RESEARCH PAPER

Reducing health disparity in Taiwan: quantifying the role of smoking

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Objective: To assess the impact of smoking disparities on health disparities, in terms of gap in life expectancy, in Taiwan cities and counties.

Methods: Using the decomposition method of life expectancy, the contribution of each disease category to the life expectancy gap was quantitatively expressed as the number of years of life. The smoking attributable fraction (SAF) was calculated for each city and county based on their respective smoking prevalence and relative risk for each smoking related disease. The smoking attributable gap (SAG) in life expectancy between two sites is the sum of the difference in SAF between two sites for each smoking related disease multiplied by the number of years this disease contributed to the life expectancy gap.

Results: Significant health and smoking disparities were present among the 23 cities and counties in Taiwan. These health disparities and smoking disparities were highly correlated (R^2 = 0.3676). Generally, the health gap increased with increasing smoking disparity. The disparity in smoking prevalence and intensity among cities and counties in Taiwan was responsible for up to 19% of the health disparity. The health disparity is also highly correlated (R^2 = 0.3745) with SAG in life expectancy.

Conclusions: Reducing smoking is important to health, and reducing the smoking disparity is also important for reducing the health disparity observed in Taiwan. The larger the health disparity is, the more important the smoking attributable disparity could be. The reduction of smoking disparities could be a realistic and cost effective way toward reducing health disparities.

Reducing health disparities has become a top priority in public health. *Healthy people 2010*, recently published by the US Centers for Disease Control and Prevention (CDC),[1] exemplify this priority and calls for eliminating health disparities as one of the two overarching goals in public health over the next 10 years. This renewed effort arose from the recognition of the importance of the issue and the ability to reduce health disparities.

Although not having received wide recognition, large health disparities have long existed in Taiwan, especially between the aborigines and the rest of the Taiwan population.[2 3] The lack of recognition is partly because most people assume that the National Health Insurance (NHI) plan of 1995, a progressive medical care access programme to promote social equity, has already addressed or even solved the disparity issue.[4] However, the authors noticed that the geographic health disparities in life expectancy in Taiwan have remained substantial more than six years after NHI implementation.[5] The 23 cities and counties of Taiwan showed distinctively wide disparities in health status, but also similarly wide disparities in smoking prevalence and smoking behaviour.[6 7] The relation between the two disparities is the subject of this study. The goal is to estimate the quantitative contribution of smoking disparities to health disparities as measured by differences in life expectancy.

METHODS

Mortality data were acquired from the government on discs from the Department of Health. Smoking prevalence data came from the Health and Safety Survey conducted by the Directorate-General of Budget, Executive Yuan in 2001.[7] The relative mortality risks of smokers in Taiwan were based on a longitudinal worker cohort study of 78 000 subjects followed during 1989–2001.[8] These data, which compared the mortality risk of smokers with that of non-smokers, provided cause specific and cigarette quantity specific relative risks. In addition, relative risks from this study were used to estimate the risk of three different smoking intensity levels for each smoking related disease, which were termed as the ''smoking intensity index'' (table 1).

For each city or county, one of the three smoking intensity indexes was assigned, according to its ranking within the 23 cities and counties, based on the prevalent rates of heavy smokers for that city/county.[7] We used the rate of heavy smoking (at least one pack per day) as a surrogate for smoking intensity in order to assign the appropriate category of the smoking intensity index.

In this study, health disparity is defined as the difference in life expectancy between Taipei City (the city with highest life expectancy in Taiwan) and each of the remaining 22 cities and counties. Smoking disparity is similarly defined as the difference in smoking prevalence between Taipei City and each of the remaining 22 cities and counties. With the use of the decomposition method of life expectancy,[9 10] the contribution of each smoking related disease category to the life expectancy gap, or health disparity gap (HDG), was quantitatively expressed as the number of years of life expectancy as well as the percentage of the health disparity. Smoking attributable fraction (SAF) for 10 groups of causes of deaths, that are significantly associated with smoking,[8 11] was calculated for each city or county based on respective smoking prevalence and relative risk. SAF is the proportion of deaths in a population for a given disease that can be attributed to smoking, which is determined by the levels of smoking prevalence and the magnitude of relative risks.[12] The proportion of the health disparity that can be caused by

Abbreviations: CDC, Centers for Disease Control and Prevention; HDG, health disparity gap; NHI, National Health Insurance; SAF, smoking attributable fraction; SAG, smoking attributable gap; SAM, smoking attributable mortality; SARS, severe acute respiratory syndrome; SES, socioeconomic status

Table 1 The relative risks by smoking intensity index* on smoking related diseases

Disease category	Smoking intensity index		
	I	II	III
All causes (001–998)	1.43	1.58	2.00
Malignant neoplasm (140–208)	1.44	1.75	2.36
Diabetes mellitus (250)	1.50	1.50	2.68
Stroke (401–405, 430–438)	1.44	1.64	2.58
Ischaemic heart disease (410–414)	1.93	2.07	2.90
Respiratory system (460–519)	1.54	1.75	1.75
Digestive system (520–579)	1.66	1.66	2.08
Genitourinary system (580–629)	1.80	2.42	2.78
Ill defined conditions (780–799)	1.51	1.51	2.38
MVA (810–829)	1.64	1.94	2.15
Non-MVA (800–809,830–999)	1.16	1.43	1.98

*Smoking intensity index: I, ⩽10 cigarettes/day; II, 11–20 cigarettes per day; III, >20 cigarettes (one pack)/day.
MVA, motor vehicle accidents.
Data adapted from Wen *et al*.[8]

smoking between the city of Taipei and one of the other 22 cities/counties is defined as smoking attributable gap (SAG), which was calculated as the sum of the difference in SAF between two areas for each smoking related disease multiplied by the number of years this disease contributed to the gap in health disparities. This relationship is expressed:

Total SAG (smoking attributable gap)

$$= \sum_{i=1}^{22}\sum_{j=1}^{10}\left(SAF_{ij} - SAF_{0j}\right) \times HDG_{ij}$$

$$= \sum_{i=1}^{22}\sum_{j=1}^{10}\left(\frac{P_i(RR_{ij}-1)}{[1+P_i(RR_{ij}-1)]} - \frac{P_0(RR_{0j}-1)}{[1+P_0(RR_{0j}-1)]}\right) \times HDG_{ij}$$

P_i: smoking prevalence in the i^{th} specific area (i.e., city/county), i = 1,2,……,22

j: the j^{th} smoking related disease category, j = 1,2,……,10

RR_{ij}: disease specific relative risk for the specific area

SAF_{ij}: disease specific smoking attributable fraction for the specific area

P_0: smoking prevalence in Taipei City

RR_{0j}: disease specific relative risk for Taipei City

SAF_{0j}: the disease specific smoking attributable fraction for Taipei City

HDG_{ij}: the life expectancy gap between Taipei City and one of the other 22 cities or counties for that disease category.

The analysis is conducted for males only. In addition to reporting each of the above measures by city/county, regression equations are estimated using SAS V8.0.[13]

RESULTS

Smokers' relative mortality risks for diseases listed in table 1 are monotonically related with the amount of cigarettes smoked. The relative risk of dying from any causes for those who smoked 10 or fewer cigarettes per day compared to non-smokers was 1.43, which increased to 1.58 among those who smoked 11–20 cigarettes per day, and to 2.00 for those who smoked more than one pack per day. Similarly the risks of dying from cancer were 1.44, 1.75, and 2.36, respectively, for the three smoking intensity categories. The health disparity gap tends to increase with the smoking prevalence gap (table 2). The correlation coefficient (R^2) between the two is 0.3676, indicating a strong relation between life expectancy gaps and smoking prevalence gaps (fig 1).

Smoking attributable gaps in life expectancy between Taipei City and other 22 cities/counties in Taiwan are displayed in table 2. The detailed steps taken in calculating the smoking attributable gap in life expectancy, with the illustration of the example between Taipei City and Taitung County, are described in table 3. While Taipei is the largest city in Taiwan, Taitung County is more rural with a high percentage of aborigines.

The life expectancy for Taipei City was 77.57 years and for Taitung County, 68.11 years. The smoking prevalence for Taipei City was 37.03% with a level I smoking intensity and for Taitung County was 52.47%, with a level III smoking intensity. The diseases significantly related to smoking contributed 7.71 years, or 81.5% of 9.46 years of total HDG between Taipei City and Taitung County. For each disease category, SAF was separately calculated for Taipei City and Taitung County, according to its respective smoking prevalence rate and levels of relative risks.

The disease specific SAG was calculated by applying the health gap caused by smoking (that is, HDG) to the difference of the two SAFs for each disease category. By summing all smoking attributable gaps in life expectancy (that is, SAGs) for each disease to get 1.71 years, this is the portion of the health disparity between Taipei City and Taitung County that could be attributable to the difference in smoking prevalence. Using this process, the SAG in life expectancy for each of the remaining cities or counties was similarly calculated and results are shown in table 2. The SAG in life expectancy ranged from 0.01 years for Tainan City with a smoking prevalence gap of 0.84% to 1.71 years for Taitung County with a smoking prevalence gap of 15.44%. These represented 0.3% to 18.1% of the total health gap. In other words, 0.3% of the life expectancy gaps between Tainan and Taipei cities and 18.1% between Taitung County and Taipei City could be attributable to the disparity on smoking behaviour (that is, prevalence and intensity). Similarly the smoking behaviour in Nantou County accounted for almost one fifth (19.2%) of the gap in life expectancy from Taipei City.

In order to assess the impact of other important confounding variables such as socioeconomic status (SES) on SAG, we have calculated SAF adjusted for SES (in addition to age) using educational level as a proxy. Three levels of education (junior high school or lower, senior high school, and college and above) were used. Although the pattern of smoking attributable fraction was similar to that exhibited in table 2, SAFs were generally lower. For example, the SAF for Taipei City was 12.90% compared to 13.74%, 6.1% lower. SAF for Taitung County was reduced to 32.08% from 34.41%, 6.8% lower. As a result, the new adjusted SAG in life expectancy was 10% lower, 1.50 years as compared to 1.71 years. Consequently, the ratio of SAG to HDG between Taitung County and Taipei City was also reduced by 10%.

Figure 2 shows the relation between the HDG and SAG/HDG in 22 cities and counties. The correlation coefficient was 0.3745 ($p < 0.05$), indicating a strong relation. The health gap increased with the contribution due to smoking disparity. In other words, the smoking gap plays an important role in observed health disparity, especially when health gaps are large.

DISCUSSIONS

Significant health and smoking disparities were both present and highly correlated in Taiwan, among the 23 cities and counties. The disparity in smoking prevalence and intensity was responsible for up to 19% of the health disparity in Taiwan cities/counties, and the health gap increased with the smoking disparity. Furthermore, the larger the health gap, the more important the smoking contribution to this gap. Thus, in addition to the well known biological mechanism through which smoking induces adverse health effects, this

Table 2 Life expectancy, smoking prevalence, and smoking attributable gap of 23 geographic areas in Taiwan

Cities/counties*	Life expectancy (years)	HDG (years)	Smoking prevalence (%)	SPG (%)	Prevalence of heavy smokers† (%)	Ranking of heavy smoker prevalence	Smoking quantity index‡	SAG (years)	SAG/HDG (%)	Total SAF§ (%)
Taipei City	77.57	0.00	37.03	0.00	9.45	4	I	0.00	–	13.74
Taipei County	74.65	2.92	43.63	6.60	11.02	7	I	0.06	2.2	15.80
Taichung City	74.54	3.03	34.19	−2.84	11.35	9	II	0.10	3.3	16.55
Taoyuan County	74.09	3.48	44.79	7.76	12.62	16	II	0.26	7.4	20.62
Hsingchu City	73.96	3.61	38.38	1.35	12.07	15	II	0.15	4.1	18.21
Kaohsiung City	73.66	3.91	40.74	3.71	13.36	17	III	0.50	12.9	28.95
Tainan City	73.46	4.11	37.87	0.84	10.92	6	I	0.01	0.3	14.00
Hsinchu County	72.77	4.80	51.53	14.50	11.11	8	I	0.19	4.1	18.14
Keelung City	72.74	4.83	45.57	8.54	11.37	11	II	0.42	8.7	20.91
Taichung County	72.53	5.04	45.79	8.76	11.56	13	II	0.35	6.9	20.98
Chiayi City	72.48	5.09	40.31	3.28	11.36	10	II	0.24	4.8	18.95
Tainan County	72.08	5.49	39.90	2.87	8.31	1	I	0.05	0.8	14.64
Penhu County	71.71	5.86	42.49	5.46	8.32	2	I	0.39	6.7	15.45
Ilan County	71.45	6.12	45.08	8.05	11.55	12	II	0.46	7.5	20.73
Changhua County	71.44	6.13	44.91	7.88	14.98	19	III	0.92	15.0	30.99
Miaoli County	71.41	6.16	47.94	10.91	10.88	5	I	0.19	3.2	17.09
Kaohsiung County	71.31	6.26	39.17	2.14	9.40	3	I	0.04	0.6	14.42
Chiayi County	71.27	6.30	46.16	9.13	15.06	20	III	0.98	15.6	31.58
Nantou County	70.79	6.78	53.29	16.26	16.74	21	III	1.30	19.2	34.76
Pingtong County	70.61	6.96	42.69	5.66	11.94	14	II	0.39	5.7	19.85
Yuinlin County	70.07	7.50	46.81	9.78	17.34	22	III	1.04	13.9	31.88
Hualien County	69.30	8.27	44.82	7.79	14.33	18	III	1.06	12.9	30.95
Taitung County	68.11	9.46	52.47	15.44	18.79	23	III	1.71	18.1	34.41

*Cities and counties are listed in the order of life expectancy.
†Heavy smokers were those who smoked 20 or more cigarettes per day at age 15 and over.
‡Smoking quantity index was based on the ranking from heavy smoker prevalence in previous column: I (ranking 1–8); II (ranking 9–16); III (ranking 17–23).
§Calculated from all causes.
HDG, health disparity gap; SAF, smoking attributable fraction; SAG, smoking attributable gap; SPG, smoking prevalence gap.

study provides additional support that smoking disparity could also play an important role in the aetiology of the health disparity observed among 23 cities/counties in Taiwan.

Some of the underlying factors for the health disparity overlap with those for smoking disparity. People with low income, low education, or low SES have been known to have poor health status.[14 15] They are also known to have higher smoking rates and different smoking behaviour, such as smoking intensity or the age at initiation.[16] This may explain part of the high correlation between smoking disparities and health disparities. Reducing the income gap and/or reducing the education gap are both highly desirable and could narrow both the gaps of health disparity and the smoking disparity. However, these approaches are beyond the traditional public health interventions because of the time, expense, and political will required to achieve results.

Smoking may exacerbate poverty. In addition to the costs of buying cigarettes, tobacco users face higher health risks and the particular vulnerabilities to illness which may lead to the loss of income by the breadwinner.[17 18] For these reasons, smoking gap reduction provides a more tangible and realistic goal for public health practitioners. In the course of reducing the smoking gap, other health risk behaviours may also be favourably affected, as people become more health conscious.

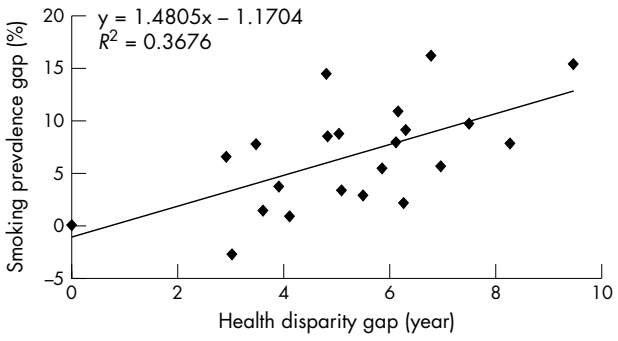

Figure 1 Relation between smoking prevalence gap and health disparity gap between Taipei City and 22 other cities and counties.

Using the smoking attributable mortality (SAM) method,[19 20] an estimated 18 800 deaths were caused by smoking annually in Taiwan.[21] This amounted to 20% of all deaths among adult males in Taiwan. The literature to date has mainly focused on the negative impact of smoking on health[22] and a relatively fewer number of studies on the contribution of smoking on health disparities.[23–25] In our study, we have demonstrated that the reduction of smoking could narrow health disparities, but wide variations exist in the extent of smoking rate disparities relative to health disparities. In some locations in Taiwan, reducing the disparity in smoking rates would likely have a negligible impact in reducing health disparities.

In the literature, many investigators surmised that the individual's health risk behaviour accounted for a significant proportion of health disparities. The US CDC in its midcourse review of *Healthy people 2000* provided a figure of 47%, while the Whitehall studies gave a range of 25–50% for all known health risks.[26–28] In our study, smoking accounted for as much as 13.7–34.4% of all adult male deaths among different geographic areas in Taiwan. These numbers were similar to the estimates for white populations.[22] The smoking rate differential alone among cities/counties in Taiwan accounted for 0.3–19.2% of the observed health disparities, and is a new finding for the existing smoking literature.

Eliminating smoking completely is a noble goal but is largely unrealistic based on the past history of tobacco control. However, less ambitious goals, like reducing smoking prevalence and intensities in heavy smoking areas, are more realistic. If residents of Taitung County could lower their smoking rates from 52.5% to the same level as that of Taipei City (37.0%), the health disparity would be narrowed by 1.71 years, or 18.1% of the total gap of 9.46 years. Although this increase in life expectancy may look modest, it is a substantial reduction of health disparity compared to the gain since the implementation of universal health care in Taiwan seven years ago in 1995, which added 1.83 years in

Table 3 Steps taken in calculating the smoking attributable gap, an illustrative example between Taipei City and Tai-tung County (total health disparity gap 9.46 years)

Smoking related disease category (ICD-9 codes)	Decomposed life years*	Proportion of smoking attributable HDG out of total HDG	SAF from smoking in Taipei City (%)	SAF from smoking in Taitung County (%)	Differences in SAF (%)	SAG (years)
Malignant neoplasm (140–208)	0.64	0.07	14.01	41.64	27.63	0.18
Diabetes mellitus (250)	0.22	0.02	15.62	26.30	10.67	0.07
Stroke (401–405, 430–438)	0.79	0.08	14.01	45.33	31.32	0.25
Ischaemic heart disease (410–414)	0.28	0.03	25.61	49.92	24.31	0.07
Respiratory system (460–519)	0.74	0.08	16.66	28.24	11.58	0.09
Digestive system (520–579)	1.73	0.18	19.64	36.17	16.53	0.29
Genitourinary system (580–629)	0.07	0.01	22.85	48.29	25.44	0.02
Ill defined conditions (780–799)	0.09	0.01	15.89	42.00	26.11	0.02
MVA (810–829)	1.57	0.17	19.16	37.63	18.47	0.29
Non-MVA (800–809, 830–999)	1.58	0.17	5.59	33.96	28.37	0.44
Total	7.71	0.82	(13.74)†	(34.41)†		1.71

*Decomposed life years from diseases significantly related to smoking in Taiwan within health disparity gap.
†Calculated with the RR of all causes; the value is shown in table 1.
HDG, health disparity gap; ICD, International classification of diseases; MVA, motor vehicle accidents; SAF, smoking attributable fraction; SAG, smoking attributable gap.

Taitung County.[5] Theoretically, because the SAF of Taitung County is 34.4%, meaning smoking accounted for 34.4% of all deaths, smoking is responsible for 3.2 years of the 9.46 years gap. In this study we dealt mainly with smoking rates. Other smoking behaviour, such as the initiation age, duration, types of cigarettes smoked, quitting behaviours, and the extent of inhalation by the individual smoker, might have accounted for part of the health effect from smoking, but were not addressed in this study.

Health disparities are inherently unfair.[29] In aspiring to reach their health potential, reducing health disparities is desirable at an individual and societal/political level. Furthermore, the adverse effect of wide health disparities could reach beyond the disadvantaged group and have an impact on the entire population. This has been termed as a ''spill over effect''.[29] For example, locally hyperendemic infectious diseases could spread and affect the rest of the population, such as tuberculosis or severe acute respiratory syndrome (SARS). The excessive consumption of medical resources in one area could drain those of the surrounding areas. Because health status baseline in the disadvantaged group is so much lower, say in Taitung County in Taiwan, a small improvement would be translated into a large percentage gain, and thus investing in reducing health disparity would look very efficient. In addition, smoking cessation has been known to be highly cost effective.[30 31] In fact, reducing smoking has been considered the gold standard against which other preventive measures have been evaluated.[32] Thus, reducing health disparities through reducing smoking disparities can be highly efficient and cost effective.

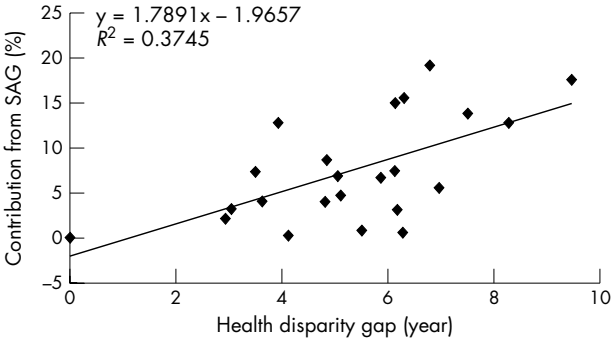

Figure 2 The relation between health disparity gap and contribution from smoking attributable gap in life expectancy between Taipei City and 22 other cities and counties.

What this paper adds

Reducing health disparity is an important public health goal, but the role of smoking in reducing such disparity has never been quantified in Taiwan. Differences in smoking prevalence and intensity are responsible for up to 19% of differences in life expectancy in 23 cities and counties in Taiwan. Health disparities are inherently unfair and theoretically avoidable. Reducing health disparities through reducing smoking is cost effective and politically attractive.

In conclusion, this study shows quantitatively that reducing the gap in smoking prevalence could reduce the gap in health disparity. This approach to reducing smoking disparities is likely to be an economically cost effective and politically feasible means of reducing health disparities, particularly in the disadvantaged areas where both the gaps in health disparity and gaps in smoking prevalence are wide.

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"Long Life" cigarettes – The most popular domestic brand for the last 40 years