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POLICIES TO INCREASE HEALTH INDUCING BEHAVIOR THAILAND

This paper proposes a new method to analyze the factors affecting health behavior. The proposed model gives more efficient parameter estimates in comparison with traditional models. Understanding the dependencies between choices in each health behavior gives useful information for designing more efficient public health promotion and national disease prevention programs. The data from Thai National Health Examination Survey were used to analyze the factor affecting physical activity, tobacco consumption and alcohol consumption, simultaneously. The empirical results show the negative correlation between tobacco consumption and physical activity behaviors. We also found a positive correlation between alcohol consumption and physical activity. Finally, from the empirical results, the recommended policies designed to reduce health-risk behavior and increase health inducing behavior in Thailand are discussed.

Keywords: *health risks; healthcare costs, alcohol consumption; tobacco consumption; physical activity; Thailand.*

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ПОЛІТИКА ПРОСУВАННЯ ЗДОРОВОГО СПОСОБУ ЖИТТЯ В ТАЇЛАНДІ

У статті запропоновано новий метод аналізу факторів, що впливають на здоровий образ життя. Розроблена модель пропонує більш якісні параметри оцінювання в порівнянні з традиційними моделями. Розуміння залежностей у виборі моделей поведінки може надати цінну інформацію для розробки більш ефективної політики просування здорового способу життя та профілактики захворювань. На матеріалах національного опитування у Таїланді проаналізовано фактори, що впливають на фізичну активність громадян, паління та споживання алкоголю. Емпіричні результати вказують на існування негативної кореляції між палінням та фізичною активністю тайців. У той же час виявлено позитивну кореляцію між фізичною активністю та споживанням алкоголю. На основі даних результатів розроблено рекомендації стосовно того, як варто переформулювати політику просування здорового способу життя в Таїланді.

Ключові слова: *ризики для здоров'я; витрати на охорону здоров'я; споживання алкоголю; споживання тютюну; фізична активність; Таїланд.*

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ПОЛИТИКА ПРОДВИЖЕНИЯ ЗДОРОВОГО ОБРАЗА ЖИЗНИ В ТАИЛАНДЕ

В статье предложен новый метод анализа факторов, влияющих на здоровый образ жизни. Разработанная модель предлагает более качественные параметры оценки по сравнению с традиционными моделями. Понимание зависимостей при выборе моделей поведения может дать ценную информацию для разработки более эффективной политики продвижения здорового образа жизни и профилактики заболеваний. На материалах национального опроса в Таиланде проанализированы факторы, влияющие на физическую активность граждан, курение и потребление алкоголя. Эмпирические результаты указывают на существование негативной корреляции между курением и физической активностью тайцев. В то же время выявлена позитивная корреляция между физической

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активностью и употреблением алкоголя. На основе данных результатов разработаны рекомендации относительно того, как следует переформулировать политику продвижения здорового образа жизни в Таиланде.
Ключевые слова: *риски для здоровья; расходы на здравоохранение; употребление алкоголя; употребление табака; физическая активность; Таиланд.*

Introduction. Global healthcare costs are permanently rising and have become a big problem, for developing countries especially. Health promotion and disease prevention are considered as the common approaches to reduce healthcare costs.

The explicit burden on society due to health-risk behaviors, particularly alcohol and tobacco consumption, includes healthcare costs, productivity loss, property damage costs, costs of criminal justice as well as law enforcement. While Thailand already implements alcohol-related policies, such as high alcohol taxation, restricted alcohol sale times, other effective measures at the social level to control alcohol consumption and alcohol-related harms are still required. The national survey in 2011 reported that about 17.7 mln people, or 20.8% of the population aged 15 years and above are alcohol users. Men consume alcohol at higher rate than women (NSO, 2011).

Equally, tobacco consumption control policies have been implemented to reduce tobacco consumption and prevent initiation of smoking, especially among youth. Current policies include high rates of tobacco taxation, control of tobacco advertising, non-smoking areas and bans on smoking in public places. These policies have been shown to be successful in decreasing the proportion of smokers in Thai population (15 y.o. and older) – from 32% in 1991 to 20% in 2013 (NSO, 2011).

On the other hand, the Thai Health Promotion Foundation has promoted physical activity among Thai population by sponsoring and supporting several public campaigns nationally on the benefits of physical activity and advising the effective frequency, duration and intensity required to achieve physical fitness. Such programs have also been supported at the local and regional levels in many areas of the country. Most of these projects are focused on increasing perceptions, attitudes, and practices related to physical activity in general (Katewongsa et al., 2014).

Previous studies on the factors affecting alcohol consumption, tobacco consumption, and physical activity were based on single equations (Katewongsa et al., 2014; Praponsin, 2007; Sirirassamee, 2009; Suwannashote, 2009).

In this paper, we determine the factors affecting alcohol consumption, tobacco consumption and physical activity to quantify the factors affecting health behaviors which are to be well specified before considering the optimal health promotion and prevention policy. Investing in lower cost-effectiveness policies may not give economic benefits as expected and attempted to quantify the dependence measures between these pairs using the copula approach. This paper proposes a new method to analyze factors affecting health behavior by accounting for the dependence between each health behavior. The proposed model will give more efficient parameter estimates in comparison with traditional models. Moreover, understanding the dependencies between choices for each health behavior gives us useful information for designing more efficient health promotion and disease prevention programs.

Data. The data used in this study are from the Thai National Health Examination Survey, No. 4 (NHES IV) from 2009. The data consists of the sample of

20,450 individuals. The ordered dependent variables are alcohol consumption (Y1), tobacco smoking (Y2), and physical activity in leisure time (Y3). The independent variables are sex, age, income, chronic diseases, marital status, education level, and occupation. The alcohol consumption variable (Y1) were: 0 for non-alcohol consumption; 1 for alcohol consumption. For tobacco consumption, variable Y2 were: 0 for non-smoking; 1 for smoking. For physical activity, variable Y3, the levels of physical activity or exercise in leisure time were: 0 for non-physical activity; 1 for physical activity. Table 1 presents a description of the variables and the related statistics.

Table 1. **Key statistics and variables' description,** *authors'*

Variables	Description	N	Mean	SD	Min	Max
Y1	1 if an individual consumes alcohol; 0 otherwise	20450	0.446	0.627	0	1
Y2	1 if an individual consumes tobacco; 0 otherwise	20450	0.052	0.339	0	1
Y3	1 if an individual has physical activity in leisure time; 0 otherwise	20450	2.201	0.845	0	1
Sex	1 if individual is male; 0 otherwise	20450	0.524	0.499	0	1
Age	in years	20450	52.917	18.236	14	98
Income	in 1,000 Baht	20450	3.310	5.698	0	32,480
Bachelor	1 if an individual graduated with a Bachelor degree or higher; 0 otherwise	20450	0.061	0.24	0	1
Age	1 if an individual works in the agricultural sector; 0 otherwise	20450	0.176	0.381	0	1
Whi	1 if an individual is a white-collar worker	20450	0.035	0.184	0	1
police	1 if an individual works as a policeman or soldier; 0 otherwise	20450	0.012	0.108	0	1
Labor	1 if an individual is in labor sector; 0 otherwise	20450	0.48	0.499	0	1
Married	1 indicates married; 0 otherwise	20450	0.636	0.481	0	1
Pe_bmi25	1 if an individual has body mass index more than 25; 0 otherwise	20450	0.348	0.476	0	1
Pe_tc200	1 if an individual has the chloresterol level more than 200; 0 otherwise	20450	0.561	0.496	0	1
qlhealth	Health quality self-assessment, where 5 is the highest level	20450	3.708	0.867	0	5
NCD	Number of chronic diseases	20450	0.632	0.959	0	10

Methods.

1. Binary choice models. Health behaviors we are going to analyze here are the binary choices of alcohol consumption, tobacco consumption, and physical activity. Let $Y_i = \{0,1\}$, for $i = 1$, 2 and 3, be the binary choices, where 1, 2 and 3 indicate alcohol consumption, tobacco consumption, and physical activity choices, respectively. For the set {0,1} of each choice outcome, 0 indicates that individual has not chosen that choice and 1 indicates individual has chosen that choice. Let X_i, for $i = 1$, 2 and 3, where 1, 2 and 3 are previously defined vector of all the explanatory variables thought to explain health behaviors, and β_i is the vector of the parameters to be estimated corresponding to X_i. For each Y_i we can think of this random variable as being generated from the following binomial distribution:

$$f(k;n,p)=\Pr(Y=k)=\binom{n}{k}p^k(1-p)^{n-k},\ \text{for}\ k=0,1,2,\ldots,n, \tag{1}$$

where $\binom{n}{k}=\frac{n!}{k!(n-k)!}$ in which n is the number of trials and p is the probability of choosing this choice. Note that we drop the subscript i for the sake of simplicity.

In our case, we assume that individual make choice only once, hence n = 1 (which is called Bernoulli distribution), and if p is assumed to be a standard normal distribution (Φ), we can derive the probability distribution as follows:

$$\Pr(Y=1|X,\beta)=\Phi(X\beta); \tag{2}$$

$$\Pr(Y=0|X,\beta)=1-\Phi(X\beta). \tag{3}$$

The above marginal distribution model has exactly the same functional form as a probit model. We introduce the idea of viewing binary choice model as a derivation from binomial distribution in contrast to derivation from latent continuous variable to model the multivariate joint distribution using discrete copula in the next section.

2. Copula. Copula has an increasing popularity in many fields of application, especially in economics. We can refer to H. Joe (1997) and R.B. Nelsen (2006) for the introduction of the copula theory and its applications. The examples of its application in health econometric models can be found in (Sirisrisakulchai and Sriboonchitta, 2014; Kanchit et al., 2016).

The fundamental theorem of copula is Sklar's theorem (1959). The theorem briefly states there exists a copula function C such that:

$$F(y_1,y_2,\ldots,y_m)=C(F_1(y_1),F_2(y_2),\ldots,F_m(y_m)), \tag{4}$$

where $y=(y_1,y_2,\ldots,y_m)$ is the realization of an m-dimensional random vector $Y=(Y_1,Y_2,\ldots,Y_m)$; F is a joint distribution function; F_j is a marginal distribution function corresponding to each marginal j. Sklar's theorem provides us the link between the dependence structure of multivariate distribution and their univariate margins.

For continuous variables, the joint density $f(y_1,y_2,\ldots,y_m)$ can be easily obtained by taking the derivative of both sides of equation (4), which gives

$$f(y_1,y_2,\ldots,y_m)=c(F_1(y_1),F_2(y_2),\ldots,F_m(y_m))f_1(y_1)f_2(y_2)\ldots f_m(y_m), \tag{5}$$

where f is a joint density function; f_j is a marginal density function corresponding to each marginal j; c is a copula density function. The copula function is unique for the continuous random vector Y. However, the copula function is unique only over the Cartesian product of the ranges of the marginal distribution function in a discrete random vector (Genest and Neslehova, 2007). Parametric modelling of discrete variables by copula acquires dependence properties in the same way as the continuous case.

For discrete variables, the probability mass function can be evaluated by taking the difference of the copula function. The joint probability mass function (PMF) of Y can be obtained as follows:

$$\Pr(Y=y)=\sum_{i_1=0,1}\cdots\sum_{i_m=0,1}(-1)^{i_1+\ldots+i_m}C(F_1(y_1-i_1),\ldots,F_m(y_m-i_m)). \tag{6}$$

Note that, to compute this PMF, we have to evaluate 2^m times of copula functions. However, one can approximate the PMF of Y by building up from the number of bivariate copulas. This approach is called pair copula constructions (PCC). PCC were initiated by H. Joe (1996) and developed in more detail by (Bedford and Cook, 2001, 2002; Kurowicka and Cooke, 2006).

For continuous Y , a PCC can be derived by factorizing the joint density function into the conditional density function and the marginal density function, as follows:

$$f(y_1,y_2,\ldots,y_m)=f_{1|2,\ldots,m}(y_1|y_2,\ldots,y_m)f_{2|3,\ldots,m}(y_2|y_3,\ldots,y_m)\ldots f_m(y_m). \quad (7)$$

K. Aas et al. (2009) have shown that the conditional density function on the right side of equation (7) can be decomposed into the product of a bivariate copula density and a univariate conditional density by using Sklar's theorem. This can be done recursively to each of the terms on the right hand side of equation (7) until $f(y_1,y_2,\ldots,y_m)$ is decomposed into the product of $m(m-1)/2$ bivariate copulas (Panagiotelis, 2012).

For discrete margins, we can decompose a PMF by using the method proposed by (Panagiotelis, 2012) as follows:

$$\begin{aligned}\Pr(Y_1=y_1,\ldots,Y_m=y_m)=\Pr(Y_1=y_1|Y_2=y_2,\ldots,Y_m=y_m)\times\\ \times\Pr(Y_2=y_2|Y_3=y_3,\ldots,Y_m=y_m)\times\ldots\times\Pr(Y_m=y_m).\end{aligned} \quad (8)$$

We can perform the same decomposition as in a continuous case for each term on the right side of equation (8) to get the product of a bivariate copula.

For example, in the case of m = 3, three-dimensional discrete margin PCC can be obtained as follows:

$$\begin{aligned}\Pr(Y_1=y_1,Y_2=y_2,Y_3=y_3)=\\ \Pr(Y_1=y_1|Y_2=y_2,Y_3=y_3)\times\Pr(Y_2=y_2|Y_3=y_3)\times\Pr(Y_3=y_3),\end{aligned} \quad (9)$$

where

$$\Pr(Y_1=y_1|Y_2=y_2,Y_3=y_3)= \\ =\frac{\left\{\sum_{i_1=0,1}\sum_{i_2=0,1}(-1)^{i_1+i_2}C_{12|3}(F_{1|3}(y_1-i_1|y_3),F_{2|3}(y_2-i_2|y_3))\right\}}{\Pr(Y_2=y_2|Y_3=y_3)} \quad (10)$$

and the arguments in the copula function are

$$F_{1|3}(y_1-i_1|y_3)=\frac{C_{13}(F_1(y_1-i_1),F_3(y_2))-C_{13}(F_1(y_1-i_1),F_3(y_3-1))}{\Pr(Y_3=y_3)} \quad (11)$$

and

$$F_{2|3}(y_2-i_2|y_3)=\frac{C_{23}(F_2(y_2-i_2),F_3(y_3))-C_{23}(F_2(y_2-i_2),F_3(y_3-1))}{\Pr(Y_3=y_3)}. \quad (12)$$

Since the dominator of equation (10) cancels with the second term on the right side of equation (9), the full expression for the PMF of the three-dimensional discrete margin PCC is

$$\Pr(Y_1=y_1,Y_2=y_2,Y_3=y_3)=$$
$$=\left\{\sum_{i_1=0,1}\sum_{i_2=0,1}(-1)^{i_1+i_2}C_{12|3}\left(\frac{C_{13}(F_1(y_1-i_1),F_3(y_3))-C_{13}(F_1(y_1-i_1),F_3(y_3-1))}{F_3(y_3)-F_3(y_3-1)},\right.\right. \quad (13)$$
$$\left.\left.\frac{C_{23}(F_2(y_2-i_2),F_3(y_3))-C_{23}(F_2(y_2-i_2),F_3(y_3-1))}{F_3(y_3)-F_3(y_3-1)}\right)\right\}\left[F_3(y_3)-F_3(y_3-1)\right].$$

The above model can be used to analyze the dependence between each health behavior considered in this paper and can also determine the factors affecting those behaviors at the same time.

Results and discussion. We select Frank copula for all bivariate copula that building up to approximate the multivariate joint distribution of multivariate binary probit models.

1. Factors affecting alcohol consumption, tobacco consumption, and physical activity behaviours. Table 2 presents the results of estimation of the multivariate binary probit models for alcohol consumption, tobacco consumption, and physical activity choices. The first dependent variable to be discussed is alcohol consumption level. The explanatory variables included in the model are age, income, high cholesterol, gender, non-communication diseases, occupation, and marrital status. The coefficient interpretations are: 1) young individuals, individuals with higher income, individuals with lower cholesterol of 200 mg/dl or a lower number of chronic diseases, and married are more likely to consume alcohol; 2) males are more likely to consume alcohol than females; 3) individuals who work in the agricultural sector and work in risky occupations such as police and soldiers are more likely to consume alcohol than white-collar workers and those from the labor sector.

Table 2. **Estimation of the multivariate binary probit models for alcohol consumption, tobacco consumption, and physical activity choices,** *authors'*

Variables	Y1		Y2		Y3	
	Coeff.	Std.err	Coeff.	Std.err	Coeff.	Std.err
age	-0.0122*	7.149e-04	-9.249e-03*	1.536e-03	-8.608e-03*	7.470e-04
income	1.394e-05*	1.892e-06	5.206e-06	3.962e-06	-5.957e-06*	1.981e-06
pe_tc200	-0.0507*	0.0201	0.0507	0.0433	-0.0138	0.0209
qlhealth	3.277e-03	0.0111	-0.0963*	0.0249	0.1781*	0.0125
sex	0.9327*	0.0202	1.427*	0.08859	0.3800*	0.0209
NCD	-0.1042*	0.01189	-0.0854*	0.0296	0.0698*	0.0115
agr	0.3053*	0.0324	0.2449*	0.0709	-0.1988*	0.0348
white	0.1866*	0.0619	7.133e-03	0.1318	-0.0621	0.0636
police	0.3109*	0.0886	0.1578	0.1536	-0.3393*	0.0991
labor	0.1623*	0.02900	0.1419*	0.0663	-0.0142	0.0299
married	0.0580*	0.0218	-0.0802	0.0504	-0.0891*	0.0221
bachalor	-0.0411	0.0452	-0.5405*	0.1287	0.2943*	0.0442
pe_bmi25	-0.0362	0.0214	-0.1751*	0.0511	0.0698*	0.02197
θ1(Y1-Y3)	0.9121*	0.1974				
θ2(Y2-Y3)	-0.5775*	0.2093				
θ3((Y1-Y2)	-0.0270	0.1349				

* significant at 0.01

The second dependent variable is the level of tobacco consumption, the explanatory variables included in the model are age, health self-assessment, gender, non-communication diseases, occupation, marital status, and body mass index. The coefficient interpretations are: 1) young individuals, individuals with lower health quality assessment or lower number of chronic diseases, individuals who are education lower than bachelor degree, and individuals who are non-obese (BMI < 25) are more likely to consume tobacco; 2) males are more likely to alcohol consumption than females; 3) individuals who work in the agricultural sector are more likely to consume tobacco than the labor sector.

The third dependent variable is physical activity level in leisure time. The explanatory variables included into the model significant are age, income, health quality self-assessment, gender, non-communicable diseases, occupation – agriculture and police, marrital status, education, and body mass index. The coefficient interpretations are: 1) young individuals, individuals with higher income, number of chronic diseases, individuals who are non-married, single individuals with bachelor education, and individuals who are obese (BMI > 25) are more likely to undertake physical activities; 2) males are more likely to undertake physical activities than females; 3) individuals who work in the agricultural sector are more likely to undertake physical activities than those from the risky occupations such as police and soldiers.

2. Dependence measures of health behaviors pairs. 2 of 3 dependence parameter estimated from the Frank copula multivariate ordered probit are significant. Firstly, the dependence parameter estimated for alcohol consumption and physical activity behavior is 0.912, that can be interpreted as the positive correlation between alcohol consumption and physical activity. Secondly, the dependence parameter estimated for tobacco consumption and physical activity behavior is -0.577, this can be interpreted as the negative correlation between alcohol consumption and physical activity behaviors.

Concluding remarks. From the empirical results previously discussed, the following are the recommended policies designed to reduce health-risk behavior and increase health-inducing behavior for Thai citizens:

a) The policies should be focused on children and teenages more than on adults to reduce alcohol and tobacco consumption, because the empirical results show that younger individuals are more inclined to alcohol and tobacco consumption, and more likely to choose physical activity in leisure time.

b) Campaigns aimed at reducing alcohol consumption should greater focus on workers in the agricultural sector and in risky occupations.

c) The empirical results show a negative correlation between tobacco consumption and physical activity. Thus, anti-smoking policies would have a more positive impact if policy makers promote physical activity campaign.

d) Thai citizens should know more about their health status, because our empirical results show that individuals who have low health status, for example, obese, high cholesterol, with more non-communication diseases, demonstrate less health-risk behaviors and more healthly behavior.

For further study, the copula-based ordered probit model should be generalized to a multivariate model that increase the level of ordinal outcomes. However, the empirical results of this paper cannot confirm the dependence between alcohol and tobacco consumption as discussed in the Alcohol Alert No.71 (US Department of Health & Human Services 2007). That study found that people who smoke are much more likely to drink, and people who drink are much more likely to smoke.

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