeons and anaesthesiologists were compared with those of the internists. The Cox proportional hazard model was constructed to explore multiple risk factors for mortality, including specialties, age, gender, geographic region of practices, regional health resources, ages of beginning practices and years of beginning practice.

Results: The all-cause-specific standardised mortality ratios for surgeons and anaesthesiologists were marginally elevated at 1.15 (95% CI 0.98 to 1.34) and 1.62 (95% CI 0.93 to 2.64), respectively. The Cox regression model showed that the anaesthesiologists had the highest HR of 1.97, seconded by surgeons at 1.23. Localities with the doctor-to-population ratio lower than 1:500 were associated with an increased HR of doctor mortality.

Conclusions: The doctor-to-population ratio and the region of practice may influence doctor's mortality. Increasing number of doctors and/or improving the practice environment may be helpful in reducing the health disparities in regions with poor resources.

ARTICLE SUMMARY

Article focus

- To determine if the effect of health disparities exists after control of potential confounding by different occupational exposures in different specialties.

Key messages

- All factors leading to health disparities also influence the mortality rates of healthcare providers, including doctors who practiced in such locality.
- Increasing the numbers of doctors and/or improving the practice environment may be helpful in reducing the health disparities of both the general public and the doctors residing in a region with poor resources.

Strengths and limitations of this study

- The cohort data include all practicing doctors in Taiwan.
- We use internists as the reference population for standardised mortality ratios calculation to minimise the potential confounding by different socioeconomic states.
- Possible misclassification of self-claimed specialty may be a source of bias while comparing the mortality rates among different specialties.
- Information was limited about the hospital level and location practiced, that is, misclassification of the region of practice without differentiating primary/referral hospital and urban/rural setting.

During practices, healthcare providers have already been noted to suffer from certain specific potential hazards like stress, radiation, anaesthetic gases or agents and biologically hazardous blood or body fluids, which have been documented in many previous studies among radiologists, pathologists, psychiatrists, dentists and anaesthesiologists.[1–6]

Beginning in 1995, Taiwan launched the National Health Insurance (NHI) programme and attempted to mitigate the health disparity among the general population living in different geographic regions. The provision of universal healthcare coverage has increased the healthcare demand.[7 8] For example, the number of outpatient visits per person increased from 10.56 in 1995 to 14.88 in 2008 and the numbers of hospitalised patients and outpatient visits per doctor increased as well.[9 10] Thus, all the healthcare professionals, including doctors, have encountered a heavier workload and a greater psychosocial demand than before. However, a standardised mortality ratio (SMR) study using the general population as the reference for comparison did not detect any increased mortality among doctors in Taiwan.[11]

From an alternative perspective, the association between demographic characteristics of human resources in health and the health of the population served has received considerable attention.[12 13] There is a growing evidence that the density of the health workforce is directly correlated with positive health outcomes in the population they serve, such as maternity mortality, infant mortality and life expectancy.[14] Other factors like geographic location, socioeconomic states and distribution of current healthcare resources might also affect health outcome and incline to intercorrelate with each other.

As all factors leading to health disparities are affecting people within respective locality,[15] we hypothesised that they also influence the mortality rates of healthcare providers, including doctors who practiced in such locality. In the present study, we used the cohort data from the registry of the doctor file maintained by the Taiwan Medical Association and recruited internists, the largest group, as referents to determine if the effect of health disparities exists after control of potential confounding by different occupational exposures in different specialties.

METHODS

Subjects and data collection

The retrospective cohort was established from the registry of the doctor file maintained by the Taiwan Medical Association. The registry has been required by the governmental regulation for verification of credentials of all practicing doctors. It contains the name of each individual, date and place of birth, gender, national identification number, medical school attended, date of graduation, self-designated specialty,[11] place of practice, vital status, date of death for decedents and date of ceasing the membership. The cohort was established beginning in January 1990 and followed up to December 2006. Practice time was accrued until 2006 or the date of deceased or termination of membership. There were 29 decedents with incomplete information on date or month of death, of which this study assumed to be on the first day of the month or year. Since all practicing doctors must be registered in compliance to the Doctors Act in Taiwan, the data set is very comprehensive and accurate.

Statistical analysis

Geographic data in doctors per 10 000 persons, per capita disposable income (US$), education, infant mortality rate (per 1000 live births) and life expectancy at birth were collected and analysed from national statistics of the Directorate General of Budget, Accounting and Statistics (Taiwan) in 1998, 2002 and 2006. Geographic region was categorised into northern, central, southern and eastern region following the naming of branches of Bureau of the NHI. Education indicated the percentage of people aged more than 15 who attained an education level of college or above.

All-cause and cause-specific SMRs were obtained by employing the personal computer version of Life Table Analysis System (LTAS.NET). The LTAS was originally developed by the National Institute for Occupational Safety and Health during the 1970s and was later converted for use on Windows 98/NT/2000/XP-compatible PCs. This programme tabulates the underlying causes of death as well as the person-years of follow-up into age-, gender- and race-specific strata and allows users to apply internal controls as referents to replace general population from vital statistics. SMRs and 95% CIs were calculated using the mortality rates of 119 underlying causes of death of the internists of Taiwan as the reference group. We used SAS V.9.1 (SAS Institute) to edit and analyse the data. In this study, we set the significance level at $p=0.05$.

Cox regression analysis was conducted to determine the HRs for the following risk factors: age, gender, specialty, geographic region of practice, age of beginning practice, calendar year of beginning practice (before or after 1995 when the NHI system was established) and doctor-to-population ratio. The ratio between doctors and population was categorised into four levels: >1:500, from 1:500 to 1:700, from 1:700 to 1:900 and <1:900. Since the northern region of Taiwan leads development for the last half a century, it was chosen to be the reference in the statistical model. The covariates considered in the regression analysis were gender, specialty, geographic region of practice, age of beginning practice, calendar year of beginning practice and doctor-to-population ratio. In Taiwan, some of our doctors were veteran who took ad hoc medical missions during the World War II and did not receive an academic medical education. They generally began their practices at an age older than most other doctors and deserved for this study to control as a potential confounder. We applied the stepwise strategy for variable selection with the significance level for entry and the significance level for stay set to 0.15. Regression diagnostics were also run, including examination of proportional hazard assumption, residual analysis, detection of influential cases and check for multicolinearity to assure the quality of analysis and goodness of fit for the model.

RESULTS

With the doctor-to-population ratio above 1:500 as the reference level, we found that a lower ratio significantly increased the HR of doctor mortality; there was also an independent effect of regional difference of higher HR for southern and eastern regions, as summarised in table 4. The differences among localities seemed to correlate well with higher average levels of income and education, lower infant mortality rates and longer life expectancies across Taiwan. And such disparities did

Table 1 Geographic disparities in doctors per 10 000 persons, per capita disposable income (US$), education, infant mortality rate (per 1000 live births) and life expectancy at birth in 1998, 2002 and 2006

	Doctors per 10 000 persons			Per capita disposable income			Education*			Infant mortality rate			Life expectancy		
Region	1998	2002	2006	1998	2002	2006	1998	2002	2006	1998	2002	2006	1998	2002	2006
Northern	14.7	16.5	17.4	8394.8	8912.6	9853.0	24.8	30.1	36.1	6.2	4.9	4.4	77.4	78.6	79.5
Central	14.1	16.5	18.3	7044.2	6940.0	7817.6	18.8	23.2	28.6	6.9	5.8	4.5	75.1	77.0	77.6
Southern	12.9	14.5	16.5	6928.8	7157.5	7891.2	18.4	22.8	27.7	6.4	5.4	4.8	74.7	76.0	76.5
Eastern	13.3	15.4	18.3	6542.2	6683.0	7987.6	11.8	14.4	20.0	12.4	8.3	7.6	70.6	72.9	73.2

*Education: the percentage of people aged more than 15 attained an education level of college or above.

not appear to have changed during the last decade (table 1).

A total of 37 545 doctors were tabulated in the study from January 1990 to December 2006. During the above period, there were 1642 deaths among 32 713 male doctors and 44 deaths among 4822 female doctors. The overall mean age at death was 69.88±14.28 years old, with 70.06±14.04 for males and 62.96±20.21 for females, respectively (table 2). Approximately half (49.7%) of the cohort had been internists and 48.1%

Table 2 Characteristics of Taiwan doctors included in the study from 1990 to 2006

	Taiwan doctors		Deceased doctors	
	n (%)	Mean censored age	n (%)	Mean age at death
Total	37 545 (100)	46.41±14.47	1686 (100)	69.88±14.28
Status				
Alive	35 859 (95.5)	45.31±13.51		
Deceased	1686 (4.5)			69.88±14.28
Sex				
Male	32 722 (87.2)	47.68±14.56	1642 (97.4)	70.06±14.04
Female	4823 (12.8)	37.81±10.30	44 (2.6)	62.96±20.21
Age of beginning practice				
Age <30	29 753 (79.2)	43.39±11.99	566 (33.6)	59.03±14.98
30≤ age <40	5573 (14.8)	52.28±14.10	472 (28.0)	73.81±11.92
Age ≧40	2219 (5.9)	74.24±10.91	648 (38.4)	76.37±8.62
Specialty				
Surgeon	4571 (12.2)	45.20±13.20	161 (9.5)	65.83±14.54
Internist	18 664 (49.7)	48.76±15.97	1190 (70.1)	71.92±12.70
Dermatologist	901 (2.4)	43.00±12.92	35 (2.1)	69.79±16.25
Otolaryngologist	2000 (5.3)	44.28±11.99	45 (2.7)	65.46±14.36
Ophthalmologist	1584 (4.2)	44.72±12.33	42 (2.5)	72.28±19.56
Pathologist	414 (1.1)	42.21±12.04	5 (0.3)	49.78±10.87
Paediatrician	2883 (7.7)	42.35±11.59	54 (3.2)	66.32±17.12
Psychiatrist	1214 (3.2)	40.37±11.81	21 (1.2)	61.85±20.52
Radiologist	1076 (2.9)	41.59±11.79	18 (1.1)	63.23±18.18
Obstetrician	2278 (6.1)	48.84±12.10	85 (5.0)	63.48±14.44
Orthopaedist	1128 (3.0)	43.56±11.07	14 (0.8)	58.78±18.32
Anaesthesiologist	832 (2.2)	40.91±10.23	16 (0.9)	45.21±15.67
Region				
Northern	18 046 (48.1)	45.71±14.52	659 (39.1)	68.90±14.32
Central	7054 (18.8)	46.25±13.70	300 (17.8)	70.04±15.58
Southern	11 376 (30.3)	47.64±14.81	667 (39.6)	70.97±13.57
Eastern	1069 (2.8)	46.24±14.12	60 (3.6)	67.67±13.96
Doctor−population ratio				
>1:500	17 185 (45.8)	45.29±14.34	620 (36.8)	68.21±15.11
1:700 to 1:500	6429 (17.1)	45.55±14.50	285 (16.9)	69.71±14.19
1:900 to 1:700	11 233 (29.9)	47.91±14.21	589 (34.9)	70.92±13.61
<1:900	2698 (7.2)	51.08±14.53	192 (11.4)	71.90±13.02
Years of practice				
Before 1995	24 337 (64.8)	53.62±12.71	1640 (97.3)	70.60±13.52
After 1995	13 208 (35.2)	33.13±5.06	46 (2.7)	44.28±16.86

were practicing in the north region. Among all doctors, there were 30.8% working in the area of low doctor-to-population ratio. About two-thirds began their practice before 1995, and over 90% started practice at age below 40.

As for the control for socioeconomic status in the analysis, we used the internists as the reference population and found that the all-cause-specific SMRs for surgeons and anaesthesiologists were marginally elevated with an SMR of 1.15 (95% CI 0.98 to 1.34) and 1.62 (95% CI 0.93 to 2.64), respectively (table 3). Among the surgeons, the SMR of 'neoplasm of lymphatic and haematopoietic tissue' was increased but without statistical significance (SMR =2.17, 95% CI 0.94 to 4.28). The observed numbers of deaths from malignant neoplasm of digestive organs and peritoneum were significantly lower than corresponding expected values (SMR =0.54, $p<0.05$, 95% CI 0.29 to 0.92). Among the anaesthesiologists, the SMR of 'malignant neoplasm of other and unspecified sites' was significantly increased (SMR =8.73, $p<0.05$, 95% CI 1.06 to 31.53), although there were only two cases on the observed number.

To further adjust for other risk factors, the Cox regression model was constructed and the results are summarised in table 4. The anaesthesiologists appeared to show the highest HRs of 1.97 (95% CI 1.20 to 3.25), followed by surgeons with a HR of 1.23 (95% CI 1.04 to 1.46). The HR of ophthalmologists was significantly lower than all other specialists, of which the HR was 0.72 (95% CI 0.53 to 0.98). In addition, doctors living in the northern region and the central region experienced lower HRs. And doctors who worked in the area with doctor-to-population ratio below 1:500 showed higher mortality or HR.

The doctors who began practice at an older age had a higher HR of 1.12 (95% CI 1.12 to 1.13) for every single year increment. Overall, doctors who began practice after the implementation of the NHI Program, or the year of 1995, showed a higher HR of 6.17 (95% CI 4.27 to 8.92).

DISCUSSION

Based on Cox model analysis, we found doctors practicing in southern and eastern regions of Taiwan suffered from statistically significant premature mortality (table 4), and such a geographic disparity appeared to correspond to the lower life expectancy and higher infant mortality rate in Taiwan (table 1). To our limited knowledge, this study is the first to show that doctors practicing in the area of a low doctor-to-population ratio or in the less resourceful regions experienced a higher HR of mortality after adjustment for gender, age of beginning practice and specialties (table 4). Because doctors in Taiwan generally have higher earnings than all other segments of professionals and there is no upper limit of retirement age, we have decided to select 'internal comparisons' among doctors with the same socioeconomic status, profession-related knowledge and health-related behaviour to prevent confounding and would leave the effects of mortality to the other two main factors, occupational workload or practice environment. In additional to internists, we have tried to use surgeons as a possibly more homogeneous reference group and the HRs of all covariates are the same except those of specialties, demonstrating a robust result for our inference.

Lowest average income, educational level and life expectancy and the highest infant mortality rate in

Table 3 The observed number of deaths and cause-specific standardised mortality ratios (SMRs) for surgeons and anaesthesiologists, using internists of Taiwan as the reference group

	Surgeon		Anaesthesiologist	
Causes of death	**O**	**SMR (95% CI)**	**O**	**SMR (95% CI)**
All causes	161	1.15 (0.98 to 1.34)	16	1.62 (0.93 to 2.64)
All malignant neoplasm (MN)	37	0.84 (0.59 to 1.16)	5	1.57 (0.51 to 3.66)
MN of digestive organs and peritoneum	13	0.54 (0.29 to 0.92)	2	1.18 (0.14 to 4.26)
MN of respiratory system	11	1.16 (0.58 to 2.07)	0	0.00 (0.00 to 6.56)
MN of urinary organs	2	1.05 (0.13 to 3.79)	0	0.00 (0.00 to 20.42)
Neoplasm of lymphatic and haematopoietic tissue	8	2.17 (0.94 to 4.28)	1	3.41 (0.09 to 19.03)
MN of other and unspecified sites	1	0.48 (0.01 to 2.68)	2	8.73 (1.06 to 31.53)
Cerebrovascular disease	7	0.59 (0.24 to 1.22)	3	3.95 (0.82 to 11.55)
Heart disease	9	0.83 (0.38 to 1.57)	0	0.00 (0.00 to 7.34)
Accidents	11	1.81 (0.90 to 3.24)	1	1.58 (0.04 to 8.79)
Diabetes mellitus	8	1.49 (0.65 to 2.94)	1	1.84 (0.05 to 10.25)
Chronic liver disease	7	1.60 (0.64 to 3.30)	0	0.00 (0.00 to 13.75)
Kidney disease	1	0.36 (0.01 to 2.01)	0	0.00 (0.00 to 21.26)
Pneumonia	5	0.97 (0.32 to 2.27)	0	0.00 (0.00 to 12.23)
Suicide	3	1.36 (0.28 to 3.98)	1	3.34 (0.08 to 18.60)
Chronic lung disease	4	2.19 (0.60 to 5.60)	0	0.00 (0.00 to 116.04)
Hypertensive disease	2	1.45 (0.18 to 5.25)	0	0.00 (0.00 to 30.76)

Table 4 HRs with 95% CI estimated through Cox regression model to control relevant risk factors on mortality among Taiwan doctors from 1990 to 2006

Covariate	HR (95% CI)
Age of beginning practice	1.12 (1.12 to 1.13)
Gender	
Female/male	0.76 (0.56 to 1.02)
Specialty	
Dermatologist/internist	1.19 (0.85 to 1.67)
Otolaryngologist/internist	0.85 (0.63 to 1.15)
Ophthalmologist/internist	0.72 (0.53 to 0.98)
Pathologist/internist	0.81 (0.33 to 1.94)
Paediatrician/internist	0.91 (0.69 to 1.20)
Psychiatrist/internist	0.81 (0.52 to 1.24)
Radiologist/internist	0.87 (0.55 to 1.39)
Surgeon/internist	1.23 (1.04 to 1.46)
Obstetrician/internist	1.19 (0.95 to 1.50)
Orthopedist/internist	0.75 (0.44 to 1.27)
Anaesthesiologists/internist	1.97 (1.20 to 3.25)
Region	
Central/northern	1.12 (0.97 to 1.29)
Southern/northern	1.30 (1.17 to 1.45)
Eastern/northern	1.68 (1.28 to 2.20)
Doctor−population ratio	
1:700 to 1:500/>1:500	1.23 (1.06 to 1.42)
1:900 to 1:700/>1:500	1.20 (1.06 to 1.34)
<1:900/>1:500	1.18 (1.00 to 1.39)
Year of beginning practice	
After 1995/before1995	6.17 (4.27 to 8.92)

Taiwan were found in the eastern region (table 1). Traditionally, this mountainous region impedes transportation tremendously and plays a significant role in reduced healthcare accessibility for people, including healthcare providers themselves. Although the doctor-to-population ratio has improved since the promulgation of Medical Care Act in 1986 and implementation of NHI in 1995, doctors living in this region still suffer from a higher HR. It may indicate that the health disparity still exists. Moreover, in analysing the central and southern regions, where similar levels of the average income and the education were found, a significantly increased HR was detected in the southern region only. As noted in table 1, the doctor-to-population ratio has been consistently found to be lower in the southern region compared with those of the northern and central regions. These findings indicate persistent health disparities in different regions of Taiwan and suggest that occupational workloads might play some role in view of the increased mortality of doctors.

In a previous study, we found that the overall and cause-specific SMRs of doctors in Taiwan were <0.34 for different specialties,[11] which may have been confounded by using the general population as the referents for comparison.[16] In this study, we use internists as the reference population for SMR calculation to minimise the potential confounding by different socioeconomic states (table 3). Although no increased mortality was found among radiologists, pathologists and psychiatrists, as reported from other countries,[2–4] we detected significantly increased HRs for surgeons and anaesthesiologists (table 4). A further analysis only detected slightly elevated SMR for malignant neoplasm of lymphatic and haematopoietic tissues among surgeons, which appeared to corroborate the hazards of operation room reported by others.[17] However, the trend was less apparent because of the small sample size of anaesthesiologists. Since the current mortality data in Taiwan only allowed for coding single underlying cause of death, it may further decrease the power of detection of occupational-related illnesses.

Our study also demonstrated that the HR of mortality was higher in the group beginning their practice since 1995, when the NHI system was implemented. This group belonged to a younger generation of doctors, who might possibly suffer from highly stressed work during their practice.[18] Such a stress might arise from their clinical training programme or the newly implemented health policy. However, the cohort was established during 1990−2006, which may have imposed a selection of healthy survivors among the doctors. They began their practice before 1995 in comparison with those who entered the workforce after 1995. Thus, more study is needed to explore the above hypothesis.

Several limitations of this study should be noted. First, possible misclassification of self-claimed specialty may be a source of bias while comparing the mortality rates among different specialties. For instance, a surgeon shifted to general practice after retiring from a medical centre may result in overestimation of the practice duration and possible underestimation of the effect of specialty. Thus, the higher HR's among surgeons and anaesthesiologists may need to be further studied for clarification. Second, information was limited about the hospital level and the locations, which the doctor has practiced, that is, misclassification of the region of practice without differentiating primary/referral hospital and urban/rural setting. Thus, we had to assume that it might be a random effect and only lead to the null or underestimation.

What is already known on this topic

All factors leading to health disparities are affecting people within respective locality.

What this study adds

All factors leading to health disparities also influence the mortality rates of healthcare providers, including doctors who practiced in such locality. Increasing the numbers of doctors and/or improving the practice environment may be helpful in reducing the health disparities of both the general public and the doctors residing in a region with poor resources.

In conclusion, disparities both in the geographic region of doctor's practice and the ratio of doctor-to-population regionally are the primary determinants to the HR of doctor mortality. Thus, we recommend increasing the number of doctors and improving the practice environment of eastern and southern regions of Taiwan, which may possibly mitigate the health disparities among doctors and people. Furthermore, more studies are needed to explore and reduce the potential hazards among workplaces of anaesthesiologists and surgeons in Taiwan.

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Contributors T-FS has acquired the data set, designed the study together with J-DW (the corresponding author), conducted the analysis under the full supervision and discussion with P-CC and J-DW, written the first draft and all three participated in the revision of the later drafts until the final one. T-FS has access to all the data in the study and takes responsibility for the integrity of the data. Together with all co-authors, we shall be responsible for the accuracy of the data analysis and interpretation of the results.

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Competing interests None.

Ethics approval The ethics review board of our institute (Institute of Occupational Medicine and Industrial Hygiene College of Public Health, National Taiwan University, Taiwan) approved the protocol before the commencement of this study.

Data sharing statement We are willing to share our data in an open repository.

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RESPONSE TO THE REVIEWER

For Reviewer

Comment # 1

They choose to keep the large group of internal medicine doctors as the reference in their statistical models, the argument for this being htat this is the largest group. However, it is clear from other comments that this is also a very heterogeneous group, so I still maintain that it might be better to use a more homogeneous group for reference, alternatively to choose another contrast function.

Response: Thanks for your comments. We have followed your advice and decided to use a more homogeneous group, surgeons, as the referent alternatively in the Cox regression model. The results appear the same (i.e., all hazard ratios of covariates except those of specialties) and summarized in the following table:

Table. Hazard ratios with 95% CI (confidence interval) estimated through Cox regression model to control relevant risk factors on mortality among Taiwan doctors from 1990 to 2006.

Covariate	Hazard ratio	95% CI
Age of beginning practice		
	1.12	1.12-1.13
Gender		
Female/male	0.76	0.56-1.02
Specialty		
Internist / Surgeon	0.81	0.69-0.96
Dermatologist / Surgeon	0.97	0.67-1.40
Otolaryngologist / Surgeon	0.69	0.49-0.96

Ophthalmologist / Surgeon	0.59	0.42-0.83
Pathologist/ Surgeon	0.65	0.27-1.59
Pediatrician / Surgeon	0.74	0.54-1.01
Psychiatrist / Surgeon	0.65	0.41-1.03
Radiologist / Surgeon	0.71	0.43-1.15
Obstetrician / Surgeon	0.97	0.74-1.26
Orthopedist / Surgeon	0.61	0.35-1.05
Anesthesiologists/ Surgeon	1.60	0.96-2.69
Region		
Central / Northern	1.12	0.97-1.29
Southern / Northern	1.30	1.17-1.45
Eastern / Northern	1.68	1.28-2.20
Doctor-population ratio		
1：700 to 1：500 / ＞1：500	1.23	1.06-1.42
1：900 to 1：700 / ＞1：500	1.20	1.06-1.34
＜1：900 / ＞1：500	1.18	1.00-1.39
Year of beginning practice		
After 1995/ Before1995	6.17	4.27-8.92

Please kindly see the revised 1st paragraph of the Discussion section, as follows: (Please see page 11, ll. 9-17)

(Table 4). Because doctors in Taiwan generally have higher earnings than all other segments of professionals and there is no upper limit of retirement age, we have decided to select “internal comparisons” among doctors with the same socioeconomic status, profession-related knowledge and health-related behaviour, to prevent confounding and would leave the effects of mortality to the other two main factors, occupational workload or practice environment. In additional to internists, we have tried to use surgeons as a possibly more homogeneous reference group and the hazard ratios of all covariates are the same except those of specialties, demonstrating a robust result for our inference.

Comment # 2
I still have problems with understanding how the Taiwanese doctors work in relation to hospitals; are all doctors affiliated with hospitals? Don't you have any "real" general practitioners who only work only in their own "surgery" (to use the UK-expression)? And if so, isn't this a group that should be identified in the statistical modelling?

Response: Again, thanks for your comment. Since 1995, Taiwan has implemented mandatory universal health insurance program with a single-payer system. Bureau of national health insurance only contracts with hospitals or clinics and doctors were only allowed to practice at one contracted hospital or run a private clinic. That is a closed system and it comes up with the lowest administration cost of health care in the world (at less than 2% of the total premium). Generally, surgeons as well as anesthesiologists in Taiwan must choose hospital as a workplace to perform major operations, rather than own a clinic. In other words, we do not have general practitioners who can undertake major operations outside hospitals. And family doctors or general practitioners in Taiwan usually open their clinics after their residency training in hospitals and they are included in the internists group.
As my response to your first comment, I have re-run the statistical analysis with surgeons as a more homogeneous reference group and the results appear the same.

Dear Sir or Madam,

Attached please find our revised manuscript entitled "**Disparities in Mortality among Doctors in Taiwan: A 17-year follow-up study of 37,545 Doctors**" (Manuscript ID bmjopen-2011-000382 R1) for your consideration to be published on your esteemed journal.

My colleagues and I are very grateful to your constructive comments and advice. Please also kindly express our sincere thankfulness and appreciation to all participating reviewers. My research team has a thorough discussion and has made some revision on this version plus point-to-point responses to every comment that you have made.

Thank you. We are looking forward to hearing from you soon.

Yours sincerely,

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cohort studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1-2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			**4-5**
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			**6-7**
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	6
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-7
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	6-7
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-7
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	6-7
		(*b*) Describe any methods used to examine subgroups and interactions	6-7
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, explain how loss to follow-up was addressed	
		(*e*) Describe any sensitivity analyses	
Results			8-9

Participants	13*	(a) 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	8
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	8
		(b) Indicate number of participants with missing data for each variable of interest	8
		(c) Summarise follow-up time (eg, average and total amount)	8
Outcome data	15*	Report numbers of outcome events or summary measures over time	8-9
Main results	16	(*a*) 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	8-9
		(*b*) Report category boundaries when continuous variables were categorized	8-9
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	8-9
Discussion			10-11
Key results	18	Summarise key results with reference to study objectives	10-11
Limitations			11-12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	11-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	11-12
Other information			13
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	13

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.