In-Utero Exposure to the Korean War and Its Long-Term Effects on Economic and Health Outcomes

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Abstract

Prenatal exposure to the disruptions caused by the Korean War (1950–1953) negatively affected individual socioeconomic and health outcomes at older ages. The educational attainment and labor market performance of the subjects of the 1951 birth cohort, who were *in utero* during the worst time of the war, were significantly lower in 1990 and 2000. The results of difference-in-difference estimations suggest that the magnitude of the negative cohort effect is significantly larger for individuals who were more seriously traumatized by the war. As for health outcomes, the 1950 male birth cohort exhibited a significantly higher disability rate in 2005. Women married to the men in the 1950 birth cohort are more likely to be disabled at old age. If potential selections in pregnancy, birth, and survival are considered, the negative effects of the war may be even greater than suggested in this study. The long-term effects of *in-utero* circumstances differ by gender. This difference may be partly attributed to the strong population selection for the 1951 female cohort and the potent influence of the husband's health status over a woman's own health. Different aspects of human capital (e.g., health and cognitive skills) were impaired by *in-utero* exposure to the war, depending on the stage of pregnancy when the negative shocks were experienced.

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1. Introduction

Research across various disciplines has suggested that *in-utero* exposure to negative health shocks has strong and persistent effects on health and socioeconomic outcomes at older ages. This argument is widely known as the fetal origins hypothesis, developed and popularized by David J. Barker and his colleagues in the 1990s (Barker 1992, 1994). Since then, a voluminous body of literature has been accumulated, providing a variety of evidence in favor of this thesis (Currie and Hyson 1999; Chay and Greenstone 2003; Behrman and Rosenzweig 2004; Black, Devereux, and Salvanes 2007; Currie and Moretti 2007). In particular, an increasing number of studies have offered semi-experimental evidence. In these studies, the long-run consequences of several exogenously generated shocks to fetal health were investigated. Such traumatic events include the 1918 Pandemic Influenza (Almond 2006, Almond and Mazumder 2005), the Dutch Famine (Neugebauer, Hoek, and Susser 1999; Roseboom, Meulen, and Ravelli et al. 2001; Bleker et al. 2005), the Chinese Famine (St. Clair et al. 2005; Luo, Mu, and Zhang 2006; Meng and Qian 2009; Chen and Zhou 2007; Almond et al. 2010), and the Chernobyl disaster (Almond, Edlund, and Palme 2009).

The Korean War (1950–1953) offers a unique opportunity to examine the long-term effects of war-related disruptions, such as arduous refugee experiences, suffering under the North Korean occupation, hunger, and direct exposure to combat. Although the war lasted more than three years, the major war damages sustained by civilians were concentrated in the first nine months following the sudden invasion of North Korea (late June 1950–late March 1951); at that time, the frontline rapidly and unexpectedly moved back and forth across South Korea (Halberstam 2007; Chung 2010; Yang 2010). Furthermore, the severity of wartime experiences differs considerably depending on place of residence. For example, the residents of the Central Region were hit particularly hard because the area is closer to North Korea and was invaded by enemy forces twice. As will be discussed in detail, these specific circumstances help identify the effects of the war on maternal and fetal health through the comparison of the adult outcomes across birth cohorts and places of birth.

Drawing from these features of the Korean War, this article explores how *in-utero* exposure to the war-related disruptions affected adult health outcomes in South Korea. For this purpose, we examine how various measures of socioeconomic performance and health at older ages differ depending on timing and place of birth. Specifically, we investigate whether the individuals born in 1950 or 1951 (who had spent some time in utero during the first nine months of the war) show discontinuous cohort effects, and whether the cohort effects are more distinct for those born in areas hit harder by the war. Four micro datasets, including micro samples of the 1990, 2000 and 2005 censuses and the Korean Longitudinal Study of Aging (KLoSA) are used to construct variables on

adult health outcomes.

This study is one of the few attempts to understand the long-term socioeconomic consequences of disruptions directly caused by combat activities. Previous studies of this kind largely focused on the effects of famine, disease, and pollution. The present paper also draws evidence from South Korea that has not been investigated in the study of the long-term consequences of in-utero circumstances: the relationship between early-life conditions and later socioeconomic outcomes can differ across periods and countries, depending on the extent of economic development, institutional features, and cultural characteristics. Such outcomes can also differ by type of shock. Thus, evidence from the Korean War presented in the current study can widen the scope of the literature.

The evidence provided in this paper strongly suggests that prenatal exposure to the disruptions caused by the Korean War negatively affected individual socioeconomic and health outcomes at older ages. Measures of the educational attainment and labor market performance of individuals born in 1951, who were *in utero* during the worst time of the war, were significantly lower in 1990 and 2000. The results of difference-in-difference estimations suggest that the magnitude of the negative 1951 cohort effect is significantly larger for individuals whose place of birth was more seriously devastated by the war. As for health outcomes, the1950 male birth cohort are more likely to have functional limitations and report poorer general health (around age 55) than that predicted by long-term trends in health variables. If potential selections in pregnancy, birth, and survival are considered, the actual negative effects of the war may be even greater than suggested in this study.

The effects of prenatal exposure to the Korean War differ by gender and birth cohort. The health outcomes of females were unaffected by the war, whereas those of the males who were in utero during the early stages of the war were significantly worse than predicted by smooth cohort trends. This gender difference can be partly attributed to the potent influence of the economic and health status of the husbands over the health of the wives. The women married to the men born in 1950 were significantly more likely to have a disability in 2005 than predicted by smooth cohort trends, which is explained in part by the higher disability rates of their husbands. Another explanation for the differences in effects is the stronger population selection among females born in 1951.

The aspects of human capital that were significantly impaired by wartime in-utero influences differ between the 1950 and 1951 birth cohorts. The 1950 cohort exhibit worse health outcomes, whereas the major consequences of the war for the 1951 cohort are lower educational attainment and labor market performance. This difference by year of birth is attributed to the fact that the two cohorts were exposed to negative health shocks at different stages of pregnancy. The subjects of the 1951 cohort were *in utero* during the first half of pregnancy, a critical period for human brain development. By contrast, the majority of the subjects of the 1950 cohort began being exposed to war-caused shocks

after prenatal brain development was completed.

2. Long-Term Consequences of *In-utero* Influences

Research across a range of disciplines has established that early-life health and circumstances play an important role in determining health and economic conditions at older ages.[2] A series of studies by physicians and epidemiologists linked many of the degenerative conditions of old age to exposure to infectious disease, malnutrition, and other types of biomedical and socioeconomic stress *in utero* and during the early years of life. Recent research by economists suggests that early-life circumstances have strong and persistent influences on human capital accumulation and labor market performance. In addition, these effects are possibly mediated by deterioration in health and cognitive ability.

Whether a certain age is particularly critical for determining health and human capital development over life course remains debated. Findings that the effects of investments in health during early childhood persist or even increase in magnitude as individuals age suggest that the early years in human life is a distinct stage of development. Such effects on health occurring in these years are more significant and cannot be fully rectified by compensatory health investments made at older ages.

A group of researchers paid particular attention to the long-term consequences of *in-utero* influences. In the 1990s, David J. Barker and his colleagues developed and popularized the argument widely known as the fetal origins hypothesis. The hypothesis argues that disruptions to the prenatal environment are related to various chronic health outcomes at older ages, including coronary heart disease and diabetes (Barker 1992, 1994). It emphasizes initial health endowment (formed *in utero*), rather than postnatal conditions, as a health determinant in early ages. A wide variety of evidence pertaining to the fetal origins hypothesis has been suggested over the last two decades. Experimental studies using animals have provided evidence that maternal malnutrition has a causal effect on the subsequent health of the offspring. A voluminous body of literature evaluated the health and socioeconomic consequences of low birth weight (LBW), a proxy of exposure to malnutrition, infection, or toxic substances while *in utero*. Most of these studies revealed significant negative effects of LBW on human capital accumulation, socioeconomic status, and health outcomes (Currie and Hyson 1999; Behrman and Rosenzweig 2004; Black, Devereux, and Salvanes 2007; Currie and Moretti 2007). For example, Black, Devereux, and Salvanes (2007) analyzed Norwegian twins and

[2] See Almond and Currie (2010, 2011) for comprehensive surveys of the literature.

found that LBW had long-run adverse effects on adult height, IQ, earnings, and education. Currie and Moretti (2007) stated that LBW among individuals born in California had modest but statistically significant negative effects on educational attainment and the probability of living in a wealthy neighborhood.

A possible concern that confronts studies on size at birth and subsequent outcomes is that the positive correlation between measures of early life and adult health can be biased by omitted variables, such as genetic factors or post-birth investments.[3] A new line of research has attempted to address this potential problem by exploiting unique opportunities offered by natural experiments, in which individuals of a particular background or cohort were randomly exposed to a type of disruption *in utero*. If the probability of experiencing negative health shocks *in utero* is uncorrelated with unobservable determinants of health, then the estimated effects of the shock is not subject to omitted variable bias.

Almond (2006) used the 1918 influenza pandemic as a natural experiment to test the fetal origins hypothesis. He found that the cohorts *in utero* during the pandemic display reduced educational attainment, increased rates of physical disability, lower income, lower socioeconomic status, and higher transfer payments compared with other birth cohorts. Almond and Mazumder (2005) discovered that cohorts *in utero* during the pandemic exhibit impaired health outcomes relative to those born a few months earlier or later, 65 to 80 years after the event. Kelly (2009) found that people who experienced prenatal exposure to the 1957 Asian flu in Britain exhibit diminished test scores.

Historical famines have also been studied as natural experiments. At middle age, a cohort *in utero* during the 1944–1945 Dutch Famine exhibited a broad spectrum of health problems, such as poor self-reported health (Roseboom, Meulen, and Ravelli et al. 2001), coronary heart disease morbidity (Roseboom, Meulen, and Ravelli et al. 2001;Bleker et al. 2005), and adult antisocial personality (Neugebauer, Hoek, and Susser 1999). Research on the Chinese Famine (1959–1961) has reported a number of negative health and socioeconomic consequences, including heightened risk of schizophrenia (St. Clair et al. 2005), obesity among women (Luo, Mu, and Zhang 2006), height reductions (Chen and Zhou 2007), and reduction in the hours worked by employees (Meng and Qian 2009). More recently, Almond et al. (2010) have reported that higher famine intensity is associated with a greater risk of being illiterate, dropping out of the labor force, late marriage (for men), and marriage with partners with less education (for women). Neelson and Stratman (2011) have found that

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[3] Almond, Chay, and Lee (2005) compared the hospital costs, health at birth, and infant mortality rates between heavier and lighter infants of twins born in the United States to reduce potential bias arising from omitted variables, such as genetic factors. They observed a much more minimal effect of LBW on infant mortality and other health measures from a sample of twins.

exposure to the Greece famine of 1941/1942 in infancy lowers educational attainment.

The effects of prenatal exposure to pollution have also been examined via some natural experiments. Chay and Greenstone (2003) used variations in air pollution across counties; these variations were exogenously triggered by the implementation of the Clean Air Act of 1970 and the recession of the early 1980s. The decline in particulates significantly reduced infant death rates. Almond, Edlund, and Palme (2009) studied the effect of pollution stemming from the Chernobyl disaster on the subjects of a Swedish cohort who were *in utero* at the time of the disaster. The subjects exposed to radiation showed significantly reduced academic performance.

However, in spite of the growing body of evidence on the link between early-life circumstances and later economic and health outcomes, unresolved issues continue to exist. These issues motivate the present research. First, how *prenatal* exposure to military conflict affects later-life outcomes is considerably less known. There is voluminous literature on the long-term impact of war in general. In particular, it is well documented that measures of wartime stress, such as exposure to combat and imprisonment in POW camp have persistent negative effects on the health and socioeconomic outcomes of veterans (Nefzger 1970, Beebe 1975, Sutker 1991, Lee 2005, Costa and Kahn 2008, Robson et al. 2009). Long-term impact of war has been found for civilians, too. Individuals who resided in war countries in childhood during World War II experienced educational and earning losses at older age compared to those from non-war countries (Ichino and Winter-Ebmer 2004). Kesternich et al. (2011) report that exposure to World War II, measured by the number of years an individual directly affected by the war, and to individual-level shocks caused by the war such as hunger periods significantly predict old-age health and socioeconomic outcomes. However, these studies do not provide a clear distinction between effects of prenatal and postnatal exposure to war. Previous studies of in-utero circumstances largely focused on the effects of famine, disease, and pollution. Thus, the present study can add to our understanding of how the long-term effects of in-utero circumstances differ by the type of negative health shock.

Second, how the effects of early-life conditions differ across periods and nations remain unclear. The strength of the effect of an adverse shock to health *in utero* depends on the patterns of postnatal investments in health and human capital accumulation. If postnatal interventions on the child's nutrition, medical care, and education are effectively implemented, the prenatal damages can be rectified to some extent. Thus, the relationship between early-life circumstances and later socioeconomic outcomes likely differ across periods and countries. The differences depend on income, quality of medical care, and educational system, as well as political and social structures. In addition, cultural and social norms matter in determining the patterns of investments in health and human capital during childhood. In some societies, for example, parents tend to invest more in children with

poorer health to achieve more equal outcomes among children (a case of compensatory investment). By contrast, parents in other societies invest in their healthiest children to increase the expected return of investment (a case of reinforcing investment). Except for studies on China, evidence previously suggested for this issue has been drawn largely from the US and European countries. Thus, the present study focusing on Korea can widen the scope of literature.

3. The Korean War (1950–1953)

The Korean War began with North Korea's surprise invasion of South Korea on 25 June 1950, and lasted three years until an armistice agreement was signed on 27 July 1953. Vastly unprepared in terms of equipment and training, South Korean troops were repeatedly defeated and forced to retreat southward. The South Korean capital, Seoul, was captured by North Korean forces in only three days. The United Nations (UN) troops arrived in the south upon the UN Security Council's resolution recommending military assistance to South Korea. However, the advance of the North Korean Army into the country could not be held off. By late August 1950 (in only two months after the war broke out), North Korea had occupied about 90% of the entire Korean Peninsula (See Appendix Figure A0-1). The remaining un-invaded region was a small area around Busan City, located in Southeast Korea.

In the resulting battle at the Busan perimeter from August to mid-September 1950, the South Korean and US forces managed to stave off fierce North Korean attacks meant to capture the entire peninsula. On 15 September, the UN troops countered with a successful landing at Inchon, and forced the North Korean Army in the south to retreat northward to avoid a siege. The UN troops liberated Seoul on 27 September. They continued northward to capture Pyongyang City, the North Korean capital (19 October), and eventually reached the Amnok (Yalu) River that divides North Korea and China.

By late November 1950, the unification of the peninsula seemed to be only a matter of time. However, Chinese communist forces secretly moved into North Korean territory and ambushed the UN troops, forcing them to fall back. Seoul was again lost to the enemy on 4 January 1951. A large number of refugees from both the south and north had to leave their hometowns, following the retreating soldiers. Regrouped and reinforced, the UN forces stabilized the battlefront and fought back. On 14 March 1951, the UN troops drove the North Korean and Chinese armies out of Seoul. This was the city's fourth conquest in only nine months. After exchanging several offensive actions around the 38th parallel between March and June, the war reached a stalemate that lasted until the armistice of July 1953.

The Korean War is the most brutal event that Korea has ever experienced in the modern era, and one of the major international wars fought after World War II. Statistical data on human losses caused by the war are unreliable and substantially differ by source. According to the official statistics of South Korea published in 1955, the number of civilian casualties during the three years of hostilities totaled 990,968 including 373,599 persons killed; 229,625 injured; 84,532 abducted; and 303,212 missing in South Korea alone (Chung 2010). These estimates are likely understated. Military casualties were also heavy. An estimated 36,940 US servicemen and 245,000 to 415,000 South Korean soldiers were killed while in service during the war.

Despite its historical significance, the Korean War has drawn considerably less attention from people outside the country compared with World War II or the Vietnam War. Even the main participants (such as the US) who were directly involved in the campaign did not pay as much attention to the war. The "Forgotten War" is one of the best books written on the Korean War, offering an account of the conflict that befits its current status. Relatively rich literature on political circumstances has been devoted to the origin, progress, and aftermath of the war (Cumings 1981, 1990, 2010). Military actions are also reasonably well documented (Halberstam 2007). However, the social and economic aspects of the conflict remain poorly understood. In particular, how the war affected the everyday lives of civilians, and how wartime experiences influenced the subsequent health and socioeconomic performance of survivors over their life course are inadequately documented. Studying the social history of the Korean War based on the narratives of survivors has recently emerged as a promising approach to filling this gap (Kim 2009; Pyo et al. 2003). However, the primary focus has been the civil disputes and massacres caused by ideological conflicts.

Although quantitative evidence and systematic documentation are rare, visualizing the terrible ordeal suffered by the majority of the Koreans during the war is not difficult. With frontline troops dramatically moving back and forth across the region, practically the entire Korean Peninsula experienced the ravages of war. The chaotic situation in the early stages of the war directly exposed civilians to combat activities, taking a tremendous toll on human life. In addition to physical wounds and illnesses, a few survivors may have suffered from mental damages, such as post-traumatic stress disorder that afflicted the soldiers.

During the first several months of the war, a large number of South Koreans remained in the areas that were occupied by North Korean forces. The number of civilians who failed to escape from North Korean control remains uncertain. It is estimated that one million (or 50%) residents in Seoul remained in the city during the first three months of captivity (Yang 2010, p. 576). Many of the people under communist control suffered from atrocities such as massacres, tortures, imprisonment, and abduction. Civilians who remained under North Korean control were also victimized by heavy

bombings by the UN air forces that attempted to destroy North Korean military facilities and supply lines (Kim 2008). The lessons learned from the terrible experience under the first occupation, as well as the more organized evacuation efforts by the government, drove virtually all residents of the Central Region to flee southward when the Chinese Army pushed the UN forces back for a second time from the late 1950 to early 1951.

Refugee experience was no less arduous. Many refugees travelled on foot for days, carrying as many belongings as possible. People who were fortunate to get a train ride had to endure overly crowded cabins. Passengers who rode on the roof had to bear suffocating smoke blowing out of the steam locomotive, especially when the train passed through tunnels. Away from home, the refugees were compelled to endure chronic hunger and sleeping without proper shelter. Refugees who joined the retreating troops pushed by the Chinese attack suffered through the harsh winter cold.[4]

The small areas in the southeast that managed to avoid occupation, especially the two large cities of Busan and Daegu, were the main refugee destinations. Busan City, with a population of about 400,000, became home to more than one million people in only several months. Most refugees lived in shabby shelters made out of cardboard boxes, wooden planks, and makeshift tarp covering. Some people who had close relatives or friends living there fared slightly better, but they had to cram themselves into small rooms. Emergency aid provided by the UN forces and distribution of rations by the government prevented mass starvation, but these measure were still not enough to solve the severe food shortage.

4. Data and Methods

4.1. Identifying the Effect of War: Timing of Birth

We hypothesize that the various disruptions caused by the Korean War adversely affected maternal and fetal health. Measuring the magnitude of war-related negative health shocks is central to evaluating this hypothesis. However, data that can be used to link adult health and socioeconomic outcomes to detailed wartime experiences are unavailable. The key strategy that we employ in measuring the effect of the war is to investigate how individual socioeconomic outcomes at old age (available from various micro data) differ by the timing and place of birth.[5]

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[4] See memoirs by Korean writers including Kim (2006) and Chun (2006).

[5] This study closely follows the methods employed in recent major studies that examine the effect of the 1918 Pandemic Influenza by looking into the differences in adult outcomes by birth group (Almond 2005, 2006).

Comparing two birth cohorts while keeping all other factors constant is infeasible. Given the linear dependence among period, age, and cohort, implementing changes in cohort necessarily imposes alterations on either age or period. Furthermore, given that most socioeconomic outcomes tend to only gradually change across cohorts, identifying a cohort effect from other smooth effects is difficult. An example is the effect of changes in secular income over time.

However, one feature of the Korean War helps disentangle the cohort effect: civilians were directly exposed to major war disruptions for only a relatively brief period. Although the war lasted more than three years, the major damages sustained by civilians were concentrated in the first nine months following the sudden invasion of North Korea (late June 1950 to late March 1951). During these months, the frontline troops rapidly and unexpectedly moved back and forth across the region, forcing many civilians to suffer through either occupation or refugee experiences (See Appendix Figure A0-1 in the appendix). The war reached a stalemate around the 38th parallel after the spring of 1951, and civilian life in the south of the battlefield more or less stabilized. Thus, that the fetal health of individuals born in 1951 or late 1950 was more seriously damaged by war-related disruptions than were other birth cohorts is a reasonable assumption to make.

Two more assumptions are required to add credence to the hypothesis of the present study. First, following the fetal origins hypothesis, it is assumed that a particular wartime event causes a stronger negative health shock while an individual is *in utero* than in the postnatal period. Nearly all Koreans born either prior to or shortly after the Korean War should be negatively influenced by the war in one way or another. With all other factors being equal, if in-utero circumstances are more critical than, say, early childhood circumstances, then the adult outcomes of the cohorts who were *in utero* from the summer of 1950 to the spring of 1951 should be worse than those of neighboring cohorts.

Second, it is assumed that all other experiences except the war effect changed continuously or gradually across the birth cohorts considered in the analysis (those born in 1945 through 1959). In other words, no other major events (epidemics, short-term economic shocks, institutional changes, and so on) differentially affected the 1950–1951 birth cohorts and those adjacent to it. This looks like a reasonable assumption. For example, the number of students entering a college each year in Korea, a key institutional factor that determines educational attainment of each birth cohort, increased rather gradually from 1960 to 2000, with no discriminating effect on a particular birth cohort (See Appendix Figure A0-2 in the appendix). Similarly, although a number of disease epidemics occurred between 1945 and 1955, there is no evidence suggesting that a particular birth cohort underwent a considerably worse disease environment (Chun 2011).

Two types of evidence for the cohort effect are presented below. First, the raw data on adult

outcomes for each birth cohort are graphically displayed. Whether the 1950 or 1951 cohort reveals a discontinuous cohort effects is determined. For measures of socioeconomic outcomes drawn from the 2000 census (reporting the place of birth), the results for individuals born in the Central Region are highlighted because they experienced particularly severe hardships during the war, as explained later in the paper.

Second, the deviations of census results from smooth cohort trends are systematically estimated for individuals born between 1945 and 1959. The estimation is carried out using the following regression equation:

$$(1)\quad y_i = \alpha + \sum_{t=1950}^{1951} \beta_t I_{it} + \gamma_1 YOB + \gamma_2 YOB^2 + \varepsilon_i$$

where y_i denotes the census outcome for individual *i*; I_t denotes the dummy variable with a value of 1 for individuals born in year *t*, and 0 otherwise; YOB denotes the last two digits of the birth year; and β_t measures the departure of outcomes for the birth cohorts *in utero* during the Korean War from the quadratic cohort trend. If the birth month or quarter is known, the deviations of health outcomes from the quadratic cohort trend are estimated in a similar manner. The dummy variables for the birth quarter of the individuals born between the third quarter of 1950 and the final quarter of 1951 are included.

4.2. Identifying the Effect of War: Place of Birth

The severity of wartime experiences differs by region of residence, which offers another opportunity to identify the effect of the war on maternal and fetal health. For example, it is likely that wartime experiences were particularly arduous for the residents of the Central Region, the northern provinces of South Korea (including Seoul, Kyunggi, Kangwon, Chungbuk, and Chungnam), for the following reasons. First, compared with the residents of the southern region, they had less time to respond to the surprise attack by the North Korean forces because of their proximity to North Korea. As a consequence, the residents of the Central Region more likely suffered from occupation by North Korea and bombings by the UN forces. Second, if the residents of the Central Region managed to escape from the communist control, they would have had to travel a longer distance to reach the Busan perimeter. Finally, a large part of the Central Region was occupied by North Korea twice. Thus, many of the residents in the region were also displaced twice. Consequently, if the war negatively affected fetal health, the effect should be more pronounced among those who lived in the Central Region when the war broke out. Even within regions, the magnitude of war-caused damage can differ

from one place to another, depending on when and how long the area was occupied by the North Korean forces, how far it is from the Busan perimeter (the major destination for refugees), and how extensively it was influenced by combat activities.

For this study, the place where the mother of a person lived at the beginning of the war (summer of 1950) should be considered in constructing the location-specific measures of war-related disruptions. Unfortunately, information regarding maternal residence is unavailable. However, the place of birth of Korean War cohorts is a reasonably good proxy for the following reasons. First, descriptive records suggest that most refugees returned home as soon as their hometowns were liberated by the UN forces. Second, even individuals who were born while in refuge regarded their permanent homes as their birthplaces. These claims are supported by the regional composition of birth-by-birth cohort, displayed in Figure 1. If many people were born in the unoccupied Busan perimeter [denoted as South (F) in Figure 1] and recorded it as their place of birth, the percentage of people born in this area should have increased during the early stages of the war. However, the figure shows that the numbers remained remarkably stable from 1949 to 1952.

A difference-in-difference method is employed in examining the variations across place of birth to study the magnitude of wartime stress experienced while *in utero*. The basic idea is that if the cohort effect captures the influences of war-related disruptions, then it should be stronger for those who had more traumatic wartime experiences. To verify this assumption, we use either OLS or logistic regression to estimate the following equation:

$$(2) \quad y_i = \alpha + \beta_1 I_i + \beta_2 (I_i \times S_i) + \beta_3 S_i + \gamma_1 YOB_i + \gamma_2 YOB_i^2 + \delta X_i + \varepsilon_i$$

where I denotes the dummy variable that identifies an individual as *in utero* between the summer of 1950 and the spring of 1951, S is a measure of wartime stress, and X represents other location-specific factors of the given adult outcome.

In the analyses provided below, the following location-specific measures of wartime stress are employed. First, a dummy variable indicating whether a person was born in the Central Region is used because of the higher degree of suffering that these citizens endured. Second, dummy variables showing if a person's place of birth belongs to either of the following two categories: the localities that were occupied twice by the communist forces and the remaining areas in the Central Region captured only once. Third, the distance between the place of birth and Busan City is employed.[6] A

[6] The distance between the municipal office of each county (or district) and city hall of Busan is measured.

longer distance from the major destination for refugees should be related to a higher probability of being occupied by the North Korean forces, greater exposure to UN bombings, and more arduous refugee experiences. Finally, the duration of North Korean control is considered.[7] The longer the duration under occupation, the more devastating the suffering of the residents should be, regardless of whether they managed to escape.

4.3. Data and Variables on Adult Outcomes

Four micro datasets are used: the 2% micro samples of the population censuses (referred to as the Census, hereafter) for 1990, 2000 and 2005, and the first wave of the Korea Longitudinal Study of Aging surveyed in 2006 (the KLoSA, hereafter). Each of these sources has its own advantages and drawbacks in terms of sample size and variables offered. Major advantages of the Census are its large sample size and its provision of the places of birth, which allows for accurate estimation of adult outcomes by birth cohort and place of birth.[8] Conversely, it has two major limitations. First, it offers only a restrictive set of variables on personal characteristics, especially health outcomes. Second, it does not provide a report on the month or quarter of birth, thereby making the identification of the exact timing and duration of in-utero exposure to wartime disruptions difficult.

The analyses offered in this study regarding the effect of the war on socioeconomic outcomes at older ages largely rely on the 2000 census because it provides a richer set of variables on adult labor market outcomes. Additionally, the individuals born during the Korean War reached their prime ages (47–50) in 2000 in terms of socioeconomic status. Furthermore, the 2000 census provides detailed geographic codes for the places of birth, which enables the study of how the effect of war differs by place of birth. The following measures of socioeconomic outcomes are considered: (1) years of schooling; (2) probability of entering college; (3) probability of having primary school education or lower; (4) probability of having professional employment; (5) probability of having an

[7] The dates of occupation of a particular place by the North Korean forces and its liberation by the UN troops are either drawn or estimated based on descriptive histories of the Korean War, and maps displaying changes in the battlefield over time. If the exact timing of an event cannot be determined based on the available sources, the frontline connecting two places is assumed, for which the date of the event is known, moving with the same pace. The six-volume histories of the Korean War compiled by a government agency (The War Memorial Society 1992) and the Military Academy of the Korean Army (1998) are used as major sources.

[8] The micro sample of the 1980 census also provides information on the place of birth as well as a number of socioeconomic outcomes. But some individuals who belong to the post-war birth cohorts, who were compared with the Korean War cohorts in this study, were too young in 1980 to provide accurate measures of adult outcomes. For example, individuals in the 1959 birth cohort, who were included in the sample used in the analyses conducted in the balance of the study, were only twenty one in 1980, too young to complete schooling and to start job career.

unskilled job; and (6) probability of using the Internet.[9] In addition, the 1990 census, another rare micro source reporting the places of birth, is used in analyzing educational attainment and employment status.[10]

The 2000 census offers information on functional limitations only for individuals aged 65 and older. Thus, measures of adult health are obtained from the 2005 census, which indicates whether a person has disability and functional limitation for all respondents. Specifically, the following health outcomes are considered: (1) probability of having disability; and (2) probability of suffering from limited daily activities. The micro sample of the 2005 census does not indicate the place of birth. Thus, comparing the health outcomes across birth cohorts cannot be carried out separately for each region of birth.

The KLoSA is perhaps not particularly appropriate for the purpose of this study because of its excessively small sample size (about 10,000 persons aged 45 and older in 2006). The number of single-year birth cohort by gender born during the Korean War ranges from 150 to 250. However, the KLoSA provides a much larger sample of cohorts born around the war than do other Korean micro data that contain more detailed information on personal characteristics (e.g., the Korean Labor and Income Study). It also offers rich information on health outcomes. Furthermore, the month of birth is available from the source; thus, examining how health outcomes change by year and quarter of birth is possible. For these reasons, the analyses of health outcomes are supplemented by the results based on the KLoSA despite the small sample size. The following measures of health outcomes are obtained from this source and analyzed: (1) score of self-reported health (one to five, representing the best and worst health status); (2) probability of reporting poor health (self-reported health is four or five); and (3) probability of having any disability.

Table 1 presents the sample means of the socioeconomic and health outcomes of the individuals born from 1945 to 1959 for all males and females and for those who were born in the Central Region. The mean years of schooling for males and females in the 2000 census are, respectively, 11.6 and 9.8. Nearly 27% of males entered college whereas only 11% of females did so. Measures of schooling did not change much between 1990 and 2000. Individuals born in the Central Region were more educated than the entire sample. As for labor-market outcomes, 14% of males and 53% of females in the sample were not working when the 2000 census was taken. Of those who

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[9] Professional occupations include professionals, managers, officials, and technical experts (2000 census occupations codes 0 to 293); Unskilled jobs include manual laborers and operatives (2000 census occupation codes 811 to 942).

[10] Measures of the quality of occupation cannot be obtained from the 1990 census because of serious errors in the occupation codes given in the public-use micro sample of the 1990 census.

worked in 2000, 26% of males and 9% of females were employed in professional jobs; the proportion of workers engaged in unskilled occupations in 2000 was 24% for males and 18% for females.

5. Long-Term Effect of the Korean War on Adult Outcomes

5.1. Deviations of Socioeconomic Outcomes from the Smooth Cohort Trend

Figures 2 to 4 plot three measures of educational attainment for males and females born in the Central Region from 1945 to 1959. These are years of schooling, percentage of individuals who entered college, and percentage of people with primary schooling or lower, obtained from the 2000 Census. Appendix Figures A1 to A3 show these educational measures for the entire sample of cohorts regardless of their place of birth.

A strong upward trend in educational attainment is shown by these cohorts. The 1950 and 1951 birth cohorts lie off this steady trend. In particular, the deviation of the 1951 cohort from the tendency of long-term increase in schooling is clearly revealed. The 1951 cohort subjects received approximately two months less schooling than those born in 1949. They were less likely to enter college and more likely to achieve the lowest educational attainment.

The departure of the 1951 birth cohort from the trend is also observed in the entire sample (Appendix Figures A1 to A3), although at a smaller magnitude. Educational attainment either stagnated (entrance to college or higher for males and females, and primary school or lower for females) or improved more slowly than predicted by the long-term trend (year of schooling for males and females, and primary school or lower for males) from the 1950 to the 1951 cohort.

Figures 5 and 6 present two measures of success in the labor market for the male subjects who were born in the Central Region from 1945 to 1959: the percentages of males with professional employment and those who were manual laborers were calculated from the 2000 census.[11] The analysis is limited to males because of the low labor force participation of females belonging in the cohorts. As with schooling trends, a much poorer occupational achievement of the 1951 male birth cohort is evidently observed. Male workers born in 1951 are much less likely to be employed in a professional job, and more likely to hold unskilled manual occupation than predicted by long-term trends. The same measures constructed for the entire sample (Appendix Figures A4 and A5) show similar handicaps for the 1951 birth cohort, although the magnitude of deviation from the trend is smaller than that for the Central Region.

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[11] These measures of labor market outcomes are computed for the entire sample, including non-participants in the labor market and the unemployed. The unconditional percentages provide similar implications that the results are not primarily driven by decisions on labor force participation.

The first two columns (1 and 2) of Table 2 show the estimates of β_t in Equation (1), indicating the magnitude of outcome deviation for the male subjects born in 1950 and 1951 from the quadratic cohort trend. Logistic specification is used for binary outcomes (Panels C to K). An OLS regression is conducted for the continuous outcome variable (Panels A and B). The regression results confirm that educational attainment, quality of occupation, and probability of using the Internet are significantly lower for the 1951 birth cohort, especially for the subjects who were born in the Central Region.[12] For all measures except "not working" in 2000 (Panel H), the 1951 cohort effect is statistically significant in the sample limited to people born in the Central Region (Col. 2 of Table 2). When the entire sample is used (Col. 1), the 1951 cohort effect continues to be statistically significant (although much smaller in magnitude) for seven out of eleven socioeconomic outcomes. In sharp contrast, the cohort effect is insignificant for individuals born in the Southern Region, regardless of whether the area was occupied by North Korea (not reported in the table).

Columns 3 and 4 of Table 3 show the regression results for females, which correspond well with the patterns of cohort effects displayed by the figures. The female subjects of the 1951 birth cohort, born in the Central Region, exhibit clear disadvantages in all six measures of educational attainment (Panels A to F of Col. 4). Unlike males, however, the 1951 female cohort does not significantly differ from other cohorts in terms of internet use, employment status, and the two measures of occupation quality. Given the low labor-force participation rate of women belonging in the cohorts included in the analysis, it is not too surprising that the 1951 cohort effect is insignificant for female labor-market outcomes. For those born in the Southern Region, a 1951 birth had no negative effect on female socioeconomic outcomes (not reported here).

5.2. Cohort Effect, Wartime Stress, and Socioeconomic Outcomes: Difference-in-Difference Method

If the deviation of the Census outcomes of the 1951 birth cohort captures the influences of war-related disruptions experienced while *in utero*, then its magnitude should be larger for individuals exposed to worse in-utero circumstances during the war. This hypothesis is consistent with the aforementioned fact that the disadvantages of the 1951 birth cohort are particularly pronounced among individuals born in the Central Region. Further analyses employing more direct and detailed measures of wartime stress, provided in the balance of this subsection, confirm that the 1951 cohort effect is indeed stronger for individuals whose in-utero wartime experiences were more arduous.

Figure 7 offers a comparison of the male years of schooling between the 1951 birth cohort

[12] The negative effect of birth in 1951 on occupation quality is not fully explained by the disadvantage of the cohort in educational attainment. Even if the education factor is controlled for, the 1951 cohort effect remains statistically significant.

and neighboring cohorts (either 1950 or 1952) by the distance between their place of birth and Busan, a measure of wartime stress. Among the individuals born in a place near Busan (within 200 kilometers), the 1951 birth cohort acquired slightly more schooling than did the adjacent cohorts. The direction of schooling gap is reversed for areas that are 200–300 kilometers away from Busan. The graph shows that the disadvantages in schooling for the 1951 cohort compared with those of other cohorts are particularly pronounced for individuals born far from Busan. The results for females are similar to those obtained from the male sample. This result suggests that the 1951 cohort effect increases with the severity of wartime stress measured by the distance from Busan.

Figure 8 presents the result of a similar analysis, in which the duration of occupation by the North Korean forces is used as an alternative measure of war-caused negative shocks to fetal health. This measure presents remarkably similar implications. Lower schooling of the 1951 birth cohort is largely observed in individuals born in an area under communist control for a prolonged period. Figures 9 and 10 suggest that the 1951 male cohort's disadvantages in terms of labor market performance (measured by the percentage of unskilled workers) are also larger for those who were exposed to more serious war-related disruptions, represented by a greater distance from Busan or a longer duration of occupation by enemy forces. A similar result is obtained using the percentage of males with professional employment as the measure of occupational success.

OLS regressions for the years of schooling are conducted based on a difference-in-difference model displayed in Equation (2). If the 1951 cohort effect increases with the magnitude of wartime stress, then the coefficient of the interaction between the dummy variable for the 1951 birth (BORN1951) and the measure of wartime stress should be negative. The quadratic cohort trend (YOB and YOB^2), dummy variable for the 1951 birth, and measure of negative shocks caused by the war are controlled for. In addition to the baseline model (model 1), an alternative specification is used, in which the variables pertaining to the extent of urbanization are added (model 2). These variables are incorporated to consider the fact that urban areas provide more favorable environments for human capital development. To construct the variables concerning the extent of urbanization, we classify places of birth into four categories: (a) Seoul (CITY_SEOUL); (b) five metro cities, namely, Busan, Inchon, Daegu, Deajun, and Kwangju (CITY_METRO); (c) all other smaller cities (CITY_SMALL); and (d) rural areas (omitted category). Four measures of wartime stress are employed: (a) dummy variable of birth in the Central Region (CENTRAL); (b) dummy variables of birth in the localities occupied twice (CENOCCUP2) and of birth in the other places in the Central Region that were captured only once (CENOCCUP1); (c) the distance between the place of birth and Busan, measured in 100 kilometers (BUSAN_DIST); and (d) the months under occupation by North Korean forces (DUROCCUP).

Table 3 presents the results of the regressions conducted for males and females. Four panels (A, B, C, and D) provide parameters that are estimated based on each of the four measures of wartime stress. The results support the hypothesis that the 1951 cohort effect on the years of schooling is stronger for those who suffered more serious war-related disruptions. For males, the coefficient of the interaction between the 1951 birth and measure of wartime stress is negative and statistically significant for all eight specifications. For females, the coefficient is also negative and statistically significant for five out of eight specifications; the other two (model 2 employing CENTRAL or BUSAN_DIS as a measure of wartime stress) miss statistical significance by small margins (p-values are 0.21 and 0.13, respectively).

The measures of wartime stress are all positively related to the years of schooling when model 1 is applied. This result may have stemmed from the fact that educational attainment is higher among the residents of Seoul metropolitan areas (including Seoul, Inchon, and smaller satellite cities), and that the Seoul metro area was more heavily devastated by war-related disruptions because of its proximity to North Korea. This conjecture is consistent with the result that when the variables pertaining to the extent of urbanization are controlled for (model 2), the effects of war-time stress either become significantly negative (panels B, C and D for males, and panel D for females) or insignificant (panel A for males and panel C for females). For the regression for females, in which CENTRAL is employed (panel A), the coefficient of CENTRAL remains negative and statistically significant, even if the extent of urbanization is controlled for. However, its absolute magnitude diminishes by two-thirds.

Table 4 reports summary results of 88 difference-in-difference regressions conducted for all eleven measures of socioeconomic outcomes considered in this study. The results suggest that for a wide range of socioeconomic outcomes the 1951 cohort effect is stronger for those who suffered more serious wartime stress while *in utero*. For males, the coefficient of the interaction between the 1951 birth and measure of wartime stress is statistically significant for 26 out of 44 regressions. For all adult outcomes with a single exception (the probability of having primary school education or less in 1900: Panel 1-E), the coefficient for the interaction term is statistically significant for at least one specification; for eight out of eleven measures, it is significant for at least two specifications.

The results for females are similar to those for males if educational outcomes and the probability of internet use are considered. However, it seems that pre-natal exposure to war-related disruptions had much weaker effects on women's labor-market outcomes than it did on men's. Only the probability of employment in unskilled occupations in 2000 was significantly affected by the interaction between the 1951 birth and measure of wartime stress (Panel 2-J, Cols. 3 and 4). The much lower, and presumably more selective, labor force participation of women born prior to 1960 is a

possible explanation for the difference by gender

5.3. Health Outcomes: Results from the 2005 Census and the 2006 KLoSA

Figures 11 and 12 present the health outcomes of the male and female individuals born between 1945 and 1959, drawn from the 2005 census: the percentages of individuals with disability, and the percentage of individuals with limited daily activity. The 2005 census does not identify the place of birth; thus, the patterns of cohort effects on health cannot be compared across birth regions.

The plots suggest that the 1950 and 1953 male subjects exhibit deviations from the quadratic trend in the prevalence rates of disability and limitations in activity. On the other hand, no clear departures of the Korean War female birth cohorts from the long-term trends in these health outcomes are observed.

The logistic regressions reported in Table 5 confirm these cohort effect patterns, in which the quadratic cohort trend is controlled for. The estimates of β_t suggest that the 1950 male birth cohort is more likely to have disability or limitation in daily activities than other birth cohorts. No statistically significant cohort effects are observed for females.

A crucial drawback of the present analysis based on the 2005 census is that the cohort effect cannot be estimated separately for people born in the Central Region, making for a difficult assessment of the actual effect of the war on fetal health. Two measures of health are compared across individuals who resided in the Central Region in 2005 to obtain a rough idea of the significance of this limitation. The region of 2005 residence is at best a highly inaccurate proxy of the region of birth given that geographic mobility since the Korean War was high.[13] Nevertheless, the plots given in Appendix Figures A6 and A7 suggest that the negative 1950 cohort effect is likely to be greater for individuals born in the Central Region. At least for males, the outcome deviations for the 1950 cohort are more pronounced when the sample is limited to the individuals living in the Central Region.

To supplement the results obtained from the 2005 census, we plot several health outcomes available from the 2006 KLoSA for each birth quarter from 1948 to 1955. These conditions are the average score of self-reported health, percentage of each cohort reporting poor health, and percentage of each cohort having disability. The place of birth is not identified in the KLoSA. Thus, only the results for the entire sample are given.

Figures 13 to 15 display the plots of these variables. Although the measures of health

[13] A comparison of the regions of birth and residence in 2000 based on the 2000 Census suggests that about 90% of individuals born in the Central Region were still living there in 2000. However, these original residents of the Central Region accounted for only 58% of the entire regional population because of the inflow of migrants from the Southern Region after the Korean War.

considered in the analysis considerably fluctuate across birth quarters (perhaps because of the small sample size), the male subjects born in the second quarter of 1951 clearly deviate from the long-term trends in all three health outcomes. By contrast, the plots for females do not reveal any clear cohort effect.

Table 6 offers the results of regressions in which the dummy variables of birth in each quarter, from the third quarter of 1950 to the last quarter of 1951, as well as the quadratic cohort trend, are considered. Logistic regressions are performed when a binary variable is used as the dependent variable (Panel B), whereas the OLS model is applied to a continuous dependent variable (Panel A).

The regression results for self-reported health and disability are consistent with the patterns of cohort effects displayed by the figures. The male subjects born in the first and second quarters of 1951 are more likely to report poorer health (Panels A); those born in the second quarter of 1951 are more likely to have disability (Panel B). Females who were *in utero* for any length of time during the worst ten months of war do not exhibit any significant disadvantages in self-reported health and disability.[14]

6. Discussion

6.1. Potential Bias Arising from Population Selections

Although no statistical data are available, the Korean War likely killed many pregnant women, as well as disrupted marital and fertility behaviors. Moreover, post-war mortality should also be influenced by wartime experiences. Thus, a natural concern related to interpreting the results of this study is the pattern of selection of the Korean War birth cohorts who survived for five decades after the conflict.

Several different types of population selections possibly influenced the composition of war-time birth cohorts: selections in (a) deaths of pregnant women; (b) conceptions or fertility behaviors; (c) prenatal deaths; and (d) postnatal deaths. Evidence regarding the first three types of selections is difficult to obtain. Comparing the socioeconomic characteristics of the parents across different birth cohorts would be useful, but no data are available for basis. For the Census, parental education can be observed only if the person co-resides with his or her parents. Any evidence from currently available

[14]Several male and female birth cohorts who were exposed to the war *in utero* also appear to experience stunted growth. Males born in the fourth quarter of 1951 or the first quarter of 1953 were shorter by 1.7 centimeters or more than indicated by the long-term trend. Females born in the quarter following the war outbreak experienced a reduction in average height by 1.4 centimeters. Females born in the second quarter of 1951 are much more likely to belong to the lowest quintile of height distribution.

data cannot determine the direction of potential selections because parental survival and co-residence decisions are non-random. However, the cohorts *in utero* during the worst time of the war are unlikely to be positively selected in these respects.

The majority of the civilians who died during the Korean War were victimized by either combat activities or politically motivated murders. Considering the unexpected outbreak and highly chaotic progress of the war, visualizing that pregnant women from a particular background were more likely to be hit by bullets or bombs is difficult. Descriptive documents suggest that migrants from North Korea, as well as family members of South Korean policemen and soldiers, were more likely to escape to the southern region for fear of possible punishment by the North Korean forces. However, whether the people who failed to escape considerably differ in terms of socioeconomic status from refugees in the Busan perimeter is difficult to determine. Refugees also had their own share of hardships. Although the possibility of selection cannot be precluded, survival during the Korean War should be more randomly determined compared with events such as famines or epidemics.

Birth before June 1950 is not affected by the war. Thus, the cohort subjects born in the spring of 1951 should not be selected in terms of conception. The probability of conception for the cohort subjects born after March 1951, and the probability of prenatal death conditional on conception for the subjects born after June 1950 should be influenced by the war. Again, no direct evidence is available as to who were more likely to be pregnant and who were more likely to have live birth. However, that women who were under a more favorable socioeconomic circumstance had better chances of having a baby than those in poorer conditions is a reasonable assumption to make. If so, the cohort offspring, whose fetal health was most seriously damaged by the Korean War, are positively selected in terms of conception and live birth. As a consequence, the cohort effect estimated in section 5 should be understated.

Some circumstantial evidence is available for positive selections in postnatal survival. Figure 16 shows the size of each cohort born from 1948 to 1955, as enumerated by the censuses of 1960 and 2000. A larger fraction of the 1951 birth cohort subjects died between 1960 and 2000. The size of the 1951 cohort diminished by 15%, whereas the 1950 and 1952 cohorts reflected losses of 9% and 11%, respectively in its population during these four decades. The cause for the rapid reduction in population of the 1951 birth cohort compared with other cohorts is unclear. This may have resulted from the worse in-utero circumstances that the cohort was exposed to, although more research is required to verify this claim. Whatever the cause was, the cohort subjects with frailer health had likely died by 2000. As a consequence, the 1951 birth cohort subjects who were still alive in 2000 are positively selected in terms of health or robustness, compared with other cohorts whose mortality rates since 1960 are lower. This type of selection should produce a downward bias in the magnitude of

the 1951 cohort effect in the health and socioeconomic outcomes, as suggested above.

6.2. Differences by Gender

A dilemma arising from the results given above is why the health outcomes of females were unaffected by the Korean War, whereas the health measures of the 1950 male cohort subjects (from the 2005 census outcomes) and the male cohort subjects born in the second quarter of 1951 (2006 KLoSA outcomes) were significantly worse than predicted by smooth cohort trends. Four possible explanations are suggested and examined, without implying that these are exhaustive or mutually exclusive.

First, the war-related shocks could have less severely impaired the fetal health of females than males because of the biological differences between genders. In the prenatal period and early childhood, females are generally known to be more robust than males, as suggested by the lower rates of still births and infant mortality among girls. However, no sharp gender differences in the relationship between in-utero circumstances and adult health outcomes have been found in previous studies that examined other disastrous events such as famines and epidemics. A possible explanation for the distinct results of the present study is that varied types of shocks to fetal health can affect the adult health outcomes of males and females in different ways.

Second, the gender differences in the health effects of the Korean War could have been generated by the gender bias in the parental investments in children. This hypothesis is based on the following assumptions. First, the effects of the Korean War on health were mediated by different parental investments in children. Second, more parental investments were made in healthier children to increase the return of investment. Finally, parents made minor investments in the wellbeing of their daughters during mid-20th century Korea because of strong son preferences. Under these conditions, the disparity in in-utero circumstances among girls would not produce any differences in their adult health outcomes because parents did not spend much to improve a daughter's health in any way. However, testing this hypothesis is difficult because neither the mechanism by which the negative influences of the Korean War affected adult health nor the patterns of parental response to health shocks to children are known.

Given the evidence that parents prefer sons over daughters even in developed countries today (Dahl and Moretti 2008, Lhila and Simon 2008), it is reasonable to assume that son preference played a significant role in parental investment in children in Korea circa 1950, although determining the magnitude of the bias is difficult. Evidence pertaining to parental response to health shocks is even harder to obtain. A study by Conti et al. (2011), based on a sample of twins in China, suggests that parental investments in children's health are compensatory, whereas their investments in children's

cognitive development are reinforcing. Although Korea and China share several common cultural features, it is unclear if the patterns of parental investments in children in Korea six decades ago and those of China today are similar given institutional and socioeconomic differences.

Third, only a small fraction of females born around the Korean War participated in the labor market, and virtually all of them eventually married. Thus, the husband's health and socioeconomic status possibly played a more important role in determining the health of older women. An underlying assumption behind this hypothesis is that the effect of the war-caused negative health shocks on adult health was mediated by different economic statuses. This hypothesis is tested by selecting married women whose family was headed by the husband from the sample of the 2005 Census. The health outcomes (the probability of having any disability) of these women are displayed in terms of their husbands' birth years (Figure 17-B), as well as in terms of their own birth years (Figure 17-A).

Logistic regressions for the health outcomes of married women are also conducted. The quadratic cohort trends and dummy variables of wartime birth of the couples are employed (Cols. 1 and 2 of Table 7). Women married to the 1950 male birth cohort subjects were significantly more likely to have disability or limitation in daily activity in 2005 than predicted by smooth cohort trends. By contrast, the married women's own birth years had no significant effect on their health at old age. This implies that the gender differences in the effect of the Korean War on health found in this study are at least partly explained by the fact that female health is strongly influenced by the husband's economic and/or health status.

In the last two regressions reported in Table 7 (Cols. 3 and 4) dummy variable indicating whether the husband has any disability is added. The results suggest that the effect of the husband's birth year on the wife's disability could be mediated by the husband's poor health. The husband's disability strongly increases the probability that the wife is disabled (Col. 3 of Table 7). Once the husband's disability is controlled for, the effect of being married to a man born in 1950 on the probability of having disability diminishes in magnitude by a third and becomes statistically insignificant (Col. 4 of Table 7). It is possible that wives of disabled men became handicapped themselves in the course of providing care. Alternatively, economic hardship caused by the breadwinner's incapacity could adversely affect the health of the wife.

Finally, a stronger population selection among females could have produced the gender differences in the effects of the Korean War on health outcomes. This hypothesis may at least partly explain why the female cohort subjects born in 1951 do not reveal diminished health outcomes, even when the KLoSA is utilized given the patterns of the changing size in each birth cohort from 1960 to 2000 (Figure 16). As noted above, the size of the 1951 birth cohort decreased more rapidly than did that of neighboring cohorts from 1960 to 2000. Normally, the male-to-female ratio of a cohort is about

1.05 at the time of birth, which continues to decline with age because the rates of male death exceed those of females. Figure 16 shows that for the majority of birth cohorts, the male-to-female ratio substantially fell between 1960 and 2000. However, the gender ratio for the 1951 cohort remained remarkably stable during the four decades. The estimated mortality rate between 1960 and 2000 for the 1951 cohort is 14.7% for females and 15.1% for males. These rates suggest that compared with the population decline in other birth cohorts, that in the population in the 1951 cohort is much more pronounced for females than for males. As noted by previous studies (Stanner et al. 1997, Bozzoli, Deaton, and Quintana-Domeque 2009), this stronger population selection should leave more robust females alive among the 1951 cohort, weakening the health effect of the war.

For the 1950 birth cohort, on the other hand, the females were more likely to survive than males by 2000 if they were alive in 1960. The question of gender differences in mortality during childhood (prior to 1960) is also considered. The male-to-female ratios of the 1950 and 1951 birth cohorts in 1950 (1.065 and 1.064, respectively) are close to the normal gender ratio at birth (1.05). Therefore, it is unlikely that considerably more girls were killed than boys among the 1950 and 1951 cohorts, resulting in a stronger population selection among females by 1960.

6.3. Differences by Birth Cohorts

Another puzzling finding is that different aspects of human capital for the 1950 and 1951 cohorts were significantly damaged by their in-utero exposure to the Korean War. If the Census outcomes are considered, the 1950 cohort exhibits largely health-related negative consequences stemming from the war, whereas the 1951 cohort show a downward deviation from neighboring cohorts only in socioeconomic outcomes.

A possible explanation is the different pregnancy stages at which the two birth cohorts were exposed to negative health shocks. Individuals born at the end of 1950 had already spent four months as fetuses by the time the war broke out in late June. Thus, the majority of the 1950 birth cohort who experienced war-related disruptions *in utero* had already survived the first half of pregnancy by the time war broke out. In particular, the 1950 cohort *in utero* during the first three months of the Korean War, when the situation was the most chaotic, spent only the final trimester of pregnancy under the influence of the war. Conversely, the majority of the 1951 cohort subjects were exposed to the war during the early stages of pregnancy.

The effects of prenatal exposure to negative health shocks differ by the stage of pregnancy at which the shocks were received (Barker 1994). The human brain develops between the 8^{th} and 25^{th} weeks of pregnancy. Thus, the 1951 birth cohort was more likely to be exposed to war-caused disruptions during these weeks in fetus than was the 1950 cohort. The socioeconomic outcomes

considered in the present study, such as educational attainment and the quality of occupation, should be closely related to cognitive skills. Therefore, with all factors considered, the education and labor market outcomes of the 1951 cohort were significantly worse than predicted by long-term trends because in-utero development of the subjects' brains was adversely affected by the war. On the other hand, the subjects of the 1950 birth cohort began to be exposed to the war *in utero* after their brains were fully formed. This conjecture is also consistent with the result that the probability of entering college is more strongly affected by in-utero exposure to the war than the probability of having primary school education or no schooling (see Panels C to F of Tables 2 and 4), because cognitive ability should matter more in entering college than in entering middle or high school.

7. Summary and Implications

The Korean War (June 1950–July 1953) likely damaged individual maternal and fetal health, especially in the first nine months of the war following the surprise invasion of North Korea. The frontline dramatically moved back and forth across the region, forcing numerous civilians to suffer from severe war-related disruptions. Motivated by growing literature on the fetal origins hypothesis, the present article investigates how *in-utero* exposure to such arduous wartime experiences (refugee experience, occupation, hunger, and combat) affected socioeconomic and health outcomes at older ages.

The evidence offered in the present paper supports the fetal origins hypothesis. A number of socioeconomic outcomes from the 1990 and 2000 censuses were significantly lower for the 1951 birth cohort. For instance, this cohort (both males and females) received significantly less schooling than predicted by the smooth cohort trends. Controlling for quadratic cohort trends in these measures shows that males born in 1951 are less likely to use the Internet, less likely to have professional employment, and more likely to be a manual laborer around the age of 50 (in 2000) than other male birth cohorts.

The disadvantages in socioeconomic outcomes experienced by the 1951 birth cohort are particularly pronounced for those born in the Central Region of South Korea. This may be because the people who resided in this region experienced the most extensive collateral damage when the war broke out: a larger fraction of residents had to endure occupation by North Korea; the refugees from the region had to travel a longer distance; and the region fell under communist control twice. Exploiting these geographic variations in wartime disruptions, a difference-in-difference model was estimated using several location-specific measures of wartime stress, including the distance from Busan and the duration of occupation by the North Korean forces. Regression results suggest that the

magnitude of the negative cohort effect is significantly larger for individuals who were more seriously traumatized by the war.

Likewise, cohorts who were *in utero* at the early stages of the war show poorer health outcomes at older ages. The 1950 male birth cohorts were more likely to be disabled and suffer from limitations in daily activities in 2005. Males born in the second quarter of 1951 were much more likely to report poor health and have disability in 2006. These negative effects of in-utero exposure to the Korean War on health are likely stronger for the people born in the Central Region, as in the case of socioeconomic outcomes. In addition, the estimated negative effects of the war are perhaps underestimated when potential selections in pregnancy, birth, and survival are considered.

The effects of prenatal exposure to the Korean War differ by gender. The health outcomes of females were unaffected by the war, whereas the health measures of the male cohorts *in utero* during the early stages of the war were significantly worse than predicted by smooth cohort trends. This gender difference can be explained in part by the fact that female health in Korea is strongly influenced by the husband's economic and health status. Women married to the 1950 male subjects were significantly more likely to have disability or limitation in daily activity in 2005 than predicted by smooth cohort trends. By contrast, the married women's own birth years had no significant effect on their health at old age. Another factor is the stronger population selection among females born in 1951. The mortality rate during 1960– 2000 was particularly high for the 1951 female cohort, making the female survivors among the 1951 cohort more robust on average than those in neighboring cohorts. Other possible explanations are: (a) biological differences in health by gender; and (b) gender bias in parental investment on children's health in Korea, a factor that cannot be directly tested.

The type of human capital that was significantly impaired by war-time *in-utero* influences differ between the 1950 and 1951 birth cohorts. The 1950 cohort exhibit worse health outcomes, whereas the 1951 cohort shows lower educational attainment and labor market performance. A possible explanation for the difference by year of birth is that the two cohorts were exposed to negative health shocks during different stages of pregnancy. For example, the majority of the 1951 cohort subjects experienced the worst time of the war during the first half of pregnancy, a critical period for the development of the human brain. On the other hand, most of the 1950 birth cohort subjects had already passed the 25th week in pregnancy with complete prenatal brain development when the war broke out. The weaker effect of the war on health found for the 1951 cohort, as noted above, may be attributed to the considerably stronger population selection experienced by the cohort.

The results of the current paper provide new evidence pertaining to the fetal origins hypothesis. A rare account of the long-run consequences of direct exposure to a war *in utero* is offered. Thus far, the major focus of previous studies has been on how famines, infections, and exposure to

toxic substances *in utero* affect adult outcomes. Several observed effects of the Korean War may in part be explained by the effects of malnutrition and infection while *in utero*. However, the extent of malnutrition during the Korean War should be considerably milder than that experienced during the Dutch or the Chinese Famine. Despite the vivid memory of hunger among many survivors, finding a case of civilian death caused by starvation is difficult. In addition, no records of major epidemics of infectious diseases during the war were found. Although further research is required to determine the main mechanisms by which the war damaged fetal health, the following wartime experiences may have played important roles: suffering from atrocities under the North Korean occupation; physical and mental hardships faced while taking refuge; and direct exposure to bloody combats.

The present study also provides semi-experimental evidence for the link between health and socioeconomic status, a rare occurrence in South Korean academic circles. In particular, little empirical evidence regarding the long-run socioeconomic consequences of fetal health is suggested for South Korea. Further research will be required to determine how wartime damage to maternal and fetal health differs by socioeconomic backgrounds. However, considering the unexpected outbreak and highly chaotic progress of the war, variations in the fetal health of individuals born around the time of the conflict were likely exogenously determined. In this sense, the present study offers a stronger case for the link between early-life health and adult outcomes.

This paper proposes implications for future changes in health outcomes at old age in Korea. Maternal and fetal health in South Korea likely improved significantly after it recovered from the war-caused destruction. Thus, assuming all other factors are equal, the post-war generations will perhaps be healthier at old age than the previous cohorts who experienced the Japanese colonial occupation, the Second World War, or the Korean War *in utero*.

The present study suggests that military conflicts can bring about long-term negative health and economic consequences by adversely affecting maternal and fetal health. This is more evident in civilians who were directly exposed to combat, as in the case of the Korean War. This implies that conventionally estimated costs of historical wars may be understated. In general, only physical damages and direct human losses, such as wartime deaths and wounds, are counted in assessing the economic costs of a war (Goldin and Lewis 1975). Several studies consider the longer-term effects on the impaired health of individuals, especially those who fought in the war (Lee 2005, 2008; Edwards 2010). If long-term adverse effect on the health and socioeconomic outcomes of the next generation is also considered, the actual total costs of modern military conflicts, which tend to expose many civilians to various disruptions, should be substantially larger than suggested by conventional estimates.

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Table 1
Sample Means of Socioeconomic and Health Outcomes of the 1945-1959 Birth Cohorts

	All		Born in the Central Region	
	Male	Female	Male	Female
1990 Census				
Years of Schooling	11.6	9.9	12.2	10.5
% College or higher	24.6	10.2	30.5	12.5
% Primary or lower	12.9	25.7	8.4	19.0
% Not working	7.5	76.8	6.2	78.7
2000 Census				
Years of Schooling	11.6	9.8	12.3	10.4
% College or higher	26.6	11.2	25.1	9.8
% Primary or lower	12.9	27.1	8.7	19.9
% Not working	13.5	53.1	12.7	56.2
% Professional job	25.8	9.0	31.7	12.0
% Unskilled job	24.2	17.5	24.8	18.3
% Internet use	32.3	15.4	37.9	18.8
2005 Census				
% Disabled	5.3	5.8	N/A	N/A
% Activity limited	3.5	3.7	N/A	N/A
2006 KLoSA				
SRH score	2.5	2.8	N/A	N/A
% Poor health	14.4	22.8	N/A	N/A
% Disabled	7.5	3.6	N/A	N/A

Source: The 2% samples of the 1990, 2000 and 2005 censuses; the first wave of the Korea Longitudinal Study of Aging (2006 KLoSA).
Note: See text for the definition of the variables.

Table 2
Deviation of the 1950-54 Male Birth Cohort Labor-Market Outcomes in 2000 from 1945-1959 Trend

Outcome	Males				Females			
	(1) South Korea		(2) Central Region		(3) South Korea		(4) Central Region	
	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value
A. 1990 Years of schooling								
Born in 1950	**-0.1366**	0.0059	**-0.1790**	0.0535	**-0.1215**	0.0113	0.1119	0.1960
Born in 1951	**-0.1830**	0.0002	**-0.4670**	<.0001	**-0.1588**	0.0009	**-0.1814**	0.0354
B. 2000 Years of schooling								
Born in 1950	-0.0655	0.2273	-0.0781	0.4425	-0.0447	0.3926	-0.0191	0.8406
Born in 1951	**-0.1525**	0.0069	**-0.4016**	0.0002	**-0.1969**	0.0002	**-0.3869**	<.0001
C. 1990 College or higher								
Born in 1950	**-0.0148**	0.0304	-0.0163	0.2343	0.0011	0.8273	0.0152	0.1090
Born in 1951	**-0.0206**	0.0026	**-0.0536**	0.0002	**-0.0163**	0.0018	**-0.0234**	0.0276
D. 2000 College or higher								
Born in 1950	-0.0013	0.8580	-0.0057	0.6952	-0.0011	0.8362	0.0049	0.6535
Born in 1951	-0.0111	0.1384	**-0.0364**	0.0214	0.0081	0.1486	**-0.0427**	0.0006
E. 1990 Primary or less								
Born in 1950	0.0065	0.1605	**0.0128**	0.0711	**0.0130**	0.0265	**-0.0168**	0.0907
Born in 1951	0.0062	0.1957	**0.0140**	0.0581	0.0055	0.3654	0.0014	0.8871
F. 2000 Primary or less								
Born in 1950	0.0032	0.4875	0.0115	0.1184	-0.0035	0.5597	0.0059	0.5630
Born in 1951	**0.0099**	0.0437	**0.0168**	0.0343	**0.0197**	0.0017	**0.0300**	0.0035
G. 1990 Not working								
Born in 1950	**0.0077**	0.0547	0.0097	0.1570	-0.0114	0.0624	-0.0152	0.1592
Born in 1951	0.0061	0.1359	**0.0131**	0.0630	-0.0095	0.1260	-0.0152	0.1633
H. 2000 Not working								
Born in 1950	0.0061	0.2291	0.0027	0.7709	0.0044	0.5747	0.0165	0.2593
Born in 1951	-0.0036	0.5178	0.0011	0.9159	0.0043	0.5869	0.0121	0.4061
I. 2000 Professional job								
Born in 1950	-0.0051	0.4989	-0.0063	0.6836	-0.0033	0.6609	0.0017	0.9196
Born in 1951	**-0.0197**	0.0128	**-0.0547**	0.0012	0.0022	0.7605	-0.0031	0.8482
J. 2000 Unskilled job								
Born in 1950	**0.0129**	0.0694	0.0101	0.4585	0.0117	0.1774	0.0271	0.1099
Born in 1951	**0.0127**	0.0854	**0.0446**	0.0015	0.0026	0.7692	0.0270	0.1088
K. 2000 Internet use								
Born in 1950	**-0.0190**	0.0127	-0.0153	0.3011	-0.0014	0.8929	0.0001	0.9931
Born in 1951	**-0.0230**	0.0027	**-0.0288**	0.0665	-0.0002	0.9728	-0.0163	0.2133

Source: The 2% micro sample of the 1990 and 2000 population censuses.
Notes: (a) "South Korea" includes persons who were born in North Korea and those for whom the place of birth is not reported; (b) Panels A and B report the results of OLS regressions, and panels C to K marginal effects ($\partial P/\partial x$)estimated from logistic regressions. (c) For panels I and J, the sample is limited to persons who were employed at the time of census enumeration.

Table 3
OLS Regressions for Difference-in-Difference Model: Interaction between Measure of Wartime Stress and Deviation of the 1951 Birth Cohort's Years of Schooling from 1945-1959 Trend in 2000

	Male				Female			
	Model 1		Model 2		Model 1		Model 2	
	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value
A. Central Region								
Intercept	15.3209	<.0001	15.7305	<.0001	-4.9106	0.0229	-3.8870	0.0630
YOB	-0.2673	0.0031	-0.2906	0.0011	0.3493	<.0001	0.3004	0.0002
YOB^2	0.0038	<.0001	0.0039	<.0001	-0.0014	0.0858	-0.0010	0.2010
BORN1951	-0.0232	0.7669	-0.0177	0.8185	0.01143	0.8739	0.0154	0.8255
CENTRAL*BORN51	-0.3525	0.0069	-0.2269	0.0772	-0.3653	0.0017	-0.1423	0.2065
CENTRAL	0.3598	<.0001	0.0413	0.1697	0.6159	<.0001	0.2194	<.0001
CITY_SMALL			0.5004	<.0001			0.5787	<.0001
CITY_METRO			1.4742	<.0001			1.858	<.0001
CITY_SEOUL			1.9974	<.0001			2.6397	<.0001
B. Occupied Twice								
Intercept	15.0380	<.0001	15.7773	<.0001	-5.4469	0.0112	-3.8972	0.0623
YOB	-0.2548	0.0048	-0.2928	0.0010	0.3720	<.0001	0.3008	0.0002
YOB^2	0.0037	<.0001	0.0040	<.0001	-0.0016	0.0429	-0.0010	0.1990
BORN1951	0.0289	0.7117	-0.0164	0.8311	0.0032	0.9647	0.0152	0.8272
CENOCCUP1*BORN51	-0.1689	0.2869	-0.1592	0.3080	-0.1566	0.2627	-0.1472	0.2794
CENOCCUP2*BORN51	-0.4546	0.0114	-0.3519	0.0468	-0.3845	0.0153	-0.1309	0.3696
CENOCCUP1	0.0334	0.3579	0.1285	0.0004	0.0729	0.0282	0.2054	<.0001
CENOCCUP2	0.6607	<.0001	-0.0977	0.0225	1.1064	<.0001	0.2404	<.0001
CITY_SMALL			0.5042	<.0001			0.5780	<.0001
CITY_METRO			1.4940	<.0001			1.8500	<.0001
CITY_SEOUL			2.1441	<.0001			2.6178	<.0001
C. Distance from Busan								
Intercept	12.9331	<.0001	12.5751	<.0001	-8.0904	0.0002	-7.7209	0.0003
YOB	-0.1810	0.0481	-0.1736	0.0535	0.4616	<.0001	0.4400	<.0001
YOB^2	0.0030	0.0005	0.0029	0.0007	-0.0024	0.0032	-0.0022	0.0038
BORN1951	0.2636	0.0725	0.1706	0.2366	0.3131	0.0186	0.1446	0.2597
BUSAN_DIST*BORN51	-0.1829	0.0016	-0.1150	0.0432	-0.1920	0.0002	-0.0757	0.1341
BUSAN_DIST	0.0517	<.0001	-0.0391	0.0048	0.1186	<.0001	0.0033	0.7930
CITY_SMALL			0.5377	<.0001			0.6345	<.0001
CITY_METRO			1.4748	<.0001			1.8820	<.0001
CITY_SEOUL			2.1236	<.0001			2.8258	<.0001
D. Duration of Occupation								
Intercept	15.9940	<.0001	15.8065	<.0001	-3.8963	0.0767	-3.7405	0.0782
YOB	-0.2825	0.0021	-0.2847	0.0016	0.3237	0.0001	0.3057	0.0002
YOB^2	0.0040	<.0001	0.0039	<.0001	-0.0011	0.1835	-0.0010	0.1944
BORN1951	0.2054	0.1513	0.1324	0.3462	0.3006	0.0209	0.1825	0.1471
DUROCCUP*BORN51	-0.1911	0.0047	-0.1166	0.0796	-0.2287	0.0002	-0.1099	0.0630
DUROCCUP	-0.1074	<.0001	-0.1243	<.0001	-0.1008	<.0001	-0.1233	<.0001
CITY_SMALL			0.4616	<.0001			0.5449	<.0001
CITY_METRO			1.3082	<.0001			1.6817	<.0001
CITY_SEOUL			2.1001	<.0001			2.8683	<.0001

Source: The 2% micro sample of the 2000 population census.
Note: The sample includes 62,670 males and 66,741 females who were aged 41 to 55 in 2000, and for whom the place of birth is reported in the census. The distance from Busan is measured in 100 kilometers, and the duration of occupation is measured in month.

Table 4
Summary of OLS Regressions for Difference-in-Difference Model: Interaction between Measure of Wartime Stress and Deviation of the 1951 Birth Cohort's Adult Outcomes from 1945-1959 Trend

Outcome	Interaction between Measure of Wartime Stress and the 1951 Birth							
	(1) CENTRAL× BORN1951		(2) CENOCCUP2× BORN1951		(3) BUSAN_DIST× BORN1951		(4) DUROCCUP× BORN1951	
	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value
1. Males								
A. 1990 Years of schooling	**-0.3346**	0.0068	**-0.5707**	0.0004	**-0.1892**	0.0006	**-0.1860**	0.0067
B. 2000 Years of schooling	**-0.3525**	0.0069	**-0.4546**	0.0114	**-0.1829**	0.0016	**-0.1911**	0.0047
C. 1990 College or higher	**-0.0303**	0.0870	**-0.0616**	0.0072	**-0.0240**	0.0024	**-0.0254**	0.0070
D. 2000 College or higher	**-0.0307**	0.0435	**-0.0457**	0.0621	-0.0110	0.1740	-0.0024	0.5229
E. 1990 Primary or less	0.0127	0.1787	0.0124	0.3410	0.0061	0.1564	0.0047	0.4111
F. 2000 Primary or less	0.0094	0.3432	0.0201	0.1582	**0.0103**	0.0206	**0.0166**	0.0037
G. 1990 Not working	0.0151	0.1170	**0.0214**	0.0813	0.0053	0.2376	0.0094	0.1099
H. 2000 Not working	0.0062	0.6285	**0.0257**	0.1224	**0.0111**	0.0530	0.0119	0.1582
I. 2000 Professional job	**-0.0547**	0.0044	**-0.0564**	0.0329	**-0.0158**	<.0001	-0.0068	0.4876
J. 2000 Unskilled job	**0.0502**	0.0030	**0.0733**	0.0016	**0.0268**	0.0005	**0.0278**	0.0024
K. 2000 Internet use	-0.0196	0.2884	**-0.0493**	0.0540	**-0.0037**	0.0512	-0.0024	0.8049
2. Females								
A. 1990 Years of schooling	-0.1558	0.1797	-0.1285	0.3783	**-0.0843**	0.0991	-0.0737	0.2402
B. 2000 Years of schooling	**-0.3653**	0.0017	**-0.3845**	0.0153	**-0.1829**	0.0016	**-0.2287**	0.0002
C. 1990 College or higher	-0.0126	0.2903	-0.0084	0.5317	**-0.0107**	0.0411	**-0.0109**	0.0707
D. 2000 College or higher	**-0.0331**	<.0000	**-0.0474**	0.0033	**-0.0203**	0.0004	**-0.0206**	0.0008
E. 1990 Primary or less	0.0137	0.3196	0.0135	0.4656	0.0058	0.3280	0.0023	0.7542
F. 2000 Primary or less	**0.0225**	0.0887	0.0249	0.1913	**0.0100**	0.0882	0.0110	0.1238
G. 1990 Not working	-0.0117	0.4517	-0.0099	0.5978	-0.0072	0.2713	-0.0101	0.2075
H. 2000 Not working	0.0065	0.8759	0.0038	0.7129	-0.0024	0.7614	0.0002	0.9827
I. 2000 Professional job	-0.0218	0.1947	-0.0243	0.2599	-0.0071	0.3794	-0.0144	0.1032
J. 2000 Unskilled job	0.0299	0.1509	0.0130	0.6660	**0.0251**	0.0111	**0.0294**	0.0139
K. 2000 Internet use	**-0.0271**	0.0618	**-0.0415**	0.0315	**-0.0165**	0.0119	**-0.0233**	0.0014

Source: The 2% micro sample of the 1990 and 2000 population censuses.
Notes: (a) Summary of 120 regressions employing the regressions (model 1) reported in Table 2. (b) The sample is limited to those for whom the place of birth is reported; (b) Panels A and B report the results of OLS regressions, and panels C to K marginal effects ($\partial P/\partial x$)estimated from logistic regressions. (c) For panels I and J, the sample is limited to persons who were employed at the time of census enumeration.

Table 5
Deviation of the 1950-54 Birth Cohort Health Outcomes in 2005 from 1945-1959 Trend

	Male				Female			
	(1) Disabled		(2) Activity Limited		(3) Disabled		(4) Activity Limited	
	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value
Born in 1950	**0.0078**	0.0494	**0.0053**	0.0640	0.0023	0.5183	0.0007	0.8170
Born in 1951	0.0037	0.3343	0.0009	0.7804	0.0054	0.1522	0.0013	0.6729
Born in 1952	0.0017	0.6385	-0.0014	0.6422	-0.0009	0.8048	0.0012	0.6930
Born in 1953	**0.0072**	0.0499	0.0041	0.1793	0.0034	0.3907	0.0019	0.5596
Born in 1954	0.0045	0.2024	0.0042	0.2024	0.0052	0.1706	0.0042	0.1653

Source: The 2% micro sample of the 2005 population census.
Note: The sample includes 83,649 males and 85,994 females who were aged 46 to 60 in 2005. The year of birth and the year of birth squared were included in the regressions, but omitted from the table.

Table 6
Deviation of the 1950-54 Birth Cohort Health Outcomes in 2006 from 1945-1959 Trend

	Male		Female	
	∂y/∂x	P-value	∂y/∂x	P-value
A. Self-reported health score (OLS)				
Born in 1950 Q3	-0.1352	0.4712	0.0095	0.9423
Born in 1950 Q4	0.0492	0.7396	0.1214	0.4255
Born in 1951 Q1	**0.3490**	0.0338	0.0919	0.5258
Born in 1951 Q2	**0.4524**	0.0291	0.0003	0.9985
Born in 1951 Q3	-0.1876	0.2882	0.0464	0.7742
Born in 1951 Q4	-0.1190	0.4283	-0.0826	0.6094
B. Having a Disability (Logistic)				
Born in 1950 Q3	0.0314	0.4736	0.0085	0.7413
Born in 1950 Q4	-6.7758	0.9832	0.0200	0.4410
Born in 1951 Q1	-0.0682	0.3366	-0.0067	0.8495
Born in 1951 Q2	**0.0755**	0.0610	0.0303	0.2472
Born in 1951 Q3	-0.0575	0.4188	-4.8050	0.9838
Born in 1951 Q4	0.0532	0.1005	-4.8049	0.9838

Source: The first wave of the Korea Longitudinal Study of Aging.
Notes: The sample includes 2060 males and 2444 females who were aged 46 to 60 in 2006. The year of birth (YOB) and the year of birth squared (YOB^2) were included in the regressions, but omitted from the table.

Table 7
Logistic Regressions: Effects of Own and Husband's Birth Year on the Probability of Having Disability of Married Women in 2005

	Model 1				Model 2			
	(1) Own YOB		(2) Husband's YOB		(3) Own YOB		(4) Husband's YOB	
	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value	∂y/∂x	P-value
Born in 1950	-0.0032	0.4034	**0.0059**	0.0547	-0.0033	0.3725	0.0041	0.1599
Born in 1951	0.0004	0.9069	0.0015	0.6899	0.0012	0.7361	0.0004	0.9157
Born in 1952	-0.0025	0.4443	0.0048	0.1793	-0.0020	0.5174	0.0036	0.2916
Born in 1953	-0.0022	0.5157	0.0060	0.1103	-0.0015	0.6522	0.0045	0.2015
Born in 1954	0.0012	0.7060	0.0015	0.6990	0.0007	0.8061	0.0014	0.6901
Husband Disabled					**0.0713**	<.0001	**0.0709**	<.0001

Source: The 2% micro sample of the 2005 population census.
Note: The sample includes 42,541 married couples aged 46 to 60 in 2005. The year of birth (YOB) and the year of birth squared (YOB^2) were included in the regressions, but omitted from the table.

Figure 1
Region of Birth by Year

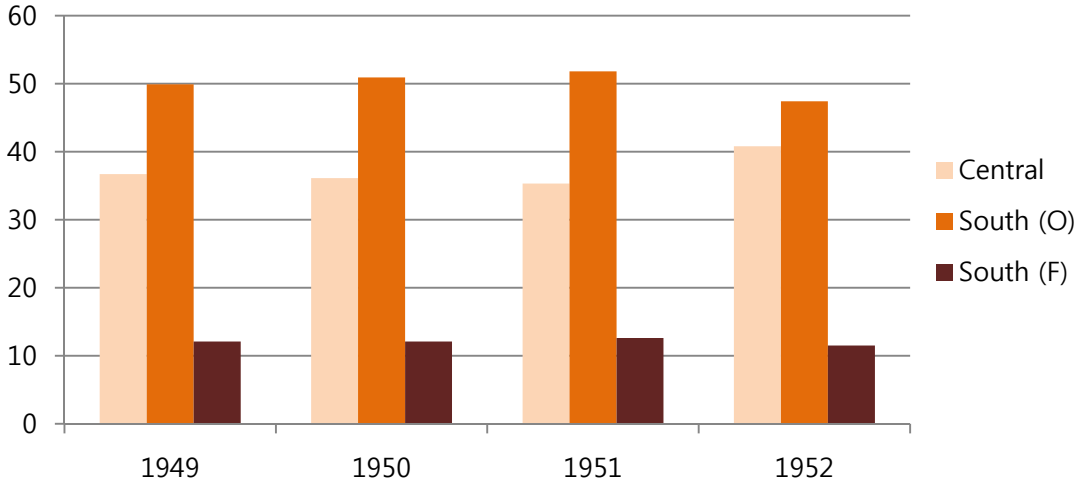


Figure 2-A
Male Years of Schooling in 2000 by Birth Cohort:
Born in the Central Region

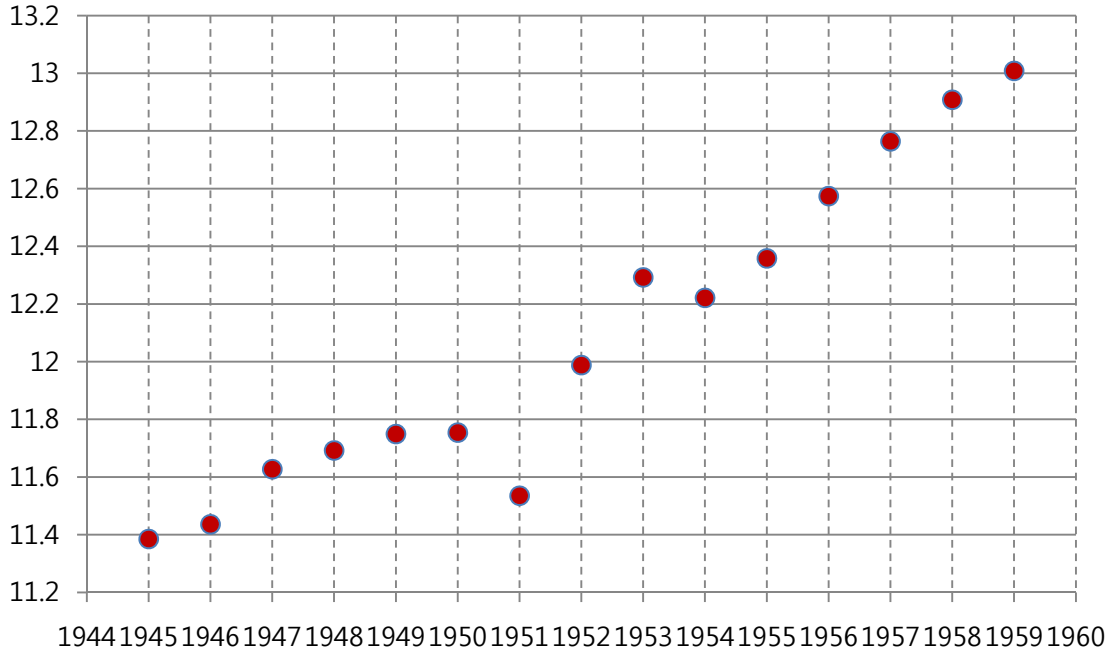


Figure 2-B
Female Years of Schooling in 2000 by Birth Cohort:
Born in the Central Region

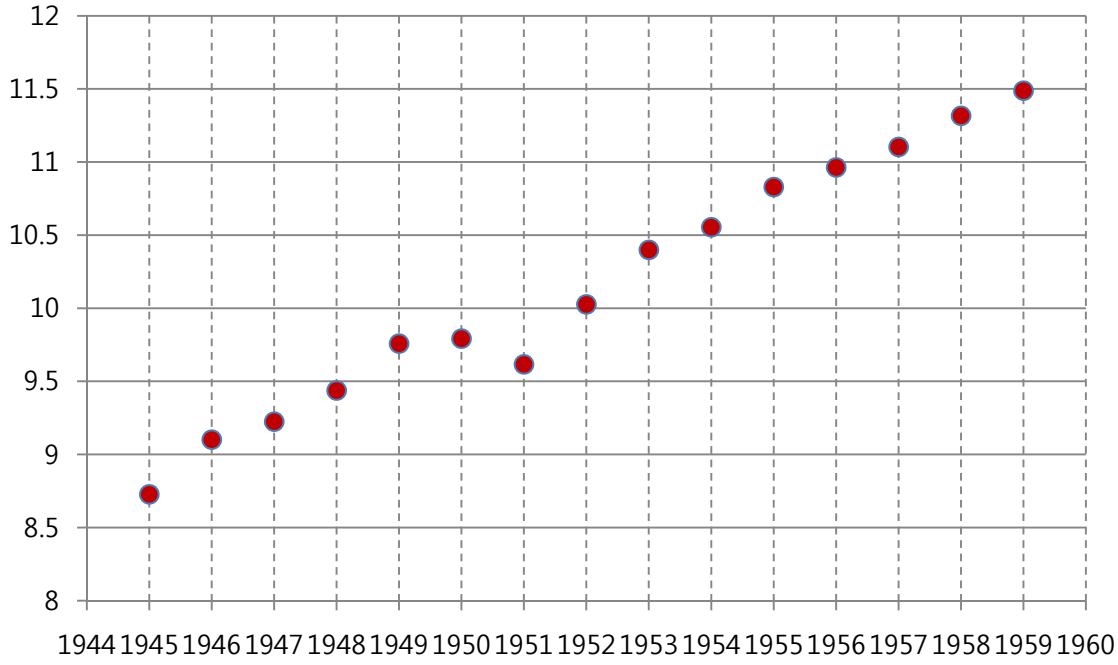


Figure 3-A
% Males College or Higher in 2000 by Birth Cohort:
Born in the Central Region

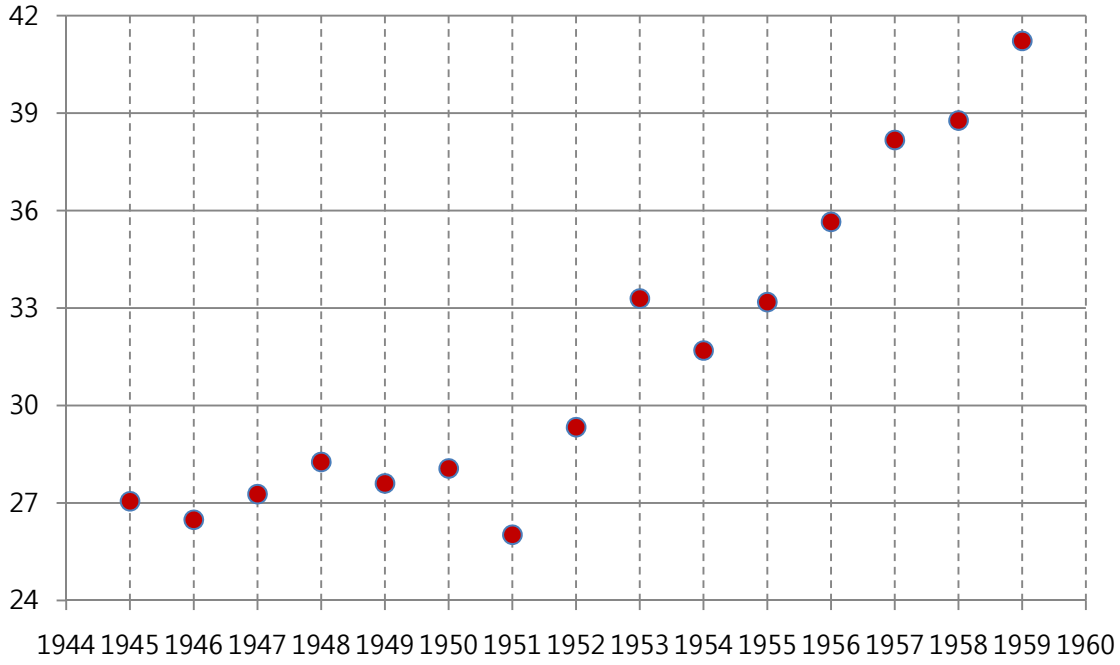


Figure 3-B
% Females College or Higher in 2000 by Birth Cohort:
Born in the Central Region

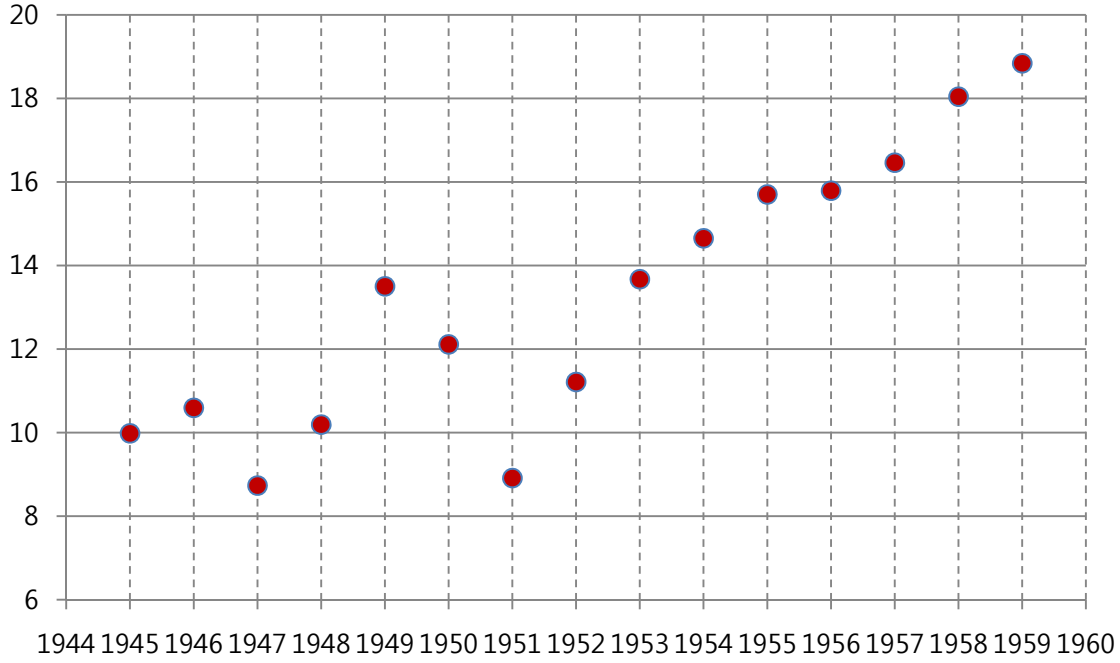


Figure 4-A
% Males Primary School or Less in 2000 by Birth Cohort: Born in the Central Region

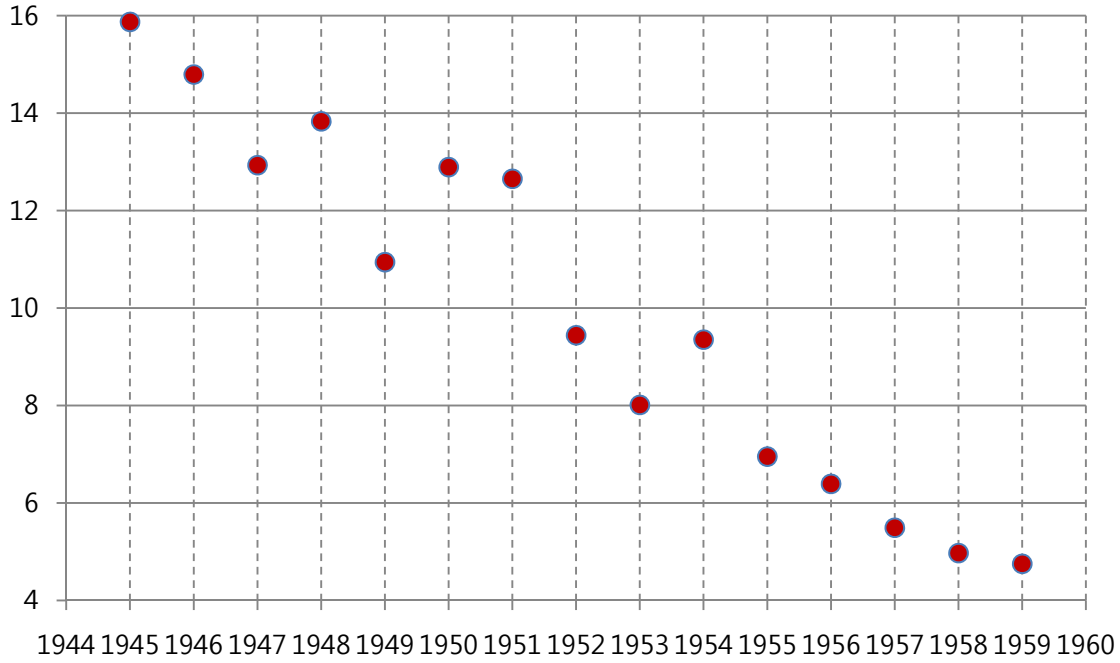


Figure 4-B
% Females Primary School or Less in 2000 by Birth Cohort: Born in the Central Region

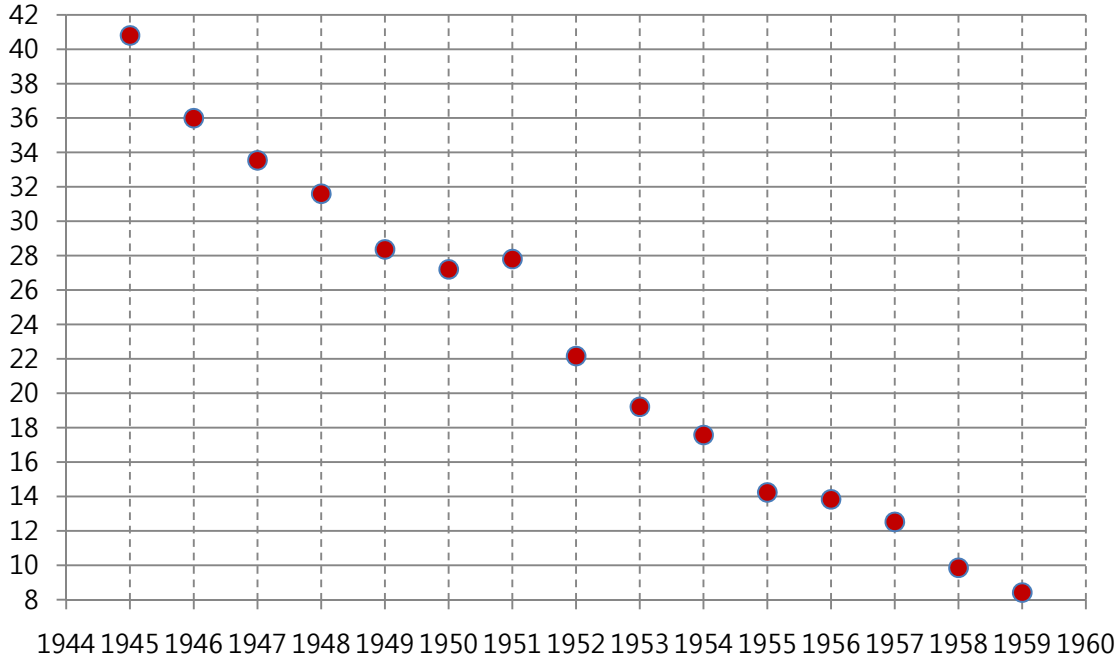


Figure 5
% Professionals among Employed Males:
Born in the Central Region

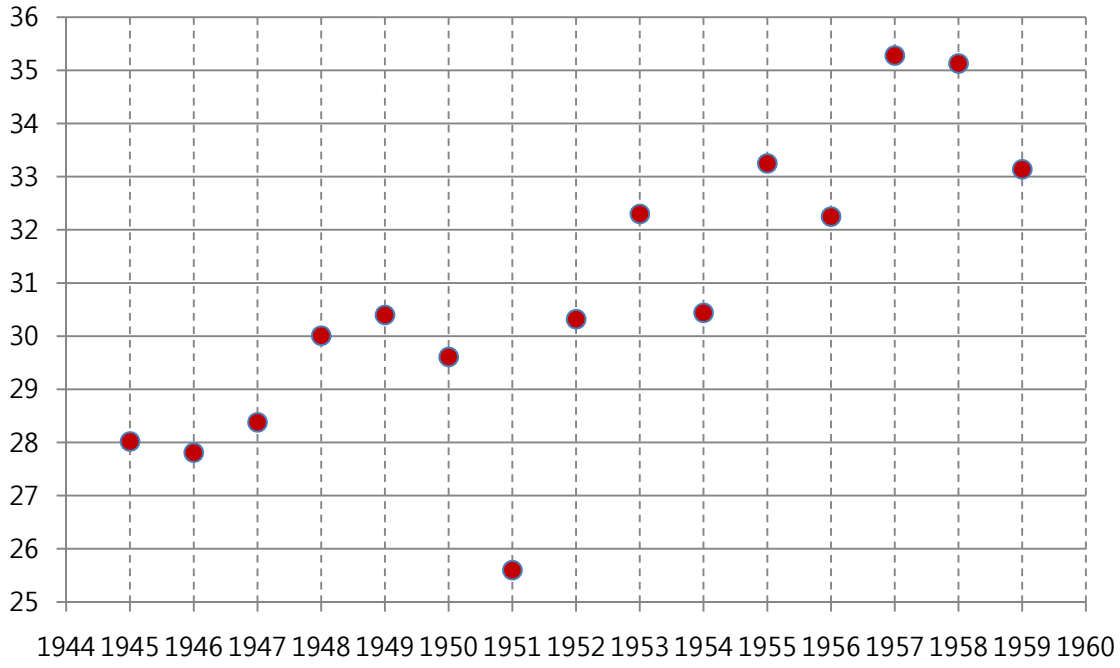


Figure 6
% Manual Laborers among Employed Males:
Born in the Central Region

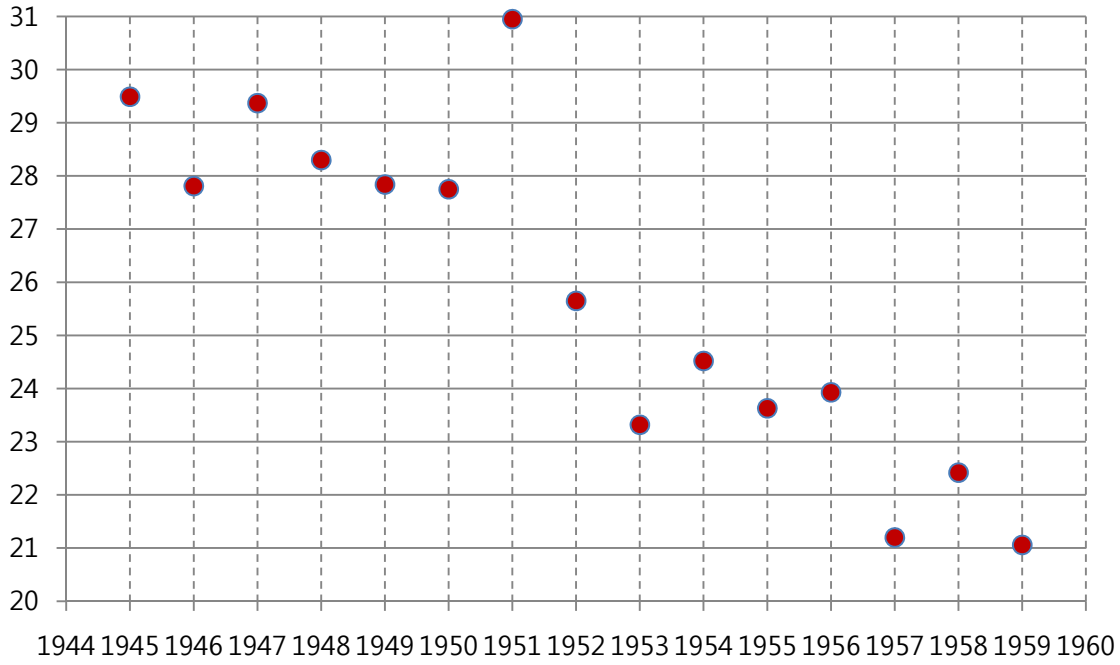


Figure 7
Years of Schooling by Distance from Busan

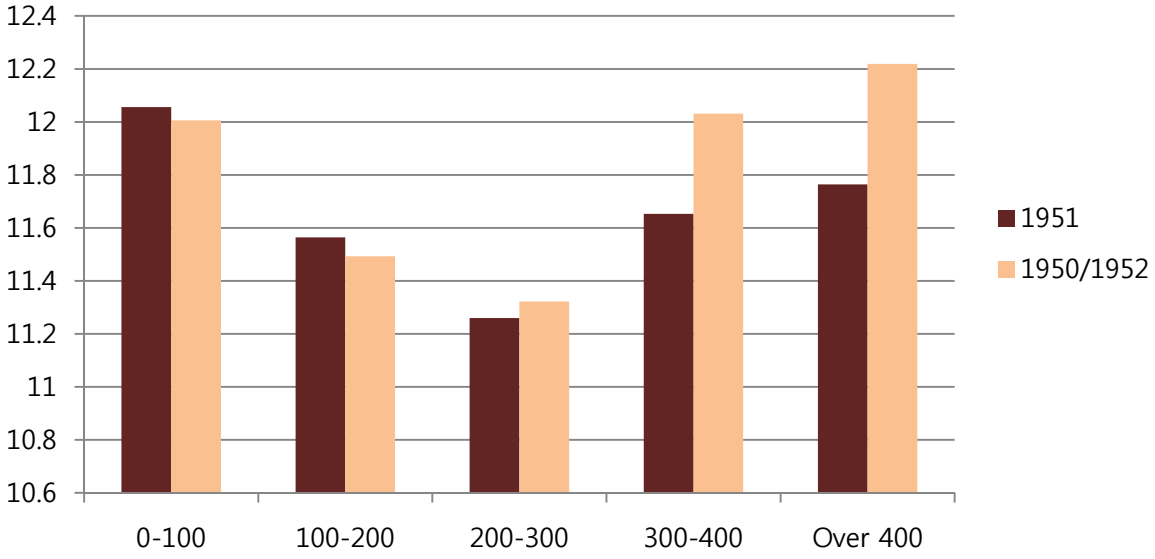


Figure 8
Years of Male Schooling by Duration of Occupation

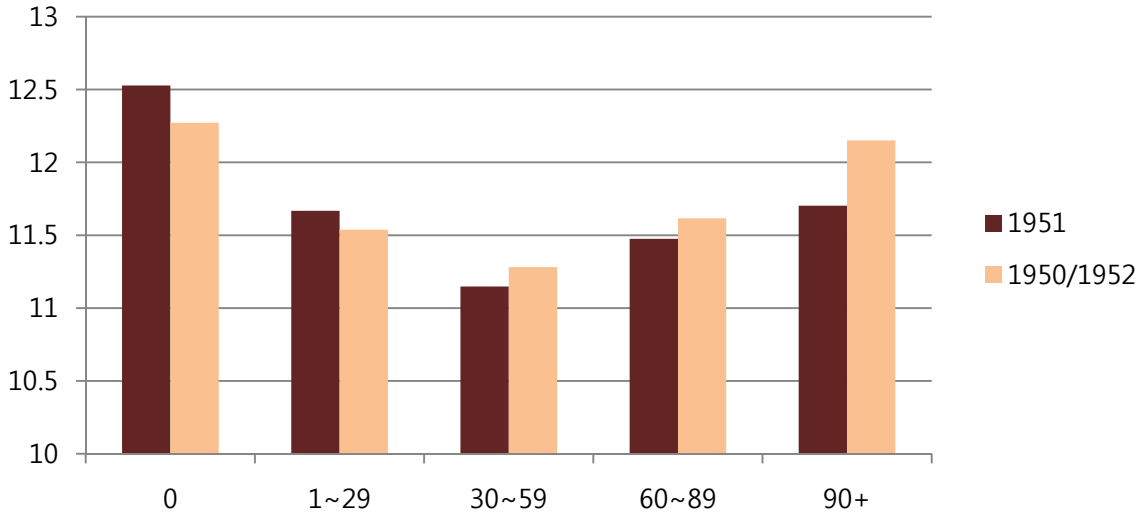


Figure 9
% Manual Laborers among Employed Males by Distance from Busan

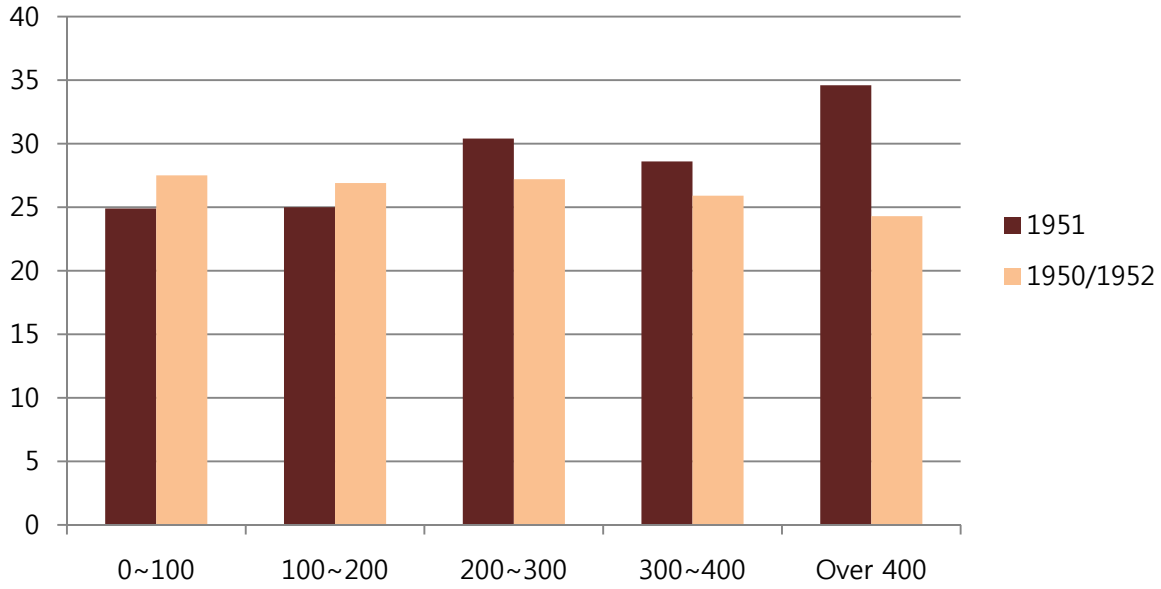


Figure 10
% Manual Laborers among Employed Males by Duration of Occupation

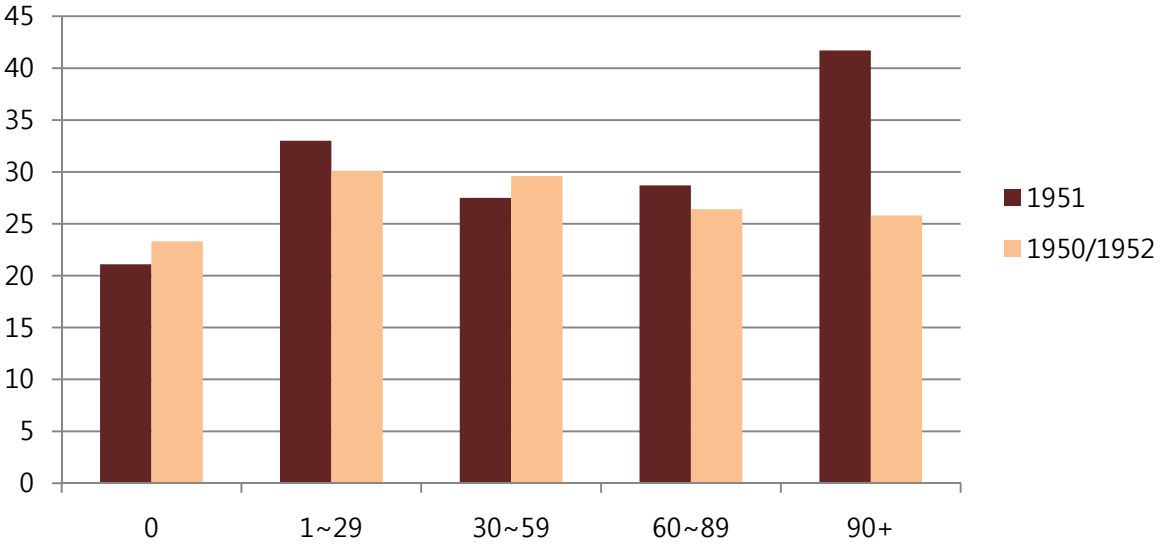


Figure 11-A
% Males with Disability in 2005 by Birth Cohort

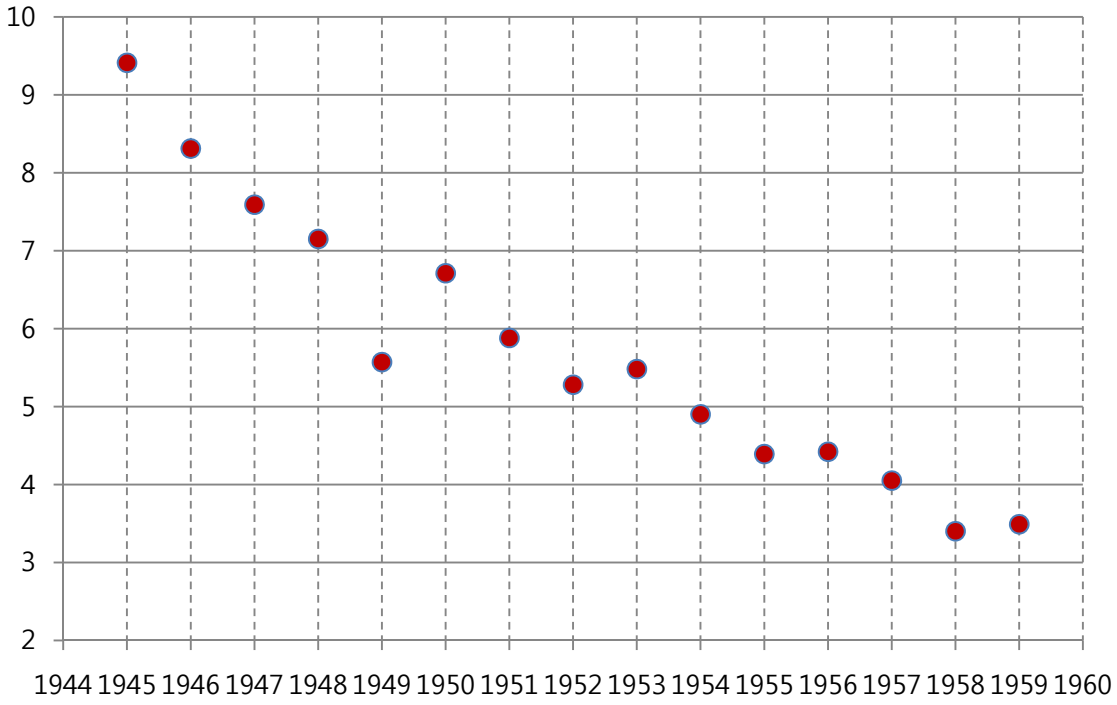


Figure 11-B
% Females with Disability in 2005 by Birth Cohort

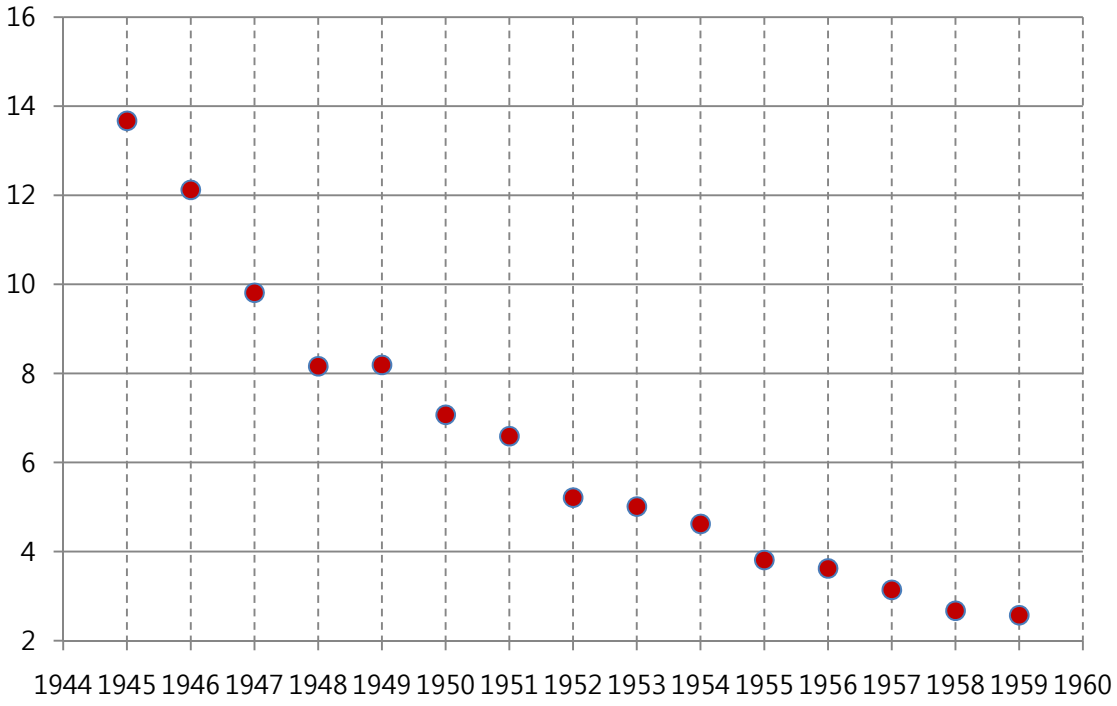


Figure 12-A
% Males with Limited Activity in 2005 by Birth Cohort

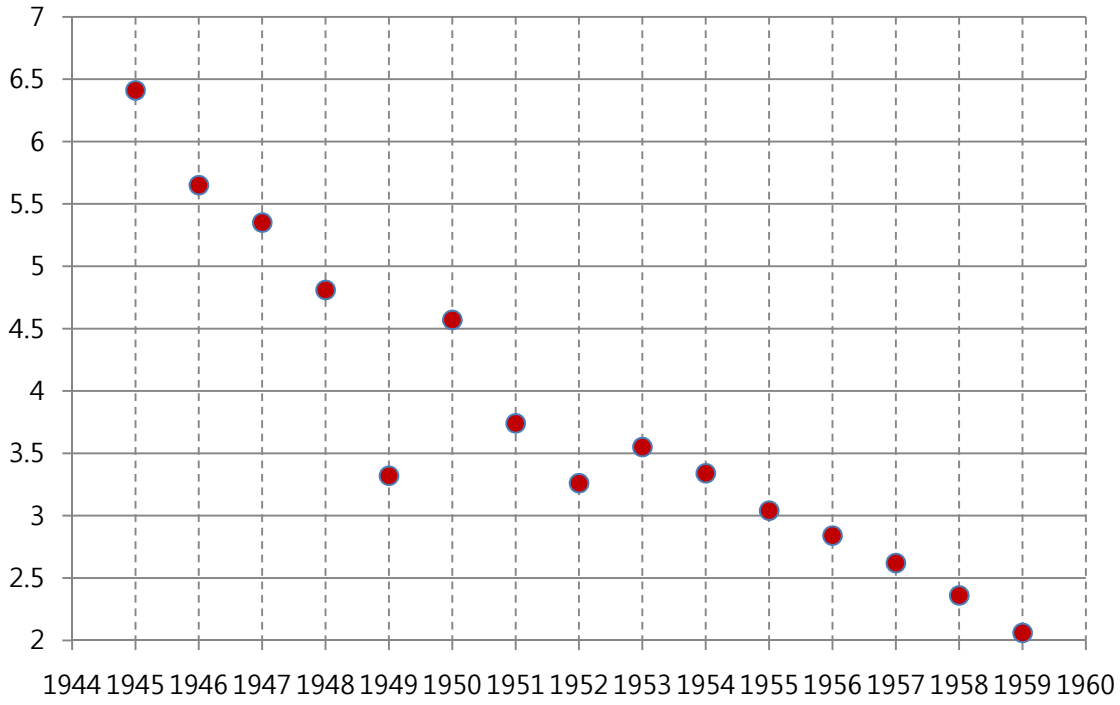


Figure 12-B
% Females with Limited Activity in 2005 by Birth Cohort

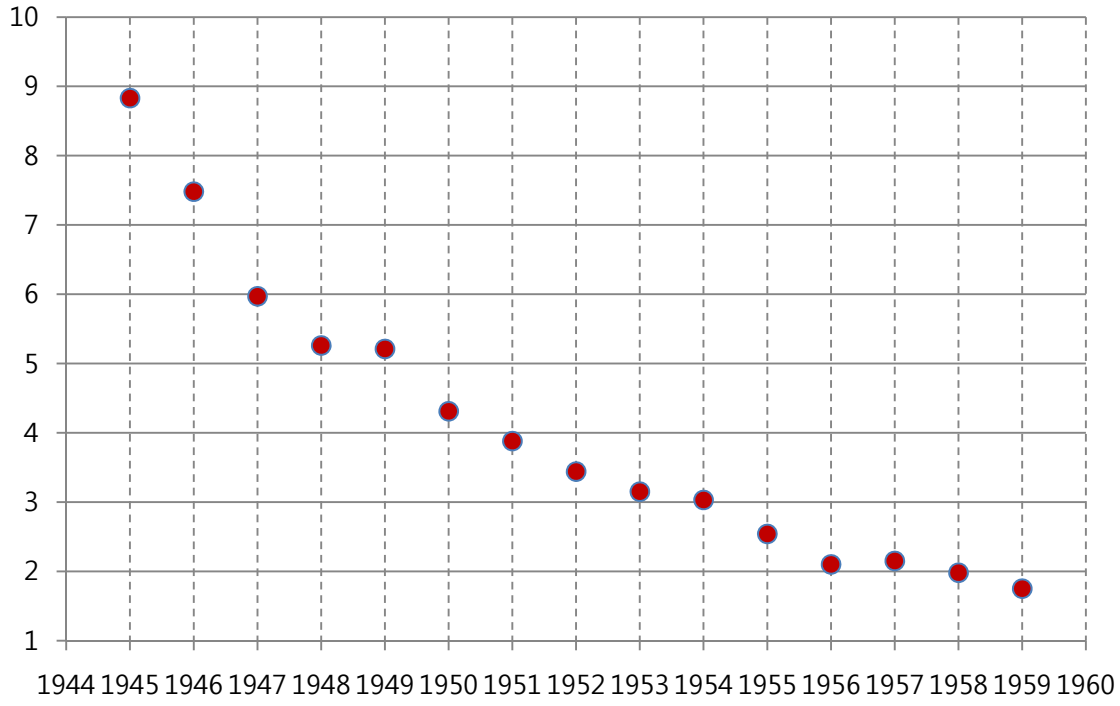


Figure 13-A
Male Self-Reported Health in 2006

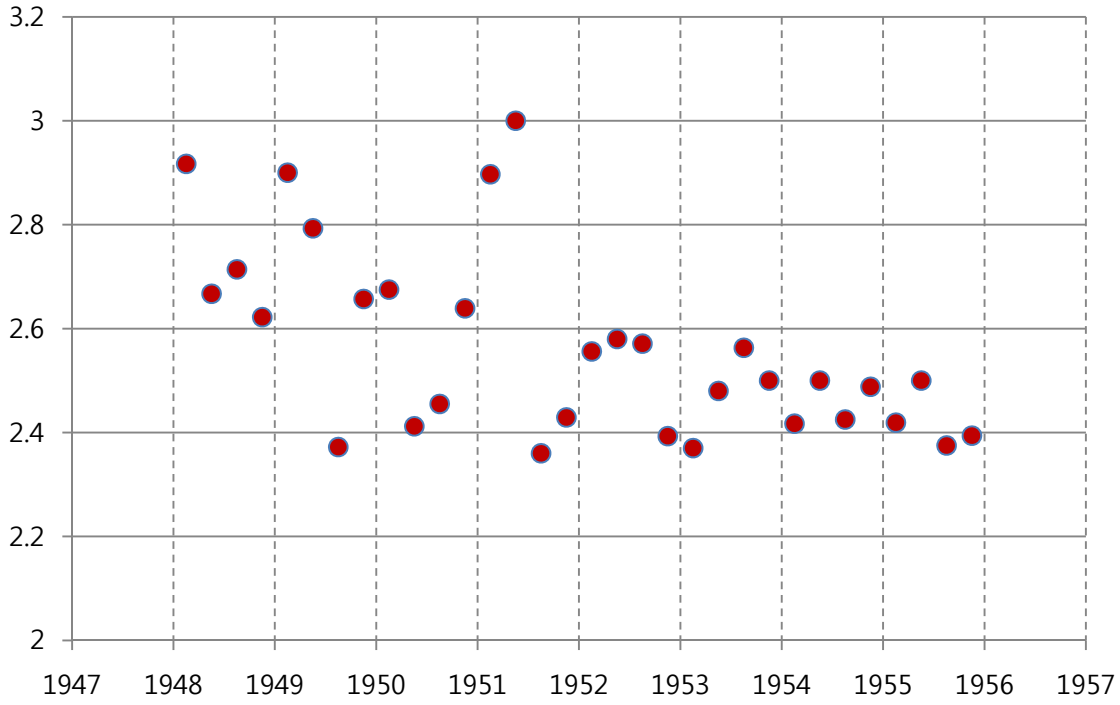


Figure 13-B
Female Self-Reported Health in 2006

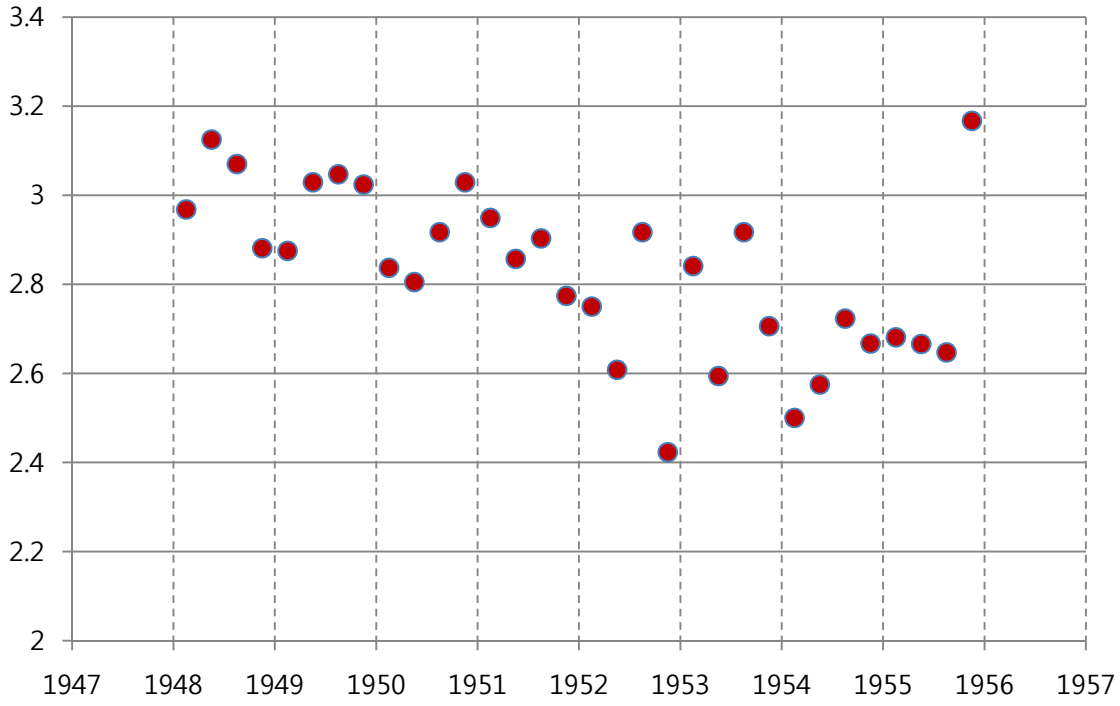


Figure 14-A
% Males Reporting Poor Health in 2006

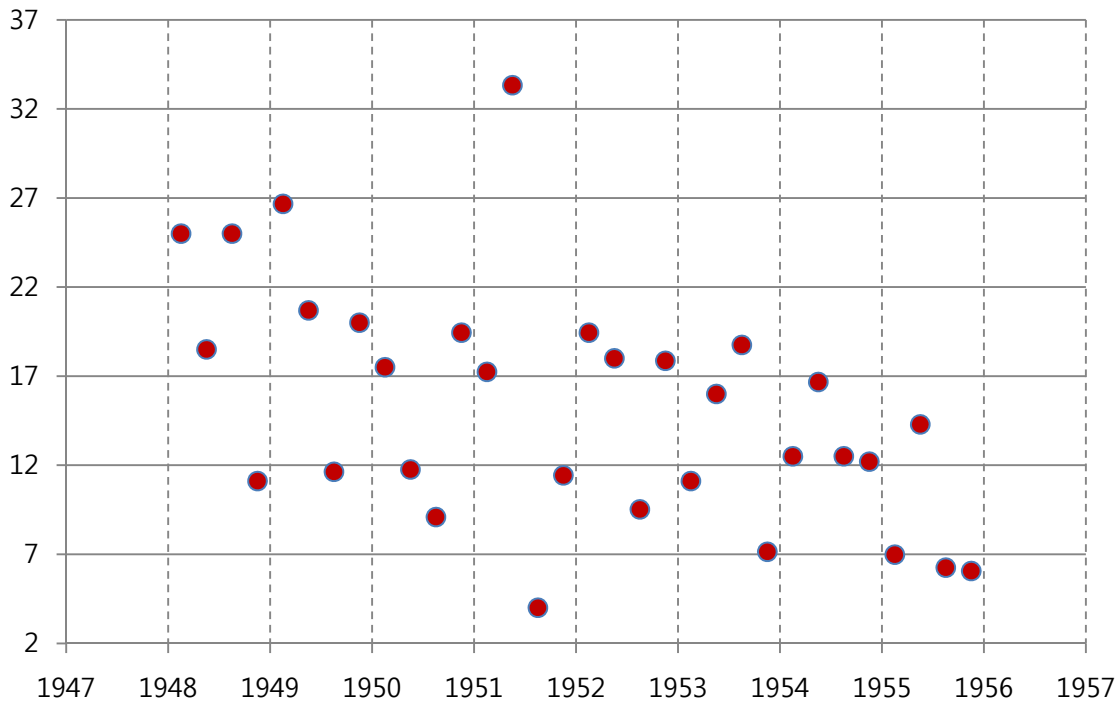


Figure 14-B
% Females Reporting Poor Health in 2006

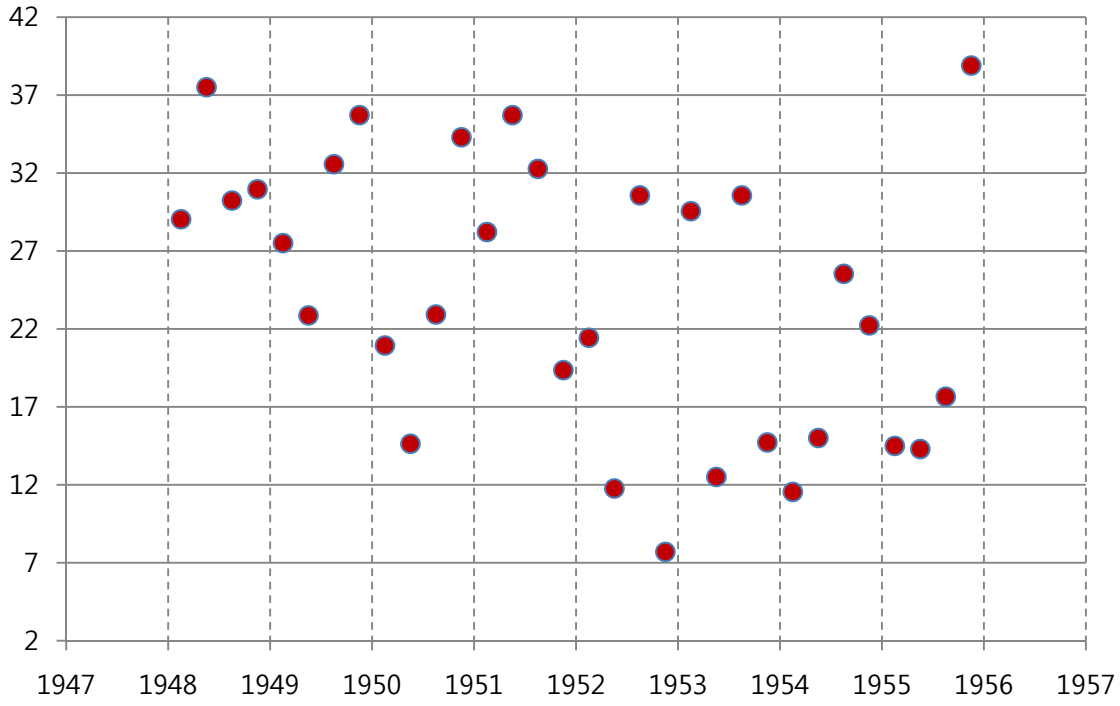


Figure 15-A
% Males with Disability in 2006

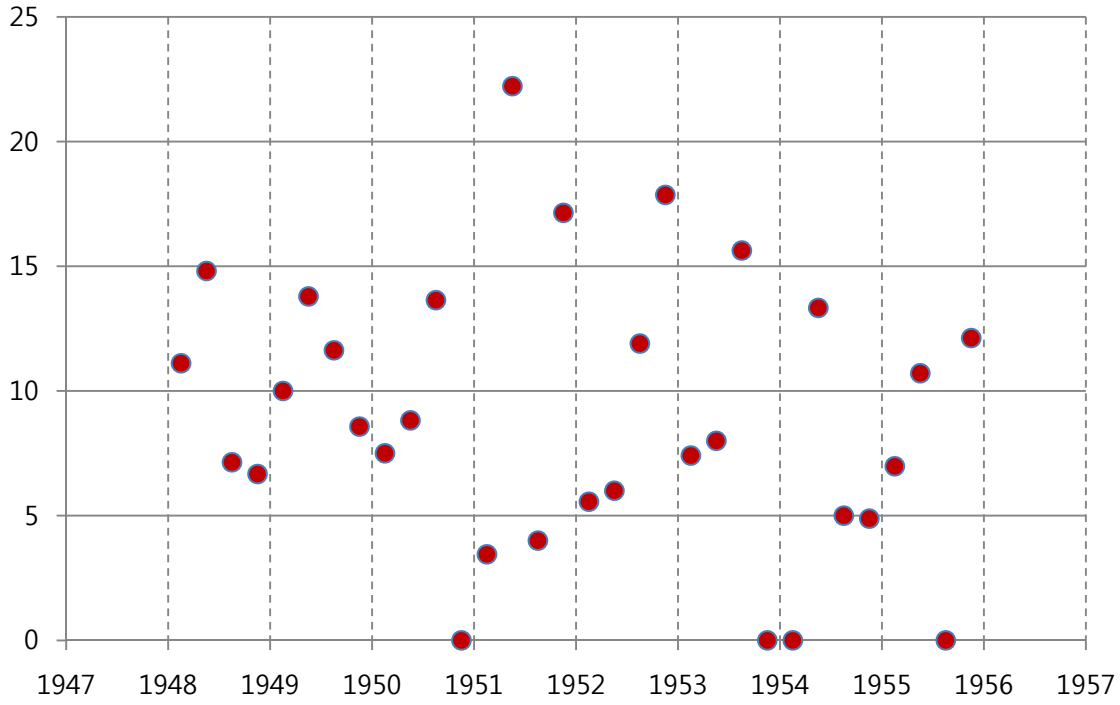


Figure 15-B
% Females with Disability in 2006

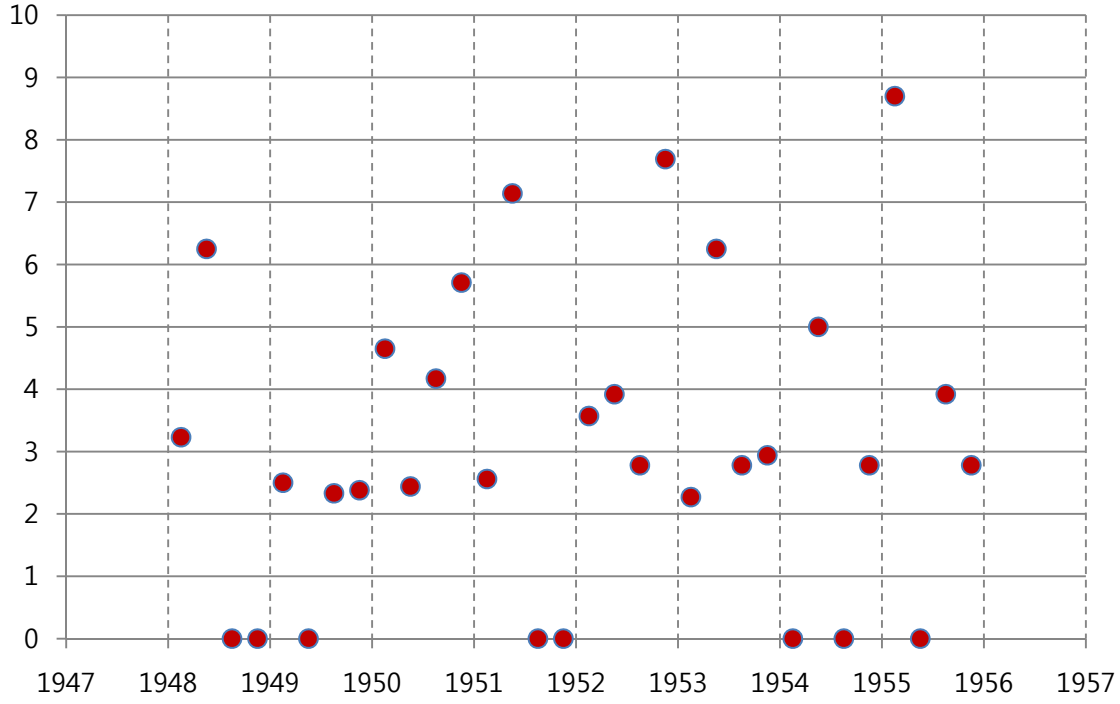


Figure 16-A
Population by Sex and Year of Birth (1960)

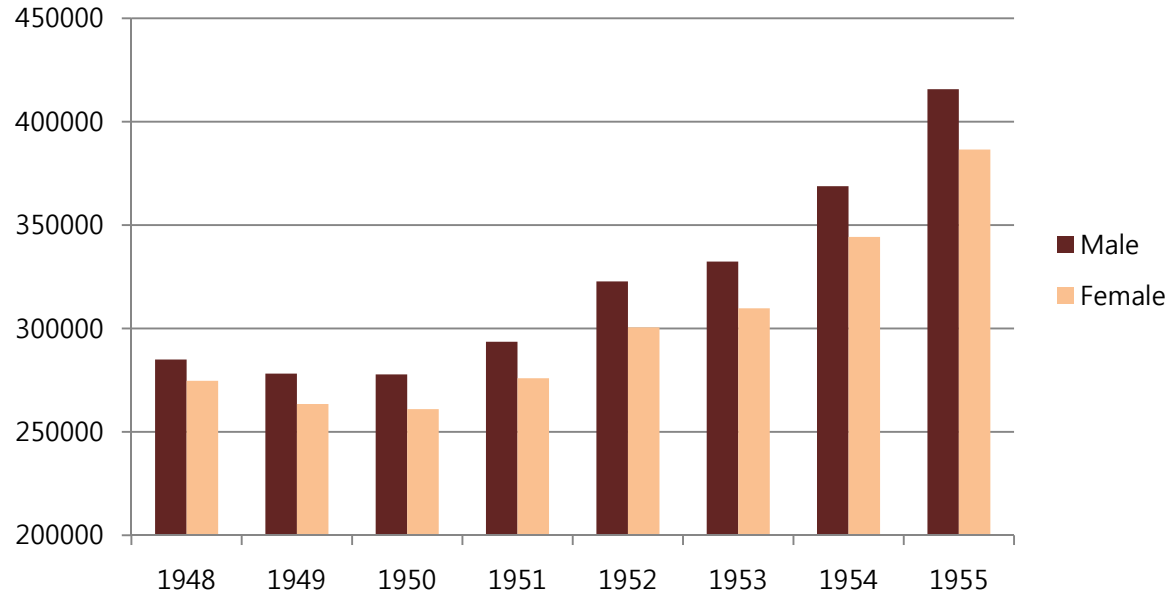


Figure 16-B
Population by Sex and Year of Birth (2000)

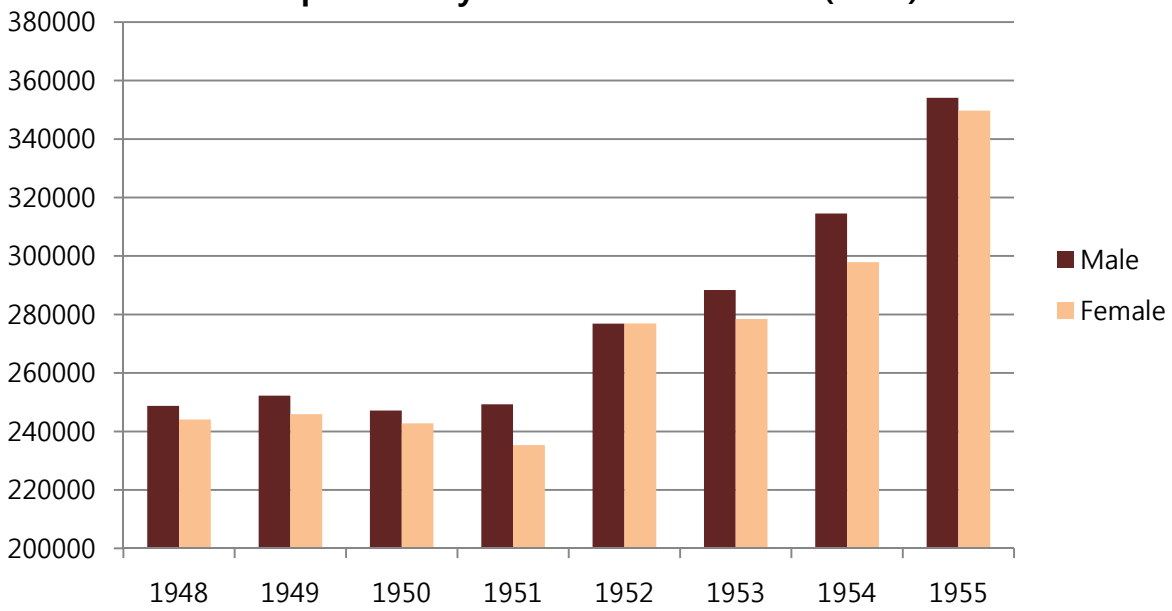


Figure 17-A
% Married Women with Disability/Limited Activity in 2005 by Own Birth Year (Central Region)

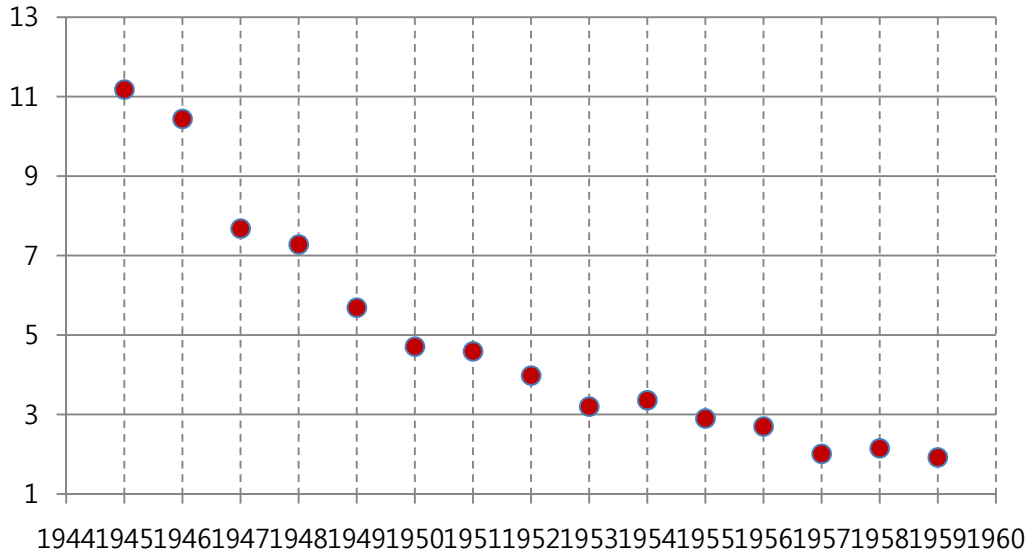
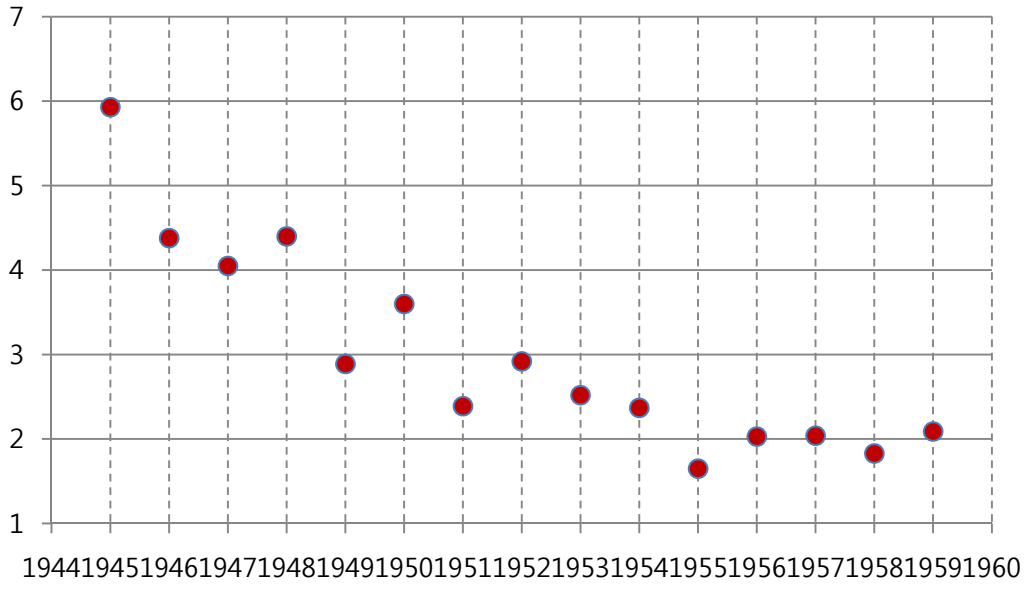
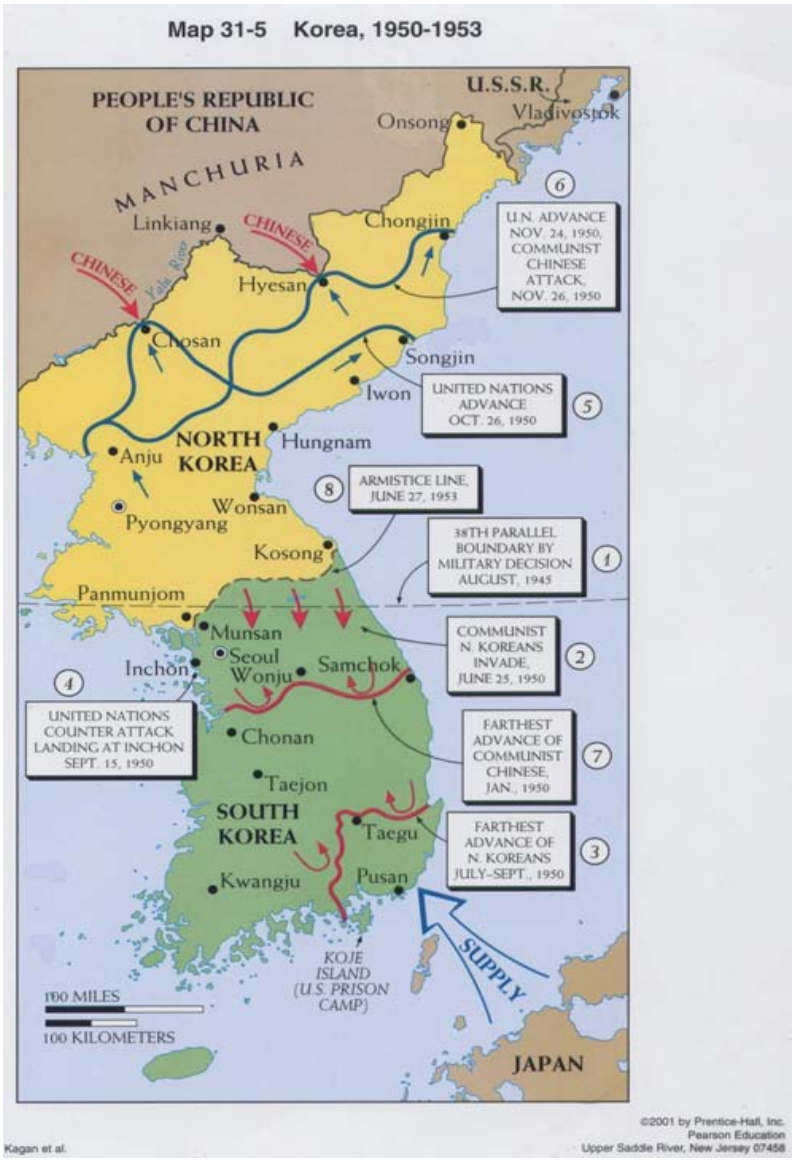
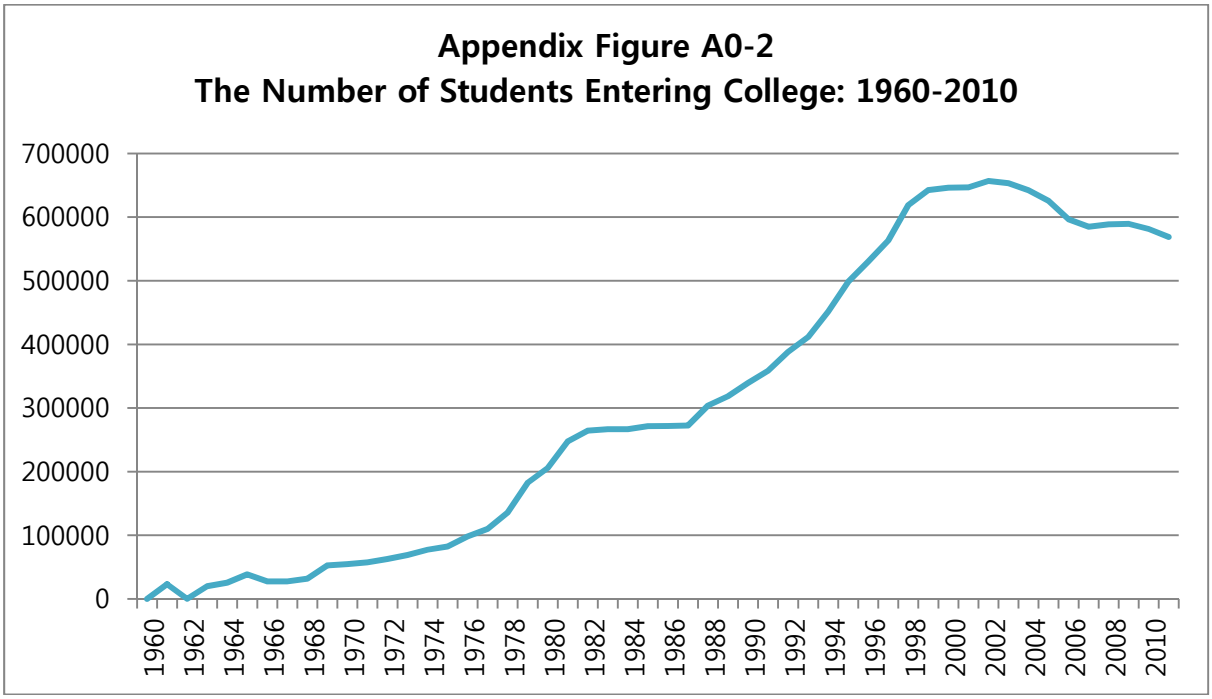


Figure 17-B
% Married Women with Disability/Limited Activity in 2005 by Husband's Birth Year (Central Region)

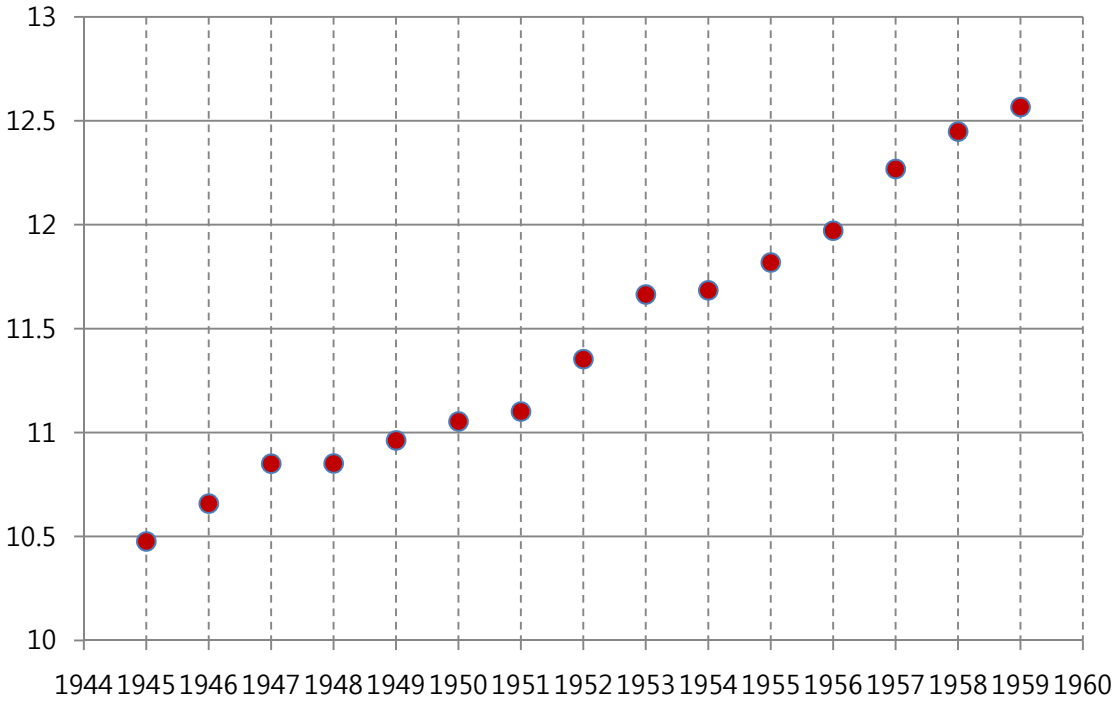


Appendix Figure A0-1
Movements of the Frontline during the Korean War: 1950-1953

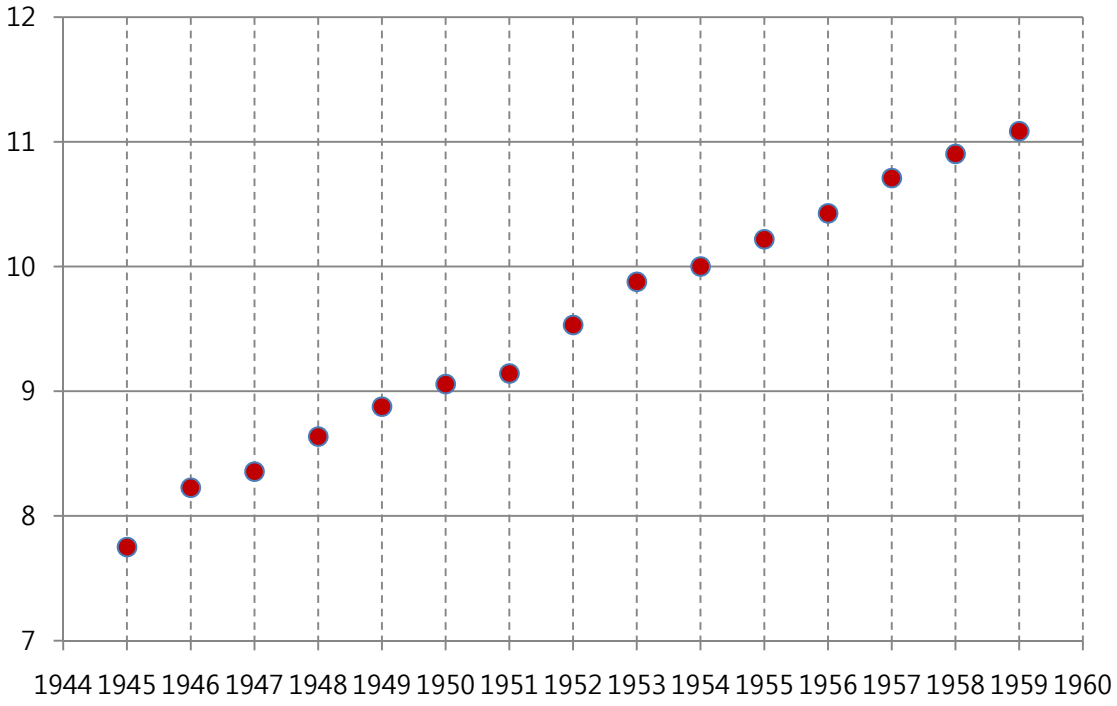



Appendix Figure A0-2
The Number of Students Entering College: 1960-2010
700000
600000
500000
400000
300000
200000
100000
0
1960
1962
1964
1966
1968
1970
1972
1974
1976
1978
1980
1982
1984
1986
1988
1990
1992
1994
1996
1998
2000
2002
2004
2006
2008
2010

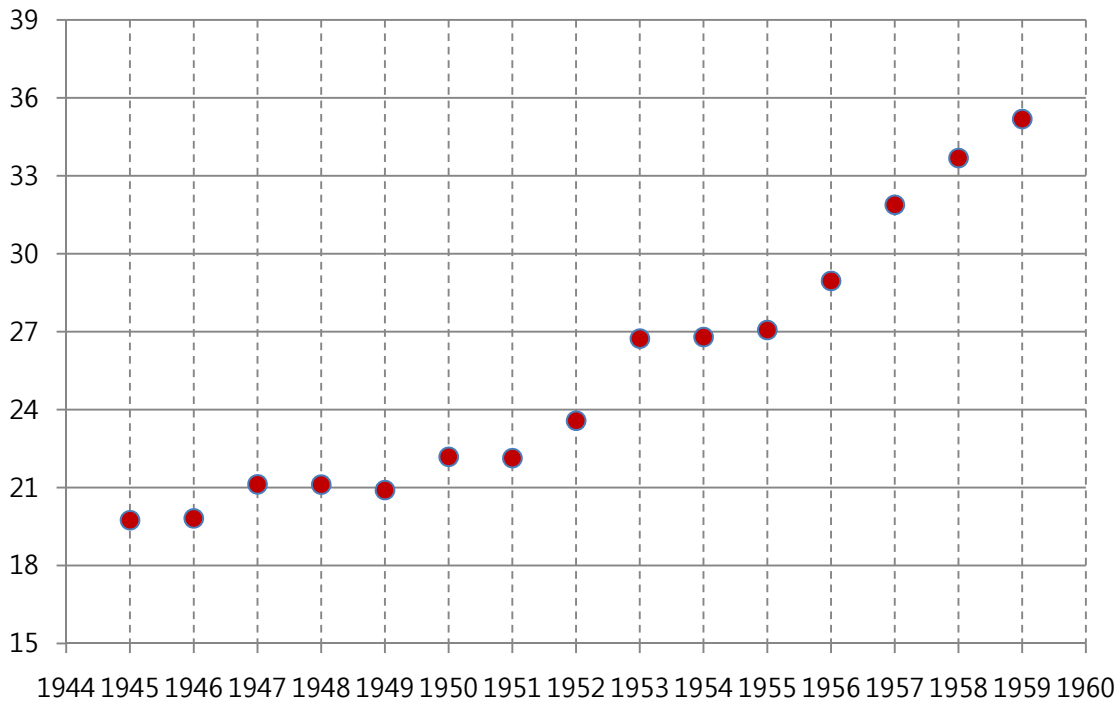
Appendix Table A1-A
Male Years of Schooling in 2000 by Birth Cohort



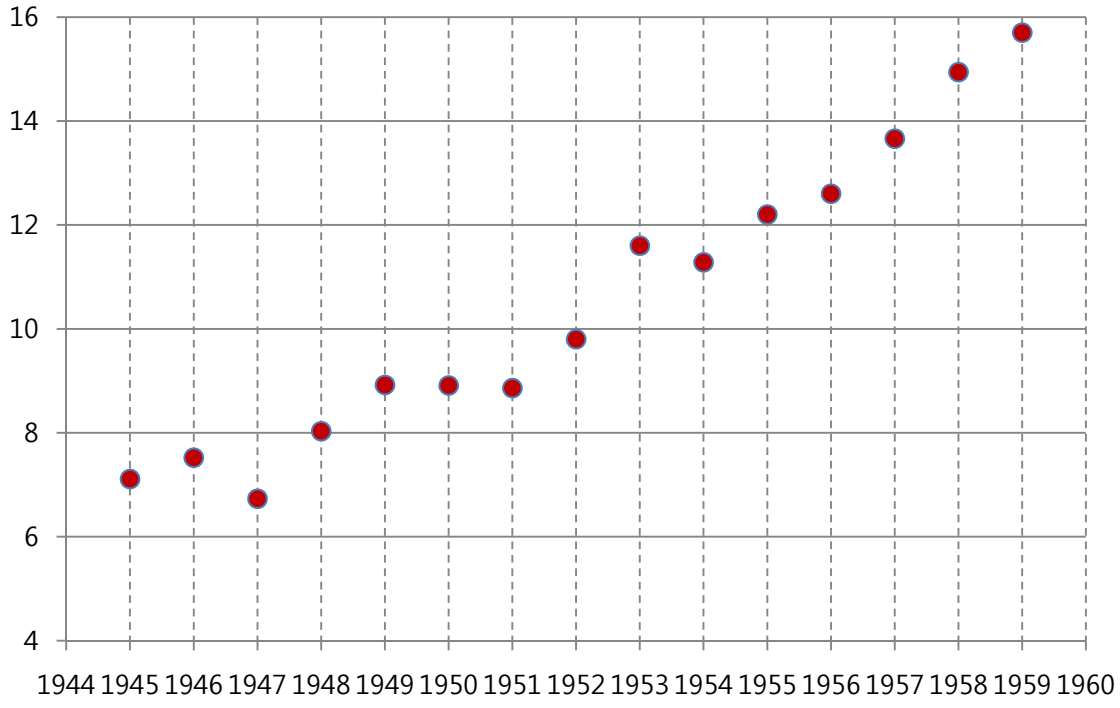
Appendix Figure A1-B
Female Years of Schooling in 2000 by Birth Cohort



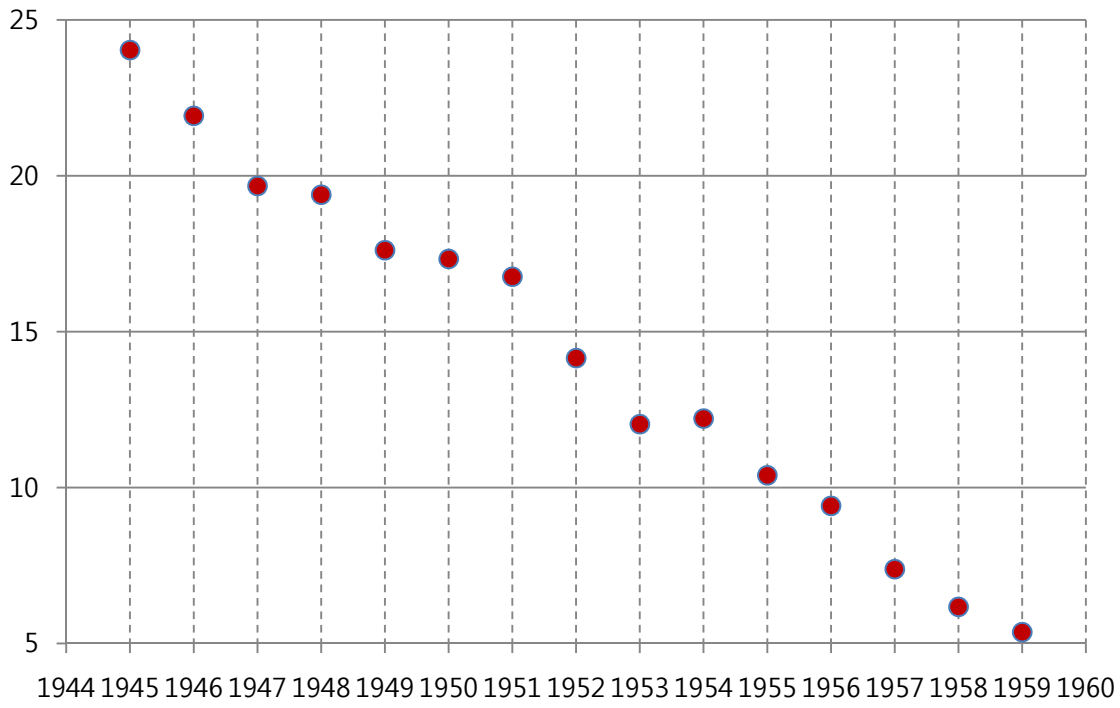
Appendix Figure A2-A
% Males College or Higher in 2000 by Birth Cohort



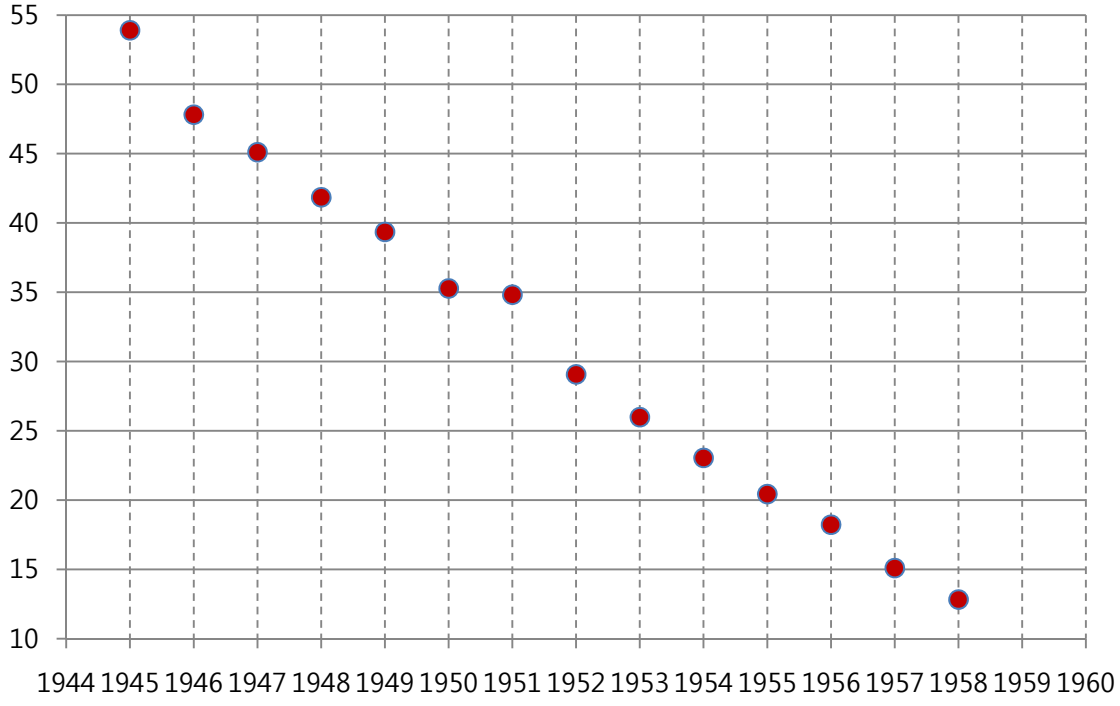
Appendix Figure A2-B
% Females College or Higher in 2000 by Birth Cohort



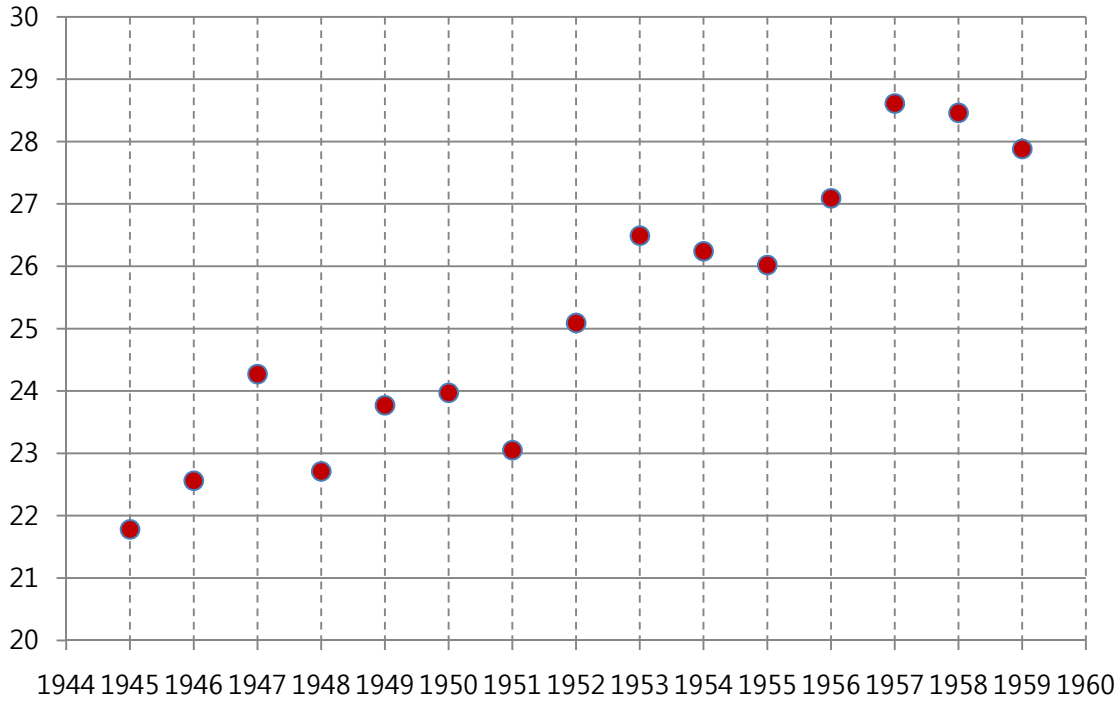
Appendix Figure A3-A
% Males Primary School or Less in 2000 by Birth Cohort



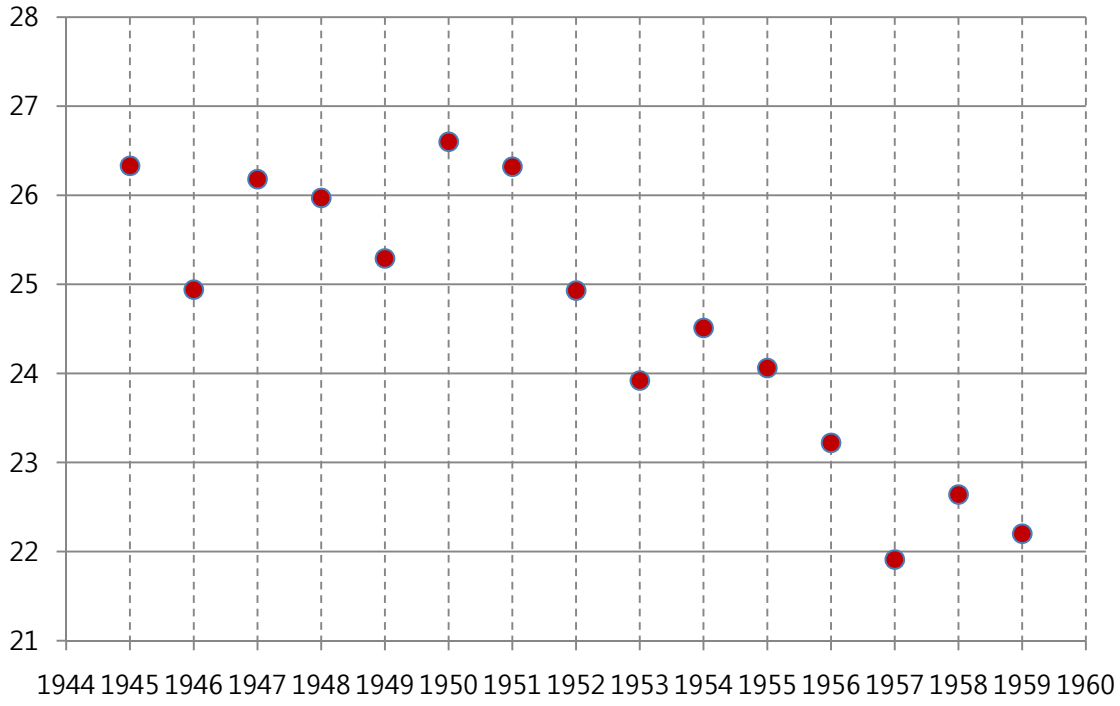
Appendix Figure A3-B
% Females Primary School or Less in 2000 by Birth Cohort



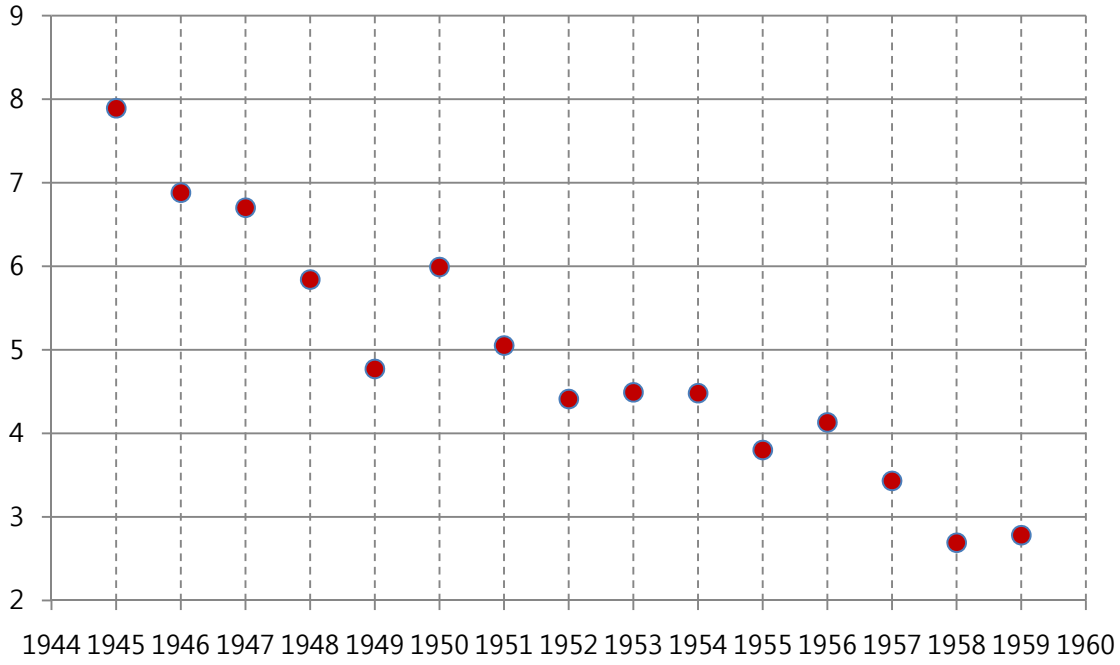
Appendix Figure A4
% Professionals among Employed Males



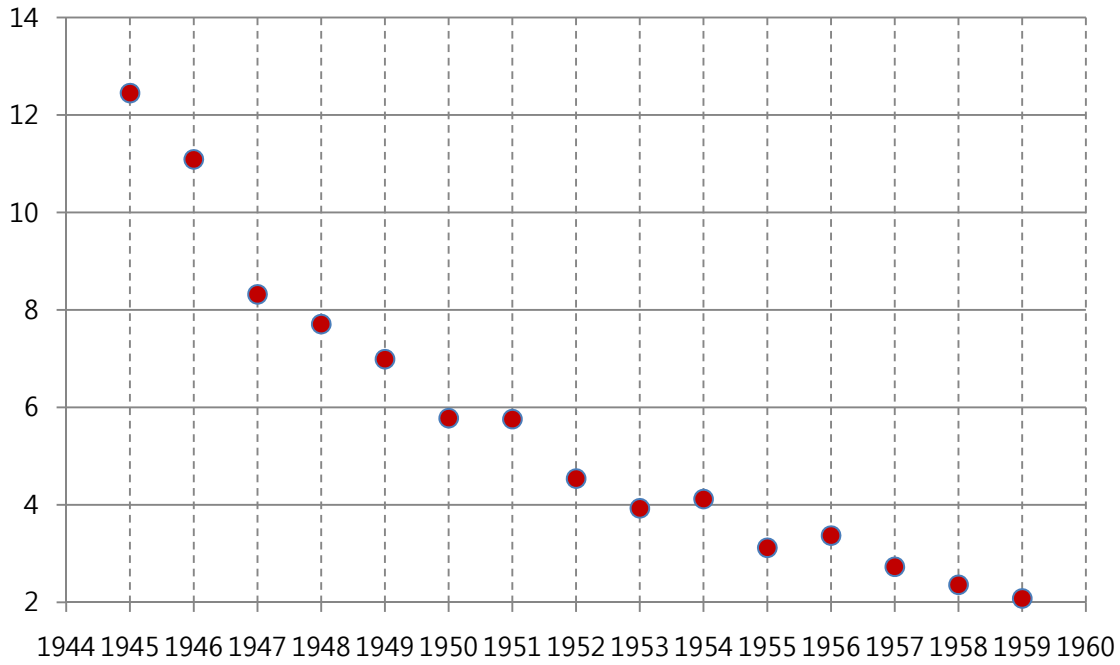
Appendix Figure A5
% Manual Laborers among Employed Males



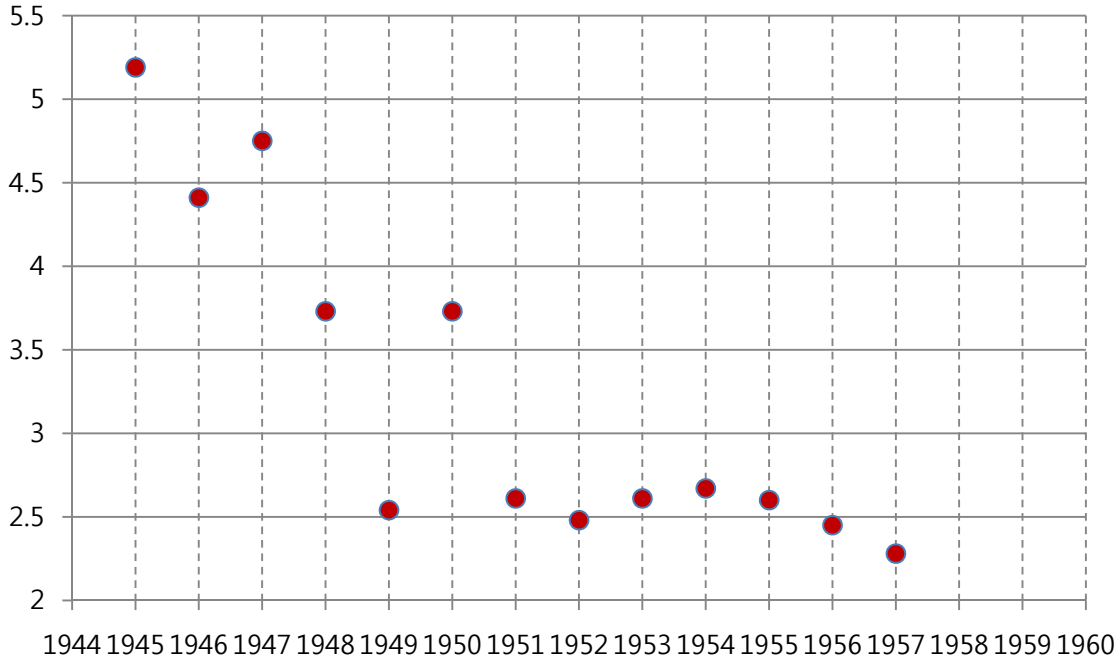
Appendix Figure A6-A
% Males with Disability in 2005 by Birth Cohort:
Residing in the Central Region



Apendix A6-B
% Females with Disability in 2005 by Birth Cohort:
Residing in the Central Region



Appendix Figure A7-A
% Males with Limited Activity in 2005 by Birth Cohort:
Residing in the Central Region



Appendix Figure A7-B
% Females with Limited Activity in 2005 by Birth Cohort:
Residing in the Central Region

