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Social inequality in motorcycle helmet use: when a reduction in inequality is not necessarily good news

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ABSTRACT

Background We sought to examine changes in the magnitude of social inequality in motorcycle helmet use in Taiwan between 2001 and 2009.

Methods Using data from the 2001 and 2009 Taiwan National Health Interview Surveys, we calculated absolute (the slope index of inequality, SII) and relative (relative index of inequality, RII) measures of inequality in helmet use by three indicators of socioeconomic position.

Results The rate of motorcycle helmet use was 92% (14 801/16 100) in 2001 and decreased to 89% (15 748/17 948) in 2009. We noted a significant decrease in social inequality in helmet use in RII according to urbanisation level, a significant decrease in SII and RII according to income level, and a significant increase in SII according to education level. The reduction in RII according to urbanisation level was more prominent than that based on income level, from 1.73 (95% CI 1.63 to 1.84) in 2001 to 1.33 (95% CI 1.27 to 1.39) in 2009. The decline in helmet use was most prominent for motorcycle users who live in suburban areas, from 94% in 2001 to 88% in 2009.

Conclusions The significant reduction of social inequality in helmet use according to urbanisation level and income is not a public health success story. Rather, it is a warning sign of slackening law enforcement in Taiwan.

INTRODUCTION

Tackling social inequality in health is an important health policy goal in many countries. However, as suggested by Victora *et al*,¹ effective new interventions will initially reach those in higher socioeconomic position and will only later trickle down to those of poorer status. Inequalities in coverage, morbidity and mortality, therefore, first increase, followed later by a reduction when those of lower socioeconomic position gain greater access to the intervention, and the minimum achievable levels of morbidity and mortality have been achieved in those of higher socioeconomic position. Woodward and Kawachi² argued that universal population strategies—such as fluoridation of the water supply, or bans on indoor smoking—are more likely to reduce social inequalities.

One such universal population strategy, the mandatory motorcycle helmet law, was passed in June 1997 in Taiwan, where the motorcycle is the primary method of transportation for many households. In 2009, car ownership was 247 per 1000 people in Taiwan, which was lower than the 648 per 1000 people in the USA.^{3–4} However, motorcycle ownership was extremely high in Taiwan (631

per 1000 people) compared with those in the USA (26 per 1000 people).^{3–4}

Systematic review has suggested the effective use of a motorcycle helmet to prevent head injury and mortality.⁵ The mandatory motorcycle helmet law effectively increased the helmet use rate from 45% in 1997 to 92% in 2002, according to the Police Traffic Accident Registry data.⁶ Studies have revealed a subsequent reduction in motorcycle head injuries and fatalities.^{7–11} Despite this great public health achievement, a recent study indicated that regional inequalities in the rate of helmet use have increased since 2002.⁶ One limitation of this study was that personal information on socioeconomic position was not available in the Police Traffic Accident Registry data. Little is known whether the social inequality at individual level also increased across years. We thus used data from the National Health Interview Survey to examine the changes in social inequality in helmet use among motorcycle users between 2001 and 2009 in Taiwan.

METHODS

Data

The National Health Interview Survey is a nationally representative survey of the total population of Taiwan conducted by the Bureau of Health Promotion every 4 years. A multistage, stratified, systematic sampling design following the principle of probability proportional to size was applied in the 2001 and 2009 surveys. Data were collected through face-to-face interviews.¹² The response rate was 93.8% (25 464/27 160) in the 2001 survey and 84.0% (25 636/30 528) in the 2009 survey. One possible explanation of the difference in response rate between 2001 and 2009 is that the unit of sampling in 2001 was by household, and in 2009 it was by individual person.

Variables

The dependent variable was rate of helmet use as determined by the question ‘Do you wear a motorcycle helmet while using a motorcycle?’ The responses include: (1) always; (2) usually; (3) sometimes; (4) almost not; (5) seldom or never ride a motorcycle. The numerator was the number of respondents who answered ‘(1) always’. The denominator was the number of respondents who answered ‘(1), (2), (3), or (4)’, that is, respondents who frequently drive motorcycles or ride as a passenger.

We selected three different levels of socioeconomic indicators as independent variables: first, urbanisation level of respondent’s residency, a

community-level indicator; second, household monthly income, a household level indicator; and third, respondent's education level, an individual-level indicator.

Measures of inequality

Presentation of the absolute and relative measures of inequality may allow for better policy decision making, especially for comparisons across times.¹³ As the three socioeconomic position indicators (urbanisation, education, and income level) we used in this study have hierarchical order, we could use regression-based measures of social inequality.¹⁴ The slope index of inequality (SII) is the linear regression coefficient which represents the relation between the frequencies of health behaviour (ie, always wearing a helmet while using a motorcycle, in this study) in each socioeconomic category and the hierarchical ranking of each category on the social scale.¹⁵ The SII can be interpreted as the absolute change in frequency of health behaviour when one goes from the lowest level in the social hierarchy to the highest level.

Because SII is an absolute measure, it is sensitive to changes in the mean frequency of health behaviours of population. If the mean frequency of health behaviour increases in the same proportion in all socioeconomic categories, the SII will increase, whereas the relative differences remain constant. One alternative is the relative index of inequality (RII), which can be estimated by dividing the predicted value of the regression at the highest point by the predicted value of the regression at the next highest point. The RII is similar to ORs calculated by logistic regression at the lowest point.¹⁵

Analysis

We first examined the characteristics of respondents from each survey. We then analysed the social inequality of motorcycle use rates. Third, we assessed the social inequality of helmet use rates among motorcycle users. We calculated 95% CI of both rates and performed χ^2 tests to check for statistically significant differences between years. The SII was estimated according to a linear regression model, and the RII was estimated according to a logistic regression model. Both models controlled sex, age and three indicators of socioeconomic position. To examine whether the change in SII and RII between 2001 and 2009 was statistically significant, we tested an interaction term between the SII/RII and survey years in the 2001 and 2009 combined model. Because of stratified sampling design in this survey, all the analyses have been weighted. The weighting coefficient of each case was provided by the Center of Surveillance of Administration of Health Promotion in charge of the sampling.

RESULTS

The basic sociodemographic characteristics of the respondents in the two survey years are presented in table 1. The distributions of age, sex and urbanisation level among the respondents in 2001 were similar to those in 2009. However, more respondents had a higher educational level and higher rate of missing income information in 2009.

The rate of using motorcycle (as driver or passenger) increased from 88% (16 100/18 323) in 2001 to 93% (17 948/19 188) in 2009 (table 2). The rate of using motorcycle increased from 2001 to 2009 in each category of each variable. However the changes in SII and RII in rate of using motorcycle between 2001 and 2009 were significant only in urbanisation level. The rate of using motorcycle increased most prominently in metropolitan areas, from 82% in 2001 to 91% in 2009; which resulted in a significant change in SII, from -0.025 (95%

Table 1 Characteristics of respondents in the 2001 and 2009 Taiwan National Interview Surveys

	2001		2009	
	n	Per cent	n	Per cent
Total	18 323	100.0	19 188	100.0
Sex				
Male	9103	49.7	9165	50.4
Female	9220	50.3	10 023	49.6
Age group (years)				
12–17	2167	11.8	2306	10.9
18–24	2865	15.6	2569	12.9
25–44	7943	43.3	8025	43.0
45–64	5348	29.2	6288	33.2
Urbanisation level				
Metropolitan	4797	26.2	5978	31.2
Urban	4735	25.8	4808	29.6
Suburban	3183	17.4	3350	16.7
Rural	5353	29.2	5035	22.5
Missing	255	1.4	17	0.1
Education level				
Primary or lower	3824	20.9	2450	11.7
Secondary	3793	20.7	3511	17.2
High school	6299	34.4	6525	33.6
College or university	4399	24.0	6693	37.5
Missing	8	0.0	9	0.0
Household monthly income (New Taiwan dollars)				
$\leq 29\ 999$	3404	18.6	3689	16.0
30 000–49 999	4299	23.5	3991	20.5
50 000–69 999	4064	22.2	3358	17.8
70 000–99 999	3342	18.2	2645	15.5
$\geq 100\ 000$	3040	16.6	2656	16.0
Missing	174	0.9	2849	14.3

CI -0.029 to -0.021) in 2001 to $+0.002$ (95% CI -0.001 to 0.006) in 2009.

Among motorcycle users, the rate of helmet use was 92% (14 801/16 100) in 2001 and decreased to 89% (15 748/17 948) in 2009 (table 3). We noted a significant decrease in social inequality in helmet use in RII according to urbanisation level and SII and RII according to income level and a significant increase in SII based on education level. The reduction in RII according to urbanisation level was more prominent than that according to income level, from 1.73 (95% CI 1.63 to 1.84) in 2001 to 1.43 (95% CI 1.27 to 1.39) in 2009. The decline of helmet use rates was most prominent for motorcycle users who are residents of suburban areas, from 94% in 2001 to 88% in 2009.

DISCUSSION

By contrast with the great increase in helmet use rates (from 45% in 1997 to 92% in 2002) in years immediately after the helmet law was passed in 1997,⁶ we noted a mild decrease of helmet use rates in this study, from 92% in 2001 to 89% in 2009. Different indicators of socioeconomic position showed divergent changes in social equality in helmet use: urbanisation level and income level displayed a significant reduction of social inequality, yet education level showed a significant increase of social inequality.

How can we explain this phenomenon? Observance of the mandatory motorcycle helmet law is similar to other traffic

Table 2 Number and rate (%) of respondents regularly riding motorcycle as the driver or a passenger from the 2001 and 2009 Taiwan National Health Interview Surveys

	2001			2009			p Value
	n	%	95% CI	n	%	95% CI	
Total	16 100	87.9	(87.4 to 88.3)	17 948	92.5	(92.1 to 92.9)	<0.0001
Sex							
Male	8131	89.3	(88.7 to 90.0)	8553	92.5	(91.9 to 93.0)	<0.0001
Female	7969	86.4	(85.7 to 87.1)	9395	92.5	(92.0 to 93.0)	<0.0001
Age group (years)							
12–17	1829	84.4	(82.9 to 85.9)	2154	92.1	(91.0 to 93.2)	<0.0001
18–24	2735	95.5	(94.7 to 96.2)	2524	97.9	(97.3 to 98.4)	<0.0001
25–44	7167	90.2	(89.6 to 90.9)	7575	93.9	(93.4 to 94.5)	<0.0001
45–64	4369	81.7	(80.7 to 82.7)	5695	88.6	(87.9 to 89.4)	<0.0001
Urbanisation level							
Rural	4848	90.6	(89.8 to 91.3)	4661	91.6	(90.8 to 92.4)	1.1611
Suburban	2882	90.5	(89.5 to 91.6)	3133	93.0	(92.3 to 93.8)	0.0005
Urban	4214	89.0	(88.1 to 89.9)	4545	94.1	(93.4 to 94.9)	<0.0001
Metropolitan	3935	82.0	(80.9 to 83.1)	5592	91.2	(90.5 to 91.9)	<0.0001
SII	−0.025		(−0.029 to −0.021)	0.002		(−0.001 to 0.006)	<0.0001
RII	0.785		(0.753 to 0.818)	1.040		(0.896 to 1.097)	<0.0001
Education level							
Primary or lower	3,22	84.2	(83.0 to 85.4)	2226	89.8	(88.6 to 91.0)	<0.0001
Secondary	3385	89.2	(88.3 to 90.2)	3276	92.6	(91.8 to 93.5)	<0.0001
High school	5697	90.4	(89.7 to 91.2)	6176	94.2	(93.6 to 94.7)	<0.0001
College or higher 3792		86.2	(85.2 to 87.2)	6262	91.8	(91.1 to 92.4)	<0.0001
SII	−0.001		(−0.006 to 0.004)	−0.003		(−0.011 to 0.002)	0.6367
RII	0.979		(0.932 to 1.029)	0.938		(0.877 to 1.003)	0.4154
Household monthly income (NT dollars)							
<=29 999	2956	86.8	(85.7 to 88.0)	3414	91.8	(91.0 to 92.7)	<0.0001
30 000–49 999	3878	90.2	(89.3 to 91.1)	3797	94.7	(94.0 to 95.4)	<0.0001
50 000–69 999	3643	89.6	(88.7 to 90.6)	3191	94.5	(93.7 to 95.2)	<0.0001
70 000–99 999	2929	87.6	(86.5 to 88.8)	2491	92.8	(91.8 to 93.8)	<0.0001
>=100 000	2540	83.6	(82.2 to 84.9)	2378	87.8	(86.5 to 89.0)	<0.0001
SII	−0.006		(−0.010 to −0.003)	−0.012		(−0.016 to −0.010)	0.2252
RII	0.941		(0.909 to 0.975)	0.839		(0.801 to 0.879)	0.0015

SII=slope index of inequality (ie, linear coefficient) according to linear regression model.
RII=relative index of inequality (ie, OR) according to logistic regression model.

laws, such as speed limits, drunk-driving laws, and mandated usage of restraints in vehicles. Thus, the primary factors determining observance are the rigorousness of the police ticketing non-helmet use and motorcycle users' compliance.¹⁶

With regard to the rigorousness of police ticketing non-helmet use, a previous study in Taiwan using the Police Traffic Accident Registry data indicated that relaxation of law enforcement by police in some counties resulted in a correspondingly greater decline of helmet use.⁶ A study in Thailand revealed high disparity in helmet use (from 36% in South region to 82% in Bangkok) and highly associated with regional conviction rate of motorcyclists. The authors recommended a more equitable distribution of the police force.¹⁷ However, policing behaviour, as indicated by Schafer,¹⁸ is not as highly structured by law, policy, and supervision as most people expect. In reality, the task of the individual police officer is negotiating various uncertainties to achieve a resolution that is optimal for the officer, his/her agency, the citizen(s) involved, and the public at large. Another study showed evidence that police discretion varied between large urban and small rural agencies.¹⁹ In other words, the policing culture of helmet law enforcement likely varies regionally and in accordance with urbanisation level in Taiwan. We argue that regional and temporal differences in police

ticketing non-helmet use was the main factor driving the decrease of social inequality in helmet use rates shown according to urbanisation level.

In terms of motorcycle users' compliance, compliance is similar to other health behaviours and, therefore, highly associated with individual education level.^{20–21} Education gradients in health behaviour, as suggested by Cutler and Lleras-Muney, are affected by specific knowledge, cognitive ability, tastes (discounting, risk aversion, and the value of the future), personality, and social integration factors.²² Motorcycle users with higher education levels likely have greater knowledge, cognitive ability, or opinions on motorcycle helmet use, and thus are less likely to be influenced by time (ie, years after the passage of the helmet law) or context (ie, rigorousness of ticketing non-helmet use in different regions). On the contrary, motorcycle users with lower education levels might be more subject to influence by contextual factors. The findings of this study suggest that motorcycle users with secondary education level suffered the largest decline in helmet use rates, from 89% in 2001 to 82% in 2009; by contrast with mild decrease among motorcycle users with college or graduate education level, from 96% in 2001 to 93% in 2009. However, we also found a moderate decrease in helmet use rate among motorcycle users with primary or lower

Table 3 Number and rate (%) of always wearing helmet among respondents who regularly use motorcycles from the 2001 and 2009 Taiwan National Health Interview Surveys

	2001			2009			p Value
	n	%	95% CI	n	%	95% CI	
Total	14 801	91.9	(91.5 to 92.4)	15 748	88.8	(88.4 to 89.3)	<0.0001
Sex							
Male	7439	91.5	(90.9 to 92.1)	7291	87.0	(86.3 to 87.7)	<0.0001
Female	7362	92.4	(91.8 to 93.0)	8457	90.7	(90.1 to 91.3)	<0.0001
Age group (years)							
12–17	1534	83.9	(82.2 to 85.6)	1593	75.9	(74.1 to 77.7)	<0.0001
18–24	2535	92.7	(91.7 to 93.7)	2287	92.1	(91.1 to 93.2)	<0.0064
25–44	6691	93.4	(92.8 to 93.9)	6772	90.2	(89.5 to 90.9)	<0.0001
45–64	4041	92.5	(91.7 to 93.3)	5096	90.0	(89.2 to 90.7)	<0.0001
Urbanisation level							
Rural	4057	83.7	(82.6 to 84.7)	3724	81.2	(80.1 to 82.4)	0.0028
Suburban	2698	93.6	(92.7 to 94.5)	2724	88.3	(87.2 to 89.4)	<0.0001
Urban	4069	96.6	(96.0 to 97.1)	4187	93.0	(92.2 to 93.7)	<0.0001
Metropolitan	3764	95.7	(95.0 to 96.3)	5096	90.5	(89.7 to 91.3)	<0.0001
SII	0.036		(0.033 to 0.040)	0.027		(0.022 to 0.031)	0.2527
RII	1.732		(1.633 to 1.836)	1.328		(1.267 to 1.392)	<0.0001
Education level							
Primary or lower	2887	89.7	(88.6 to 90.7)	1899	85.7	(84.2 to 87.1)	<0.0001
Secondary	3020	89.2	(88.2 to 90.3)	2641	82.5	(81.2 to 83.8)	<0.0001
High school	5261	92.3	(91.7 to 93.0)	5425	88.9	(88.1 to 89.7)	<0.0001
College or higher	3627	95.6	(95.0 to 96.3)	5777	92.7	(92.0 to 93.3)	<0.0001
SII	0.019		(0.015 to 0.024)	0.033		(0.027 to 0.039)	0.0004
RII	1.344		(1.253 to 1.441)	1.403		(1.325 to 1.486)	0.1204
Household monthly income (NT dollars)							
<=29 999	2590	87.6	(86.4 to 88.8)	2918	85.8	(84.6 to 87.0)	0.0008
30 000–49 999	3563	91.9	(91.0 to 92.7)	3382	90.2	(89.2 to 91.1)	<0.0001
50 000–69 999	3380	92.8	(91.9 to 93.6)	2819	89.6	(88.5 to 90.6)	<0.0001
70 000–99 999	2758	94.2	(93.3 to 95.0)	2240	90.8	(89.7 to 92.0)	<0.0001
>=100 000	2383	93.8	(92.9 to 94.8)	2115	90.2	(89.0 to 91.4)	<0.0001
SII	0.007		(0.003 to 0.010)	–0.002		(–0.006 to 0.002)	0.0027
RII	1.095		(1.045 to 1.147)	0.987		(0.946 to 1.028)	0.0004

SII=slope index of inequality (similar to linear coefficient) according to linear regression model.
RII=relative index of inequality (similar to OR) according to logistic regression model.

education level, from 90% in 2001 to 86% in 2009. One possible explanation was that the motorcycle users with lowest education level were more sensitive to economic consequence of ticketing of the non-helmet use.²³

The magnitude of social gradient in helmet use according to income level was small relative to urbanisation and education level. A possible explanation is the selected recruitment effect. We excluded respondents who never use motorcycles; these respondents likely have higher income levels and regularly use cars instead. According to a survey in Taiwan, the average monthly income was US\$900 for a regular motorcycle user, and US\$1300 for a regular car user.²⁴ In other words, motorcycle users were relatively economically disadvantaged compared with car users. A second explanation is the high rate of missing information on household monthly income in 2009. It is likely that respondents with higher income levels were less prone to provide income information. The occurrence of either or both these phenomena would have flattened the income gradient in helmet use rate.

We also found the greatest increase in rate of motorcycle use among respondents living in metropolitan areas, from 82% in 2001 and increased to 91% in 2009. This might be due to the financial crisis 2007–2008, which made many households in

metropolitan areas shift from car use to motorcycle use. The cost of using a car is higher in metropolitan areas than it is in other regions, so under financial strain, metropolitan households were prone to making this shift. However, we do not know whether these new motorcycle users in metropolitan areas were more likely to wear helmets.

The main limitation of this study is that the rate of helmet use might be overestimated. However, as suggested by Cohen & Einav,²⁵ despite the fact that self-reports overestimate actual use, secular trends in self-reported and observed use are similar. Thus, the changes between 2001 and 2009 that we observed are likely still valid. We further argue that as time after the passage of the helmet law increases, there is less effect of social desire on over-reporting of helmet use. Another limitation is that only two waves of data were available, and that little is known about the helmet use rate changes in years between 2001 and 2009.

In conclusion, based on nationally representative survey data, we noted divergent changes according to different indicators of socioeconomic position for social inequality in helmet use in Taiwan between 2001 and 2009. The reduction of social inequality in helmet use was most prominent according to urbanisation level, which was mainly due to larger decline in helmet use in areas with less rigorous enforcement of the helmet law.

Therefore, the significant reduction of social inequality in helmet use, according to urbanisation level, is not good news; rather, it is a warning sign of slackening enforcement of the helmet law by the police. Efforts are needed to ensure consistent rigorosity of enforcement of helmet law in each county and city to promote the rate of helmet use, which will further reduce the remaining social inequality in helmet use.

What is already known on this subject

- ▶ The mandatory motorcycle helmet use law was passed in June 1997 in Taiwan. The helmet use rate increased dramatically from 45% in 1997 to 92% in 2002.
- ▶ However, little is known about increases or decreases of the social inequality in helmet use across years.

What this study adds

- ▶ The reduction of social inequality in helmet use between 2001 and 2009 was most prominent according to urbanisation level.
- ▶ Helmet use rates showed a reduction of social inequality; however, the rate of helmet use decreased in all socioeconomic positions, and declined most among motorcycle users who live in suburban areas.
- ▶ The differential decline in helmet use rate might be due to differential rigour in enforcement of helmet law across years and areas.

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Collaborators Tsung-Hsueh Lu.

Contributors STC initiated the idea and supervised the study. THL designed and analysed the data and wrote the first draft of the manuscript. All authors participated in the interpretation of the results and critically reviewed the manuscript.

Competing interests None.

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