

# **Life Course and Cohort Impacts of Education on Depression in Taiwan\***

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## **ABSTRACT**

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A growing body of literature has demonstrated that the impacts of education on physical health vary across the life course and across birth cohorts in Western societies. However, since aging effects and cohort effects are difficult to disentangle empirically, most previous studies have estimated one effect while ignoring the other. In addition, whether the temporal impacts of education can be extended to depression and whether they exist in non-Western societies are much less known. Thus, this study is conducted to elucidate the patterns between education and depression across the life course and across cohorts in Taiwan, by

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using age-cohort regression models on the sequential cross-sectional data pooled from the *Taiwan Social Change Survey* and using latent growth curve models on the longitudinal data obtained from the 1989–2003 *Survey of Health and Living Status of the Elderly in Taiwan*. The main findings are: (1) both approaches consistently indicate a favorable direction of life-course relationship in depression for the well educated within the same cohort. Thus, the age-specific rates of change in depression differ across levels of education in a manner that progressively enlarges the gap in late life, supporting *the cumulative advantage hypothesis*; (2) the education-based difference in depression is larger and appears earlier for younger cohorts, which is consistent with *the rising importance hypothesis*; and (3) evidence for *the age-as-lever hypothesis* appears in the TSCS analyses, but is limited in the latent growth analyses obtained from the elderly panels. The cross-sectional analyses are affected by selective mortality. Thus, the convergence of depression by levels of education in late life may be illusory.

**Keywords:** Education, Depression, Aging, Cohort

## 教育對憂鬱作用的生命歷程和世代模式

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### 摘要

本文以累積優勢論、老化槓桿論和世代重要論等三種視角，來剖析教育對憂鬱作用的跨生命歷程和跨世代模式。藉由年齡世代迴歸模型分析「台灣社會變遷基本調查：1990、1995、2000、2005」和潛在成長模型探究「台灣中老年身心社會生活狀況長期追蹤調查：1989、1993、1996、1999、2003」，本文發現：(1)「教育」和「教育與年齡交互項」皆與橫斷面的憂鬱以及縱貫面的憂鬱斜率有顯著負向關係。

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當教育對憂鬱的主效果和年齡交互效果皆為負向時，因教育而別的憂鬱差異隨生命歷程而擴大。此外，較低教育者的憂鬱在中年後攀升，但較高教育者的憂鬱隨年齡增加維持平緩，故累積優勢論獲得支持；(2)「教育」和「教育與世代交互項」與憂鬱有顯著負向關係。對年輕世代而言，教育對憂鬱的影響出現較早且程度更高，故符合世代重要論；(3) 橫斷面分析契合老化槓桿論，但縱貫分析僅提供有限的支持，故老化槓桿論仍需商榷。

關鍵詞：教育、憂鬱、生命歷程、世代

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## A. Introduction

The association between education and health is a principal interest of researchers studying the sociology of health and illness (Beckett 2000; Herd et al. 2007; House et al. 1994). A tremendous body of Western literature has pointed out that education is a strong determinant of a variety of health outcomes, including higher levels of self-reported health and physical functioning, lower rates of mortality, depression, anxiety, malaise and pain, and the course of anger (Elo and Preston 1996; Lantz et al. 2001; Mirowsky and Ross 1998; Pappas et al. 1993; Ross and van Willigen 1997; Schieman 2000). A growing body of research has also demonstrated that education displays similar impacts on physical and mental health for Taiwanese (Beckett et al. 2002; Liang et al. 1999; Liu et al. 1998; Tung and Mutran 2005; Zimmer et al. 1998; Zimmer et al. 2002). Moreover, the links between education and health have been well established. Education improves health because it provides an opportunity for nonalienated paid jobs and economic resources, increases access to stable social and marital relationships that

facilitate social support, and enables a healthy lifestyle such as exercise (Chang et al. 2012; Ross and van Willigen 1997; Ross and Wu 1995). Taken together, education has been regarded as a fundamental cause of a healthy life that promotes good physical health and psychological wellbeing by incorporating economic and social-relationship mediators (Miech and Shanahan 2000; Turner and Lloyd 1999).

Previous studies have attentively and substantially documented the education-health relationship and explained the mediating mechanisms by which education operates to influence health. Therefore, relatively little recent research has switched attention to ascertaining whether the education-health patterns are dynamic across time. In essence, with the tremendous transformation of the distribution and content of education and the prolongation of healthy life expectancy over the twentieth century, the relationship between education and health may have changed over time. As a result, whether the impacts of education on health vary across the life course and across birth cohorts are critical questions worthy exploring. However, to date, what little research has found about the temporal relationship between education and health remains unclear and even under recurrent debate. The inconsistent findings may result from the following two conditions.

Firstly, the literature on the temporal education-health relationship has been fragmented (Herd 2006; Lynch 2003; Ross and Wu 1996). On the one hand, medical sociologists have mainly concentrated on the relationship between education and physical health. They have often assumed that the temporal variation in the relationship is mainly due to aging effects. Additionally, this approach has developed into two conflicting perspectives: (1) the “cumulative-advantage” theory states that the benefits of education on health are cumulative and self-amplifying. Hence, the impacts of education

on health increase with age, which results in the widening education-based gap in health across the life course; (2) the “age-as-lever” theory suggests that biological effects eventually replace social effects—resources provided by a person’s socioeconomic status decline in old age, when a person enters a stage such as retirement—and lead to the decreasing impacts of education on health, subsequently shrinking the education-based inequality in health in late adulthood. On the other hand, demographers have mostly focused on the education-mortality relationship. Besides, they have often attributed the temporal variation in the relationship to the cohort effects and neglected life-course explanations. The “rising importance” theory is hence proposed, emphasizing that the influence of education is greater in newer cohorts. For instance, health knowledge and the cost of medical care in more recent eras are greater than in previous eras, implying that education may be more important in determining access to health-enhancing resources than was previously the case.

Subsequently, most studies analyze only one dataset, regardless of cross-sectional or longitudinal design. Additionally, since aging effects and cohort effects are difficult to disentangle empirically, most studies estimate one effect while ignoring the other (House et al. 1994; House et al. 2005; Ross and Wu 1996). Consequently, these studies are unable to fully avoid the internal limitations of the dataset and are even forced to draw an incomplete conclusion. For example, the failure to consider mortality selection in cross-sectional models often produces ambiguous findings (Beckett 2000; Beckett and Elliott 2001; Noymer 2001). Moreover, the lack of adjustment of both aging effects and cohort effects in the same statistical model could bias estimations and occasionally even lead to inaccurate conclusions in health studies (Lauderdale 2001). For instance, old people are less educated, so

they may be more depressed than younger ones (Mirowsky and Ross 1992); thus, certain associations between age and depression might reflect differences between cohorts rather than the internal development of depression in people as they age. In particular, Lynch (2003) has thoroughly discussed the consequences of ignoring age effects, cohort effects and selectivity mortality, respectively, in examining and interpreting the effects of education on health across time. He hence demonstrates the benefits of adopting different modeling techniques on data from different sources and designs in the same article.

On the basis of the foregoing discussion, previous research usually considers only one type of temporal pattern (either aging effects or cohort effects) and analyzes one type of dataset, resulting in the common situation of mixed empirical results and ambiguous interpretation of the overall temporal education-health relationship. Therefore, this research aims to delineate the overall temporal patterns between education and depression in Taiwan by adopting both medical-sociological (life-course) and demographic (cohort) perspectives and by using two different modeling techniques respectively on repeated cross-sectional data and longitudinal data. Besides, because most studies focusing on the temporal impacts of education on physical health or mortality are conducted on Western populations (Beckett et al. 2002), it is unclear whether education displays similar impacts on mental health, and whether these impacts exist in non-Western societies. Thus, the result obtained in a Taiwanese setting might complement the existing findings that are derived from studies on Western societies, and this can enhance our understanding of how the social arrangements of society affect the wellbeing of people.

The core questions of this research are (1) whether the influence of

education on depression increases with age, consistent with the cumulative advantage theory, or decreases with age, consistent with the age-as-lever theory, and (2) whether the influence of education on depression increases across birth cohorts, consistent with the rising importance theory. In order to answer above questions, this study includes the impacts of the education-age interaction and the education-cohort interaction term on depression in the analyses. When education and its interaction with age both display negative and significant impacts on depression, the education-based gap in depression diverges with age. In other words, the total impacts of education become larger and larger with age, supporting the cumulative advantage theory (Ross and Wu 1996); alternatively, when education presents negative impacts on depression, but education's interaction with age shows positive impacts, the education-based gap in depression converges with age. In other words, the negative impacts of education on depression are diminishing with age, supporting the age-as-lever theory. Similarly, when education and its interaction with cohort both display negative and significant impacts on depression, the education-based gap in depression increases in successively newer cohorts, supporting the rising importance theory.

Meanwhile, in order to lessen the risk of biased estimation and to achieve comprehensive conclusions, this study uses a standard age-cohort regression model (Lynch 2003) on data drawn from repeated cross-sectional surveys, namely, the 1990, 1995, 2000, and 2005 *Taiwan Social Change Survey* (TSCS), and a latent growth model with aging-vector techniques (Mirowsky and Kim 2007) on data obtained from longitudinal surveys, that is, the 1989, 1993, 1996, 1999, and 2003 *Survey of Health and Living Status of the Middle-Aged and Elderly in Taiwan*. The age-cohort regression model can be used for examining whether the location of the age-education

patterns differs across cohorts, and vice versa, on the repeated cross-sectional data. In other words, this approach provides an opportunity to observe individuals from the same cohort at different stages in the life course, decreasing the confusion between within-individual change and between-individual heterogeneity. Furthermore, the latent growth curve model with aging vectors can be used to investigate whether the origins and slopes of the change in depression vary across levels of education and even used to reveal intercohort trends in the panel data. Both analytical approaches allow aging effects and cohort effects to be partially distinguished in temporal education-depression patterns. Besides, the pooled TSCS data include respondents aged over 19, whose birth years are from 1908 to 1986, while the elderly panels interview respondents whose birth years are from 1893 to 1946. In sum, by comparing results from these two kinds of data, this study may acquire a broader image of the temporal impacts of education on mental health across more age groups and across more birth cohorts in Taiwan.

## **B. Theoretical Background**

### **1. Education Years, Learned Effectiveness, and Health**

The years of formal education, reflecting the “quantity” aspect of education, is the most crucial educational indicator that affects health. Empirically speaking, the “quantity” of education is not only widely used in health studies, especially those focusing on the temporal relationship between education and health, but also displays stronger and more significant association with health than the “credential” aspect of education (i.e., college degree) and the “selectivity” aspect of education (i.e., the quality or prestige of one’s college) (Dupre 2007; Lynch 2003; Mirowsky and Kim 2007; Ross



and Mirowsky 1999). Meanwhile, three major mediating pathways models explain why people with longer education years tend to have better well-being: (1) the economic resource pathway model argues the well educated are less likely to be associated with economic hardship, unemployment, lower income and worse work; (2) the social relationship pathway model states that the well educated tend to have more supportive and satisfying marital, familial and interpersonal relationships; and (3) the learned effectiveness pathway model suggests that the well educated display higher human capital, such as the internal ability to manage health (Chang et al. 2012; Miech and Shanahan 2000; Turner et al. 1995; Ross and van Willigen 1997; Ross and Wu 1995).

Among these pathways, the learned effectiveness pathway is especially important for the life-course relationship between education and health. Theoretically speaking, formal education represents an investment in human capital, which is the learned productive capability developed, embodied, and stocked in human beings themselves. Through education, people gradually develop the internal ability to effectively learn, think, communicate, analyze data, solve problems, implement plans, organize resources, and integrate information. During the process of the pursuit of education, the assignments or exams that people encounter become progressively more complex or difficult. The more years of schooling people receive, the more difficult challenges people can eventually overcome. Therefore, the well educated accumulate more successful experiences of problem solving, develop greater cognitive abilities, and establish higher confidence, habits and motivation in their attempts to resolve problems. That is, the higher the level of education, the greater the level of learned effectiveness. More importantly, these inherent cognitive abilities and values boost the well-educated people's levels of

sense of control, which refers to the higher learned belief that an individual can master or alter his or her own outcomes. The sense of control fosters stable psychological well-being, even for a person who experiences the most difficult times. Higher levels of sense of control also enable people to achieve effective means toward a health-enhancing lifestyle and create new ways of ameliorating or overcoming health crises (Coleman 1988; Mirowsky and Ross 2003a; Seeman and Lewis 1995; Sen 1997).

In sum, it is the learned effectiveness that education instills into people, not the specific knowledge that individuals have learned in school or the educational credentials that individuals have acquired, which enables the well educated to be more likely to achieve better health. Since the amount of education in years reflects a person's stock of human capital, it is an adequate measurement that enables examination of the learned effectiveness perspective. As a result, this study focuses on the temporal impacts of "education years" on depression.

## **2. The Temporal Relationships Between Education and Health**

Since the mechanisms between education and health have been well established, recent studies shift their attention to the aging effects or the cohort effects of education on health. On the one hand, researchers are curious about whether education influences the location and slope of the classic U-shape of the depression life-course trajectory, which is the path demonstrating that middle-aged adults felt less depressed than younger and older adults (Mirowsky and Ross 1992). For instance, the "cumulative-advantage" theory states that the education-based difference in the depression trajectory diverges with age, while the "age-as-lever" theory proposes that the education-based difference in the depression trajectory converges with

age. Both theories are popular ones focusing on interactive education-aging effects (Herd 2006; Lynch 2003; Ross and Wu 1996). On the other hand, the “rising importance” theory emphasize interactive education-cohort effects (Lynch 2003; Mirowsky and Ross 2008). These theories were originally adopted in the research to delineate the temporal relationship between education and physical health. But, they can be extended to depression studies because physical manifestations of psychological distress are often observed, and because the effects of physical ailments can potentially elevate depression (Miech and Shanahan 2000; Ross and van Willigen 1997).

#### (1) The Cumulative-Advantage Theory

The cumulative-advantage theory predicts that education has increasing impacts on health with age and structures the resources that accumulate throughout life. Thus, an education-based gap in health widens over age. The concepts of cumulative advantage were originally proposed to explain the growth in economic heterogeneity in adulthood (Crystal and Shea 1990; O’Rand 1996), and were then extended to the study of health (Ross and Wu 1996). Three major elements of this theory are introduced as follows.

First, on the basis of the foregoing learned effectiveness perspective, the cumulative-advantage theory argues that education is not only a resource in itself; it is also training that instills highly effective abilities, habits, and attitudes in people, all of which enhance people’s ability to avoid the onset of physical ailments and to deal with health problems. Since learned effectiveness is an internal ability of an individual, it is inalienable and stays across the life course. Second, well-educated people typically receive higher incomes and work in more favorable environments. Conversely, less-educated people are more likely to experience economic hardship or alienating work environments. Meanwhile, poverty makes it challenging for poorly

educated people to escape the negative impacts of economic hardship or switch to jobs that feature beneficial work characteristics, and the unfavorable consequences of these economic disadvantages worsen over time. Third, low education levels are associated with unhealthy lifestyle choices (such as smoking) that lead to poor health over time (Mirowsky and Ross 1998; Ross and Wu 1995, 1996). These harmful behaviors influence mental health either directly through their cumulative effects or indirectly through their impacts on physical health (Miech and Shanahan 2000).

Taken together, health-enhancing effects accumulate progressively over time in people who are well educated, and this widens the health gap between poorly educated and well-educated people (Mirowsky and Ross 2003a). Empirical evidence supports the cumulative advantage of education in the cases of physical health and self-reported health (Ross and Wu 1996), survival (Lauderdale 2001), depression (Miech and Shanahan 2000), and health-fostering resources such as a sense of control over one's life (Schieman 2001).

## (2) The Age-As-Lever Theory

According to the age-as-lever theory, the education-based health gap is large in midlife but extremely small or nonexistent in early adulthood and in old age (Beckett 2000; House et al. 2005): (1) the education-based health gap is negligible in early adulthood because young people do not display substantial socioeconomic difference and are generally healthy; (2) education-based health inequality is greatest in middle age and early old age because of two reasons. First, during this period, the socioeconomic difference becomes larger, resulting from different levels of exposure to health risk factors, such as chronic stress caused by poverty, acute stress caused by unemployment, a lack of social relationships and support, unhealthy behaviors such as smok-

ing, and the sense of a lack of control over one's life. Second, the risk factors also start affecting physical health during middle age and early old age. That is, both socioeconomic differences and the health effects widen the inequality in health; and (3) the difference in health shrinks again in late old age for several reasons. First, like everyone else, highly educated people become frail late in life and encounter an accelerating decline in health. Second, social-welfare programs such as Social Security and Medicare in the USA slow the deterioration of health in poorly educated old people (Herd 2006; House et al. 1994). Furthermore, education-related stressors such as economic hardship decline in old age, which might lead to a narrowing education-based gap in mental health (Mirowsky and Ross 1999).

In summary, the age-as-lever theory argues that the effect of age on health increases but the effect of education on health declines with increasing age. In other words, the health gap grows through much of adulthood but eventually converges as people with better health status (disproportionately with high education) encounter a biological ceiling on the postponement of disability (Lynch 2003; Mirowsky and Ross 2008). Empirical support for the age-as-lever hypothesis has been obtained for mortality (Elo and Preston 1996) and functional status (Herd 2006; House et al. 1994), but whether the effects detected in the case of physical health are also displayed in mental health remains unclear.

It is important to note that the apparent decrease of the education-based health gap in late life is commonly attributed to selective survival: people with low levels of education are more likely to die in early adulthood than well-educated people are, and thus in the population of elderly people, the people who are poorly educated are physically robust. In addition, being unhealthiest (disproportionally with low education) increases the inability or

unwillingness to participate in a survey. Consequently, the education-based difference in health in old age is small in surveys, which is biased because it includes poorly educated people and highly educated people who are both healthy and have survived until old age. However, by using distinct methodological and statistical approaches, researchers have argued that selective survival alone is unlikely to account for the apparently narrowing education-based gap in physical health of elderly people (Beckett 2000; Beckett and Elliott 2001; Herd 2006; Noymer 2001).

### (3) The Rising-Importance Theory

The historical trend of increasing levels of education in successive generations raises attention to cohort effects. To begin with, the effects of education in explaining physical health and life expectancy improvement have gradually been highlighted. Demographic studies have typically shown that the education-based gap in mortality has widened since the 1960s (Freedman and Martin 1999; Pappas et al. 1993). Certain studies have also demonstrated that education affects survival in each 10-year-birth cohort to a greater extent in later cohorts than in earlier cohorts at the same age (Lauderdale 2001), and that the effect of socioeconomic status (SES) on mortality is higher in the case of death resulting from highly preventable causes than in the case of death resulting from poorly preventable causes (Phelan et al. 2004). These findings indicate that people with higher SES are more likely than people with lower SES to take advantage of new preventive and remedial treatments for chronic diseases in an effort to improve health and prolong life (Lynch 2006). Because people in younger cohorts live in times in which health-improving knowledge and technology are more advanced when compared with the times in which people in older cohorts lived, well-educated people in younger cohorts are more likely to benefit

than their counterparts in older cohorts at the same age. Conversely, the education-based gap in health might shrink in old age because the old people belong to cohorts that had grown up in times when the extent of divergence was smaller than the current extent.

Furthermore, some researchers suggest that at any given age, young people are likely to be less depressed than old people because young people belong to cohorts that, based on favorable historical trends, exhibit an aggregated increase in education (Mirowsky and Ross 1992). Thus, certain age-depression associations reflect differences between cohorts rather than the inherent development of depression in people as they age. The difference in age-specific levels of depression across cohorts is investigated empirically by Mirowsky and Kim (2007) and Yang (2007). However, the findings of these two studies disagree: the results of Mirowsky and Kim suggest that depression increases with age within each cohort and demonstrate substantial changes in age-specific depression between cohorts, which is highlighted by the finding that depression levels in late adulthood are higher in the case of people in young cohorts than in the case of people in old cohorts when they are at the same age; by contrast, the results of Yang indicates that depression decreases with age in people in young cohorts and displays increasing levels of age-specific depression in successively older cohorts.

To sum up, although the existing findings are inconsistent, the rising importance theory usually states that education's association with health is greater in newer cohorts. However, whether this hypothesis can be extended to depression remains underexplored.

#### **4. The Taiwanese Setting**

Taiwan presents two characteristics that enable researchers to examine

the aforementioned theories and ascertain the temporal impacts of education on depression. First, Taiwan is optimal for evaluating the aging effects of education on depression. The core element of the cumulative-advantage theory is based on the learned effectiveness perspective. That is, formal education instills lifelong problem-solving and resource-generating abilities in people and these abilities enable people to handle diverse situations effectively; the effect is not produced because of any specific knowledge that people might have gained in school or because of any educational credentials they might have earned (Mirowsky and Ross 2003b). Accordingly, regardless of the average levels of education in the society, people who have been educated for a greater number of years are less depressed and suffer depression to a lesser extent during the periods when they face obstacles than do their counterparts who have been educated for fewer years. Thus, if this trend is also detected in elderly people in Taiwan, who are on average educated for less than 6 years and are likely to have received an education that is considerably distinct from the education received by people in the West, then it would indicate that education provides a universal, inalienable ability to improve emotional wellbeing, irrespective of the social or cultural background to which the people belong.

Second, Taiwan is an optimal setting for examining whether the association between education and depression varies across birth cohorts. Taiwanese society has undergone drastic social change over the past century, which is highlighted by the aggregate increase in education—the proportion of people aged 15 years and over who have received at least a junior-college degree grew from 5.5% to 24.4% between 1970 and 2000 (Executive Yuan 2001)—and by the improvement in overall social and demographic environments. Therefore, Taiwan provides a research setting that has hardly been



found in Western societies.

## 5. Hypotheses

This study addresses three central hypotheses about the temporal relationships between education and depression in the Taiwanese setting:

First, the cumulative-advantage hypothesis predicts that the effects of education strengthen over the course of life and lead to an increase in education-based differences in depression. In order to support this theory, the following results should be displayed: (1) the regression models on the sequential cross-sectional data show that education and its interaction terms with age are both negatively and significantly associated with depression, after adjusting for cohort effects; and (2) the latent growth curve models on the longitudinal data show that education and its interaction terms with age are negatively and significantly associated with the level and slope of depression.

Second, the age-as-lever hypothesis states that the effects of education start decreasing after early old age and lead to a converging education-based difference in depression, especially when selective mortality is completely ignored. In order to support this theory, the following results should be displayed: (1) the regression models on the cross-sectional data show that education is negatively and significantly associated with depression, but education's interaction terms with age are positively and significantly associated with depression; and (2) the latent growth curve models on the longitudinal data show that education is negatively and significantly associated with the level and slope of depression, but its interaction terms with age, especially the interaction term with the quadratic form of age, are positively and significantly associated with the level and slope of depression.

Third, the rising-importance hypothesis proposes that the effects of education increase across birth cohorts and accelerate education-based divergence in depression in young cohorts. In order to support this theory, the following results should be displayed: (1) the regression models on the cross-sectional data show that education and its interaction terms with cohorts are both negatively and significantly associated with depression; and (2) the inter-cohort illustrations obtained from the latent growth curve models on the longitudinal data show that younger cohorts with more years of education have lower levels of depression than their older cohort counterparts at the same age.

## C. Methods, Data, and Measures

### 1. Methods

#### (1) Age-Cohort OLS Regression Model

In this study, the repeated cross-sectional TSCS data are used for predicting depression in people of the same cohort at distinct ages and people of the same age but different cohorts (Lynch 2003). The age-cohort regression model used is:

$$\hat{D} = b_0 + b_1Age + b_2Age^2 + b_3Cohort + b_4AgeCohort + b_5Edu + b_6AgeEdu + b_7Age^2Edu + b_8CohortEdu + b_9AgeCohortEdu + b_{1c}ControlVar \quad (1)$$

This model estimates the curvilinear effects of age and age<sup>2</sup> ( $b_1$ ,  $b_2$ ), the effect of cohort ( $b_3$ ), and the effect of education ( $b_5$ ) on depression. Moreover, it allows the effects of education on depression to differ across age ( $b_6$ , the age-education interaction term) and be nonlinear across age ( $b_7$ , the age<sup>2</sup>-education interaction term), and across cohorts ( $b_8$ , the cohort-

education interaction term). The three-way interaction of age, cohort, and education ( $b_9$ ) allows the position of the quadratic age-education patterns to vary across cohorts.

This model can be rewritten to emphasize the sum of all coefficients contingent on education:

$$\hat{D} = (b_0 + b_1Age + b_2Age^2 + b_3Cohort + b_4AgeCohort + b_{10}ControlVar) + (b_5 + b_6Age + b_7Age^2 + b_8Cohort + b_9AgeCohort)Edu \quad (2)$$

## (2) Latent Growth Curve Model with Aging Vector

The latent growth curve model with aging vector is a multilevel latent-growth model that is used not only for estimating the origin and slope of the changes that occur during a survey's follow-up period as function of age at that time, but also for illustrating virtual-cohort projections. Mirowsky and Kim (2007) have addressed the development, procedures, interpretation and illustration of the latent growth curve model with aging vector in detail. Their approach is hence emulated by this study.

In brief, this aging-vector modeling technique provides two specific characteristics that reduce the model misspecification error and estimation bias resulting from ignoring of the confounding life-course and cohort effects, and mortality selection: (1) aging vector models predict both the level of an outcome at the beginning or middle of a period and the slope of changes with respect to time throughout the period, each adjusted for the other. In other words, it allows age at baseline or mid-follow-up to appear in the between-person equations that delineate how the passing of time influences within-person changes from baseline levels. This allows researchers to facilitate the inter-cohort comparison of the age-specific vector slopes (Mirowsky and Kim 2007); and (2) the aging vector models correct for

missing values based on all available data regardless of their status in the follow-up interviews via an estimating approach called Full-Information Maximum Likelihood (FIML), as detailed in a later section. The health trajectories of individuals who drop out due to death or other reasons can still be estimated. Mortality selection bias is thus reduced (Wothke 2000).

The basic aging-vector model comprises sets of equations, including within-person equations and between-person equations. As an example, Figure 1 illustrates the form of Model 4 in Table 4, which corresponds to the following sets of equations.

#### **a. Within-Person Equations**

Equation (3) shows that the depression outcome  $D$  for a person  $i$  at time  $t$  is a linear function of time plus an error term  $e_{it}$  that is random with respect to time. The terms  $\alpha_{i_0}$  and  $\alpha_{i_1}$  represent the original level of predicted depression at the survey wave designated at time zero and the slope of predicted depression over the follow-up period.

$$D_{it} = \alpha_{i_0} + \alpha_{i_1}t + e_{it} \quad (3)$$

The most critical feature of Equation (3) is that it is used for analyzing changes with respect to time rather than age, which means that the within-person equation indicates the effect of aging  $t$  years rather than the effect of the age differences at distinct times at which interviews are conducted. This approach allows the age at a designated time to appear in the between-person model. Thus, the effects of aging  $t$  years depend on the age at the time of the study.

Equation (4) demonstrates that time  $t$  can be measured as the difference between the calendar year of the survey wave and the calendar year of the wave designated at time zero, which equals the difference between the age

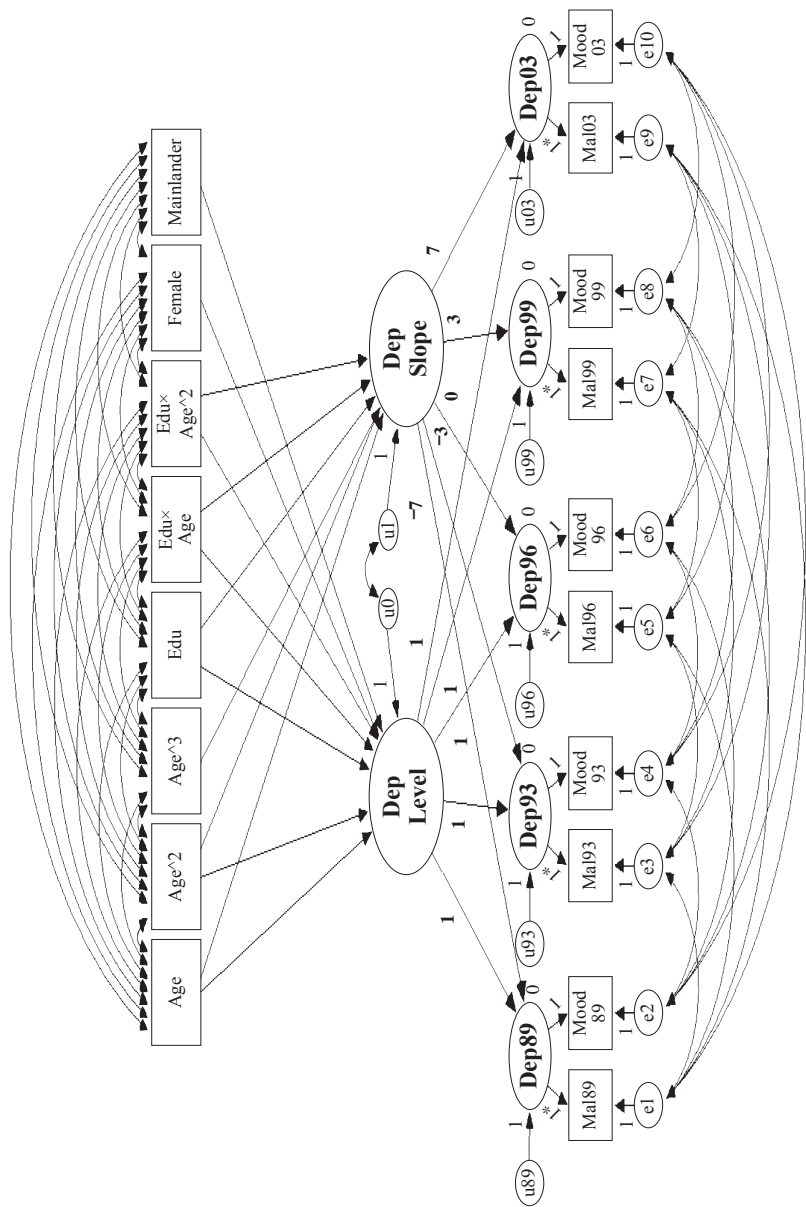


Figure 1 Path Diagram Representing the Full Structural Equation Model.

at the time of an observation and the age in the reference year.

$$t = S_t - S_0 = Age_{it} - Age_{i_0} \quad (4)$$

This model was used for demonstrating two latent factors, the level and slope of depression. The level factor has a fixed  $1.0 \times$  effect on the depression level reported in the 5 survey waves in this study. The slope factor exerts fixed effects that centered on the middle of the follow-up periods of the survey, and thus time is measured as a deviation from the middle of the follow-up period. Consequently, 0 years of change is in 1996, less-7 and less-3 years of change are in 1989 and 1993, and 3 and 7 years of change are in 1999 and 2003, respectively.

#### **b. Between-Person Equations**

Equation (5) is used for predicting peoples' origin of depression as a function of age at time zero ( $Age_{i_0}$ ), which is centered on a reference age of 70 (linear, squared or cubic terms); education, which is centered on 6 years of education; controlled covariates; and random deviations  $u_{i_0}$  from the expected value, which describe the cumulative effects up to that wave. Equation (6) shows the subsequent change over time depending on these effects and a residual  $u_{it}$ , and it includes an adjustment for the accumulation of the effects. The interaction term between education and age is added in both between-person equations to examine the divergence and convergence patterns. A negative sign of the interaction term will indicate that the effects of education on depression level or slope increase with age; a positive sign will indicate that the effects decrease with age; and an insignificant term will indicate that the effects are the same in all age groups.

$$a_{io} = a_{0_0} + a_{0_1}(Edu - 6) + a_{0_2}(age_{i_0} - 70) + a_{0_3}(Age_{i_0} - 70)^2 + a_{0_4}(Edu - 6) \times (Age_{i_0} - 70) + a_{0_5}ControlVar + u_{i_0} \quad (5)$$

$$a_{i_1} = a_{1_0} + a_{1_1}(Edu - 6) + a_{1_2}(Age_{i_0} - 70) + a_{1_3}(Age_{i_0} - 70)^2 + a_{1_4}(Age_{i_0} - 70) + a_{1_5}(Edu - 6) \times (Age_{i_0} - 70) + a_{1_6}ControlVar + u_{i_1} \quad (6)$$

Equation (7) shows that age at time zero ( $Age_{i_0}$ ) is the difference between the calendar year of the survey at time zero ( $S_0$ ) and a person's birth year ( $B_i$ ), and it represents the confounding relationship between age, cohort, and period. Thus, the reference age  $Age_{i_0}$  in equations (5) and (6) is the age in the year  $S_0$  (reference year  $t=0$ ) of a reference cohort, which means that the age at time zero can also represent a cohort. For instance, all 70-year-old people in the survey year 1996 were born in 1926.

$$Age_{i_0} = S_0 - B_i \quad (7)$$

## 2. Data

### (1) Taiwan Social Change Survey

The TSCS is a cross-sectional nationally representative sampling survey that is conducted annually by the Institute of Sociology and the Center for Survey Research, Academia Sinica. This project has adopted 5-year rounds that rotate selective modules in order to track long-term trends of social change in Taiwan since 1985 (Fu and Chang 2017). For instance, the 1990, 1995, 2000, and 2005 samples contained questions related to mental health. The same multistage stratified random-sampling scheme and “probability proportional to their size (PPS)” method are used in all TSCSs. The townships or districts of Taiwan are divided into strata according to the degree of urbanization and geographic locations, and then administrative neighborhoods and people in each stratum are randomly selected.

In this study, the TSCS data from 1990 (Year 1 of Round 2, Questionnaire 2), 1995 (Year 1 of Round 3, Questionnaire 2), 2000 (Year 1 of Round 4, Questionnaire 2), and 2005 (Year 1 of Round 5, Questionnaire 1) are used, which include 2,531 respondents ranging in age from 20 to 64, 2,081 respondents ranging in age from 20 to 75, 1,895 respondents ranging in age from 21 to 91, and 2,146 respondents ranging in age from 19 to 97, respectively. These samples are pooled so that people from distinct cohorts can be studied at the same life-course phases, an approach that is also used in an American study (Lynch 2003). After cases featuring missing values are excluded using a listwise-deletion approach, the combined sample contains 8,628 respondents. The oversampling problem caused by distinct age structures and sample sizes across samples do not seriously bias the results because age and cohort are specified appropriately as independent variables in all analyses (Winship and Radbill 1994).

(2) The Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan

The data from these surveys are a nationally representative sample of middle-aged and elderly people living in nonaboriginal areas of Taiwan. The surveys are conducted jointly by the Department of Health, Taiwan, and by various institutions at the University of Michigan, Georgetown University, and Princeton University. In these surveys, multistage equal-probability sampling is performed. Townships form the primary sampling unit, whereas blocks of selected townships serve as clusters in the second stage of the sampling. Each stage is selected with the PPS method, and two elderly people are selected randomly from each chosen block.

Two samples are merged: The first sample includes 4,049 respondents who were aged over 60 in 1989; the response rate is 91.8%. Follow-up



interviews were conducted in 1993, 1996, 1999, and 2003, and the sample sizes are 3,154, 2,669, 2,310, and 1,743, respectively. The second sample includes 2,462 respondents who were 50–66-years old in 1996; the response rate is 81.2%. Follow-up interviews were conducted in 1999 and 2003 and the sample sizes are 2,130 and 2,035, respectively. Age is an independent variable in all the models used, so the results are not seriously biased by the oversampling problem caused by distinct age structures and sizes of the two samples (Winship and Radbill 1994).

In this study, model estimates are obtained by including all available data and by correcting for data missing by using the Full-Information Maximum Likelihood (FIML) procedure, which is implemented using the AMOS Structure Equation Modeling program. FIML is a method of estimation in which all available data are used regardless of their status in follow-up interviews (Wothke 2000), and data “missing at random” are corrected by assuming that the structural relationships vary only randomly across groups defined by missing data patterns, and that the absence of values depends on a combination of random change and tendencies that can be predicted when all observed data are used (Mirowsky and Ross 2007; Singer and Willett 2003). When aging-vector models are estimated using FIML procedures, attrition bias is decreased considerably and the estimates obtained are more accurate than those obtained using common approaches such as listwise deletion, pairwise deletion, and mean imputation (Mirowsky and Kim 2007).

### **3. Measurements**

#### **(1) Taiwan Social Change Survey**

*Depression* is measured using a 4-item index that is based on the question “Have you had the following experience in the past two weeks?

Have you felt that (1) you did not sleep well; (2) many things were a burden for you; (3) you have lost confidence in yourself; and (4) there was no hope in life?” Responses are “not at all,” “same as usual,” “a bit more than usual,” and “more than usual” (coded as 0 to 3). The depression index is calculated as the mean response to applicable items; data on respondents who answer two items or less are omitted (4 cases).

*Education* is scored in years of education as per the highest level of education reported. *Age* is set as the year of the survey minus the year of birth. Furthermore, in the models, age is a deviation centered on the age of 45. *Cohort* is measured as the year of birth and then calculated as a deviation centered on the birth year of 1955. Among control variables, *Female* is a dummy variable for comparing females (1) with males (0). *Mainlander* is a dummy variable for comparing Mainland Chinese (1) with people of other ethnic groups (0). This ethnic division reflects the distinct historical and sociostructural background of Taiwanese society and is used in most Taiwanese health studies (Beckett et al. 2002).

## (2) The Survey of Health and Living Status of the Middle-Aged and Elderly in Taiwan

*Depression* is measured using two sets of indicators: depressed mood and malaise. The questions used for these indicators are drawn from the Center for Epidemiological Studies-Depression Scale (CES-D). In *Depressed Mood*, the scores of 4 items are averaged: “In the past year, have you experienced the following situations or feelings? Have you felt (1) that you were in a terrible mood; (2) lonely (isolated, with no companions); (3) that people around you were not nice to you (were unfriendly); or (4) anguished?” Responses include are “rarely,” “sometimes,” “often,” and “chronically” (coded as 0 to 3). In *Malaise*, the scores of these 4 items are averaged: “In

the past year, have you experienced the following situations or feelings? Have you felt that (1) you were not interested in eating and had a poor appetite; (2) doing anything was exhausting; (3) you sleep poorly (unable to sleep); or (4) you were unable to gather energy to do things?" Responses included are "rarely," "sometimes," "often," and "chronically" (coded as 0 to 3).

*Education* is scored in years of highest level of schooling. Respondents who attend graduate school are scored as 19. Respondents who did not receive formal education but report that they are "literate" are scored as 3. Education is calculated as a deviation centered on 6 years, which is an appropriate division considering the low average years of education among elderly Taiwanese people. *Age* is measured in number of years in 1996 and is a deviation centered on the age of 70 years.

About control variables, *Female* is a dummy variable for comparing females (1) with males (0). *Mainlander* was a dummy variable for comparing Mainland Chinese people (1) with people of other ethnic groups (0). *Physical Impairment* is calculated as the mean response provided for 6 questions regarding the ability of people to perform general physical movements that might be necessary for conducting daily tasks: bathing, walking, crouching, climbing stairs, reaching up over one's head, and grasping with fingers. Responses are "no problem," "some difficulty," "very difficult," and "cannot do it" (coded as 0 to 3). Finally, seven of the eight leading causes of death in Taiwan—stroke, heart disease, diabetes, lung disease, liver disease, kidney disease, and hypertension—are each constructed as a dichotomous measure and used for constructing *the Number of Life-Threatening Diseases*, which is denoted as a continuous measure (ranging from 0 to 7 of the aforementioned diseases). However, questions

about cancer, the primary cause of death in Taiwan, are not included in the 1989 baseline wave.

## **D. Empirical Results**

### **1. Descriptive Statistics: the levels of depression by age, cohort, and education**

Table 1 demonstrates the means of depression across 10-year age groups and across 5-year cohorts by three levels of education, based on the pooled 1990, 1995, 2000, and 2005 TSCS data. Three major patterns are shown. First, the life-course relationships in depression are not entirely identical among groups across levels of education. For respondents with 6 or less years of education, the average levels of depression generally follow a classic U-shaped aging relationship (or the J-shaped relationship, when the oldest elders are included), meaning that the middle-age group reports a lower level of depression than those of the younger and older age groups. For instance, the average levels of depression for the 36–45 and 66–75 age groups are 0.447 and 0.605, respectively. Thus, the less-educated Taiwanese in late adulthood are more depressed. Conversely, for those with more education years, the levels of depression generally become lower and lower across age groups, meaning that the relatively well-educated elders tend to demonstrate lower levels of depression. In fact, among age groups with more than 50 respondents, the lowest level of depression occurs at the 66–75 group for those with 7–12 years of education and for those with more than 12 years of education. Second, although disjunctive cohort variations in the trends of depression are partially displayed, most recent cohorts are generally associated with higher levels of depression than their older cohorts counter-

parts at the same educational level. For instance, for respondents who are 56–65 years old and have 6 or less years of education, the average levels of depression for the 1926–30, 1931–35, 1936–40, 1941–45 and 1946–50 birth cohorts are 0.502, 0.526, 0.599, 0.607, and 0.719, respectively. Third, people with less years of education are generally more depressed than their well-educated counterparts within the same age group and cohorts. For example, for the 1931–35 cohort aged 66–75, the average levels of depression for those with 6 or less years, 7–12 years, and more than 12 years of education are 0.609, 0.435, and 0.409, respectively.

Table 2 demonstrates the means of depression across 10-year age groups and across 5-year cohorts on all surveys from the 1989, 1993, 1996, 1999, and 2003 “Survey of Health and Living Status of the Middle Aged and Elderly in Taiwan.” The analyses regard the elderly panel samples as if they were cross-sectional, utilizing a person-year structure for the data, and ignoring within-individual error correlation. Three major findings are shown. To begin with, although the levels of depression become higher and higher across age groups, regardless of educational levels, respondents with less years of education experience a higher degree of rise across age groups. For instance, from the group less than 55 years old to the 76–85 age group, the average levels of depression for respondents with less than, equal to, and more than 6 years of education, increase from 0.465 to 0.613, from 0.287 to 0.436, and from 0.212 to 0.340, respectively. Second, although disjunctive-cohort variations in the trends of depression are also displayed, depression seems to strengthen in successively more recent cohorts for those with less than 6 years of education. Finally, people with less years of education are generally more depressed than their well-educated counterparts within the same age group and cohorts. For example, for the 1921–25 cohort aged 76–

Table 1 Means of Depression (4-items CES-D Scores) by Age and Cohort: Taiwan,  
Pooled TSCS Data (1990, 1995, 2000, and 2005).

Age Group	Birth Cohort														Total
	≤ 1925	1926 ~30	1931 ~35	1936 ~40	1941 ~45	1946 ~50	1951 ~55	1956 ~60	1961 ~65	1966 ~70	1971 ~75	1976 ~80	1981 ~86		
Education ≤ 6															
≤ 35 (n=209)							.489	.409	.492	.611	.417	.750		.473	
36-45 (n=609)					.365	.388	.393	.615	.730	.350				.447	
46-55 (n=709)			.520	.528	.459	.563	.629	.894						.553	
56-65 (n=655)		.502	.526	.599	.607	.719								.576	
66-75 (n=464)	.556	.625	.609	.623										.605	
76-85 (n=99)	.623	.750												.664	
≥ 86 (n=17)	.471													.471	
N	185	305	334	375	368	345	498	217	97	32	3	3		2,762	
Education 7-12															
≤ 35 (n=1,733)							.506	.417	.474	.562	.693	.696	.659	.547	
36-45 (n=1,116)					.250	.416	.443	.484	.571	.598				.496	
46-55 (n=473)			.464	.442	.393	.418	.513	.567						.481	
56-65 (n=201)		.288	.412	.552	.429	.761								.450	
66-75 (n=89)	.385	.403	.435	.591										.432	
76-85 (n=26)	.453	.450												.452	
≥ 86 (n=5)	.350													.350	
N	34	91	95	70	142	223	472	791	686	537	251	152	99	3,643	

Table 1 Means of Depression (4-items CES-D Scores) by Age and Cohort: Taiwan, The Pooled TSCS Data (1990, 1995, 2000, and 2005). (Continued)

Age Group	Birth Cohort													Total
	≤ 1925	1926 ~30	1931 ~35	1936 ~40	1941 ~45	1946 ~50	1951 ~55	1956 ~60	1961 ~65	1966 ~70	1971 ~75	1976 ~80	1981 ~86	
Education ≥ 13														
≤ 35 (n = 1,252)							.466	.537	.447	.557	.559	.609	.592	.549
36-45 (n = 556)					.250	.457	.425	.550	.428	.538				.474
46-55 (n = 257)				.289	.439	.308	.394	.396						.371
56-65 (n = 91)		.396	.484	.286	.260	.424								.362
66-75 (n = 53)	.341	.204	.409	.250										.278
76-85 (n = 10)	.250	.250												.250
≥ 86 (n = 4)	.313													.313
N	23	41	27	37	72	162	235	311	346	349	224	205	191	2,223

Note: n refers to the number of respondents within each age interval; N refers to the number of respondents within each cohort group.

Table 2 Means of Depression (8-items CES-D Scores) by Age and Cohort:  
Taiwan, the 1989, 1993, 1996, 1999, and 2003 Survey of Health and  
Living Status of the Middle Aged and Elderly in Taiwan.

Age Group	Birth Cohort								Total
	≤ 1910	1911 ~15	1916 ~20	1921 ~25	1926 ~30	1931 ~35	1936 ~40	1941 ~46	
Education <6									
≤ 55 (n=278)								.465	.465
56-65 (n=2,513)				.452	.481	.502	.467	.479	.476
66-75 (n=4,130)		.513	.508	.580	.612	.512	.551		.568
76-85 (n=2,191)	.527	.596	.663	.614	.579				.613
≥ 86 (n=307)	.651	.728	.628						.670
N	419	837	1,409	2,364	2,068	780	957	585	9,419
Education =6									
≤ 55 (n=510)								.287	.287
56-65 (n=2,055)				.340	.352	.403	.284	.265	.323
66-75 (n=2,296)		.480	.358	.353	.425	.362	.290		.386
76-85 (n=731)	.313	.491	.446	.403	.444				.436
≥ 86 (n=41)	.500	.679	.202						.497
N	41	206	498	1,006	1,655	604	638	985	5,633
Education >6									
≤ 55 (n=374)								.212	.212
56-65 (n=1,359)				.306	.262	.386	.269	.230	.275
66-75 (n=1,800)		.296	.397	.313	.304	.284	.265		.313
76-85 (n=600)	.549	.357	.445	.294	.168				.340
≥ 86 (n=43)	.780	.411	.469						.602
N	54	132	345	972	1,250	323	400	700	4,176

Note: 1. The pooled data include all waves in 1989, 1993, 1996, 1999, and 2003. At each follow-up wave, those who survived had aged by years from the age in 1989.

2. n refers to the number of respondents within each age interval; N refers to the number of respondents within each cohort group.



85, the average levels of depression for those with less than, equal to, and more than 6 years of education, are 0.614, 0.403, and 0.294, respectively.

Taken together, Table 1 and Table 2 summarize that depression increases across the life course after middle adulthood. It is also important to note that the levels of depression for the well educated remain more stable over time than their less-educated counterparts. In addition, for some certain age groups and educational groups, the levels of depression grow in successively more recent cohorts.

## 2. The TSCS Results

### (1) The Impacts of Age, Cohort, and Education on Depression

Table 3<sup>1</sup> presents the results of the age-cohort model of the pooled TSCS data. The first two models are designed to clarify whether the aging functions on depression differ after considering cohort effects. The first model only focuses on aging effects, and demonstrates the expected U-shape curvilinear aging relationship in depression (Mirowsky and Ross 1992). That is, age is inversely and significantly associated with depression, while age<sup>2</sup> is positively and significantly associated with depression. Nonetheless, when aging effects and cohort effects are considered concurrently in Model 2, the results differ noticeably from those predicted in Model 1, in which aging effects are estimated independently. Model 2 shows that both age and age<sup>2</sup> are positively and significantly associated with depression. Accordingly, the

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1 Theoretically, the effect of age may be small “in a year” but grow larger and larger over time. Thus, the coefficient of age variables usually looks relatively small in health research and is usually displayed with negative powers of 10 in empirical tables (Kim and Durden 2007; Mirowsky and Kim 2007; Mirowsky and Ross 2007, 2008). This study also follows this approach to present results in Table 3 and Table 4.



Table 3 Depression (Square-Root) Regressed on Age, Cohort, Education, and Their Interactions, Adjusting for Sex and Ethnicity: Taiwan, TSCS 1990, 1995, 2000, and 2005 (N = 8,602, aged less than 86). (Continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Female (= 1)	.066*** (7.086)	.067*** (7.232)	.055*** (5.826)	.051*** (5.435)	.053*** (5.650)	.050*** (5.342)	.052*** (5.521)
Mainlander (= 1)	-.024+ (-1.710)	-.017 (-1.239)	.005 (.367)	.008 (.589)	.007 (.501)	.009 (.598)	.004 (.287)
R <sup>2</sup>	.010	.020	.024	.030	.027	.031	.033

Note: 1. Unstandardized coefficients with t-statistics in parentheses shown. Aging components are centered as 45, birth cohort is centered as 1955, and education is centered as its mean.

2. +p < .10; \*p < .05; \*\*p < .01; \*\*\*p < .001.

level of depression is lowest for younger age groups, higher for middle-aged groups, and highest for older age groups in Taiwan. Additionally, cohort is also positively associated with depression, which suggests that younger cohorts have higher levels of depression. Taken together, these findings demonstrate that the age pattern in the education-depression relationship is attenuated if the cohort pattern is totally ignored on the cross-sectional data, underscoring the importance of considering age effects and cohort effects simultaneously.

Table 3 also suggests that education is inversely associated with depression, which is indicated by the significant and negative coefficients of education that are obtained in all models, which progressively adjust for demographic variables and interaction terms from Model 3 to Model 7. It is important to note that the effects of aging variables remain relatively constant while the effect of cohort function increases noticeably after adding education into the analyses, as indicated by the change in coefficients of these temporal functions from those obtained in Model 2 to those in Model 3. This implies that the cohort variation in depression is partially obscured because of the cohort difference in education.

#### (2) The Temporal Interactive Impacts of Education on Depression

When education and the multiple forms of the interaction terms between age functions and education and terms between cohort and education are included in the age-cohort regression analyses presented in Table 3, the coefficients of age functions and cohort vary substantially, which underscores the importance of understanding the dynamic temporal effects of education in Taiwan. The following section details the findings related to the three hypotheses about the temporal relationships between education and depression.

### **a. The Findings of Cumulative Advantages and Age-As-Lever Perspectives**

In the TSCS samples, ranging in age from 19 to 85, the patterns observed initially agree with both the cumulative-advantage hypothesis and the age-as-lever hypothesis. On the one hand, Model 4 in Table 3 suggests that the inverse relationship between education and depression increases across the life course, which is indicated by the significant negative coefficient of the age-education interaction. In addition, after adding the education-cohort interaction term into Model 6, the pattern remains solid. Therefore, these models consistently show that the impacts of education increase with age after considering cohort effects, supporting the cumulative advantage hypothesis. On the other hand, after considering the three-way interaction term among age, cohort, and education in Model 7, the results suggests that the inverse relationship between education and depression slightly declines in later adulthood, which is indicated by the significant positive coefficients of the age<sup>2</sup>-education interaction. Therefore, this model shows that the effects of education strengthen up to a point over the course of life, but eventually decline, supporting the age-as-lever hypothesis.

The results of the age-cohort regression model are easier to interpret and distinguish when they are presented graphically. As illustrated in Figure 2 (corresponding to Model 7 in Table 3, in which the three-way interaction of education, age, and cohort is included, and using 9, 12, and 16 years of education to compute the predicted depression, respectively), the predicted depression of the well-educated people in Taiwan who were born in 1955 (the mean cohort of the samples) is highest for younger age groups and then becomes lower at a stable rate for older age groups. Conversely, in the case of poorly educated people born in 1955, predicted depression is lowest

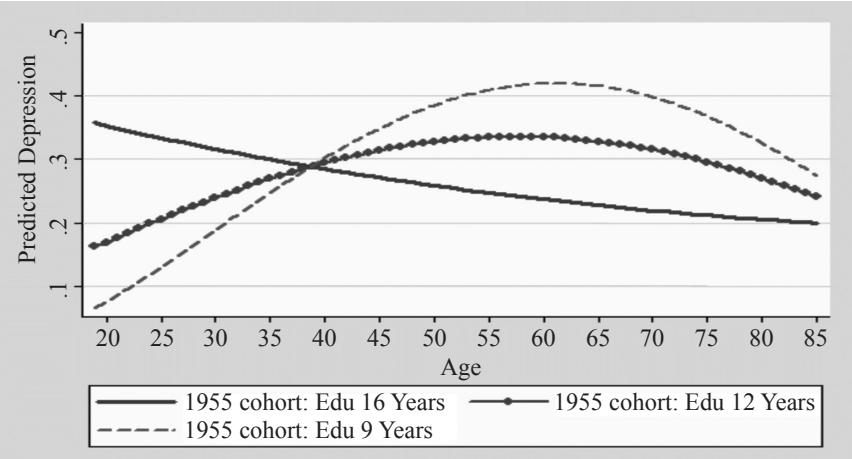


Figure 2 Predicted Depression (Square of the Predicted Value in Models) Across Life Course by Education, Adjusting for Cohort (Fixed at 1955), Sex, and Ethnicity (Fixed at Means).

for younger age groups, becomes much higher and peaks for middle-aged groups, and then declines at an accelerating rate for older age groups. In sum, the aging relationship in depression of well-educated Taiwanese people is the opposite of that of poorly educated Taiwanese people, which is a specific education-depression aging pattern different from those found in the Western context. Although the level of depression is higher in young well-educated Taiwanese, the patterns encounter a crossover around the age of 40 and lead to an increase in the education-based difference in depression that favors the well-educated people in middle life.

Taken together, the above findings generally support the cumulative advantage hypothesis because the negative education-age interaction terms are consistently significant in most models and because of the favorable direction of the life-course relationship in depression for the well educated.

Meanwhile, although Figure 2 reveals depression across levels of education in old age, the positive significant interaction terms of education-age<sup>2</sup> do not consistently appear in the analyses. Hence, the aging-as-lever hypothesis is only partially supported.

### **b. The Findings of the Rising Importance Hypothesis**

The results obtained in the TSCS data provide empirical support for the rising importance hypothesis, since Model 6 and Model 7 in Table 3 indicate that the coefficient for the interaction term between education and cohort is negative and significant. In other words, the effect of education increases across birth cohorts.

Similarly, the results of Model 7, in which the three-way education-age-cohort interaction is included, are better interpreted graphically. Figure 3 (corresponding to Model 7 in Table 3 and using the 1955 and 1970 cohort with 9 and 16 years of education, respectively, to compute the predicted depression) displays three phenomena: (1) depression levels are higher among younger cohorts (those born more recently) than among older cohorts, regardless of the level of education; (2) the magnitude of the differences among cohorts depends on education: among poorly educated people, depression is substantially higher in younger cohorts than in older cohorts, especially at an earlier age; by contrast, among well-educated people, the levels of predicted depression are only marginally higher in younger cohorts than in older cohorts, across age groups; (3) an education-based difference in depression has been emerging at progressively earlier ages for younger cohorts: the crossover point of the reversed patterns appears as early as in the 20s in the case of the 1970-birth cohort, whereas this point is in the late 40s in the case of the 1955-birth cohort.

In addition, in Figure 5 (which corresponds to Model 7 in Table 3 and

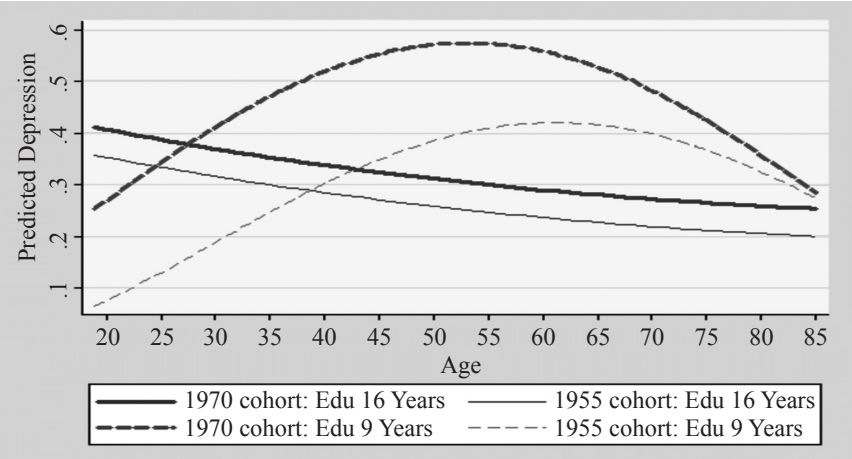


Figure 3 Predicted Depression (Square of the Predicted Value in Models) Across the Life Course by Birth Cohorts.

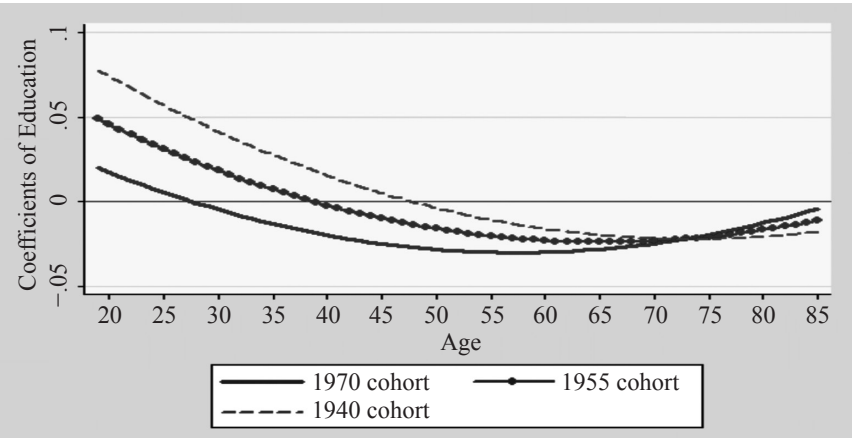


Figure 4 The Effects of Education on Depression Across the Life Course by Birth Cohorts.

Note: Graph corresponds to Equation 2 in the method section.



Equation 2 in the method section), the total effects of education on depression (computed as the sum of coefficients contingent on education) across the life course are delineated for three birth cohorts, the 1940-, 1955-, and 1970-birth cohorts. The results obtained for these birth cohorts show that education strongly affected depression (high negative coefficients) at all ages, but the shape and the location of the quadratic life-course patterns vary across cohorts. As shown in the figure, in the case of the 1970-birth cohort, the beneficial effects of education on depression start to emerge as early as in the 20s (the coefficients pass the coefficient line at 0 and become negative) and peak in middle life, whereas the beneficial effects occur in the late 30s and the late 40s in the case of the 1955- and 1940-birth cohorts, respectively.

Collectively, the rising importance hypothesis is supported because the education-cohort interaction term is negative and significant, and the educational-based difference in depression is larger and appears earlier for younger cohorts.

### **3. The Elderly Panel Results**

The foregoing results from the TSCS pooled data present empirical support for both aging impacts and cohort impacts of education on depression. However, the age-cohort analysis used in the repeated cross-sectional data only lessens, but does not eliminate, the issue of selective mortality (Lynch 2003). Hence, this study also studies the longitudinal Taiwanese elderly data by using the latent growth model with aging-vector techniques, so that selective mortality is less of a problem and within-person depression trajectory can be successfully portrayed.

#### **(1) The Impacts of Age, Cohort, and Education on Depression**

The latent growth curve estimates based on the panel samples of the

Taiwanese middle aged and elderly across five waves and 14 years are presented in Table 4 and are generally consistent with the hypothesized life course trajectory of depression, meaning that depression increases in late adulthood. All models in Table 4 fit the observed data well with the comparative fit indexes (CFI) over 0.995 and the root mean square of the analysis below 0.015.

To begin with, Model 1 and Model 2 are the prototypes that confirm the expected quadratic effects of age on the within-person level and slope of depression. These models are estimated without education in an attempt to get a general picture of the within-level depression trajectory across time. The significant and positive coefficients of the age and age<sup>2</sup> functions indicate that the predicted level and slope of depression increase across age, while the significant and negative coefficient of the age<sup>2</sup> function on the level of depression represents the falling curve occurring in old age, which slightly offsets the overall rising depression. In addition, Model 1 shows that the cubic effects of age on the level and slope of depression are not statistically significant, but Model 2 demonstrates that the cubic effect exists when the function only estimates the slope of depression. As a result, the aging functions of Model 2 are still used in the following analyses.

Furthermore, Model 3 in Table 4 demonstrates that well-educated people exhibit lower initial levels of depression and also lower rates of change in depression over time than poorly educated people do, according to the significant and negative educational impacts on the level and slope of depression. Moreover, education's inverse associations with the level and with the slope of depression remain solid and significant after adjusting for demographic and physical health measures (i.e., Model 6 of Table 4). This shows that education is a strong and consistent determinant of depression

for the Taiwanese elderly.

According to Model 3 and Model 6 in Table 4, control variables correlate with depression. Being female, suffering physical impairment, and having life-threatening diseases are also associated with high levels of depression, whereas only physical impairment increases the slope of depression. Meanwhile, the effects of being a Mainlander are inconsistent and not significant.

## (2) The Temporal Interactive Impacts of Education on Depression

### **a. The Findings of Cumulative Advantages and Age-As-Lever Perspectives**

The results in Table 4 sequentially reveal that the models include various interaction terms between age and education and terms between age<sup>2</sup> and education. Two major findings are displayed. First, although the age-education interaction with respect to the level of depression is not significant (i.e., the coefficient in Model 4 in Table 4), the negative and significant coefficients of the age-education interaction with respect to the slope (i.e., the coefficients in Models 4 to those in Model 7) suggest that the effects of education on the change in depression strengthen in middle life and late adulthood, which agrees with the core element of the cumulative advantage theory: the cumulative effects of education reduce the magnitude of the increase in depression as age increases. Consequently, the effects of the statistically insignificant coefficients of the age-education interaction on the constant of depression only weaken but do not seriously undermine the assumption of the cumulative-advantage theory. Second, Models 5 to 7 show that the positive coefficients of the age<sup>2</sup>-education interaction on the level of depression are only marginally significant. This implies that the effects of education slightly diminish in old age, and only provides slim

Table 4 Level and Slope in Depression Regressed on Age, Education, and Their Interaction Terms, Adjusting for Sex, Ethnicity, and Physical Health Measures, based on a Multi-Indicator Structural Equation Model With Time Centered on Mid-Follow-Up (N = 6,511).

Variables	Total Sample with FIML Estimation <sup>a</sup>						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
<b>LEVEL</b>							
(Age-70) × 10 <sup>-2</sup>	.857*** (9.779)	.897*** (17.745)	.765*** (15.442)	.754*** (13.194)	.763*** (14.891)	.482*** (10.358)	.280*** (5.457)
(Age-70) <sup>2</sup> × 10 <sup>-2</sup>	-.007 <sup>+</sup> (-1.948)	-.008* (-2.193)	-.006 (-1.619)	-.005 (-1.131)	-.004 (-1.082)	-.008* (-2.128)	-.014*** (-3.984)
(Age-70) <sup>3</sup> × 10 <sup>-4</sup>	.020 (.749)						
(Educ.-6) × 10 <sup>-2</sup>			-1.417*** (-11.749)	-1.684*** (-11.424)	-1.672*** (-11.389)	-1.388*** (-10.428)	-1.360*** (-10.348)
Education × Age <sup>b</sup>				-.004 (-.390)			
Education × Age <sup>a,b</sup>				.001 (1.606)	.001 <sup>+</sup> (1.745)	.001 <sup>+</sup> (1.665)	.001 <sup>+</sup> (1.821)
Phys. Impairment						.296*** (29.624)	.279*** (28.604)
# of Life-Threatening Diseases						.071*** (16.186)	.067*** (15.483)

Table 4 Level and Slope in Depression Regressed on Age, Education, and Their Interaction Terms, Adjusting for Sex, Ethnicity, and Physical Health Measures, based on a Multi-Indicator Structural Equation Model With Time Centered on Mid-Follow-Up (N = 6,511). (Continued)

Variables	Total Sample with FIML Estimation <sup>a</sup>						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Death <sup>c</sup>							.134*** (12.849)
Female (=1)	.155*** (15.405)	.155*** (15.368)	.116*** (11.419)	.115*** (11.377)	.115*** (11.381)	.084*** (9.266)	.092*** (10.187)
Mainlander (=1)	-.021 <sup>+</sup> (-1.696)	-.021 <sup>+</sup> (-1.726)	.024 <sup>+</sup> (1.873)	.033 (2.574)	.033* (2.532)	.023* (1.956)	.028* (2.396)
Intercept	.322*** (37.273)	.322*** (37.497)	.310*** (35.490)	.306*** (34.579)	.306*** (34.645)	.225*** (24.531)	.205*** (20.627)
Residual Variance	.073*** (21.531)	.073*** (21.436)	.072*** (22.282)	.072*** (22.422)	.072*** (22.400)	.056*** (23.760)	.055*** (23.921)
R <sup>2</sup>	.169	.166	.203	.208	.207	.488	.521
<i>SLOPE</i>							
(Age-70) × 10 <sup>-2</sup>	.051*** (4.198)	.053*** (4.402)	.055*** (4.422)	.044*** (3.410)	.045*** (3.468)	.051*** (3.947)	.025 <sup>+</sup> (1.859)
(Age-70) <sup>2</sup> × 10 <sup>-2</sup>	.002*** (3.500)	.002*** (3.138)	.002*** (3.389)	.001* (2.402)	.001* (2.397)	.002*** (3.653)	.001 (1.450)

Table 4 Level and Slope in Depression Regressed on Age, Education, and Their Interaction Terms, Adjusting for Sex, Ethnicity, and Physical Health Measures, based on a Multi-Indicator Structural Equation Model With Time Centered on Mid-Follow-Up (N = 6,511). (Continued)

Variables	Total Sample with FIML Estimation <sup>a</sup>						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
(Age-70) <sup>3</sup> × 10 <sup>-4</sup>	-.006 (-1.590)	-.008 <sup>+</sup> (-1.949)	-.009* (-2.273)	-.009* (-2.085)	-.010* (-2.395)	-.009* (-2.154)	-.009* (-2.234)
(Educ.-6) × 10 <sup>-2</sup>			-.034* (-2.013)	-.065*** (-3.398)	-.058*** (-3.893)	-.061*** (-4.113)	-.061*** (-4.155)
Education × Age <sup>b</sup>				-.004** (-2.862)	-.005** (-3.044)	-.004** (-2.963)	-.004** (-2.899)
Education × Age <sup>2b</sup>				.000 (.539)			
Phys. Impairment						.007*** (5.329)	.006*** (4.057)
# of Life-Threatening Diseases						-.001 (-1.631)	-.001* (-2.099)
Death <sup>c</sup>							.020*** (12.238)
Female (=1)	.003** (2.602)	.003** (2.605)	.002 (1.504)				
Mainlander (=1)	-.004* (-2.183)	-.004* (-2.215)	-.003 (-1.596)				

Table 4 Level and Slope in Depression Regressed on Age, Education, and Their Interaction Terms, Adjusting for Sex, Ethnicity, and Physical Health Measures, based on a Multi-Indicator Structural Equation Model With Time Centered on Mid-Follow-Up (N = 6,511). (Continued)

Variables	Total Sample with FIML Estimation <sup>a</sup>						
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	.004*** (3.555)	.005*** (3.655)	.004*** (3.504)	.004*** (4.269)	.005*** (4.371)	.005*** (4.386)	.003** (2.805)
Residual Variance	.001*** (8.085)	.001*** (8.078)	.001*** (8.219)	.001*** (8.234)	.001*** (8.237)	.001*** (8.734)	.001*** (8.550)
R <sup>2</sup>	.041	.038	.042	.045	.044	.097	.216
Residual Covariance	.001***	.001***	.001***	.001***	.001***	.001***	.001***
<b>FIT STATISTICS</b>							
$\chi^2$	134.411	134.706	152.739	176.670	177.177	249.572	248.133
<i>df</i>	59	60	68	86	88	104	112
CFI	.997	.997	.997	.997	.997	.996	.996
NFI	.994	.994	.994	.995	.995	.993	.994
RMSEA	.014	.014	.014	.013	.012	.015	.014

Note: Metric coefficients with critical-ratio in parentheses.

- a. Full Information maximum-likelihood is used to correct for attrition (assuming MAR).
  - b. Education  $\times$  Age is modeled as (Education-6)  $\times$  (Age-70)  $\times 10^{-2}$ . Education  $\times$  Age<sup>2</sup> is modeled as (Education-6)  $\times$  (Age-70)<sup>2</sup>  $\times 10^{-2}$ .
  - c. Compared to respondents who are not dropouts due to death.
- <sup>†</sup> $p < .10$ ; \*\* $p < .05$ ; \*\*\* $p < .01$ ; \*\*\*\* $p < .001$ .

evidence for the age-as-lever hypothesis.

Likewise, the results of the latent growth curve model can be interpreted most accurately when they are presented graphically. The results in Figure 5 show that the education-based gap in depression vectors widen in middle-aged and elderly people over the 14 years considered (corresponding to Model 5 in Table 4 and following Mirowsky and Kim's (2007) drawing procedure). The direction and magnitude of the aging trajectory depend on education. Although the predicted origins of depression increase with age regardless of education, the slopes of the change in depression differ: depression remains mostly stable across late adulthood in the case of well-educated people; by contrast, the slopes of the change in depression increase

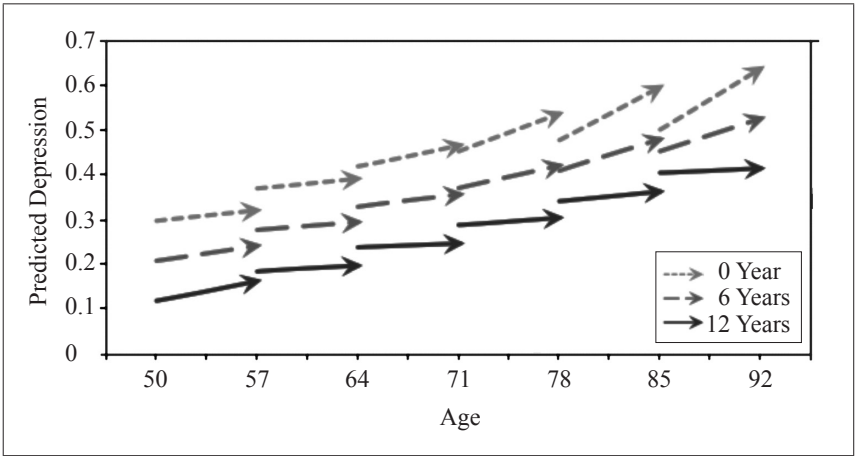


Figure 5 Simplified 7-Year Vector Graph of Predicted Level and Slope of Depression by Education Years.

*Note:* Graph corresponds to Model 5 in Table 4. In order to emphasize disjunction across models, the original 14-year aging vectors are simplified to 7-year vectors. These selected vectors (from left to right) represent respondents born in 1942–1943, 1935–1936, 1928–1929, 1921–1922, 1914–1915, and 1907–1908.



steeply in old age in the case of poorly educated people. Collectively, these results indicate that the education-based gap in depression remains stable during middle adulthood and then widens late in life. In addition, Figure 5 displays the obvious old-age divergence in depression across levels of education within older cohorts (i.e., the vectors of the 1914–1915 cohort and the 1907–08 cohort).

Taken together, the aging-vector models obtained using FIML estimations on the elderly panel data mainly show that the age-specific rates of change in depression differ across levels of education in a manner that progressively enlarges the gap in late life, supporting the cumulative advantage hypothesis.

### **b. The Findings of the Rising Importance Hypothesis**

Empirical evidence obtained in this study indicates that the effects of education on depression have varied across cohorts. The results in Figure 5 show that intercohort trends differ across levels of education among elderly people in Taiwan. A favorable trend is detected consistently in the case of well-educated people. For instance, among people who are educated for 12 years, the predicted depression at 78 is lower in the case of the 1921–1922–birth cohort than in the case of the 1914–1915–birth cohort (i.e., the vector head is lower than its adjoining vector end); conversely, among the people with 0 years of education, the predicted depression at 78 is substantially higher in the case of the 1921–1922–birth cohort than in the case of the 1914–1915–birth cohort. Taken together, the rate at which depression diverges across levels of education in late adulthood may itself be expanding for younger cohorts, which is consistent with the rising importance hypothesis.

#### 4. Inconsistent Findings Between TSCS and Elderly Panel Data

On the basis of the foregoing discussion, the results obtained from the sequential cross-sectional TSCS data and from the elderly panel data both provide substantial empirical evidence for the cumulative advantage hypothesis and the rising importance hypothesis. Nonetheless, these two distinct approaches reveal inconsistent late-life patterns of depression, as illustrated in Figure 2 and Figure 5.

On the one hand, the TSCS results show that the decline in depression in late life is more obvious in the case of poorly educated people than in the case of well-educated people. This suggests that the educational gap in depression starts shrinking after middle life and narrows noticeably after the age of 85, which is consistent with the age-as-lever hypothesis. However, it is important to note that the results obtained from the TSCS samples can potentially be attributed to selective mortality. Although the attrition issue is lessened with the utilization of age-cohort regression analysis on the repeated cross-sectional data, it is not totally eliminated, especially when a limited number of waves are used. Therefore, people in whom the trajectories of depression rise most steeply are possibly eliminated from the population because they die earlier than other people. Poor health also increases the inability or unwillingness to participate in a survey. In sum, it is possible for the average levels of depression to converge even though the changes in depression remain less for the better educated.

On the other hand, the evidence for the age-as-lever hypothesis from the aging vector analyses based on the elderly panel data is limited. In essence, results from the elderly panel data seem more convincing. First, latent-growth models can simultaneously predict the levels and slopes from age at the

time, education, and their interactions, making it possible to portray and compare aging trajectories in depression. And the result illustrated in Figure 5 is the obvious old-age divergence in depression across levels of education within older cohorts, rejecting the age-as-lever hypothesis. Second, previous research has explained that a latent growth curve model with aging vector techniques is able to distinguish education's effect on depression trajectories within cohorts from trends in its effect across cohorts. So, the results of such a model may be more accurate (Mirowsky and Kim 2007; Mirowsky and Ross 2008). Third, the latent growth curve model with FIML approach retains sample members who would otherwise be lost due to attrition and utilizes the tendencies predictable from the observed values to correct for attrition (Kim and Durden 2007; Mirowsky and Kim 2007). Besides, after adjusting for a dummy variable indicating dropouts due to death, the education-age pattern on the level and slope of depression remains constant in the analyses (i.e., the coefficients in Models 6 to those in Model 7 in Table 4). As a result, mortality selection bias is reduced to a certain degree in this approach.

Moreover, Mirowsky and Ross (2008) pointed out that when the cumulative advantage perspective and the rising importance perspective both exist, then each phenomenon tends to obscure the other, creating the false appearance of convergence in old age. That is, younger cohorts have higher rates of divergence, creating a gap at an earlier age. However, older cohorts have had longer for the health gap to develop. Thus, it seems that differences across age groups in a study are shrinking.

## **E. Discussion**

Studies conducted over the past two decades have identified the cumu-

lative-advantage theory and the age-as-lever theory as two competing hypotheses that debate whether education-based disparities in physical health and mortality increase over the course of life (Lauderdale 2001; Lynch 2003; Ross and Wu 1996) or decline in late life (Beckett 2000; House et al. 2005). This inconsistency has been frequently attributed to the selective mortality that is detected in cross-sectional data, the differences among the selected indicators (e.g., prevalence, incidence, or duration), and the lack of examination of cohort effects (Dupre 2007; Lynch 2003). This study has extended the discussion on the effects of education to the field of depression—a health outcome rarely examined in this type of research—and to Taiwan, which provides a non-Western setting. This study provides new evidence delineating that successful postponement of depression during the aging process is partially contingent on the level of education.

The core findings of this study support the cumulative-advantage theory. Whereas the depression trajectories obtained for all educational levels rise as people enter old age, the magnitude of the progression of depression is substantially lower in well-educated people than in poorly educated people, and this leads to increasing differences in the levels of depression in late life at the individual level. The results are critical for two reasons. Theoretically, the selection issue in old age (poor health increases the inability or unwillingness to participate in surveys) has been reported to compress the differences in health across levels of education (Beckett 2000; Beckett and Elliott 2001; Herd 2006). If this also occurred in this study, then the divergence detected here should be even larger than that measured. Methodologically, the results obtained using aging-vector models that include FIML estimations are valid. In this type of a method, the influence of mortality selection (i.e., the decrease observed in education-based disparities, which are composi-

tional artifacts that result from selective mortality caused by a cumulative disadvantage in terms of the onset of disease and survival) is lessened because information on decedents is imputed and included in the analyses (Mirowsky and Kim 2007; Wothke 2000).

In this study, the interaction terms between education and age with respect to the slope of depression are consistent and significant in all analyses and are mostly independent of physical impairment, chronic diseases and demographic characteristics. This finding provides new insights because the temporal relationships between education and depression have not been previously fully examined in non-Western societies. Although the patterns of divergence with respect to the depression level are determined to be similar in Taiwanese and American societies, the pattern with respect to the slope of depression is distinct: the effects of education on depression slope increase over time in Taiwan, whereas the effects decreased over the course of life in the USA according to the results of a study using the same methods as those used here (Kim 2006). Future studies should clarify whether this discrepancy in results is caused by cultural differences, the distinct age structures of the samples, or the use of dissimilar variables in statistical models.

Meanwhile, the effects of education are stronger in younger generations than in older generations in Taiwan, which agrees with the rising-importance theory: the results obtained using the TSCS samples clearly demonstrate that the effects of education on depression strengthen in successively younger cohorts. Moreover, the aging-vector analyses using the data on elderly people also demonstrate a favorable trend toward lower depression across cohorts in the case of people with a high number of years of education than in the case of people with only a few or no years of education. Collectively,

although depression levels increase across young cohorts in Taiwan, the effects of education on depression are becoming increasingly potent. However, the change reflects a trend toward increasingly rapid progression of depression in poorly educated people. That is, compared with well-educated people, younger people who are poorly educated probably face elevated levels of the risks associated with the high levels of depression prevalent today. Similar patterns have been detected in the results of self-reported health and mortality studies conducted in the USA (Lauderdale 2001; Lynch 2003). Because health-improving knowledge and medical technology are highly advanced today, the mortality rate is low in the case of all people, and because of an increase in overall material wealth, people who are highly educated are more likely than poorly educated people to maintain good health, including psychological wellbeing.

As shown in the appendix, the patterns displayed in this research remain solid after adding newer data into the analyses (i.e., the 2010 and 2015 TSCS are included in the analyses). However, the number of higher-education institutions in Taiwan has increased dramatically over the last decade, peaking at around 150 schools in 2000, and thus young people today can readily obtain advanced education and even experience different contents of education. This raises two questions. First, at the aggregate level, do the rise in the average number of years of education and the increase in the number of people with a college degree eliminate the education-based inequality in depression? Second, at the person level, does “years of education” still robustly predict depression in future generations, or, by comparison, do “prestige of schools” and “types of schools” (e.g., national versus private university; university versus technical college) become more valid measurements? Thus, future work should refine the association between

education and health by assessing the effects of educational quantity, selectivity, and credentials in the case of recent generations.

In terms of the relationships between education and depression over the course of life, the results of this study show that the directions of relationships across levels of education in early adulthood are distinct in the USA and Taiwan. In the study conducted using the American sample, U-shaped aging relationships in depression are observed in the case of people of all education levels (Miech and Shanahan 2000), whereas opposite patterns are detected in the results using the TSCS samples: the results of this study indicate that well-educated Taiwanese people are more depressed in early adulthood than poorly educated people are, but this pattern is reversed when people enter middle life. One plausible reason is that education affects the pace of a person's life course: well-educated Taiwanese people are typically in school, which delays the accumulation of marital, economic, and work resources in early adulthood; however, as these resources accumulate over the course of life, depression in well-educated people gradually declines. In contrast, poorly educated people are more likely to be employed and married in early life than well-educated people are, and both of these factors improve emotional wellbeing; however, in the case of poorly educated people, the accumulation of resources over the course of life does parallel the increase in the challenge of supporting a family (e.g., being able to continue paying for increasing costs of children's education or aging parents' medical care), and thus for these people, depression increases steadily as they age. As a result, conducting future empirical investigations is critical because this study is not designed to comprehensively elucidate the mechanisms by which education affects depression in early adulthood.

Appendix

Depression (Square-Root) Regressed on Age, Cohort, Education, and Their Interactions, Adjusting for Sex and Ethnicity: Taiwan, TSCS 1990, 1995, 2000, 2005, 2010, 2015 (N=11,714).

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Intercept	.511***	.499***	.502***	.501***	.498***	.501***	.502***
Age (10 <sup>-2</sup> )	-.148*** (-5.271)	.378*** (7.985)	.371*** (7.834)	.383*** (7.758)	.358*** (7.555)	.383*** (7.726)	.443*** (8.506)
Age <sup>2</sup> (10 <sup>-2</sup> )	.004** (2.736)	.005** (3.197)	.004** (2.992)	.000 (.105)	.002 (1.180)	.000 (.114)	-.005 (-1.405)
Cohort (10 <sup>-2</sup> )		.650*** (13.768)	.739*** (14.651)	.711*** (14.000)	.708*** (13.902)	.711*** (13.946)	.809*** (14.009)
Age × Cohort (10 <sup>-3</sup> )							-.076+ (-1.795)
Educ. (10 <sup>-2</sup> )			-.535*** (-4.977)	-.431*** (-3.435)	-.418*** (-3.768)	-.431*** (-3.434)	-.451*** (-3.595)
Age × Educ. (10 <sup>-3</sup> )				-.390*** (-4.968)		-.382** (-3.089)	-.558*** (-4.208)
Age <sup>2</sup> × Educ. (10 <sup>-3</sup> )				.004 (1.408)		.004 (1.399)	.025*** (3.502)



(Continued)

Variables	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
Cohort $\times$ Educ. ( $10^{-3}$ )					.259*** (4.204)	.008 (.076)	-.242+ (-1.847)
Age $\times$ Cohort $\times$ Educ. ( $10^{-3}$ )							.026*** (3.329)
Female (= 1)	.041*** (5.347)	.043*** (5.539)	.035*** (4.430)	.033*** (4.179)	.034*** (4.282)	.033*** (4.179)	.034*** (4.353)
Mainlander (= 1)	-.021+ (-1.762)	-.012 (-1.006)	.002 (.204)	.003 (.287)	.004 (.310)	.004 (.289)	-.000 (-.003)
Physical-Impairment	.182*** (30.209)	.183*** (30.625)	.181*** (30.162)	.179*** (29.845)	.179*** (29.905)	.179*** (29.838)	.178*** (29.718)
R <sup>2</sup>	.079	.093	.095	.097	.097	.097	.098

Note: 1. Unstandardized coefficients with t-statistics in parentheses shown. Aging components are centered as 45, birth cohort is centered as 1955, and education is centered as its mean.

2. + $p < .10$ ; \* $p < .05$ ; \*\* $p < .01$ ; \*\*\* $p < .001$ .

## References

- Beckett, Megan, 2000, "Converging Health Inequalities in Later Life—An Artifact of Mortality Selection?" *Journal of Health and Social Behavior* 41(1): 106–119.
- Beckett, Megan, Noreen Goldman, Maxine Weinstein, I-Fen Lin, and Yi-Li Chuang, 2002, "Social Environment, Life Challenge, and Health among the Elderly in Taiwan." *Social Science & Medicine* 55(2): 191–209.
- Beckett, Megan K., and Marc N. Elliott, 2001, "Mortality and Sample Selection: Reply to Noymer." *Journal of Health and Social Behavior* 42(3): 328–331.
- Chang, Ly-Yun, Meng-Li Yang, and Hsing-Yan Hsieh, 2012, "Education and Health in the Context of Social Change: Trend and Mediating Mechanisms." Pp. 301–336 in *Social Change in Taiwan, 1985–2005: Social Stratification and Labor Market*, edited by Yeu-Sheng Hsieh and Yang-Chih Fu. Taipei: Institute of Sociology, Academia Sinica.
- 張苙雲、楊孟麗、謝幸燕，〈社會變遷脈絡下教育的健康效應：趨勢和居間機制〉。頁 301–336，收錄於謝雨生、傅仰止主編，〈台灣的社會變遷 1985–2005：社會階層與勞動市場〉。台北：中央研究院社會學研究所。
- Coleman, James S., 1988, "Social Capital and the Creation of Human Capital." *American Journal of Sociology* 94: S95–S120.
- Crystal, Stephen, and Dennis G. Shea, 1990, "Cumulative Advantage, Cumulative Disadvantage, and Inequality among Elderly People." *The Gerontologist* 30(4): 437–443.
- Dupre, Matthew E, 2007, "Educational Differences in Age-Related Patterns of Disease: Reconsidering the Cumulative Disadvantage and Age-As-Leveler Hypotheses." *Journal of Health and Social Behavior* 48(1): 1–15.
- Elo, Irma T., and Samuel H. Preston, 1996, "Educational Differentials in Mortality: United States, 1979–1985." *Social Science & Medicine* 42(1): 47–57.
- Executive Yuan, Taiwan. 2001. "Population and Housing Census, 2000". Taipei: Directorate-General of Budget, Accounting and Statistics, Executive Yuan, Taiwan.
- Freedman, Vicki A., and Linda G. Martin, 1999, "The Role of Education in Explaining and Forecasting Trends in Functional Limitations among Older Americans." *Demography* 36(4): 461–473.
- Fu, Yang-Chih and Ying-Hwa Chang, 2017, "A Brief Introduction to the Taiwan Social Change Survey." In *Taiwan Social Change Survey*, <http://www.ios.sinica.edu.tw/sc/>

- en/home2.php (Date visited: April 10, 2017).
- Herd, Pamela, 2006, "Do Functional Health Inequalities Decrease in Old Age? Educational Status and Functional Decline among the 1931-1941 Birth Cohort." *Research on Aging* 28(3): 375-392.
- Herd, Pamela, Brian Goesling, and James S. House, 2007, "Socioeconomic Position and Health: The Differential Effects of Education versus Income on the Onset versus Progression of Health Problems." *Journal of Health and Social Behavior* 48(3): 223-238.
- House, James S., James M. Lepkowski, Ann M. Kinney, Richard P. Mero, Ronald C. Kessler, and A. Regula Herzog, 1994, "The Social Stratification of Aging and Health." *Journal of Health and Social Behavior* 35(3): 213-234.
- House, James S., Paula M. Lantz, and Pamela Herd, 2005, "Continuity and Change in the Social Stratification of Aging and Health over the Life Course: Evidence from a National Representative Longitudinal Study from 1986 to 2001/2002 (Americans' Changing Lives Study)." *Journal of Gerontology: Series B*, 60(Special Issue 2): S15-S26.
- Kim, Jinyoung, 2006, *Socioeconomic Status, Daily Work Qualities, and Psychological Well-Being Over the Adult Life Course: Age Trajectories and the Mechanisms of Mental Health Divergence*. Unpublished doctoral dissertation, Department of Sociology, The University of Texas at Austin, Austin, TX.
- Kim, Jinyoung, and Emily Durden, 2007, "Socioeconomic Status and Age Trajectories of Health." *Social Science & Medicine* 65(12): 2489-2502.
- Lantz, Paula M., John W. Lynch, James S. House, James M. Lepkowski, Richard P. Mero, Marc A. Musick, and David R. Williams, 2001, "Socioeconomic Disparities in Health Change in a Longitudinal Study of U.S. Adults: The Role of Health-Risk Behaviors." *Social Science & Medicine* 53(1): 29-40.
- Lauderdale, Diane S., 2001, "Education and Survival: Birth Cohort, Period, and Age Effects." *Demography* 38(4): 551-561.
- Liang, Jersey, Joan M. Bennett, Neal M. Krause, Ming-Cheng Chang, Huei-Sen Lin, Yi-Li Chuang, and Shwu-Chong Wu, 1999, "Stress, Social Relations, and Old Age Mortality in Taiwan." *Journal of Clinical Epidemiology* 52(10): 983-995.
- Liu, Xian, Albert I. Hermalin, and Yi-Li Chuang, 1998, "The Effect of Education on Mortality among Older Taiwanese and Its Pathways." *Journal of Gerontology: Series B*, 53B(2): S71-S82.
- Lynch, Scott M., 2003, "Cohort and Life-Course Patterns in the Relationship between

- Education and Health: A Hierarchical Approach.” *Demography* 40(2): 309-331.
- , 2006, “Explaining Life Course and Cohort Variation in the Relationship between Education and Health: The Role of Income.” *Journal of Health and Social Behavior* 47(4): 324-338.
- Miech, Richard Allen, and Michael J. Shanahan, 2000, “Socioeconomic Status and Depression over the Life Course.” *Journal of Health and Social Behavior* 41 (2): 162-176.
- Mirowsky, John, and Catherine E. Ross, 1992, “Age and Depression.” *Journal of Health and Social Behavior* 33(3): 187-205.
- , 1998, “Education, Personal Control, Lifestyle and Health: A Human Capital Hypothesis.” *Research on Aging* 20(4): 415-449.
- , 1999, “Economic Hardship across the Life Course.” *American Sociological Review* 64(4): 548-569.
- , 2003a, *Education, Social Status, and Health*. Hawthorne, NY: Aldine de Gruyter.
- , 2003b, *Social Causes of Psychological Distress*. Hawthorne, NY: Aldine de Gruyter.
- , 2007, “Life Course Trajectories of Perceived Control and Their Relationship to Education.” *American Journal of Sociology* 112(5): 1339-1382.
- , 2008, “Education and Self-Rated Health: Cumulative Advantage and Its Rising Importance.” *Research on Aging* 30(1): 93-122.
- Mirowsky, John, and Jinyoung Kim, 2007, “Graphing Age Trajectories: Vector Graphs, Synthetic and Virtual Cohort Projections, and Cross-Sectional Profiles of Depression.” *Sociological Methods & Research* 35(4): 1-45.
- Noymer, Andrew, 2001, “Mortality Selection and Sample Selection: A Comment on Beckett.” *Journal of Health and Social Behavior* 42(3): 326-327.
- O’Rand, Angela M., 1996, “The Precious and the Precocious: Understanding Cumulative Disadvantage and Cumulative Advantage over the Life Course.” *The Gerontologist* 36(2): 230-238.
- Pappas, Gregory, Susan Queen, Wilbur Hadden, and Gail Fisher, 1993, “The Increasing Disparity in Mortality between Socioeconomic Groups in the United States, 1960 and 1986.” *The New England Journal of Medicine* 329:103-109.
- Phelan, Jo C., Bruce G. Link, Ana Diez-Roux, Ichiro Kawachi, and Bruce Levin, 2004, “‘Fundamental Causes’ of Social Inequalities in Mortality: A Test of the Theory.” *Journal of Health and Social Behavior* 45(3): 265-285.
- Ross, Catherine E., and Chia-Ling Wu, 1995, “The Links between Education and Health.”

- American Sociological Review* 60(5): 719-745.
- , 1996, "Education, Age, and the Cumulative Advantage in Health." *Journal of Health and Social Behavior* 37(1): 104-120.
- Ross, Catherine E., and John Mirowsky, 1999, "Refining the Association between Education and Health: The Effects of Quantity, Credential, and Selectivity." *Demography* 36(4): 445-460.
- Ross, Catherine E., and Marieke van Willigen, 1997, "Education and the Subjective Quality of Life." *Journal of Health and Social Behavior* 38(3): 275-297.
- Schieman, Scott, 2000, "Education and the Activation, Course, and Management of Anger." *Journal of Health and Social Behavior* 41(1): 20-39.
- , 2001, "Age, Education, and the Sense of Control: A Test of the Cumulative Advantage Hypothesis." *Research on Aging* 23(2): 153-178.
- Seeman, Melvin, and Susan Lewis, 1995, "Powerlessness, Health and Mortality: A Longitudinal Study of Older Men and Mature Women." *Social Science & Medicine* 41(4): 517-525.
- Sen, Amartya, 1997, "Editorial: Human Capital and Human Capability." *World Development* 25(12): 1959-1961.
- Singer, Judith D., and John B. Willett, 2003, *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence*. New York: Oxford University Press.
- Tung, Ho-Jui, and Elizabeth J. Mutran, 2005, "Ethnicity and Health Disparities among the Elderly in Taiwan." *Research on Aging* 27(3): 327-354.
- Turner, R. Jay, and Donald A. Lloyd, 1999, "The Stress Process and the Social Distribution of Depression." *Journal of Health and Social Behavior* 40(4): 374-404.
- Turner, R. Jay, Blair Wheaton, and Donald A. Lloyd, 1995, "The Epidemiology of Social Stress." *American Sociological Review* 60(1): 104-125.
- Winship, Christopher, and Larry Radbill, 1994, "Sampling Weights and Regression Analysis." *Sociological Methods & Research* 23(2): 230-257.
- Wothke, Werner, 2000, "Longitudinal and Multigroup Modeling with Missing Data." Pp. 197-216 in *Modeling Longitudinal and Multilevel Data: Practical Issues, Applied Approaches and Specific Examples*, edited by Todd Little, Kai U. Schnabel, and Jürgen Baumert. Mahwah, NJ: Lawrence Erlbaum.
- Yang, Yang, 2007, "Is Old Age Depressing? Growth Trajectories and Cohort Variations in Late-Life Depression." *Journal of Health and Social Behavior* 48(1): 16-32.
- Zimmer, Zachary, Albert I. Hermalin, and Hui-Sheng Lin, 2002, "Whose Education Counts? The Added Impact of Adult-Child Education on Physical Functioning of

Older Taiwanese.” *Journal of Gerontology: Series B*, 57(1): S23-S32.

Zimmer, Zachary, Xian Liu, Albert Hermalin, and Yi-Li Chuang, 1998, “Educational Attainment and Transitions in Functional Status among Older Taiwanese.” *Demography* 35(3): 361-375.