Attrition Effects in Panel Study: Its Determinants and Consequences

Yeu-Sheng Hsieh[*], Chyi-In Wu[**], and Ping-Yi Shih[***]

Abstract

This paper discusses the attrition problems and estimates the determinants of attrition in the Taipei Youth Panel Study (TYPS). It examines whether the data collection methods and youth's school transitions have significant impacts on the sample attrition in particular. And, it also investigates the influence of sample attrition on youths' criminal and violent behaviors which used as a hypothetical example of a panel data. TYPS conducted by the Institute of Sociology, Academia Sinica, and focused on the issues of the deviance behavior development among Taipei Youths through their adolescent and early adulthood period. It began in 1996 with 1,434 individuals and followed up interview or mail survey each year. All samples of TYPS were in the first year of junior high school in 1996. These 7-wave panel data sets are used for the purpose of this paper. The logistic regression and discrete time regression model of event history analysis are separately utilized to identify the important determinants of influencing sample attrition in TYPS. In addition, a regression analysis of youths' criminal and violent behaviors with the correction of sample attrition has applied to examine the impact of sample attrition in a panel study. The results demonstrate that attrition sample in 7-wave panel study has a significant difference in criminal and violent behavior and stressors from parents and school at wave 1. Both data collection methods and adolescents' high school and college transitions affect the likelihood of individual attrition in TYPS. Missing report on either parent's education also increase the probability of dropping out of panel study. Attrition exerted a greater impact upon youths' violent behaviors than criminal behaviors in a hypothetical example using panel data of TYPS.

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Panel studies, in which the same respondents are interviewed repeatedly at different points of time, are widely used in the Economics, Health, Political, and Social Science in the U.S. and European Countries. Only until recent decade, several panel studies have been conducted in the social science field in Taiwan, such as Taipei Youth Panel Study (TYPS), Taiwan Youth Project (TYP), family dynamic panel study, and education panel study, etc. In the youth study, panel study is so important for understanding the development of educational progress and occupational process and for identifying factors which influence deviance behavior and depression. When conducting panel research, a common problem is the loss of sample members between the first wave of data collection and subsequent waves due to inability to locate or refuse to response, and it results in having incomplete data records. In other words, sample attrition is a common problem in a panel study. Sample attrition or loss to follow-up, however, leads to a potential threat to the external and internal validity of panel studies if the research discards the respondents with incomplete records. Besides, the characteristics of completed sample may be significantly different from those of the proposed population.

Typically, literature on the attrition bias or selective bias takes two forms. In the first form, sample attrition is viewed as a threat of external validity and internal validity (Aneshensel 1989; Miller and Wright 1995; Berk 1995; Lucas 1996; Yang 1994). The

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main focus of this form is that how sample attrition develops intuition about the cause, size, and direction of selectivity effects in a panel study. In the second view, the main concern centers on what selection correction can be applied to model estimation if the potential selectivity bias has been identified (Heckman 1979; Fitzmaurice et al. 1996; Brown 1990; Diggle et al. 1994; Gray et al. 1996; Hughes 1997; Braver and Bay 1992; Winship and Mare 1992; Stolzenberg and Relles 1997; Hirano et al. 2001; Berk 1995).

Although attrition bias in the panel study has been examined intensively, the findings about attrition bias are inconclusive in the literature. Nevertheless, it has received little attention in the sociological research here in Taiwan due to lack of panel data in the past. Indeed, few local researchers address this issue when reporting the results of their analysis of panel data. Up to date, several panel data sets in the field of social science have been available for local researchers in Taiwan and this has made this issue be more important. Therefore, by using the available panel data sets in Taiwan, this paper attempts to provide the sample attrition problems and to explore the causes of sample attrition in a local panel study in one hand. It also assesses how the attrition correction influences the finding of a hypothetical research interest regarding criminal and violent behavior of Taiwanese adolescents in a seven-wave panel study.

With regard to sample attrition bias or selective bias, most research used only two-wave panel data sets although they may have a larger time interval. The larger the time interval between two-wave surveys, the more confounding factors contributing to its sample attrition. This study has an advantage to use seven-wave panel data in which they are collected annually. While most panel studies maintained the same data collection method, TYPS applied different data collection method to the panel survey due to research costs. During study period, adolescents in TYPS experienced two big

life transitions, high school entrance examination and college entrance examination. The outcomes of these two transition examination influence the academic achievement and occupational trajectories of adolescent and also affect the perception of psychological well-being which may further lead to different motivation or feel uncomfortable to participate in interviews. It is worth detecting how these important life transitions of adolescents influence their participation in TYPS. In addition, even though the approach of changing data collection method has met much challenges and criticism, it provides a great chance to examine how different data collection method relates to sample attrition in a panel study which is not intensively evaluated yet.

Methods

SAMPLE

The data used here are taken from the Taipei Youth Panel Study (TYPS), started to implement in 1996 by the Institute of Sociology, Academia Sinica. The first wave of TYS started to interview 1,434 adolescents aged around 13 who were in the seventh grade year of randomly sampled 33 junior high schools in Taiwan City. The annual survey was administrated in adolescents' schools in the first three-wave surveys, followed by the telephone survey to adolescent's home at wave four, six and seven. The self-administrated questionnaire approach had been applied at wave five. The TYS has collected the valuable and comprehensive information about adolescent's family background, school life, friendship networks, self-esteem, deviance behavior, stress life events, and distress, etc. This study utilized TYS data sets from the first wave, when the adolescents were about 13 years old, to the seventh wave, when the respondents were around 19 years old.

PROCEDURES

MEASUREMENTS AND ANALYSIS

The primary dependent variable was whether the adolescent was re-interviewed at each of the following wave. In the analysis, the respondents have been classified to two subsamples, named complete sample and attrition sample. Complete sample refers to the youths participating in interviews of different waves in TYPS. And, attrition sample consists of the adolescents who only participated in the first interview and dropped out of the interviews during the later surveys.

Two sets of independent variables measured at wave 1 were examined: (1) background variables, which are residence area, gender, and school quality of adolescents, and family characteristics, including parents' education and family structure which indicates if the family is non-intact family; and (2) attitude and behavioral variables of adolescent at the time 1 interview, which may influence the participation of sequential-wave surveys. They include self-esteem, deviance behavior, stress life events from parents, school, sibling, friends, and others, and five measures of depression. Adolescent's residence area also reflects his/her school district of junior high school. Self-esteem continues to be one of the most commonly researched concepts in social psychology. Self-esteem refers most generally to an individual's overall positive evaluation of the self. The researchers have argued that self-esteem is a multidimensional concept rather than uni-dimensional concept. Following this theoretical argument, self-esteem in this study has divided four distinct dimensions: self-worth, self-efficacy, self-deprecation, and self-control. Self-worth, a positive components of self-esteem, measures not only the degree to which one is self-assured in one's capacities, but also the degree to which one believe in one's moral worth or virtue (Owns 1994:933). Self-deprecation is the self-critical and negative part of self-esteem and measures the degree to which an individual disparages his or her worth and efficacy. According to Cast and Burke (2002:1047), self-efficacy, a measure of efficacy-based self-esteem, results from the 'successful' behavior which one reflects on his or her behavior and observe that he or she has been successful at maintaining a match between situational meanings and identity standards. Self-control refers to one's ability to regulate his conduct and to inhibit actions. If one never learned to control his immediate impulses, he would constantly be at odds with other people for violating their rights, breaking rules, and failing to display the patience and self-sacrifice that permit him to achieve important long-range objectives (Shaffer

1999:445). Self-esteem, either on global measures or on specific dimensional measures, has intensively been used to examine the link with youth problems, such as grades, depression, and delinquency (Owens 1994:394-396). Therefore, the concept of self-esteem with four-dimension measures is used to be a potential predictor of youth's criminal and violent behaviors.

Adolescent's deviance behaviors are categorized to three types, deviant behavior, criminal behavior, and violent behavior. Adolescent's stress life events are also grouped into six types: stressors from parents, stressors of self, stressors from siblings, stressors from school, stressors from friends, and stressors from others. Each type of stress is measured by summing the number of events which occur to adolescent in the past year. Adolescent's distress, originally includes 47 symptom measures, is divided into 5 subscales based on the dimensions of the concept of distress: somatization, depression, anxiety, hostility, and additional symptoms. As a measure of dimension of distress, respondents were asked whether they had the symptom of each distress item and in what degree with five ordinal scaling from no (score 1) to very often (score 5). A scale was created by summing the score of items in each dimension, and high score indicates a greater level of distress in that dimension. The detailed measurement items of the above concepts are referred to Appendix Table A1.

Discrete-time regression models of event history analysis was used to examine whether the school transitions in terms of high school and college transitions influence sample attrition, to evaluate if the different data collection methods affect sample attrition, and to analyze the effects of the background, attitude, and behavior variables on the probability of sample attrition. Finally, the regression models of adolescent's deviance behavior with the correction of sample selection effect, including Lambda in Hackman's terminology, are applied to assess how the model

parameter estimators are influenced by the selected sample only with the complete sample in a panel study. In other words, it attempts to answer how the selected sample in a panel study influences the results of interested issue, adolescent's deviance behaviors here. Due to the characteristics of repeat participation in TYPS surveys, it is so important to include the number of previous attritions as a control variable in discrete-time regression models of event history analysis. The person-year data set has been re-created for this analysis.

Results

SAMPLE ATTRITION IN SEVEN-WAVE SURVEYS

The profile of sample attrition in TYS from wave 1 to wave 7 is presented in Table 1. As shown in the Table 1, original number of adolescents interviewed at wave 1 was 1434 and respondents gradually drop to 755 at wave 7 across the study process. The cumulative attrition rate during these seven-wave surveys is around 47%, which is about the similar degree of attrition level with the studies conducted in the U.S. For school-based studies of Adolescents, attrition rates range between 18% and 56% (Josephson and Rosen 1978; Aneshensel et al. 1989). The cumulative attrition rate of TYS was less than 10% before the respondents transferred to high school. There was a significant jump in attrition rate when adolescents entered to high school period. The first three waves of the study were conducted in the schools that adolescents studied. However, they went to the different high schools which depend on respondent's score of entrance exam for high school. Basically, this high school transition may lead to the difficulty in contacting respondents in this period. The sample was steadily decreased over high school and college periods. Besides, the data collection had been changed to telephone survey at wave 4, 6, and 7, and to self-administered questionnaire at wave 5.

It is important to keep in mind, however, that sample attrition in panel survey in ubiquitous and rarely random (Aneshensel et al. 1989:549). To exam whether and if so how the attrition sample differs from the retention sample in terms of backgrounds and attitude and behaviors changed over survey time, the t-test results of comparing means between attrition sample and retention sample (also complete sample) by

different waves are shown in Table 2. The t-test results by different waves are particularly interesting. Only the difference in criminal behavior of adolescents between attrition sample and retention sample was found as early as wave 3 and has shown the steadily significant difference across study points of time.

In addition, the adolescents' violent behavior, their stressors from parents and from school at wave 1 were also found a significant difference between attrition sample and retention sample in the later study periods. Except for criminal or violent behavior and stressors from parents as well as from school, all individual and family backgrounds, self-esteem measures, other types of stressors, and distress or depression of adolescents of attrition sample do not show any difference from those of retention sample across survey time. The attrition sample had a higher tendency to report criminal and violent behavior at wave 1 than its counterparts. The attrition sample also reported more stressors from parents or from school at wave 1 than retention sample. Due to this partial selectivity of attrition sample, the use of retention (or complete) sample for further analysis on some interested issue is expected to lead to selection bias.

Before examining the effect of sample attrition on the results of interested issue, it is necessary to assess the determinants of respondent's attrition probability in the different wave comparison. Logistic regression estimates of individual attrition have shown in Table 3 and Table 4. Not surprising, the criminal behavior, violent behavior, and stressors from parents at wave 1 are shown to be the best predictors of participating in different waves of surveys in at later periods. The higher the reported criminal behavior, violent behavior, or stressors from parents at wave 1, the higher the likelihood to lose in the later surveys. Furthermore, no individual and family

backgrounds and distress characteristics at wave 1 are capable of predicting the possibility of individual attrition. These are the consistent findings as those in the mean comparison shown in the Table 2.

Further, it is worth examining the effect of school transition and survey methods on the possibility of individual attrition of TYPS. The estimators of discrete time regression models of event history analysis are presented in Table 5. Holding other variables constant, the estimators of different models consistently indicate that both high school transition and college transition have significant effects on the possibility of individual attrition in terms of hazard rate of attrition. That is, adolescents in the high school and college periods have a higher possibility to be reconnected in the later waves of surveys of TYPS. Furthermore, data collection with telephone survey or self-administered survey in TYPS is more likelihood to lose adolescent respondents owing to either inability to locate or contact adolescents or refusal of response.

It is also found that the number of previous attritions does have a significant effect on the participation in the following interviews. As expected, after controlling for the other variables, the more frequencies of not participating in the interviews, the higher the possibility of dropping out of the next survey in TYPS. While the education of parents has no impact on the hazard of attrition, the missing report on father's or mother's education at wave 1 displays a positive effect on the hazard of attrition in the later wave survey. In other words, it indicates that adolescents who report missing data on either parent's education at the first interview are more likely to drop out of the later waves of survey.

Our results are consistent with our claim that school transitions and survey methods

significantly influence the possibility of individual attrition. It is worth noting that the number of prior attritions is a significant predictor of the participation of next survey. And, we believe that missing report on parent's education by the adolescent at the beginning of a panel study reflects more possibility to be not re-contacted in the following survey. Therefore, there are clear effects of school transitions, data collection methods, and the number of previous attrition on the likelihood of participating in the following interview of TYPS.

If a particular pattern of selection dominates the sample attrition in a panel study, then this selective sample might have greater influence in shaping findings in a specific research issue. To shed light on this selection bias, two hypothetical examples of adolescent's criminal behaviors and violent behaviors are proposed to provide the evidences of attrition influence. We here model individual criminal behaviors and violent behaviors separately on a set of potential predictors using the strategy of comparing the estimates in model with the correction for sample attrition in terms of Lambda Value and those without the correction. Those proposed potential predictors for the models include school area, gender, parents' education, attend school, happiness, three dimensions of self-esteem, including self-worth, self-efficacy, and self-deprecation, stressors of self and from others, and distress measures. Looking at the model 1 and 2, the patterns of significant coefficient showed a similar type between the model taking sample attrition effect into account and the model without considering the attrition correction. However, turning to model 3 and 4, the significant parameters in the model without correction (model 3) became all insignificant in the model with the sample attrition correction (model 4).

Substantively, these findings suggest that even taking the sample attrition effect into

account, the corrected estimates need not reach the parallel conclusions, instead showing different effect of sample attrition on estimators in different research issues. This finding is controversial to Hughes' (1997). Examining the relationship between political democracy and income inequality, Hughes also applied Heckman's two-step correction procedure to three studies and found that even when statistically significant bias exists, coefficient estimates for political democracy are affected. Apparently, whether sample selection bias or attrition bias does matter in a pane study is not consistent.

Conclusions

In this paper, the findings from using complete sample in TYPS, nonrandomly selective sample, to estimate predictors' effect of adolescent deviance behaviors are discussed with Heckman's correction approach for the selective bias. As a concluding remark, we believe it is essential that the researchers attempt to convey the generalization of sample attrition in a panel study. However, this research findings based on the selective sample in a panel study seem hard to generalize to the targeted population. It is worth noting that the influential direction and size of sample attrition seem to be inconsistent in different panel data sets. Nevertheless, it does not imply that sample attrition problem can totally be neglected. In fact, sample attrition is substantively important issue in a panel study and its effect depends on both panel data per se and research issue interested. Further research should determine if the finding of this study holds true for other panel studies as well.

Table 1: The Characteristics of Seven-wave Surveys and Their Sample Attrition

	Wave of survey						
Characteristics	Wave1	Wave2	Wave3	Wave4	Wave5	Wave6	Wave7
School year of students	Grade7	Grade8	Grade9	Grade10	Grade11	Grade12	College
Year of survey	1996	1997	1998	1999	2000	2001	2002
Complete Sample size	**1434**	**1354**	**1300**	**1101**	**924**	**847**	**755**
Data collection method	Face to face	Face to face	Face to face	Telephone	Self administered questionnaire	Telephone	Telephone
Attrition cases of survey year	-	80	54	199	177	77	92
Male	-	36	26	102	86	44	53
Female	-	44	28	97	91	33	39
Cumulative attrition cases	-	**80**	**134**	**333**	**510**	**587**	**679**
Male	-	36	62	164	250	294	347
Female	-	44	72	169	260	293	332
% of attrition based on sample of previous wave	-	5.58	3.99	15.31	16.08	8.33	10.86
Male	-	2.51	1.92	7.85	7.81	4.76	6.26
Female	-	3.07	2.07	7.46	8.27	3.57	4.60
% of cumulative attrition cases of original sample	-	**5.58**	**9.43**	**23.22**	**35.56**	**40.93**	**47.36**
Male	-	2.51	4.32	11.44	17.43	20.50	24.21
Female	-	3.07	5.02	11.78	18.13	20.43	23.15

Table 2: Descriptive Statistics of Complete Sample and Attrition Sample (N=990)

	Wave1→Wave2					Wave1→Wave3				
	Complete Sample		Attrition Sample			Complete Sample		Attrition Sample		
Independent variables	Mean	S.E	Mean	S.E	t-value	Mean	S.E	Mean	S.E	t-value
New city area	0.133	0.340	0.071	0.262	-0.951	0.132	0.339	0.115	0.321	-0.395
Old city area	0.419	0.494	0.500	0.509	0.856	0.417	0.493	0.492	0.504	1.152
Gender	0.508	0.500	0.500	0.509	-0.087	0.510	0.500	0.475	0.504	-0.526
Good School	0.495	0.500	0.429	0.504	-0.690	0.492	0.500	0.508	0.504	0.246
Father's education	3.216	1.447	3.214	1.548	-0.007	3.200	1.448	3.459	1.456	1.351
Mother's education	2.826	1.342	2.750	1.323	-0.297	2.814	1.343	2.984	1.310	0.958
Non-intact Family	0.054	0.226	0.036	0.189	-0.425	0.054	0.226	0.049	0.218	-0.156
Self-worth	16.298	4.637	16.750	5.352	0.506	16.313	4.628	16.279	5.113	-0.056
Self-efficacy	14.945	3.701	14.214	4.500	-1.023	14.956	3.668	14.443	4.519	-0.869
Self-deprecation	13.334	3.341	12.679	3.591	-1.021	13.349	3.328	12.803	3.637	-1.233
Self-control	4.016	1.050	4.107	0.875	0.457	4.011	1.046	4.131	1.024	0.872
Deviant behavior	0.083	0.325	0.214	0.630	1.097	0.082	0.321	0.164	0.522	1.213
Criminal behavior	0.193	0.555	0.786	1.686	1.857	0.185	0.498	0.590	1.542	2.044*
Violent behavior	0.693	1.093	0.929	1.412	0.874	0.687	1.074	0.902	1.480	1.115
Stressors from parents	0.384	0.708	0.393	0.737	0.068	0.370	0.691	0.590	0.920	1.834
Stressors of self	0.923	0.930	1.179	1.335	0.066	0.915	0.911	1.164	1.331	1.439
Stressors from siblings	0.122	0.401	0.143	0.448	1.006	0.122	0.401	0.131	0.427	0.179
Stressors from school	0.640	0.752	0.786	0.833	0.275	0.637	0.745	0.754	0.888	1.005
Stressor from friends	0.635	0.760	0.679	0.905	1.005	0.640	0.761	0.574	0.805	-0.660
Stressors from others	0.375	0.598	0.393	0.567	0.296	0.372	0.592	0.426	0.670	0.682
Somatization	5.104	6.372	3.429	4.598	0.154	5.069	6.338	4.869	6.299	-0.239
Depression	5.949	8.017	5.607	6.226	-1.876	5.897	7.895	6.590	9.076	0.658
Anxiety	5.520	6.359	5.036	4.978	-0.224	5.510	6.354	5.443	5.861	-0.081
Hostility	3.264	3.649	3.107	3.814	-0.399	3.242	3.505	3.525	5.458	0.399
Addition symptoms	3.523	4.337	3.964	4.655	-0.224	3.488	4.253	4.262	5.546	1.070
Cases	962		28			929		61		

***P< 0.001; ** P < 0.01; * P< 0.05.

Table 2: (Continued)

	Wave1→Wave4					Wave1→Wave5				
	Complete Sample		Attrition Sample			Complete Sample		Attrition Sample		
Independent variables	Mean	S.E	Mean	S.E	t-value	Mean	S.E	Mean	S.E	t-value
New city area	0.133	0.340	0.122	0.329	-0.404	0.137	0.344	0.117	0.322	-0.847
Old city area	0.410	0.492	0.468	0.500	1.446	0.416	0.493	0.433	0.496	0.488
Gender	0.509	0.500	0.505	0.501	-0.084	0.510	0.500	0.503	0.501	-0.195
Good School	0.499	0.500	0.468	0.500	-0.756	0.497	0.500	0.483	0.501	-0.401
Father's education	3.200	1.447	3.287	1.460	0.747	3.246	1.439	3.148	1.474	-0.976
Mother's education	2.803	1.337	2.915	1.361	1.030	2.832	1.331	2.805	1.367	-0.290
Non-intact Family	0.050	0.218	0.069	0.254	0.960	0.052	0.222	0.057	0.232	0.322
Self-worth	16.228	4.659	16.665	4.645	1.158	16.263	4.623	16.423	4.739	0.495
Self-efficacy	15.004	3.680	14.585	3.905	-1.387	15.040	3.664	14.654	3.858	-1.497
Self-deprecation	13.352	3.365	13.160	3.280	-0.708	13.377	3.355	13.171	3.333	-0.888
Self-control	3.993	1.052	4.128	1.010	1.597	4.033	1.049	3.983	1.036	-0.691
Deviant behavior	0.080	0.322	0.117	0.397	1.198	0.079	0.324	0.104	0.366	1.001
Criminal behavior	0.176	0.480	0.356	1.016	2.375 *	0.169	0.477	0.305	0.863	2.563*
Violent behavior	0.667	1.046	0.840	1.315	1.687	0.636	1.028	0.849	1.250	2.590*
Stressors from parents	0.353	0.683	0.516	0.798	2.590*	0.329	0.671	0.510	0.775	3.497**
Stressors of self	0.904	0.899	1.043	1.108	1.596	0.900	0.897	1.000	1.041	1.439
Stressors from siblings	0.113	0.388	0.160	0.458	1.277	0.110	0.387	0.151	0.435	1.411
Stressors from school	0.637	0.757	0.676	0.743	0.628	0.633	0.750	0.671	0.765	0.731
Stressor from friends	0.627	0.757	0.676	0.792	0.781	0.627	0.743	0.658	0.810	0.577
Stressors from others	0.382	0.599	0.351	0.589	-0.630	0.373	0.587	0.383	0.621	0.235
Somatization	5.062	6.343	5.032	6.305	-0.059	5.045	6.468	5.084	6.017	0.089
Depression	5.945	7.936	5.915	8.133	-0.047	5.834	7.960	6.185	8.001	0.635
Anxiety	5.592	6.515	5.138	5.423	-0.992	5.616	6.669	5.252	5.434	-0.900
Hostility	3.237	3.494	3.356	4.271	0.357	3.244	3.550	3.295	3.885	0.202
Addition symptoms	3.489	4.236	3.734	4.787	0.646	3.522	4.335	3.567	4.375	0.151
Cases	802		188			692		298		

***P< 0.001; ** P < 0.01; * P< 0.05.

Table 2: (Continued)

	Wave1→Wave6					Wave1→Wave7				
	Complete Sample		Attrition Sample							
Independent variables	Mean	S.E	Mean	S.E	t-value	Mean	S.E	Mean	S.E	t-value
New city area	0.131	0.338	0.132	0.339	0.049	0.127	0.333	0.137	0.345	0.492
Old city area	0.420	0.494	0.424	0.495	0.140	0.410	0.492	0.436	0.496	0.813
Gender	0.506	0.500	0.511	0.501	0.149	0.504	0.500	0.514	0.500	0.333
Good School	0.497	0.500	0.486	0.501	-0.329	0.504	0.500	0.479	0.500	-0.773
Father's education	3.257	1.429	3.143	1.484	-1.186	3.259	1.422	3.159	1.485	-1.074
Mother's education	2.850	1.335	2.778	1.353	-0.811	2.854	1.322	2.784	1.368	-0.806
Non-intact Family	0.054	0.225	0.053	0.225	-0.017	0.049	0.217	0.059	0.236	0.687
Self-worth	16.200	4.671	16.508	4.631	0.999	16.160	4.708	16.514	4.584	1.183
Self-efficacy	15.017	3.680	14.758	3.806	-1.049	15.019	3.760	14.796	3.680	-0.932
Self-deprecation	13.454	3.331	13.067	3.369	-1.746	13.433	3.359	13.156	3.331	-1.286
Self-control	4.024	1.037	4.008	1.060	-0.220	4.058	1.042	3.964	1.048	-1.395
Deviant behavior	0.074	0.301	0.110	0.393	1.475	0.069	0.286	0.111	0.395	1.884
Criminal behavior	0.156	0.408	0.306	0.875	3.055**	0.157	0.414	0.282	0.818	2.886**
Violent behavior	0.609	0.986	0.862	1.272	3.252**	0.604	0.981	0.829	1.238	3.089**
Stressors from parents	0.323	0.644	0.492	0.800	3.398***	0.317	0.644	0.474	0.779	3.374** *
Stressors of self	0.891	0.885	1.000	1.037	1.668	0.887	0.900	0.988	0.998	1.639
Stressors from siblings	0.103	0.369	0.157	0.454	1.944	0.104	0.373	0.147	0.438	1.627
Stressors from school	0.609	0.732	0.708	0.790	1.985*	0.600	0.725	0.704	0.789	2.137*
Stressor from friends	0.610	0.716	0.683	0.841	1.365	0.604	0.715	0.680	0.824	1.522
Stressors from others	0.375	0.593	0.376	0.604	0.026	0.380	0.600	0.370	0.594	-0.277
Somatization	4.872	6.292	5.385	6.401	1.222	4.982	6.426	5.156	6.212	0.427
Depression	5.653	7.781	6.449	8.282	1.510	5.704	7.868	6.256	8.103	1.077
Anxiety	5.513	6.619	5.494	5.766	-0.045	5.597	6.703	5.384	5.777	-0.535
Hostility	3.215	3.559	3.340	3.816	0.518	3.245	3.565	3.280	3.770	0.149
Addition symptoms	3.461	4.299	3.669	4.428	0.723	3.421	4.315	3.690	4.385	0.963
Cases	634		356			568		422		

***P< 0.001; ** P < 0.01; * P< 0.05.

Table 3: Logistic Regression Estimates of Sample Attrition on Individual Background, N=1289

Independent variables	Wave1→Wave2			Wave1→Wave3			Wave1→Wave4		
	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio
Intercept	-3.0868***	0.4543		-3.0761***	0.3553		-1.4790***	0.2118	
New city area	-0.7827	0.6397	0.457	0.0452	0.3852	1.046	-0.0570	0.2317	0.945
Old city area	0.1369	0.3220	1.147	0.1203	0.2406	1.128	0.1028	0.1499	1.108
Gender	-0.1375	0.3085	0.872	-0.1377	0.2247	0.871	-0.0772	0.1393	0.926
Good School	-0.3847	0.3280	0.681	-0.1127	0.2371	0.893	-0.1389	0.1467	0.87
Father's education	0.0930	0.1657	1.097	0.1004	0.1214	1.106	0.0283	0.0746	1.029
Mother's education	-0.0964	0.1800	0.908	0.0582	0.1303	1.06	0.0210	0.0807	1.021
Non-intact Family	-1.0171	1.0228	0.362	-0.1960	0.5306	0.822	0.2573	0.2832	1.293
Attritions cases	44			86			261		
Model L^2	5.271			4.213			3.440		

*** p< 0.001. ** p< 0.01. *p< 0.05.

Table 3: (Continued)

Independent variables	Wave1→Wave5			Wave1→Wave6			Wave1→Wave7		
	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio
Intercept	-0.5524**	0.1799		-0.3360	0.1739		-0.1513	0.1702	
New city area	-0.2005	0.1980	0.818	-0.0838	0.1878	0.92	0.0828	0.1823	1.086
Old city area	0.0351	0.1293	1.036	0.0442	0.1247	1.045	0.1258	0.1218	1.134
Gender	-0.1196	0.1199	0.887	-0.0630	0.1153	0.939	0.0094	0.1125	1.009
Good School	-0.0945	0.1259	0.91	-0.0491	0.1210	0.952	-0.0661	0.1181	0.936
Father's education	-0.0370	0.0642	0.964	-0.0164	0.0617	0.984	-0.0033	0.0602	0.997
Mother's education	0.0042	0.0697	1.004	-0.0311	0.0670	0.969	-0.0457	0.0654	0.955
Non-intact Family	0.1966	0.2519	1.217	0.1649	0.2452	1.179	0.2090	0.2418	1.232
Attrition cases	413			486			571		
Model L^2	4.112			2.554			4.265		

*** p< 0.001. ** p< 0.01. *p< 0.05.

Table 4: Logistic Regression Estimates of Sample Attrition on Individual Background, Attitude and Behavioral Measures, N=990

	Wave1→Wave2			Wave1→Wave3			Wave1→Wave4		
Independent variables	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio
Intercept	-1.2226	1.9997		-2.0043	1.3759		-2.1772**	0.8259	
New city area	-0.9068	0.8147	0.404	0.0887	0.4760	1.093	0.0498	0.2796	1.051
Old city area	-0.0308	0.4324	0.970	0.1660	0.3011	1.181	0.1517	0.1823	1.164
Gender	-0.2581	0.4332	0.772	-0.3331	0.2951	0.717	-0.1305	0.1789	0.878
Good School	-0.3474	0.4308	0.707	-0.0329	0.2953	0.968	-0.1311	0.1765	0.877
Father's education	0.0737	0.2168	1.077	0.1643	0.1505	1.179	0.0214	0.0914	1.022
Mother's education	-0.0911	0.2300	0.913	-0.0250	0.1592	0.975	0.0804	0.0984	1.084
Non-tact Family	-0.3519	1.1139	0.703	-0.6133	0.7031	0.542	0.1677	0.3770	1.183
Self-worth	-0.0207	0.0494	0.980	-0.0335	0.0342	0.967	0.0177	0.0204	1.018
Self-efficacy	-0.0722	0.0610	0.930	-0.0413	0.0412	0.960	-0.0445	0.0253	0.956
Self-deprecation	-0.0643	0.0738	0.938	-0.0499	0.0503	0.951	-0.0007	0.0312	0.999
Self-control	0.1079	0.2223	1.114	0.1483	0.1476	1.160	0.1916*	0.0890	1.211
Deviant behavior	-0.2503	0.7066	0.779	-0.0873	0.4371	0.916	-0.0627	0.2705	0.939
Criminal behavior	0.9240**	0.3117	2.519	0.6122**	0.2139	1.845	0.3451*	0.1520	1.412
Violent behavior	-0.1113	0.2446	0.895	0.0092	0.1557	1.009	0.0764	0.0925	1.079
Stressors from parents	-0.0365	0.3327	0.964	0.3744	0.1942	1.454	0.2871*	0.1292	1.333
Stressors of self	0.0511	0.2384	1.052	0.0555	0.1585	1.057	0.0394	0.0959	1.040
Stressors from siblings	-0.5509	0.5962	0.576	-0.2331	0.3796	0.792	0.1857	0.2028	1.204
Stressors from school	0.2010	0.2873	1.223	0.0911	0.1953	1.095	-0.0466	0.1228	0.954
Stressor from friends	0.1170	0.2829	1.124	-0.2166	0.1994	0.805	0.0526	0.1145	1.054
Stressors from others	-0.0451	0.3476	0.956	0.0463	0.2287	1.047	-0.2397	0.1509	0.787
Somatization	-0.1159	0.0596	0.891	-0.0252	0.0333	0.975	0.0039	0.0196	1.004
Depression	-0.0041	0.0467	0.996	0.0011	0.0286	1.001	-0.0082	0.0184	0.992
Anxiety	0.0107	0.0519	1.011	-0.0218	0.0367	0.978	-0.0340	0.0236	0.967
Hostility	-0.1421	0.0884	0.868	-0.0590	0.0559	0.943	-0.0118	0.0332	0.988
Addition symptoms	0.0939	0.0662	1.099	0.0570	0.0457	1.059	0.0238	0.0292	1.024
Attritions cases	28			61			188		
Model L^2	26.098			31.557			36.268		

*** p< 0.001. ** p< 0.01. *p< 0.05.

Table 4: (Continued)

	Wave1→Wave5			Wave1→Wave6			Wave1→Wave7		
Independent variables	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio	Estimate	S.E.	Odds ratio
Intercept	-0.0724	0.6921		-0.3197	0.6647		-0.1207	0.6449	
New area	-0.2529	0.2385	0.777	-0.0231	0.2239	0.977	0.0850	0.2162	1.089
Old area	0.0285	0.1558	1.029	0.0437	0.1501	1.045	0.1450	0.1454	1.156
Gender	-0.1704	0.1524	0.843	-0.0939	0.1458	0.910	-0.0640	0.1410	0.938
Good School	-0.0306	0.1500	0.970	0.0265	0.1437	1.027	-0.0208	0.1390	0.979
Father's education	-0.0699	0.0783	0.932	-0.0398	0.0749	0.961	-0.0217	0.0724	0.978
Mother's education	0.0516	0.0846	1.053	0.0091	0.0810	1.009	0.0060	0.0784	1.006
Non-intact Family	-0.2784	0.3430	0.757	-0.3878	0.3325	0.679	-0.1262	0.3153	0.881
Self-worth	-0.0057	0.0175	0.994	-0.0046	0.0168	0.995	0.0044	0.0163	1.004
Self-efficacy	-0.0298	0.0214	0.971	-0.0091	0.0206	0.991	-0.0102	0.0200	0.990
Self-deprecation	-0.0061	0.0264	0.994	-0.0246	0.0253	0.976	-0.0048	0.0245	0.995
Self-control	0.0027	0.0722	1.003	0.0607	0.0698	1.063	-0.0345	0.0673	0.966
Deviant behavior	-0.1270	0.2341	0.881	-0.0540	0.2265	0.947	0.0625	0.2199	1.065
Criminal behavior	0.2688	0.1380	1.308	0.3212*	0.1418	1.379	0.2393	0.1390	1.270
Violent behavior	0.1571*	0.0788	1.170	0.1669*	0.0765	1.182	0.1428	0.0752	1.154
Stressors from parents	0.3724**	0.1151	1.451	0.3047**	0.1133	1.356	0.2688*	0.1121	1.308
Stressors of self	0.0071	0.0834	1.007	0.0063	0.0802	1.006	0.0055	0.0782	1.005
Stressors from siblings	0.0397	0.1799	1.040	0.1153	0.1751	1.122	0.0621	0.1745	1.064
Stressors from school	-0.0453	0.1049	0.956	0.0596	0.1005	1.061	0.0939	0.0981	1.098
Stressor from friends	-0.0226	0.0987	0.978	0.0519	0.0946	1.053	0.0706	0.0924	1.073
Stressors from others	-0.0789	0.1255	0.924	-0.1437	0.1210	0.866	-0.1541	0.1172	0.857
Somatization	0.0077	0.0169	1.008	0.0221	0.0160	1.022	0.0073	0.0155	1.007
Depression	0.0153	0.0155	1.015	0.0223	0.0148	1.023	0.0180	0.0145	1.018
Anxiety	-0.0350	0.0201	0.966	-0.0326	0.0191	0.968	-0.0342	0.0185	0.966
Hostility	-0.0360	0.0284	0.965	-0.0477	0.0275	0.953	-0.0511	0.0266	0.950
Addition symptoms	-0.0080	0.0257	0.992	-0.0225	0.0245	0.978	0.0070	0.0236	1.007
Attritions cases	298			356			422		
Model L^2	35.440			41.551			37.195		

*** p< 0.001. ** p< 0.01. *p< 0.05.

Table 5: Discrete Time Event History Analysis of Sample Attrition from Wave 1 to Wave 7 of TYS, N of Person-year = 10038

Independent variables	Model 1			Model 2			Model 3			Model 4			Model 5			Model 6		
	Estimate	S.E	Odds ratio	Estimate	Stand error	Odds ratio	Estimate	S.E	Odds ratio	Estimate	S.E	Odds ratio	Estimate	Stand error	Odds ratio	Estimate	S.E	Od ra
Intercept	-3.055***	0.072		-3.238***	0.114		-3.421***	0.144		-3.053***	0.072		-3.235***	0.114		-3.424***	0.144	
School Transition																		
High school	1.139***	0.085	3.125	1.168***	0.109	3.217	1.333***	0.113	3.793									
College or University	0.641***	0.116	1.898	0.671***	0.134	1.957	0.892***	0.138	2.440									
Survey Method																		
Telephone										0.909***	0.088	2.482	0.939***	0.112	2.556	1.119***	0.116	3.
Self-administered										1.365***	0.101	3.917	1.394***	0.122	4.029	1.568***	0.126	4.
No. of Previous Attrition	1.957***	0.060	7.079	1.961***	0.060	7.105	1.880***	0.06	6.553	1.927***	0.058	6.868	1.931***	0.059	6.893	1.853***	0.059	6.
New area				0.230*	0.105	1.259	0.204	0.109	1.227				0.230*	0.105	1.259	0.205	0.109	1.
Old area				0.171*	0.073	1.186	0.162*	0.074	1.176				0.172*	0.073	1.188	0.163*	0.074	1.
Gender				0.096	0.068	1.100	0.061	0.069	1.063				0.094	0.068	1.099	0.060	0.069	1.
School				0.059	0.144	1.061	0.074	0.148	1.077				0.059	0.144	1.061	0.074	0.148	1.
Father's education							0.015	0.038	1.015							0.015	0.038	1.
Mother's education							-0.033	0.04	0.968							-0.032	0.040	0.
Missing of father's education							0.727***	0.183	2.069							0.738***	0.183	2.
Missing or mother's education							0.940***	0.190	2.560							0.952***	0.19	2.
Model χ^2	3307.199			3317.049			3480.007			3306.995			3316.86			3484.943		

***p< 0.001. **p< 0.01. *p< 0.05.

Table 6: A Hypothetical Analysis of Criminal or Violet Behavior without and with Attrition Selective Correction

Independent variables	Model 1(criminal) Without Correction		Model 2(criminal) With Correction		Model 3(violent) Without Correction		Model 4(violent) With Correction	
	Estimate	S.E	Estimate	S.E	Estimate	S.E	Estimate	S.E
Intercept	-0.233	0.144	-0.466	0.602	-0.130	0.086	-0.707	0.826
New area	0.023	0.051	0.010	0.064	0.047	0.030	0.015	0.088
Old area	-0.066	0.034	-0.083	0.057	-0.006	0.020	-0.050	0.079
Gender	0.228***	0.032	0.226***	0.034	0.020	0.019	0.016	0.047
Father's education	-0.019	0.016	-0.018	0.018	0.001	0.010	0.002	0.025
Mother's education	0.009	0.018	0.016	0.025	0.010	0.011	0.025	0.035
Attend school	0.014	0.039	0.014	0.039	-0.054*	0.023	-0.053	0.040
Happy life	0.002	0.027	0.002	0.026	-0.006	0.016	-0.006	0.028
Self-worth	0.009	0.011	0.009	0.011	0.003	0.006	0.003	0.011
Self-efficacy	0.014	0.009	0.014	0.009	-0.003	0.005	-0.003	0.009
Self-deprecation	0.011	0.011	0.011	0.011	0.005	0.007	0.005	0.011
Stressors of self	0.117***	0.032	0.116***	0.032	0.032	0.019	0.028	0.033
Stressors from others	0.084**	0.027	0.083*	0.027	0.025	0.016	0.021	0.028
Somatization	-0.012	0.013	-0.012	0.013	0.009	0.008	0.009	0.013
Depression	0.026	0.014	0.025	0.014	0.021*	0.008	0.020	0.014
Addition symptoms	0.041	0.023	0.041	0.023	0.022	0.014	0.021	0.024
Lambda			0.323	0.805			0.797	1.107
R^2	0.130		0.130		0.057		0.062	

N of Substantial Equation =723; N of Selection Equation = 1294.

***p< 0.001. ** p< 0.01. *p< 0.05.

Appendix:

Appendix Table 1: Measurement of Variables in the Study

Variables	Description
New city area Old city area	Jung Jeng, Jung Shan, Da An, ShinYi, and Sung Shan = 1, others = 0. Da Tung, Uan Hua =1, others=0. (Reference Area includes Nei Hu, Nan Gang, Bei Tou, Uen Shan, and ShrLin.)
Gender	Male=1, female=0.
Good School	Good School =1 if % of entering the first three ranks high schools in each sampled school is greater than 10%; else=0.
Father's education Mother's education	Years of education of father at the first wave; if father's education is missing at the first wave, then father's education is substituted by that of the following wave. Primary school=1, junior high=2, senior high=3, college=4, university=5, and graduate school=6. Years of education of father at the first wave; if father's education is missing at the first wave, then father's education is substituted by that of the following wave. Primary school=1, junior high=2, senior high=3, college=4, university=5, and graduate school=6.
Non-intact Family	Parent died or divorced=1, else =0.
Self-esteem (Dimension A) --Self-worth	Do you agree with the following statements regarding yourself? 6. The future is under my effort. 8. I am a useful person.。 9. I have much excellent virtue.。 11. I can do things as good as others do.。 13. I am optimistic about myself. 14. I am satisfied with myself. 16. I hope I am able to respect myself.
Self-esteem (Dimension B) --Self-efficacy	1. I can not solve some personal problems. 2. I can not control what happens to me. 3. I feel incapable to solve some daily problems. 4. I am not a worthy person. 5. I am incapable of solving any problem. 7. I couldn't change many important things of mine.
Self-esteem (Dimension C) --Self-deprecation	10. I am a loser. 12. I don't have much to be proud of. 15. Sometimes I feel like I am useless.

	17. Sometimes I feel that I don't have any desirable quality.
Self-esteem (Dimension D) --Self-control	4. I can do anything that I want to.
Deviant behavior	1. run away from home 5. ditch school 11. get drunk in public
Criminal behavior	2. steal things valued less than NT$500 3. steal things valued more than NT$500 4. get drunk and ride motorcycles 6. steal other's motorcycle or car for sightseeing. 8. appear in court or reprieve. 9. in jail or be detained 10. steal other's purse but do not hurt person. 17. sell illegal drug. 19. be arrested by police. 21. free rider to theater and sports. 22. drive without license and fined 23. over-speed and violate traffic regulation and get ticket.
Violent behavior	7. Hit someone who makes you angry. 12. Purposely destroy or break some things which are not yours. 13. Break in a building for fun or just taking a look. 14. Break in a building to steal or destroy things. 15. Throw a small stone or things to hurt someone. 16. Use arms to attack someone and make him/her seriously injured. 18. Use arms or violence to coerce or extort money from someone. 20. Play with fire and burn some things.
Stressors from parents	9. My parents divorced or separated. 10. My mother bore me a younger brother or sister. 16. My family ran out of money. 17. My parents argue more often. 18. Father or mother was not at home more and more often. 25. Father or mother was seriously ill or injured. 5. My father/mother lost his/her job. 36. My father or mother broke the law.
Stressors of self	1. My family moved to a new place. 2. I started to dating. 15. I started wearing glasses or tooth brace. 21. I was seriously ill or injured. 29. I started drinking. 30. I started taking drug. 33. I ran away from home. 34. I broke the law. 37. I am a victim of violent crime. 39. I argue more often with others. 41. My pet died.
Stressors from siblings	7. My brothers or sisters ran away from home. 13. My brothers or sisters stirred up troubles in school. 14. My brothers or sisters broke the law. 26. My brothers or sisters were seriously ill or injured.

	42. My brothers or sisters died.
Stressors from school	12. My achievement rank in class lay behind. 19. I was drop-out from school. 20. I didn't get along with classmates. 28. I changed school. 31. I stirred up troubles in school. 32. I won't allowed to participate in important school activities (e.g. sports, band, or student organizations).
Stressor from friends	6. My good friend has moved. 7. I broke up a relation with a good friend. 22. My good friend was seriously ill or injured. 23. My good friend has the first sex. 24. My good friend got pregnancy. 40. One of my good friends died.
Stressors from others	11. Someone moved in and lived with my family. 27. My close relative was seriously ill or injured. 38. My family was a victim of violent crime. 43. My close relative passed away.
Somatization	1. Headache 3. Faintness or dizziness 6. Pains in heart or chest 16. Pains in lower back 23. Nausea or upset stomach 24. Soreness of muscles 26. Trouble getting your breath 27. Hot or cold spells 28. Numbness or tingling in parts of the body. 29. Lump in your throat. 31. Feeling weak in parts of the body. 33. Heavy feeling in your arms of legs
Depression	7. Feeling low in energy or slowed down 8. Thoughts of ending your life 11. Crying easily 12. Feelings of being trapped or caught 15. Blaming yourself for things 17. Feeling lonely 18. Feeling blue 19. Worrying too much about things 20. Feeling no interest in things 30. Feeling hopeless about the future 40. Feeling everything is an effort 44. Feeling myself valueless
Anxiety	2. Nervousness or shaking inside 7. Trembling 13. Suddenly scared for no reason 21. Feeling fearful 22. Heart pounding or racing 32. Feeling tense of keyed up 41. Spells of terror or panic 43. Feeling so restless you couldn't sit still 45. The feeling that something bad is going to happen to you 47. Thoughts or images of a frightening nature
Hostility	5. Feeling easily annoyed or ittitated

	14. Temper outbursts that you could not control 36. Having urges to beat, injure or harm someone 39. Having urges to break or smash things 42. Getting into frequent arguments 46. Shouting or throwing things
Addition symptoms	4. Feeling of something wrong in brain 10. Poor appetite 25. Trouble falling asleep 34. Thoughts of death or dying 35. Overeating 37. Awakening in the early morning 38. Sleep that is restless or disturbed 48. Feeling of guilt

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