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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 the 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 in 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 the findings 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 the 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.

Keywords: fetal origins hypothesis; maternal stress; childhood health; Korean War

JEL Classification Codes: I10, J24, N35

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1. Introduction

Research across various disciplines suggest 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, which was 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 offer semi-experimental evidence on the long-run consequences of exogenously generated shocks to fetal health. Such traumatic events include the 1918 Pandemic Influenza (Almond 2006; Almond and Mazumder 2005), the Dutch Famine (Neugebauer, Hoek, and Susser 1999; Roseboom, Meulen, 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 for more than three years, the major war damage sustained by civilians was concentrated in the first nine months following the sudden invasion of North Korea (late June 1950 to 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 experience considerably differs depending on the place of residence. For example, Central Region residents were hit particularly hard because they lived closer to North Korea and their area was invaded twice by enemy forces. These specific circumstances help identify the effects of the war on maternal and fetal health through a 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 war-related disruptions affects adult health and economic outcomes in South Korea. For this purpose, we examine how various measures of socioeconomic performance and health at older ages differ depending on the timing and the place of birth. Specifically, we investigate whether the individuals born in 1950 and 1951 (those who spent 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 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 draws from South Korea evidence that were not 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, which depends on the extent of economic development, institutional features, and cultural characteristics. Thus, evidence from the Korean War in the current study can widen the scope of the literature.

The evidence 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 places of birth were more seriously devastated by the war. As for health outcomes, the 1950 male birth cohort is more likely to have functional limitations (around age 55) than 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 what this study suggests.

The effects of prenatal exposure to the Korean War differ by gender and birth cohort. The health outcomes of females are unaffected by the war. However, the health of males who were *in utero* during the early stages of the war are significantly worse than predicted by the 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 exhibits worse health outcomes, while 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 exposure of the two cohorts 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. In contrast, the majority of the subjects of the 1950 cohort became 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 establishes 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 links 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. These effects are also possibly mediated by the deterioration in health and cognitive ability.

Debates remain regarding whether a certain age is particularly critical for determining health and human capital development over life course. As individuals age, the effects of investments in health during early childhood persist or even increase in magnitude. This finding suggests that the early years in human life comprise a distinct stage of development. Such effects on health occurring in these years are 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). The hypothesis further 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 presented over the last two decades. Experimental studies using animals provide evidence that maternal malnutrition has a causal effect on the subsequent health of the offspring. A voluminous body of literature evaluates 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 reveal 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 found that LBW has long-run adverse effects on adult height, IQ, earnings, and education. Currie and Moretti (2007) stated that LBW among individuals born in California has

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

modest but statistically significant negative effects on educational attainment and the probability of living in a wealthy neighborhood. A growing number of biomedical studies suggest that maternal stress during pregnancy may increase the likelihood of preterm birth, developmental delays, and behavioral abnormalities (Weinstock 2001; Aizer et al. 2009).

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 addresses this potential problem by exploiting unique opportunities offered by natural experiments, in which individuals of a particular background or cohort are 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 are 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 displayed 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 exhibited 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 exhibited diminished test scores.

Historical famines were studied as natural experiments as well. 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, Ravelli et al. 2001), coronary heart disease morbidity (Roseboom, Meulen, Ravelli et al. 2001; Bleker et al. 2005), and adult antisocial personality (Neugebauer, Hoek, and Susser 1999). Research on the Chinese Famine (1959–1961) reported 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 working hours of employees (Meng and Qian 2009). Almond et al. (2010) reported that higher famine intensity is associated with a greater risk of illiteracy, dropping out of the labor force, marrying late (for men), and marrying partners with less education (for women). Neelson and Stratman (2011) claimed that exposure to the famine in Greece (1941–1942) in infancy lowered educational attainment.

The effects of prenatal exposure to pollution were examined via natural experiments. Chay

[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 minimal effect of LBW on infant mortality and other health measures from a sample of twins.

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) analyzed 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.

The influences of maternal stress during pregnancy on offspring outcomes were investigated. Eccleston (2011) found that cohorts exposed to the stress of the September 11, 2001 terrorist attacks *in utero* have lesser weight, shorter gestation length, and lower initial education attainments. Lauderdale (2006) reported that Arabic-named women in California, who experienced a period of increased harassment, violence, and workplace discrimination immediately following September 11, 2001, have increased risks of preterm birth and LBW. Currie and Rossin-Slater (2012) found that exposure to a hurricane during pregnancy increases the probability of labor and delivery complications as well as abnormal conditions of the newborn.

Unresolved issues continue to exist in spite of the growing body of evidence on the link between early-life circumstances and later economic and health outcomes. These issues motivate the present research. First, how *prenatal* exposure to military conflict affects *adult* outcomes is considerably less known. Well-documented studies report 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). A long-term impact of war was found for civilians, too. Individuals who resided in war-torn countries in childhood during World War II experience greater educational and earning losses at older age compared to those from countries not involved in the war (Ichino and Winter-Ebmer 2004). Kesternich et al. (2011) reported that exposure to World War II, as measured by the number of years an individual was 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 clear evidence pertaining to the effects of *prenatal* exposure to war. Although a number of biomedical studies examined the impact of maternal stress on offspring outcomes (Os and Selten 1998; Selten et al. 2003; Meijer 2007), they were largely concerned with the short-term influences on birth or childhood outcomes, with a special focus on mental disorders such as schizophrenia. Thus, this study can add to our understanding of how the long-term effects of *in utero* circumstances differ based on 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 nutrition, medical care, and education of a child are effectively implemented, the prenatal damages can be rectified to a particular extent. Thus, the relationship between early-life circumstances and later socioeconomic outcomes is likely to 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 comparison, 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 for this issue is drawn largely from the US and from Europe. Thus, by focusing on Korea, this study can widen the scope of the literature.

3. The Korean War (1950–1953)

The Korean War began with the surprise invasion of South Korea by North Korea on 25 June 1950. The war lasted three years and ended when an armistice agreement was signed on 27 July 1953. Vastly unprepared in terms of equipment and training, the 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 only after the resolution of the UN Security Council recommendation of military assistance to South Korea. By this time, the North Korean Army advancing into the country could not be held off. By late August 1950 (only two months after the war broke out), North Korea had occupied about 90% of the entire Korean Peninsula (Figure 1). The remaining uninvaded 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, which 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 the troops to fall back. Seoul was again lost to the enemy on 4 January 1951. Refugees from both the south and the north left 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 event was the fourth conquest of the city in only nine months. After exchanging 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 vary based on sources. 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 draws 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, which presents an account of the conflict that befits its current status. Relatively rich literature on political circumstances is 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, documents are inadequate on 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. Studying the social history of the Korean War based on the narratives of survivors is a promising approach to fill this gap (Kim 2009; Pyo et al. 2003). However, the primary focus of such studies is 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, which took a tremendous toll on human life. In addition to physical wounds and illnesses, a few survivors suffered from the mental damages that afflicted the soldiers,

such as post-traumatic stress disorder.

During the first several months of the war, numerous South Koreans remained in the areas that were occupied by North Korean forces. The exact number of civilians who failed to escape from North Korean control remains unknown. An estimated 1 million (or 50%) residents in Seoul are believed to have 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 and the 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 late 1950 to early 1951.

Refugee experience was no less arduous. Many refugees travelled on foot for days, carrying as many of their belongings as possible. People who were fortunate to get a train ride endured overly crowded cabins. Passengers who rode on the roof bore the suffocating smoke blowing out of the steam locomotive, especially when the train passed through tunnels. Away from home, the refugees endured chronic hunger and slept without proper shelter. The refugees joined the retreating troops pushed by the Chinese attack and 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 1 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 in Busan and Daegu fared slightly better, but they needed to cram themselves into small rooms. Emergency aid provided by the UN forces and ration distributions by the government prevented mass starvation, but these measure were still insufficient to solve the severe food shortage.

Prenatal exposure to war-related disruptions such as those described may negatively affect maternal and fetal health in different ways. First, food shortage during a war forces pregnant women to suffer from hunger. Malnutrition suffered while *in utero* can increase the risk of developing various degenerative diseases at older age (Barker 1992, 1994). Second, maternal stress from exposure to combat activities and from physical or emotional hardship can adversely affect fetal health. Excessive noise causes stillbirth, birth defects, and decreased birth weight as a result of changes in the uterine and placental blood flow (Geber 1970; Jones and Tauscher 1978; Knipschild et al. 1981). Among the

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

Finnish population, Huttunen and Niskanen (1978) found that the prenatal loss of fathers increases the risks of suffering from schizophrenia and committing crimes. Rofe and Goldberg (2011) reported increases in the blood pressure of pregnant women who lived in an area in Israel that was a target of terrorist activities for a long period and suffered the effects of war.

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 employed in measuring the effect of the war is to investigate how individual socioeconomic outcomes at old age (available from various micro data) differ using the timing and the place of birth.[5]

A comparison of 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. Given that most socioeconomic outcomes only tend to change gradually 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, that is, civilians were directly exposed to major war disruptions for only a relatively brief period. Although the war lasted more than three years, the major damage sustained by civilians happened 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, and civilians suffered through occupation or refugee experience (Figure 1). The war reached a stalemate around the 38th parallel after the spring of 1951, and the civilian life in the south of the battlefield more or less stabilized. Thus, a more reasonable assumption is that the fetal health of individuals born in 1951 or late 1950 is more seriously damaged by war-related disruptions than other birth cohorts.

Two more assumptions are required to add credence to the hypothesis of this study. First, following the fetal origins hypothesis, a particular wartime event is assumed to cause a stronger negative health shock while an individual is *in utero* than in the postnatal period. Nearly all Koreans

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

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, all other experiences, except the war effect, is assumed to continuously or gradually change 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 affect the 1950 to 1951 birth cohorts and those adjacent to it. This premise appears to be a reasonable assumption. For example, the number of students entering a college each year in Korea, a key institutional factor that determines the educational attainment of each birth cohort, gradually increased from 1960 to 2000, with no discriminating effect on a particular birth cohort (Figure 2). Similarly, although several disease epidemics occurred between 1945 and 1955, no evidence suggests 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 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 outcomes 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, 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 of the North Korean forces because of their proximity to North Korea. As a consequence, the residents of the Central Region likely suffered from the occupation of North Korean troops and the bombings by 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 differed from one place to another, depending on when and how long the area was occupied by the North Korean forces, how far the area was from the Busan perimeter (the major destination for refugees), and how extensive were the influences of the combat activities.

For this study, the residence of the mother of a person who 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 effective 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 (Figure 3). If many people were born in the unoccupied Busan perimeter [denoted as South (F) in Figure 3] 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.

To study the magnitude of wartime stress experienced while *in utero*, a difference-in-difference method is employed in examining the variations across places of birth. The basic idea is that if the cohort effect captures the influences of war-related disruptions, then it should be stronger for those persons who underwent 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.

The analyses below employ the following location-specific measures of wartime stress. 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 show if the place of birth belongs to either of the following two categories: the localities that were occupied twice by the communist forces or 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 longer distance from the major destination for refugees should be related to a higher probability of being occupied by the North Korean forces, a 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 KLoSA. Each of these sources has its own advantages and drawbacks in terms of sample size and variables offered. The major advantages of the Census are its large sample size and its provision of the places of birth, which allow for an accurate estimation of adult outcomes by birth cohort and place of birth.[8] Conversely, the Census 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

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

[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) were used as major sources.

[8] The micro sample of the 1980 census also provides information on the place of birth as well as several socioeconomic outcomes. However, some individuals who belonged to the post-war birth cohorts and 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 in 1980, were only 21 years old, too young to complete school, and to start a job career.

quarter of birth, thereby making the identification of the exact timing and duration of *in utero* exposure to wartime disruptions difficult.

The analyses 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 to 50 years old) in 2000 in terms of socioeconomic status. Furthermore, the 2000 census provides detailed geographic codes for the places of birth, which enables this paper to study how the effect of war differs by places 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 unskilled job; and (6) probability of using the Internet.[9] The 1990 census, another rare micro source reporting the places of birth, is also used to analyze 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 larger sample of cohorts born around the war period than do other Korean micro data that contain additional detailed information on personal characteristics (e.g., the Korean Labor and Income Study). The KLoSA offers rich information on health outcomes. Furthermore, the month of birth is available from the source. Thus, the examination of how health outcomes changes 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 (1 to 5, representing the best and worst health status); and (2) probability of having any disability.

[9] The occupations include professionals, managers, officials, and technical experts (2000 census occupation codes 0 to 293). The unskilled jobs include manual labor 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.

Table 1 presents the sample means of the socioeconomic and health outcomes of all male and female individuals born in the Central Region from 1945 to 1959. The mean of schooling years in the 2000 census for the males and females are 11.6 and 9.8, respectively. Almost 27% of males entered college, whereas only 11% of females did. The statistics on schooling did not change much between 1990 and 2000. Individuals born in the Central Region were more educated than the entire sample. In terms of labor-market outcomes, 14% of males and 53% of females of the sample were not working during the 2000 census. Of those who worked in 2000, 26% of males and 9% of females held professional jobs, while 24% of males and 18% of females comprised those in unskilled occupations.

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

5.1. Deviations of Socioeconomic Outcomes from the Smooth Cohort Trend

The educational attainment of individuals born in the Central Region from 1945 to 1959 were measured in terms of years of schooling (Figure 1), college admission (Appendix Figure A1), and completion of primary schooling or lower (Appendix Figure A2), as obtained from the 2000 Census.

A strong upward trend in educational attainment is shown by these cohorts, with the 1950 and 1951 birth cohorts veering from this steady trend. A deviation of the 1951 cohort from the tendency for long-term increase in schooling is clearly revealed; the1951 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.[11]

Figures 5 and 6 present two measures of success in the labor market for male subjects born in the Central Region from 1945 to 1959. The percentages of those professionally employed and those who were manual laborers were calculated from the 2000 census.[12] The analysis is limited to males because of the low labor force participation of females belonging to the cohorts. As with schooling trends, the lower occupational achievement of the 1951 male birth cohort is evident. 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.[13]

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[11] Although not presented here, digression of the 1951 birth cohort from the trend is also observed in the entire sample, albeit at a smaller magnitude. Educational attainment either stagnated (admission to college or higher for males and females, and primary school or lower for females) or improved at a rate slower than the predicted long-term trend (years of schooling for males and females, and primary school or lower for males) from the 1950 to the 1951 cohorts.

[12] 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.

[13] The same measures constructed for the entire sample (also not presented in the paper) show similar

Columns 1 and 2 of Table 2 contain estimates of β_t in Equation (1), indicating the magnitude of outcome deviation of male subjects born in 1950 and 1951 from the quadratic cohort trend. Logistic specification is used for the binary outcomes (Panels C to K). An OLS regression is conducted on the continuous outcome variable (Panels A and B). The regression results confirm that educational attainment, quality of occupation, and Internet usage of the 1951 birth cohort are significantly lower, especially among subjects born in the Central Region.[14] 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 (Table 2, Col. 2). Such effect continues to be statistically significant when the entire sample is used (Col. 1), although in a much smaller magnitude, for seven out of eleven socioeconomic outcomes. In sharp contrast, the cohort effect is insignificant for individuals born in the Southern Region, including areas occupied by North Korea (not reported in the table).

Columns 3 and 4 of Table 3 present the regression results for females, which correspond well with the patterns of the cohort effect. Female subjects of the 1951 birth cohort, who were born in the Central Region, exhibit clear disadvantages in all six measures of educational attainment (Panels A to F of Col. 4). However, unlike males, this female cohort does not significantly differ from other cohorts in terms of Internet use, employment status, and the two measures of quality of occupation. This unremarkable effect on female-labor market outcomes is unsurprising, given the low labor-force participation of women from this cohort. No negative effect on female socioeconomic outcomes (not reported here) was observed among those born in the Southern Region in 1951.

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

If the deviation of Census outcomes of the 1951 birth cohort reflects 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 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 remainder of this subsection) confirm that the 1951 cohort effect is indeed stronger for individuals with more arduous *in-utero* wartime experiences.

Figure 7 compares the schooling years of males from the 1951 birth cohort against those of

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handicaps for the 1951 birth cohort, although the magnitude of deviation from the trend is smaller compared to that in the Central Region.

[14] The negative effect of being born in 1951 on quality of occupation is not fully explained by the cohort's disadvantage in educational attainment. Although the education factor is controlled, the 1951 cohort effect remains statistically significant.

neighboring cohorts (either 1950 or 1952) using the distance between their place of birth and Busan, a measure of wartime stress. Individuals born near Busan (within 200 kilometers) and who were from the 1951 birth cohort acquired slightly more schooling than those from adjacent cohorts. The direction of this schooling gap is reversed for areas that are 200 km to 300 km away from Busan. The disadvantages in schooling for the 1951 cohort versus other cohorts are particularly pronounced for individuals born far from Busan. The results obtained from female samples are similar to those from males, wherein the 1951 cohort effect increases with the severity of wartime stress measured by the distance from Busan.

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

OLS regressions for the years of schooling are conducted based on a difference-in-difference model, as displayed in Equation (2). If the 1951 cohort effect increases with the magnitude of wartime stress, then the coefficient of 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. In addition to the baseline model (model 1), an alternative specification is used in which variables pertaining to extent of urbanization are added (model 2). These variables recognize that urban areas provide more favorable environments for human capital development. To construct the variables for extent of urbanization, places of birth were classified as follows: (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 for birth in the Central Region (CENTRAL); (b) dummy variables for birth in the localities occupied twice (CENOCCUP2) and birth in 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 number of months under occupation by North Korean forces (DUROCCUP).

Table 3 presents the results of regressions conducted on males and females. Panels A, B, C,

and D provide parameters estimated using each of the four measures of wartime stress. The results support the hypothesis that the 1951 cohort effect on years of schooling is stronger for those who suffered more serious war-related disruptions. For males, the coefficient of interaction between birth in 1951 and wartime stress is negative and statistically significant in all eight specifications. For females, the coefficient is also negative and statistically significant in five out of eight specifications; CENTRAL and BUSAN_DIS (in model 2) obtained p-values of 0.21 and 0.13, respectively.

In model 1, all measures of wartime stress are positively related to the years of schooling. This results can be attributed to the fact that educational attainment is higher among residents of Seoul metropolitan areas (including Seoul, Inchon, and smaller satellite cities), and that the Seoul metro area was more heavily devastated because of its proximity to North Korea. This conjecture is consistent with results after controlling variables pertaining to the extent of urbanization (model 2), wherein 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). In the regression for females involving CENTRAL (panel A), the coefficient remains negative and statistically significant, although the extent of urbanization is controlled. However, its absolute magnitude diminishes by two-thirds.

Table 4 reports the summary results of 88 difference-in-difference regressions conducted on the 11 measures of socioeconomic outcomes cited in this study. The results suggest that for a wide range of socioeconomic outcomes, the 1951 cohort effect is stronger for individuals who suffered more serious wartime stress while *in utero*. For males, the coefficient of the interaction between birth in 1951 and wartime stress is statistically significant in 26 out of 44 regressions. In all adult outcomes, except primary schooling or less in 1990 (Panel 1-E), the coefficient for interaction is statistically significant in at least 1 specification; in 8 out of 11 measures, it is significant in at least 2 specifications.

The results among females are similar to those among males in terms of educational attainment and Internet usage. However, prenatal exposure to war-related disruptions had considerably weaker effects on the labor-market outcomes of women than men. Only the probability of employment in unskilled occupations in 2000 was significantly affected by the interaction between birth in 1951 and measure of wartime stress (Panel 2-J, Cols. 3 and 4). The significantly lower and, presumably, more selective labor force participation of women born prior to 1960 is a possible explanation for the gender difference.

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

Figures 11 and 12 respectively present the health outcomes of male and female individuals

born between 1945 and 1959 as drawn from the 2005 census. These outcomes present the percentages of individuals with disability and individuals with limited daily activity. The charts suggest that the 1950 and 1953 male subjects exhibit deviations from the quadratic trend in terms of disability and limitations in activity. Conversely, no clear departures from long-term trends in health outcomes appear among female birth cohorts of the Korean War.

The logistic regressions reported in Table 5 confirm these cohort effect patterns, in which the quadratic cohort trend is controlled. Estimates of β_t suggest that the 1950 male birth cohort is more likely to have disability or limitations in daily activities than other birth cohorts. There were no such statistically significant cohort effects observed among females.

A crucial drawback of the analyzing the 2005 census data is that the cohort effect cannot be estimated separately based on the subjects' particular locality, thereby causing difficulty in assessing the actual effect of the war on fetal health. As in the case of socioeconomic outcomes, the 1950 cohort effect is considered stronger for those born in the Central Region.[15]

To supplement the results obtained from the 2005 census, several health outcomes were plotted based on data from the 2006 KLoSA for each birth quarter from 1948 to 1955. These conditions reflect the average score of self-reported health and the percentage of each cohort having disability. Place of birth is not identified in the KLoSA, thus the results pertain to the entire sample.

These variables are plotted in Figures 13 to 14. Although the measures of health 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 long-term patterns predicted in all three health outcomes. In contrast, the plotted variables for females do not reveal any clear cohort effects.

Table 6 offers regression results that consider 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. 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).

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

[15] Their 2005 residence region is at best a highly inaccurate proxy of their region of birth given that geographic mobility since the Korean War was high. 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 continued to reside 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. Nevertheless, the graphs in Appendix Figures 3 and 4 suggest that the negative 1950 cohort effect is likely to be greater for individuals born in the Central Region. For males, deviations of the 1950 cohort are more pronounced when the sample is limited to individuals living in the Central Region.

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 10 months of the war do not exhibit any significant disadvantages in self-reported health and disability.[16]

6. Discussion

6.1. Potential Bias Arising from Population Selections

Several types of population selections possibly influenced the composition of war-time birth cohorts, including (a) marriage and fertility behaviors; (b) deaths of pregnant women; (c) prenatal deaths; and (d) postnatal deaths. A natural concern in interpreting the results of this study is the pattern of selection of Korean War birth cohorts that survived five decades after the conflict. If individuals who were *in utero* during the worst time of the war were positively selected in terms of characteristics correlated with later life health and economic outcomes, then maternal health can no longer be considered as explanation for the results given in the preceding section.

Marriage and fertility behaviors before June 1950 were not affected by the war. Thus, cohort subjects born prior to the spring of 1951 should not be selected in terms of conception. The probability of conception for cohort subjects born after March 1951 and the probability of prenatal death during conception by subjects born after June 1950 were deemed influenced by the war. No direct evidence is available as to which subjects were more likely to be pregnant or have live birth. A possible source of selection in fertility behaviors is selective enlistment in the military (Brown 2011). Documentations of military conscription during the Korean War do not show how men were selected into the armed forces. However, the process was obviously extremely chaotic, especially in the early stage of the war.[17] Under these circumstances, men from particular socioeconomic backgrounds were unlikely to be recruited more than the others.

How fertility behaviors differed among socioeconomic classes during the war is likewise

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[16] Several male and female birth cohorts exposed to the war *in utero* also exhibited stunted growth. Males born in the fourth quarter of 1951 or the first quarter of 1953 were shorter by at least 1.7 centimeters compared to the long-term trend. Females born in the quarter following the war outbreak experienced a decrease 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.

[17] Immediately following the outbreak of the war, the South Korean military attempted to recruit more than 200,000 men on compulsory basis. However, these mobilization efforts were seriously hampered by rapid advancing of the North Korean force and by a paralyzed administrative infrastructure. A number of men were, in fact, conscripted by force on the street, bypassing formal enlistment procedures including medical examination, and being sent directly to training camps (Korean Military Manpower Administration 1985, pp. 264–286; Tucker 2002, pp. 354–359).

unclear. Brown (2011) suggested that higher-income U.S. families concerned with providing higher quality education to their children during the First World War postponed reproduction until the war was over. However, given the fact that Korea circa 1950 was a poor agrarian society in which the fertility transition had not begun, women who were under a more favorable socioeconomic circumstance can be assumed to have better chances of conceiving than those in poorer conditions.[18]

The majority of civilians who died during the Korean War were victims of either combat activities or politically motivated murders (Chung 2010). 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 punishment by the North Korean forces (Chun 2010). 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 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.

Direct evidence regarding the selections in conceptions and live birth is difficult to obtain, yet a comparison of socioeconomic characteristics of the parents across different birth cohorts would be useful in determining the magnitude and direction of potential section bias. Figure 15 provides the average years of schooling of the parents by the children's year of birth, computed from the 2006 KLoSA.[16] Beginning with the 1949 birth cohort, parental education increased across cohorts. The years of schooling for both the fathers and the mothers of children born in 1951 are longer than those predicted by long-term cohort trends. This suggests that the subjects of the 1951 birth cohort are positively selected in terms of family background.

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. More 1951 birth cohort subjects died between 1960 and 2000. The size of the 1951 cohort was reduced by 15%, while the 1950 and 1952 cohorts decreased by 9% and 11%, respectively, during

[18] Total fertility rate in South Korea was 5.99 in 1960, and the country is believed to have undergone its first fertility transition during the 1960s (Kim et al. pp. 84–87).

[16] The sample size of each birth cohort ranges from 236 (1951) to 368 (1957). In the Census, parental education can be observed only when the person co-resides with his or her parents. Any evidence from the source cannot determine the direction of potential selections because parental survival and co-residence decisions are not random.

these four decades. The cause of the rapid decline in population of the 1951 birth cohort compared with other cohorts is unclear. While this may be attributed to the *in utero* circumstances faced by this cohort, further research is required to verify this claim. Regardless of the cause, cohort subjects with frailer health tended to die by 2000. Consequently, the 1951 birth cohort subjects who were still alive in 2000 are positively selected in terms of health or robustness compared with other cohorts with lower mortality rates since 1960.

In sum, available evidence suggests that the cohort offspring, whose fetal health was most seriously damaged by the Korean War, are positively selected in terms of conception and live birth. Therefore, the cohort effect estimated in Section 5 could be understated. At the least, the results of this study are unlikely driven by selection bias.

6.2. Differences by Gender

The above results do not explain why the health outcomes of females were unaffected by the Korean War, whereas those of male cohort subjects born in 1950 (from 2005 census) and in the second quarter of 1951 (from the 2006 KLoSA) were significantly worse than predicted by smooth cohort trends. Four possible explanations are 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 of 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 females. However, previous studies examining other disastrous events such as famines and epidemics report no sharp gender differences in the relationship between *in utero* circumstances and adult health outcomes. A possible explanation for the distinct results of this 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 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 investment return. Finally, parents made minor investments in the wellbeing of their daughters during the mid-20th century because of the strong preference for sons in Korea. Under these conditions, the disparity in *in utero* circumstances among girls would not produce any differences in their adult health because their parents did not spend much to improve their daughter's health in the first place. 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 on 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), such a bias is assumed to significantly influence parental investment in children in Korea circa 1950, although its magnitude is difficult to determine. 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, similarities in the patterns of parental investments in children in Korea six decades ago and those of China today are unclear, considering these countries' institutional and socioeconomic differences.

Third, only a small fraction of females born during 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 is that the effect of war-driven negative health shocks on adult health was mediated by different economic statuses. Using a sample from the 2005 Census, this hypothesis is tested by selecting married women whose families were headed by the husband. The health outcomes (the probability of having any disability) of these women are displayed in terms of their husbands' birth years (Appendix Figure 4-A) and their own birth years (Appendix Figure 4-B).

The logistic regressions on the health outcomes of married women employed quadratic cohort trends and dummy variables of birth by the couples during wartime (Cols. 1 and 2 of Table 7). Women married to subjects from the 1950 male birth cohorts were significantly more likely to have disability or limitations in daily activities in 2005 than predicted by smooth cohort trends. In contrast, the married women's own birth years had no significant effect on their health at old age. This finding implies that the previously cited gender differences in the effects of the Korean War on health are at least partly explained by the strong influence on female health by the husband's economic and/or health status.

The last two regressions reported in Table 7 (Cols. 3 and 4) include a dummy variable indicating whether the husband has any disability. The results suggest that the effect of the husband's birth year on the wife's disability can be mediated by the husband's poor health. The husband's disability strongly increases the likelihood of disability in the wife (Col. 3 of Table 7). Once the husband's disability is controlled, 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). The wives of disabled men are likely to become handicapped themselves in the course of

providing care. Alternatively, economic hardship caused by the breadwinner's incapacity can 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 partly explains why the female cohort subjects born in 1951 do not reveal diminished health outcomes even when the KLoSA is utilized. As noted above, the size of the 1951 birth cohort decreased more rapidly than that of neighboring cohorts from 1960 to 2000 (Figure 16). Normally, the male-to-female ratio of a cohort is about 1.05 at the time of birth, which continuously declines with age because the rate of male deaths exceeds that of females. Figure 16 shows that for the majority of birth cohorts, the male-to-female ratio substantially dropped 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, population selection in the 1951 cohort is much more pronounced among females than among 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 within the 1951 cohort, thus weakening the health effects of the war.

On the contrary, the 1950 birth cohort shows that 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. Male-to-female ratios of the 1950 and 1951 birth cohorts in 1960 (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 than boys were killed 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. Considering the Census outcomes, the 1950 cohort mostly exhibits health-related negative consequences from the war, whereas the 1951 cohort only shows lower socioeconomic outcomes than neighboring cohorts.

This result can be attributed to the difference in pregnancy stages during which the two birth cohorts were exposed to negative health shocks. Individuals born at the end of 1950 had already spent four months as a fetus or *in utero* by the time the war broke out in late June; thus, majority of this cohort survived the first half of pregnancy before the war. In particular, the 1950 cohort *in utero* during the first three months of the Korean War spent only the final trimester of pregnancy during what is considered as the most chaotic period 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 according to the stage of pregnancy at which the shocks were received (Barker 1994). The human brain develops between the 8th and 25th weeks of pregnancy. Thus, the 1951 birth cohort was more likely to be exposed to war-related disruptions as a fetus during these weeks than the 1950 cohort. This study considers socioeconomic outcomes, which are closely related to cognitive skills including educational attainment and quality of occupation. 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. In contrast, the subjects of the 1950 birth cohort were 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 attending at least primary school (see Panels C to F of Tables 2 and 4) because college demands cognitive ability more than 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 civilians to suffer from severe war-related disruptions. Motivated by growing literature on the fetal origins hypothesis, this 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 this paper supports the fetal origins hypothesis. A number of socioeconomic outcomes from the 1990 and 2000 census were significantly lower for the 1951 birth cohort. For instance, males and females of this cohort 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 and have professional employment, as well as 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 result can be attributed to the extensive collateral damage experienced by the residents of this region when the war broke out: a larger percentage of residents endured North Korean occupation; refugees from this

region traveled longer distances; and the region fell under communist control twice. By 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 North Korean forces. Regression results suggest that the magnitude of the negative cohort effect is significantly larger for individuals 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 disability in 2006. These negative effects of *in utero* exposure to the Korean War on health are likely stronger for individuals born in the Central Region, as in the case of socioeconomic outcomes. The estimated negative effects of the war are also 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 those of 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 influence of the husband's economic and health status on female health in Korea. Women married to the 1950 male subjects were significantly more likely to have disability or limitation in daily activities in 2005 than predicted by smooth cohort trends. In contrast, these married women's own birth years had no significant effect on their health at old age. Stronger population selection among females born in 1951 can be a factor; the mortality rate from 1960 to 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 significantly impaired by war-time *in utero* influences differs between the 1950 and 1951 birth cohorts. The 1950 cohort exhibits worse health outcomes while 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 the health of the 1951 cohort, as noted above, may be attributed to the considerably stronger population selection experienced by this cohort.

The results of this 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, previous studies have focused on how famines, infections, and exposure to toxic substances *in utero* affect adult outcomes. Several observed impacts of the Korean War may partly 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 Chinese famine. Despite the vivid memories of hunger among many survivors, finding a case of civilian death caused by starvation proved difficult. In addition, there were no records found on major epidemics of infectious diseases during the war. 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.[17]

This study suggests that military conflict can lead to long-term negative health and economic consequences by adversely affecting maternal and fetal health. This finding is more evident in civilians directly exposed to combat, as in the case of the Korean War, which implies that the 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 the long-term adverse effect on the health and socioeconomic outcomes of the next generation is also considered, the actual total costs of modern military conflict, which tend to expose civilians to various disruptions, should be substantially larger than suggested by conventional estimates.

[17] 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 recovering from destruction caused by the war. Thus, assuming all other factors are equal, the post-war generations are likely to be healthier at old age than previous cohorts who experienced the Japanese colonial occupation, the Second World War, or the Korean War *in utero*.

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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 and 1951 Birth Cohorts' Adult Outcomes 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 and Logistic 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 Cohorts' 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 Cohorts' 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
Movements of the Frontline during the Korean War: 1950-1953

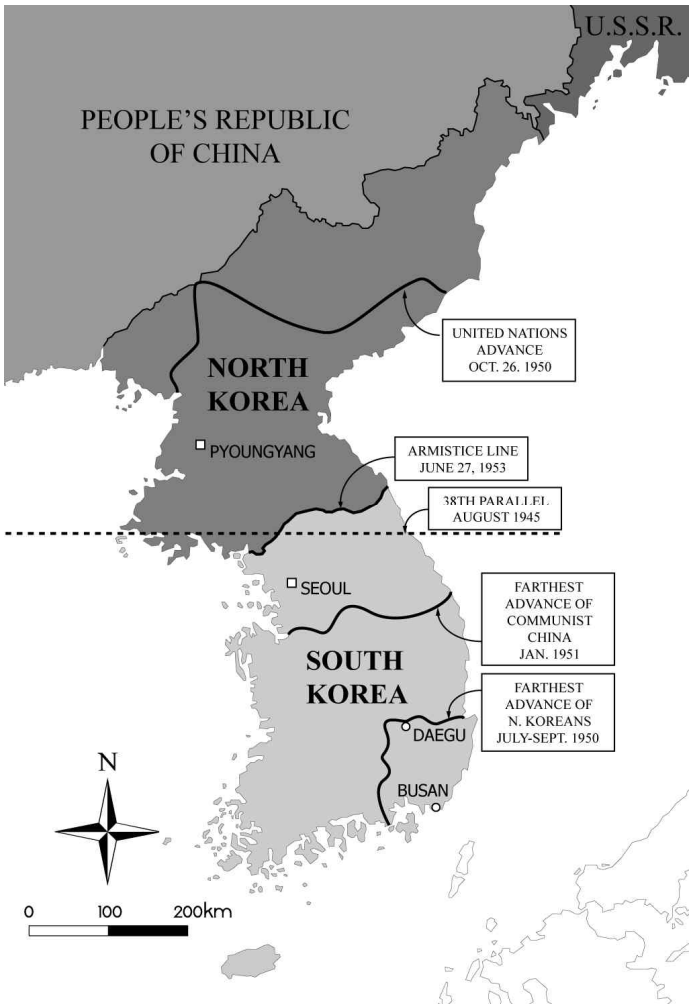


Figure 2
The Number of Students Entering College: 1960-2010

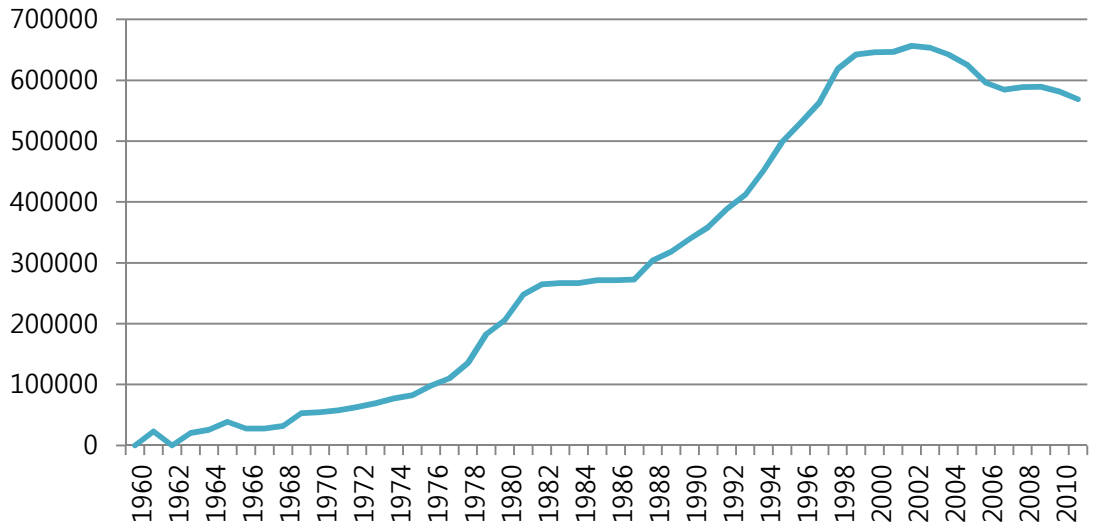


Figure 3
Region of Birth by Year

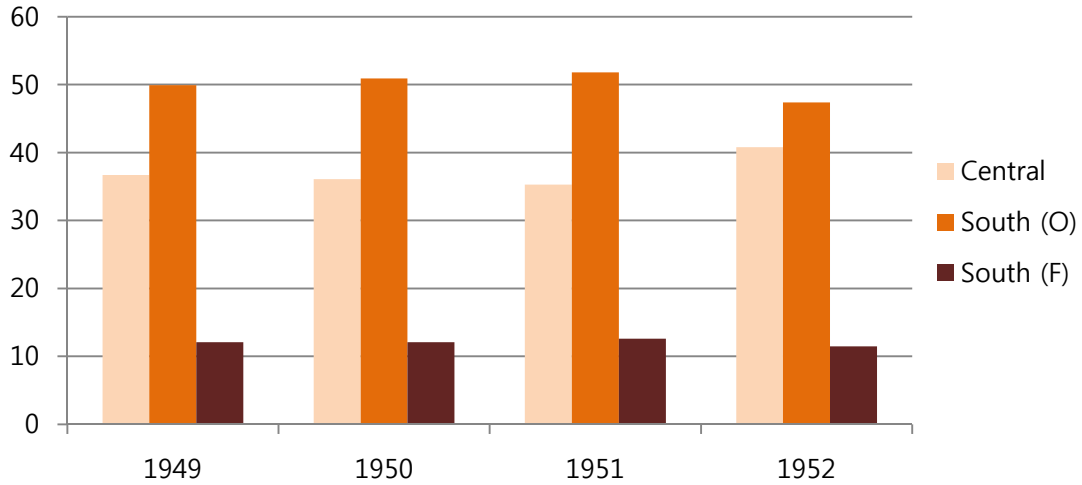


Figure 4-A
Male Years of Schooling in 2000 by Birth Cohort:
Born in the Central Region

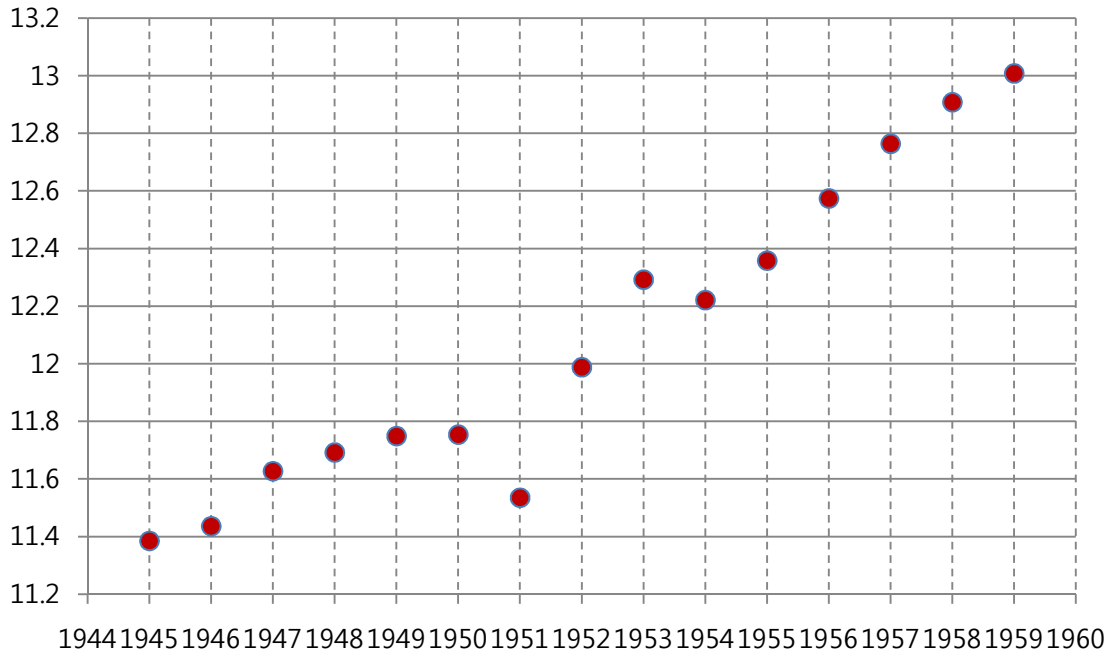


Figure 4-B
Female Years of Schooling in 2000 by Birth Cohort:
Born in the Central Region

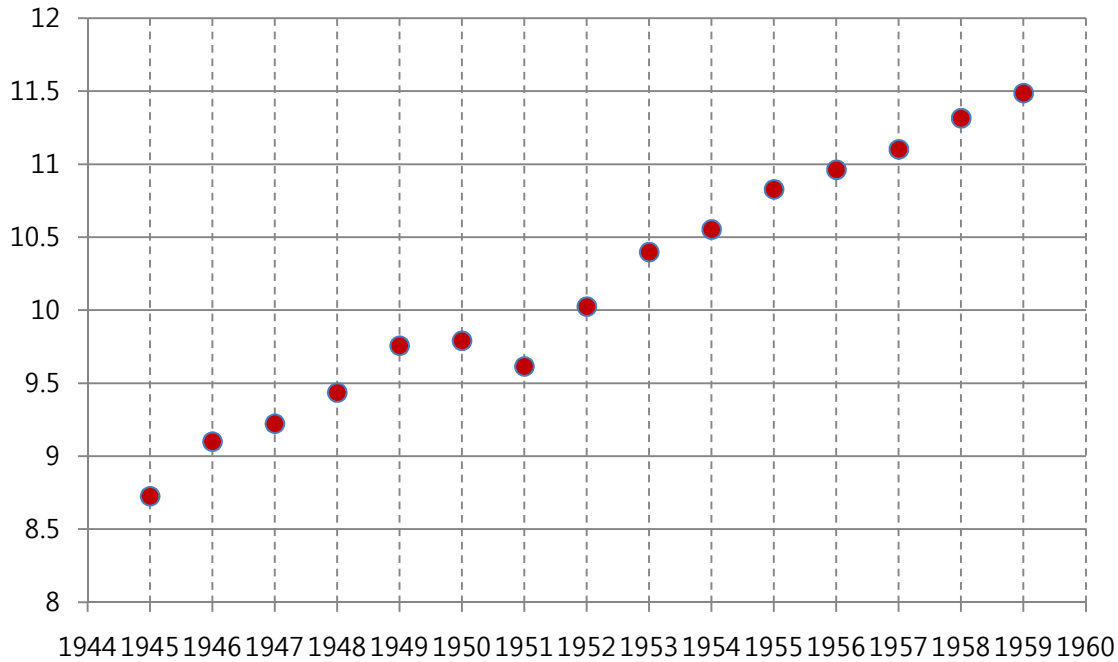


Figure 5
% Professionals among Employed Males:
Born in the Central Region

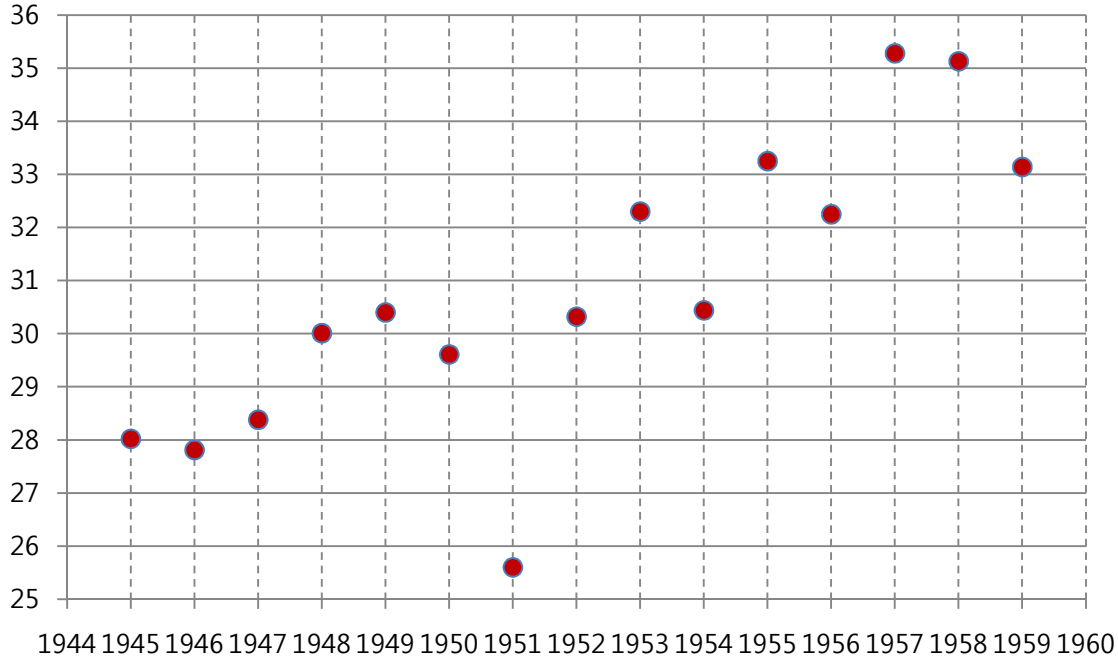


Figure 6
% Manual Laborers among Employed Males:
Born in the Central Region

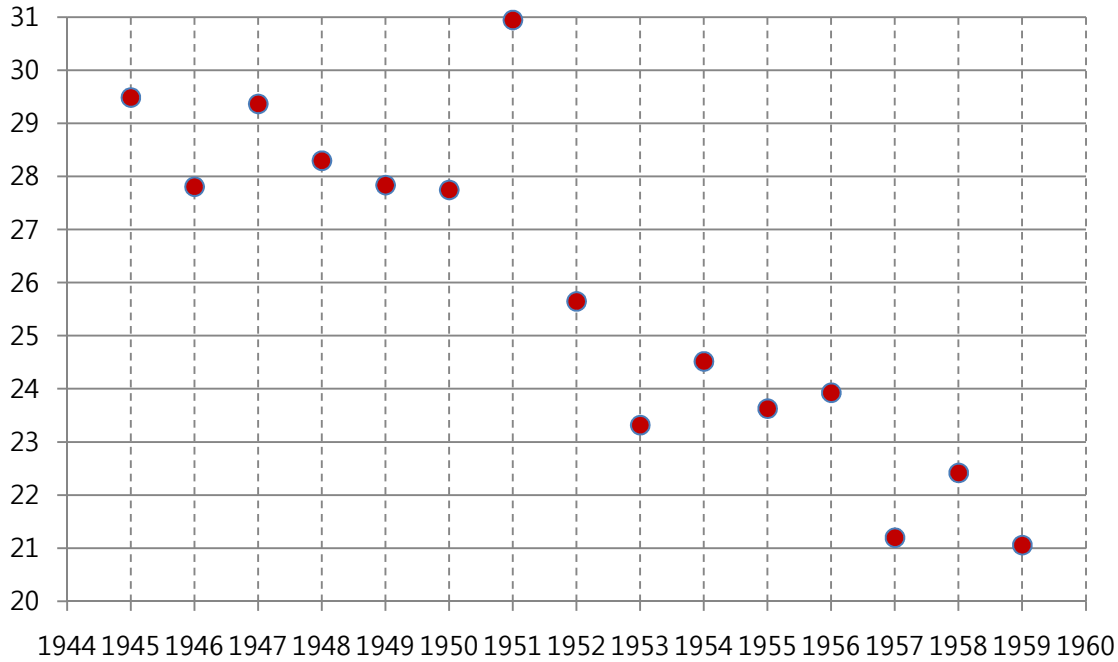


Figure 7
Years of Schooling by Distance from Busan

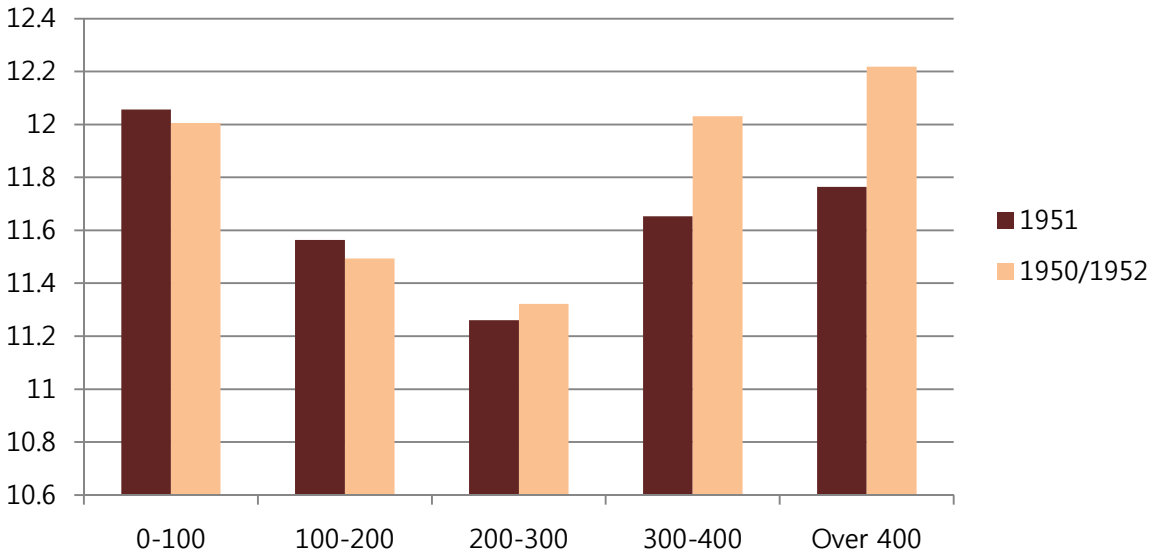


Figure 8
Years of Male Schooling by Duration of Occupation

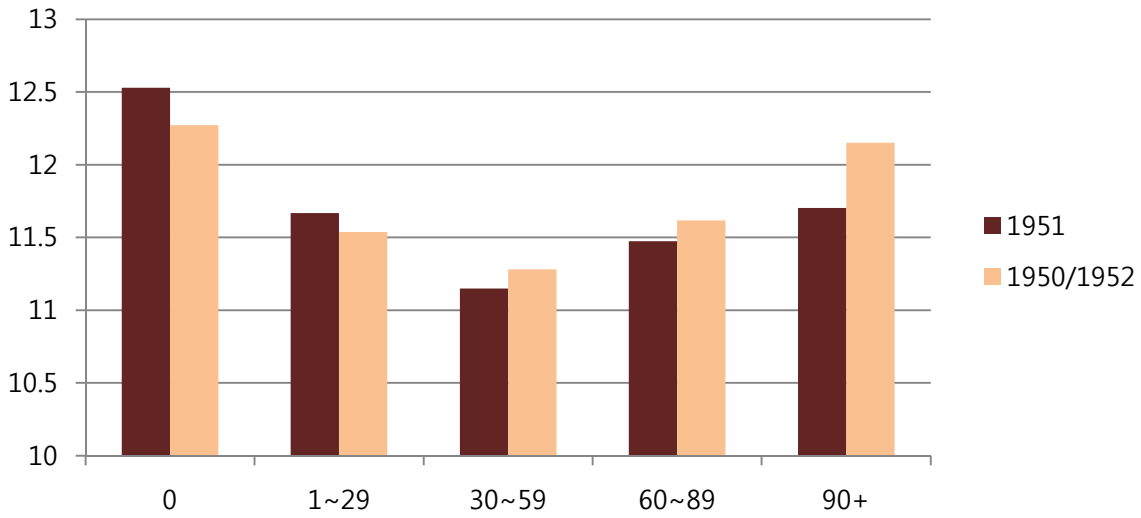


Figure 9
% Manual Laborers among Employed Males by Distance from Busan

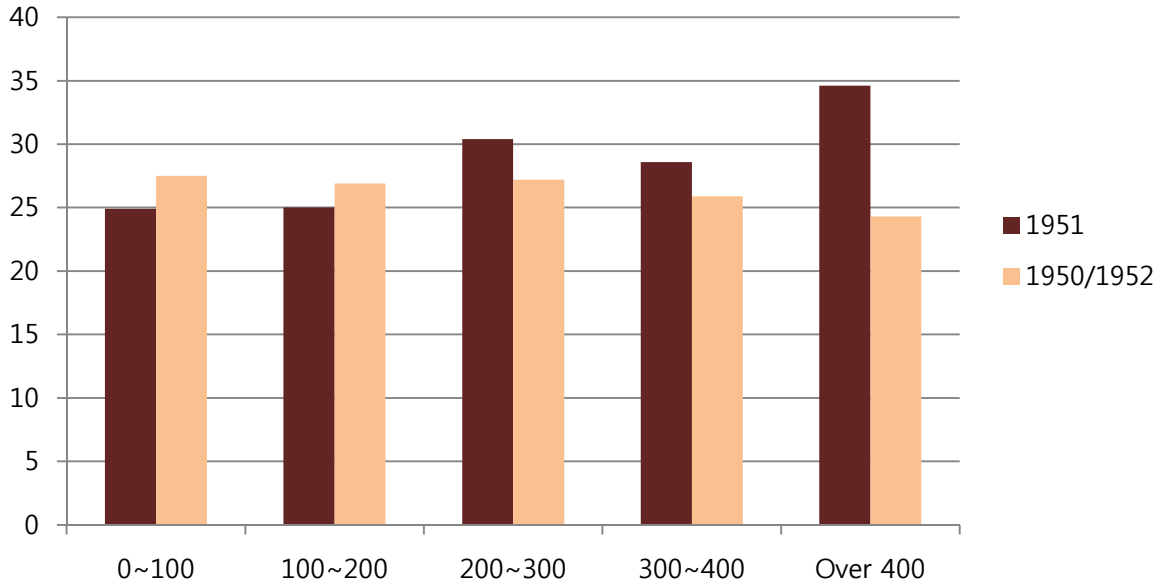


Figure 10
% Manual Laborers among Employed Males by Duration of Occupation

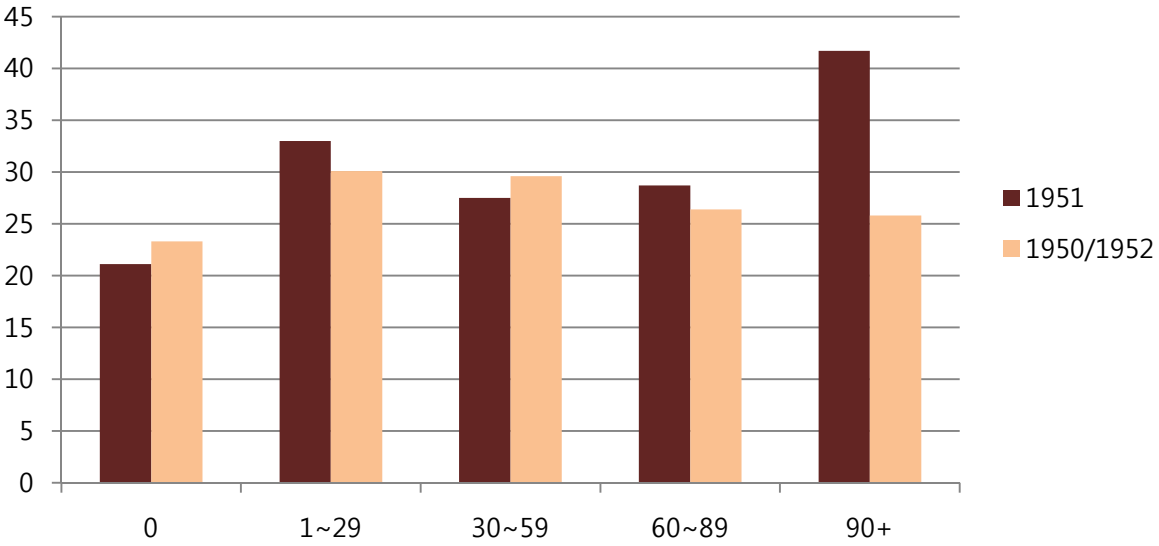


Figure 11-A
% Males with Disability in 2005 by Birth Cohort

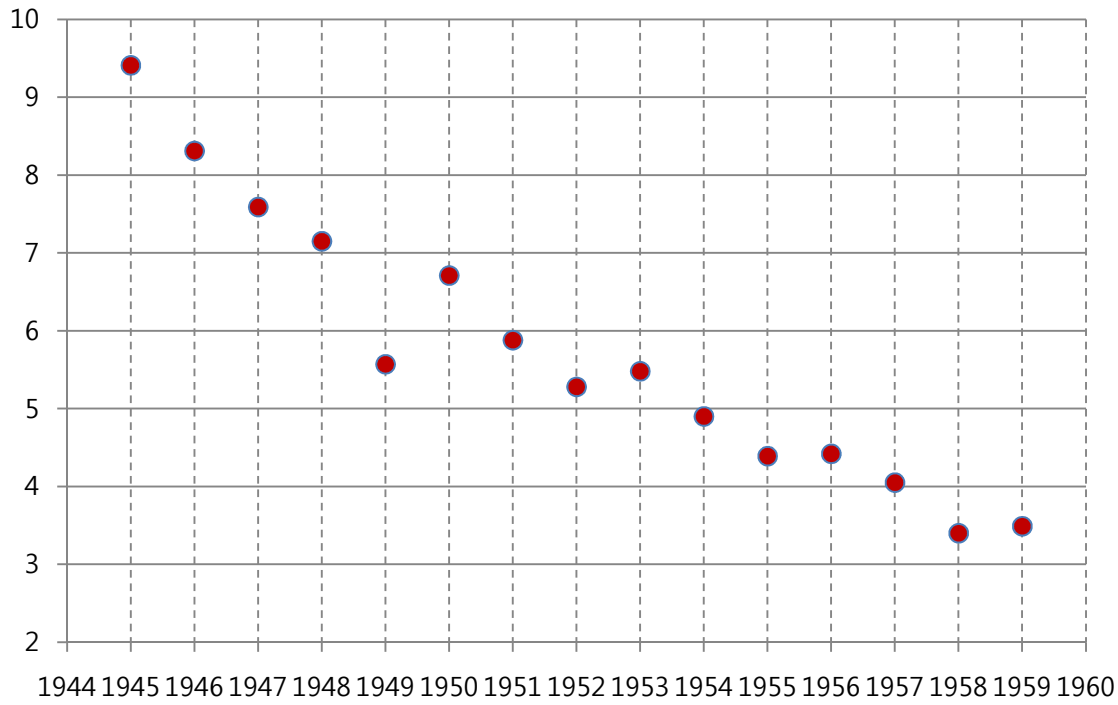


Figure 11-B
% Females with Disability in 2005 by Birth Cohort

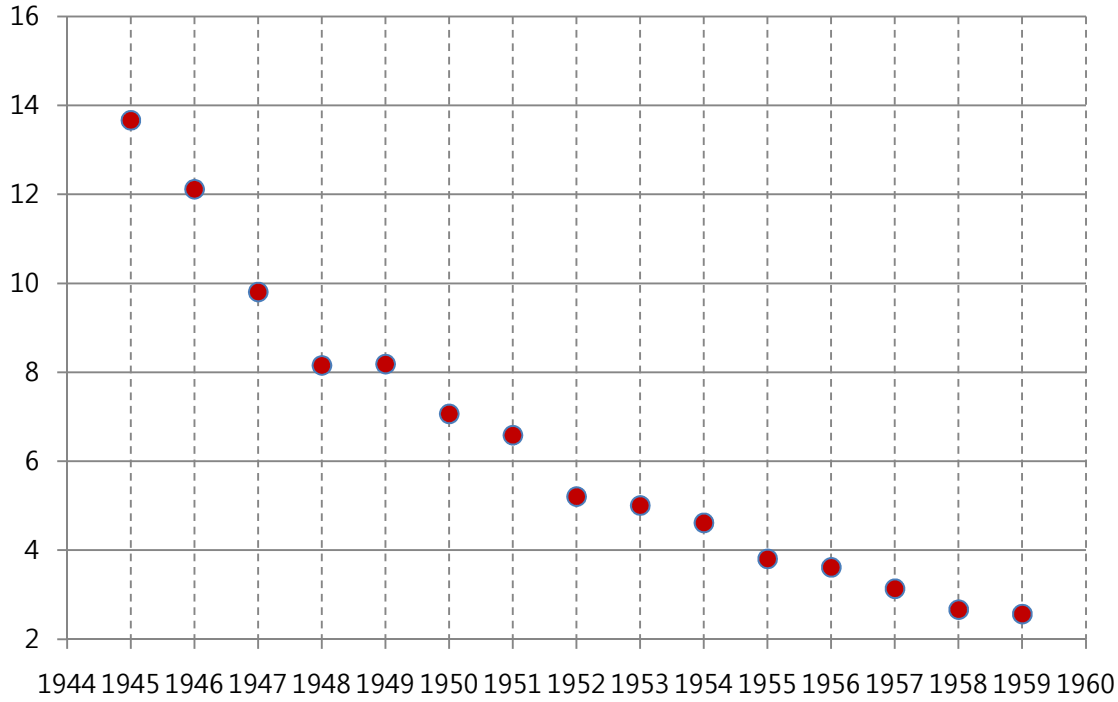


Figure 12-A
% Males with Limited Activity in 2005 by Birth Cohort

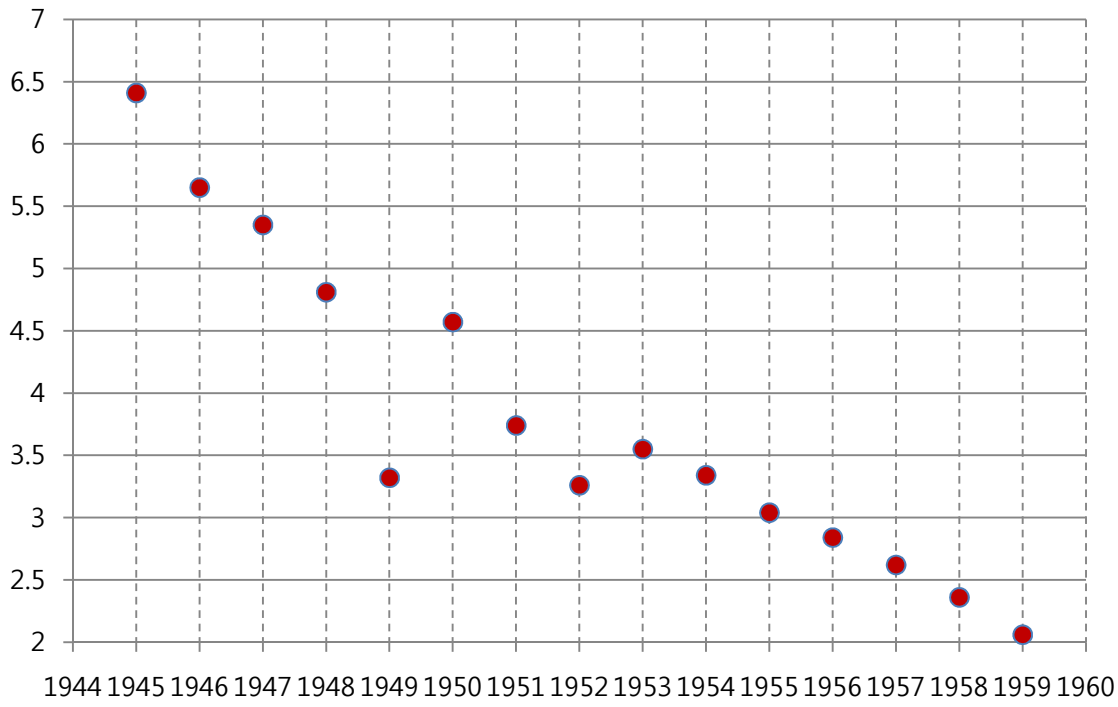


Figure 12-B
% Females with Limited Activity in 2005 by Birth Cohort

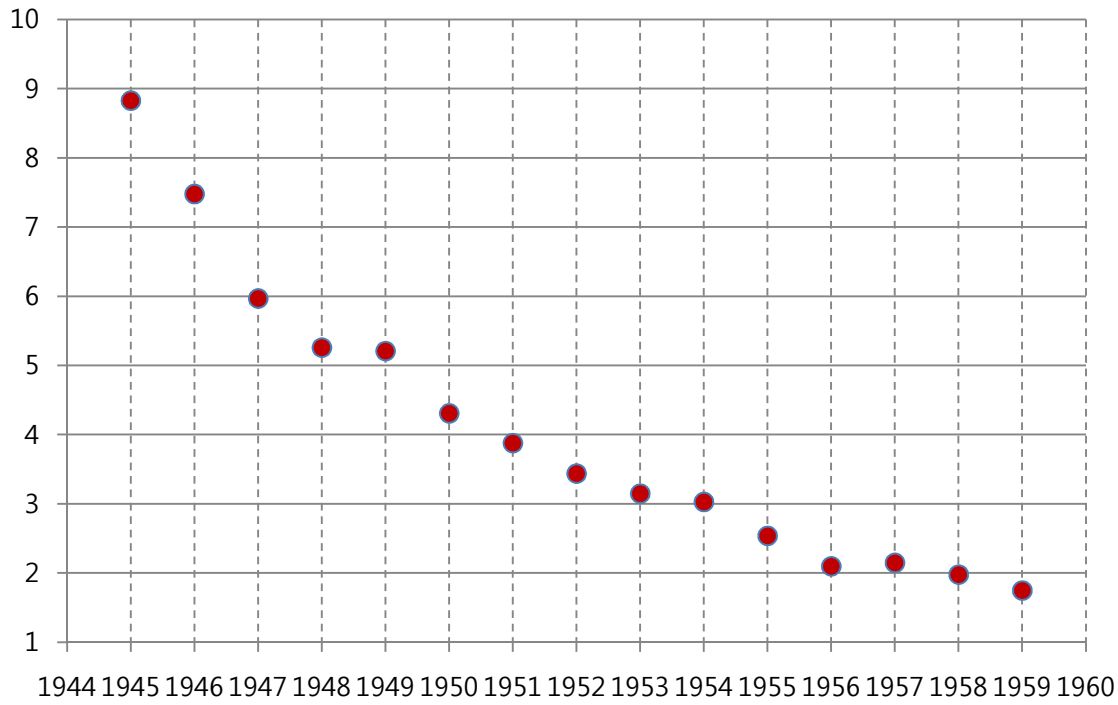


Figure 13-A
Male Self-Reported Health in 2006

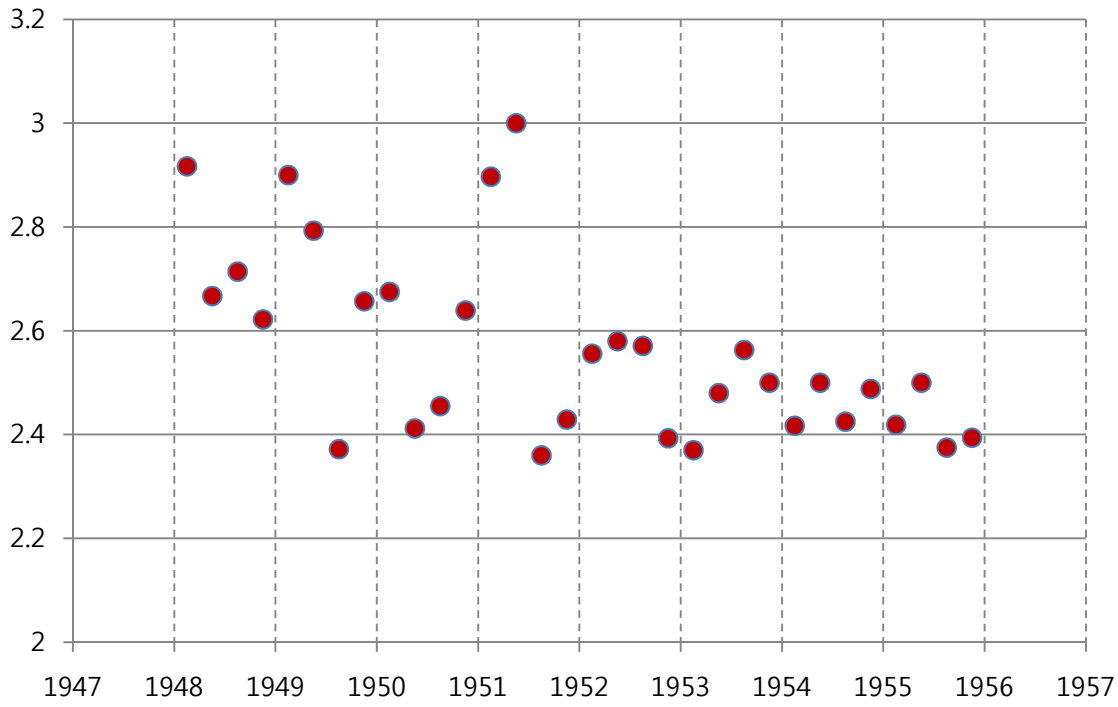


Figure 13-B
Female Self-Reported Health in 2006

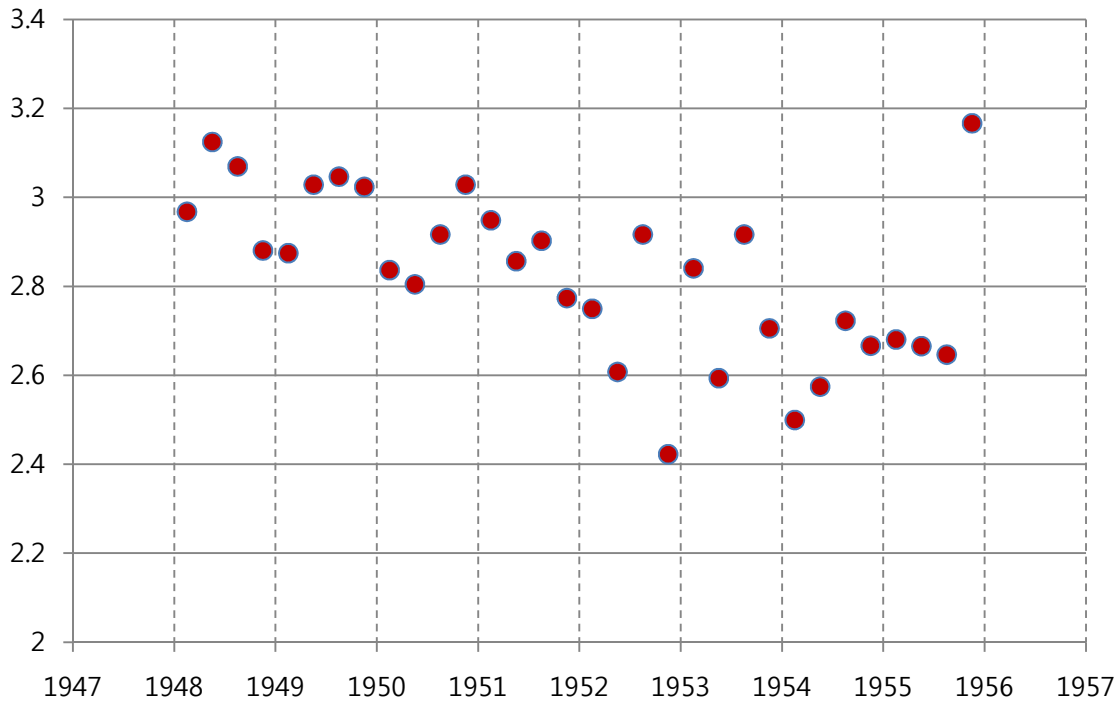


Figure 14-A
% Males with Disability in 2006

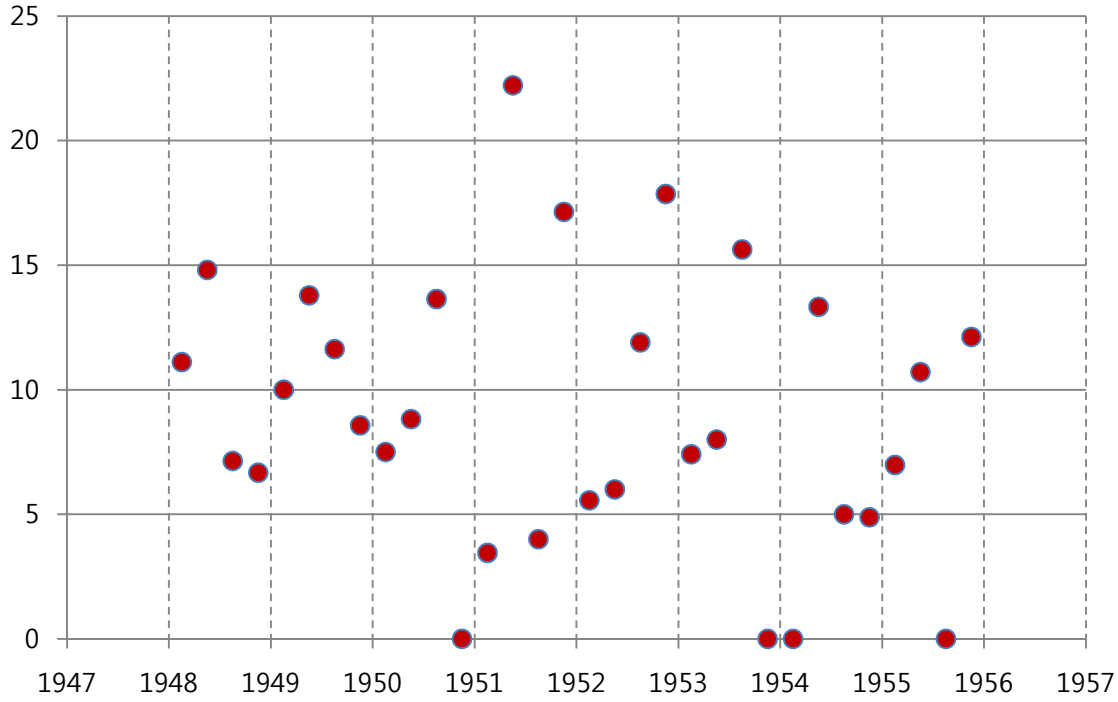


Figure 14-B
% Females with Disability in 2006

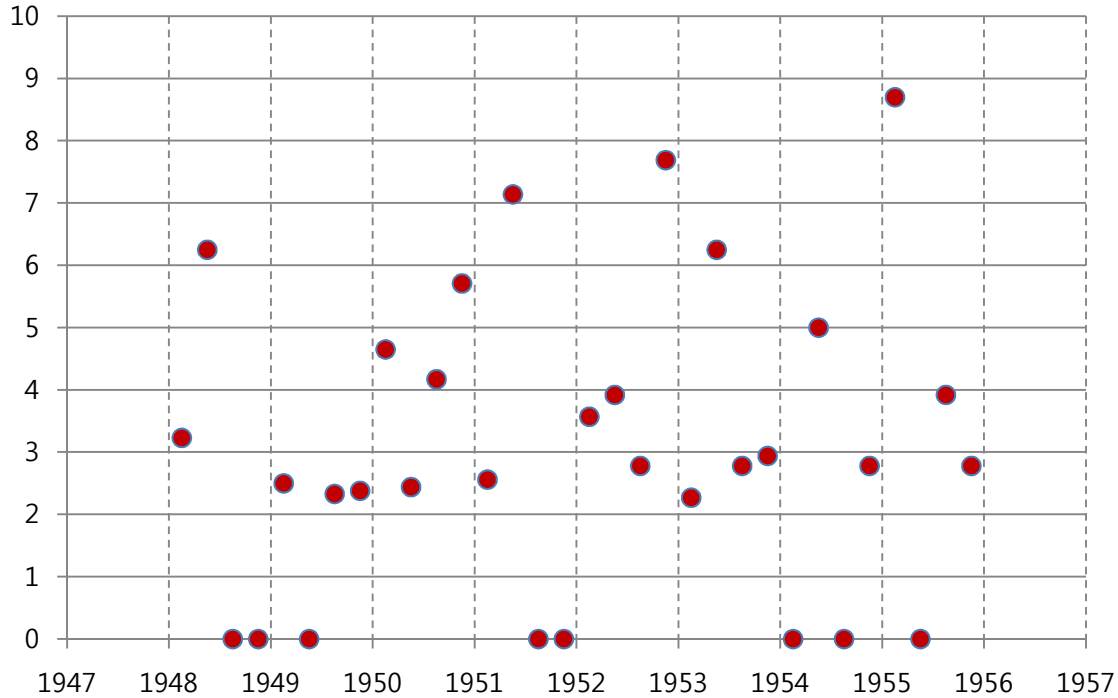


Figure 15
Parents' Years of Schooling by Children's Year of Birth

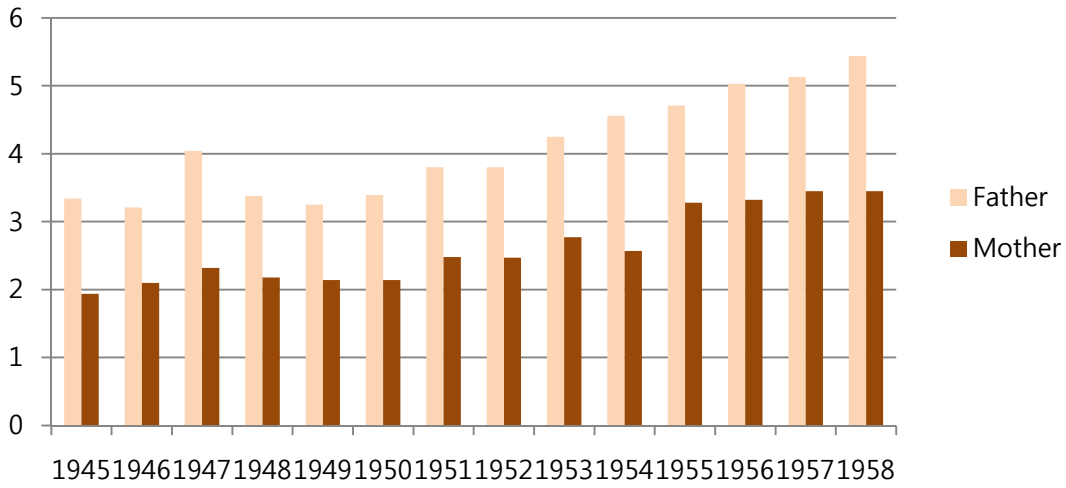


Figure 16-A
Population by Sex and Year of Birth (1960)

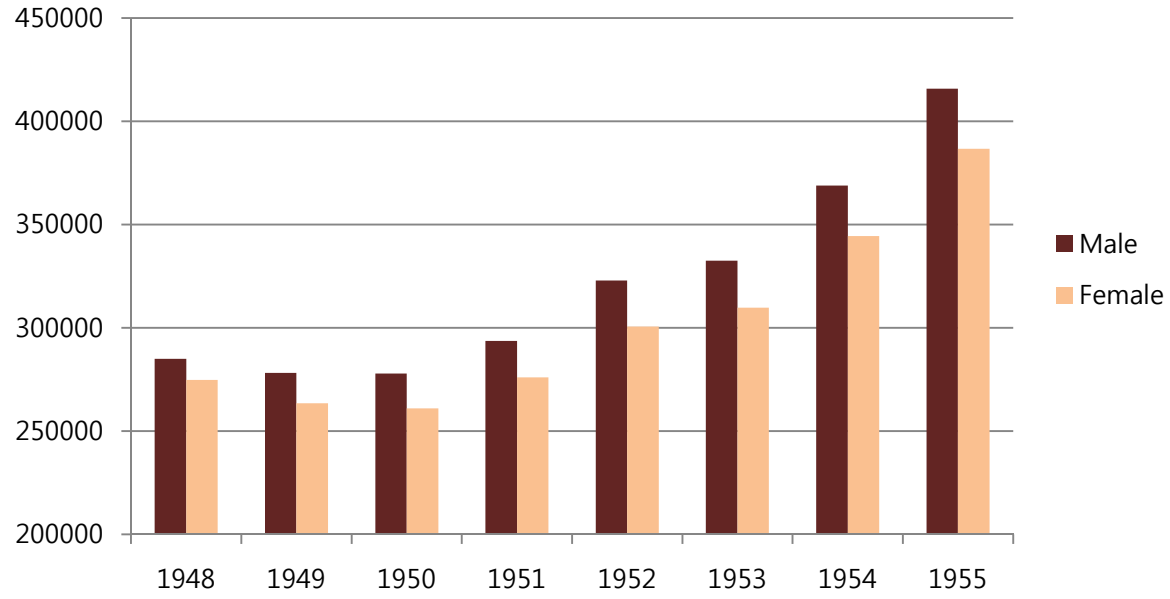
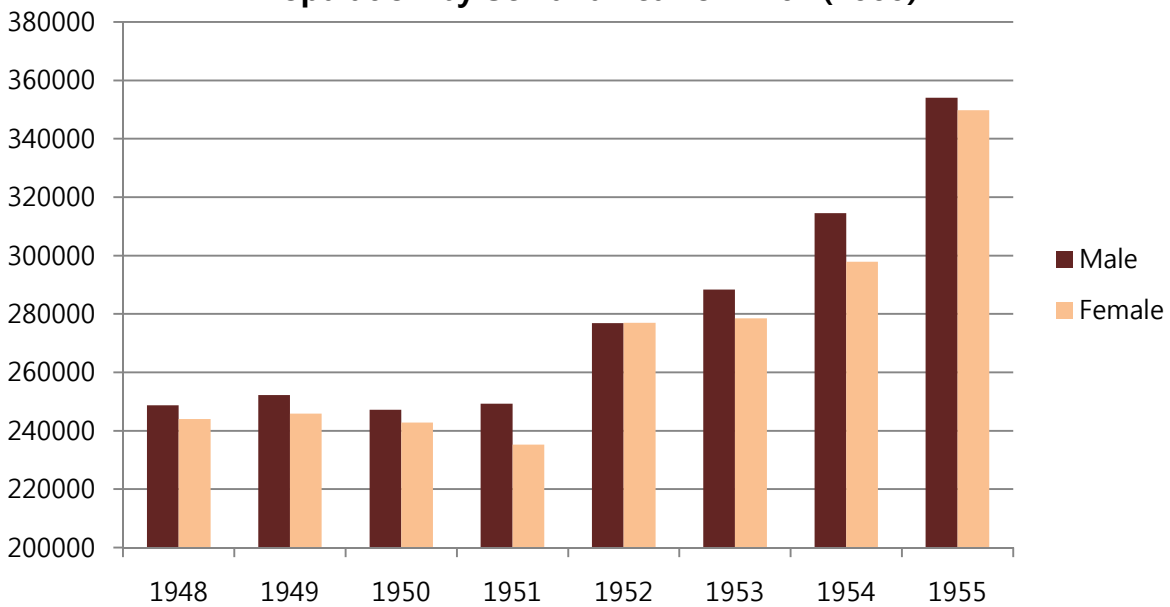
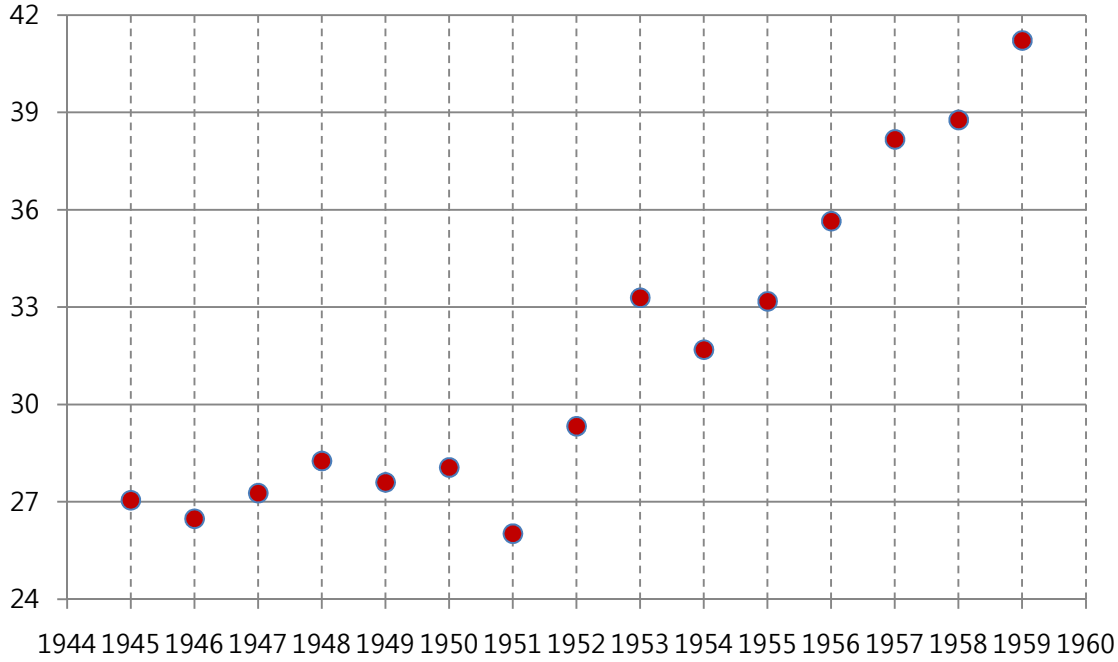


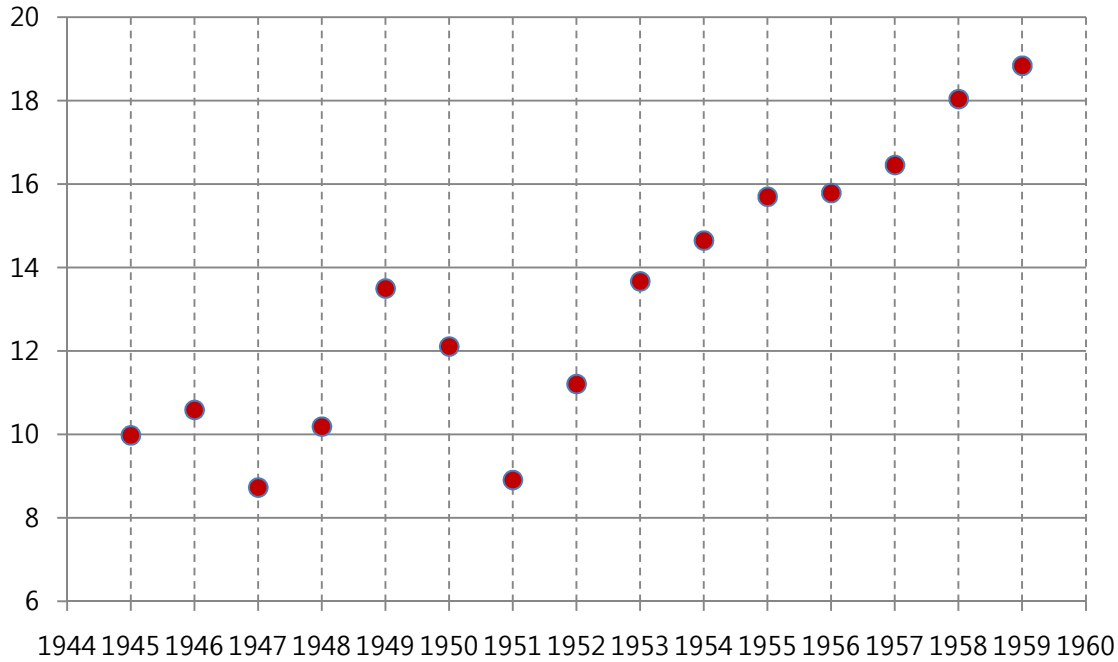
Figure 16-B
Population by Sex and Year of Birth (2000)



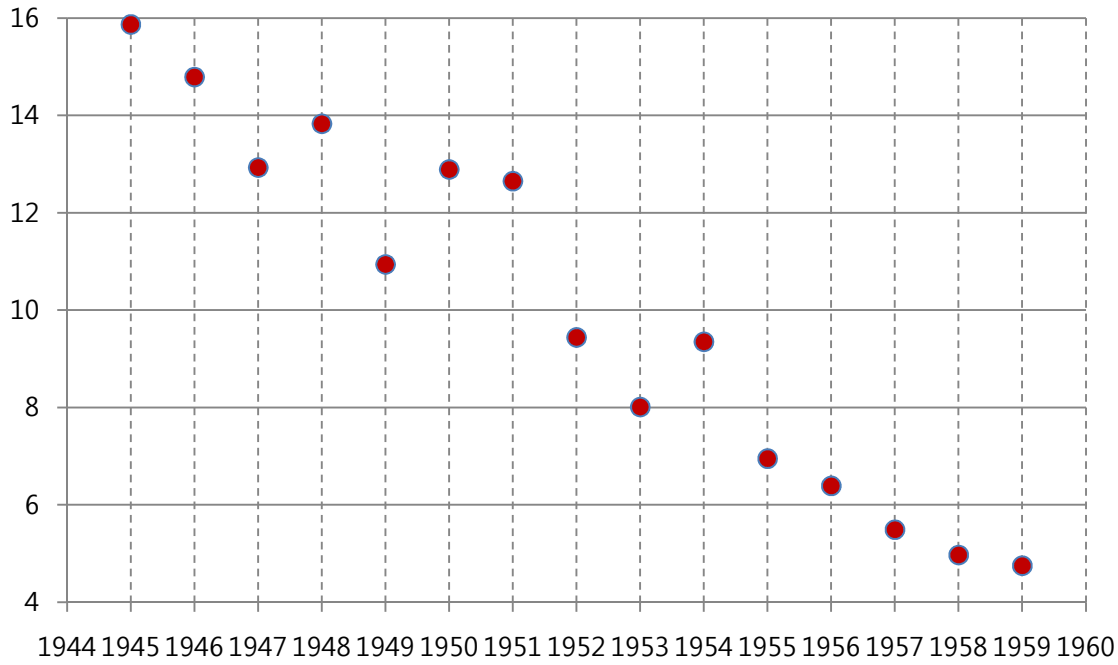
Appendix Figure 1-A
% Males College or Higher in 2000 by Birth Cohort:
Born in the Central Region



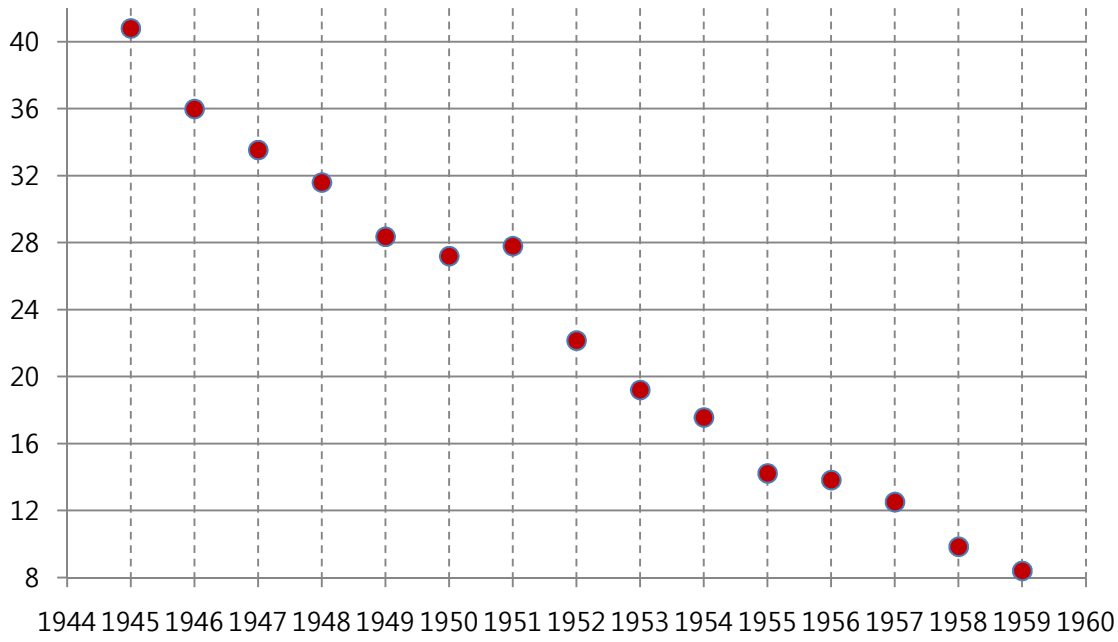
Appendix Figure 1-B
% Females College or Higher in 2000 by Birth Cohort:
Born in the Central Region



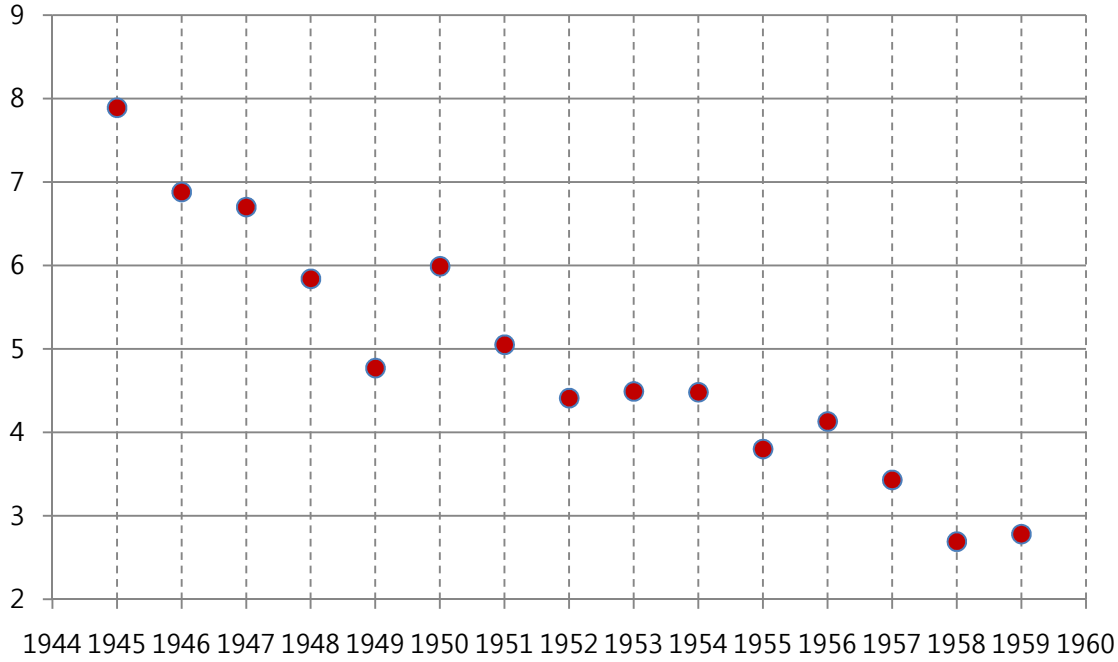
Appendix Figure 2-A
% Males Primary School or Less in 2000 by Birth Cohort: Born in the Central Region



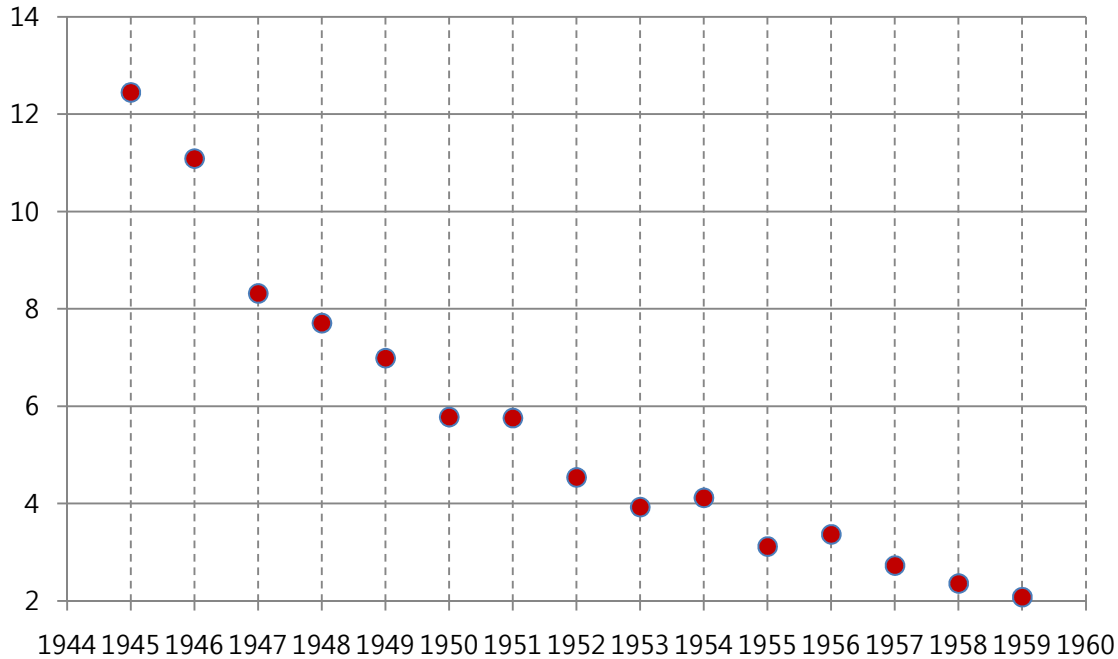
Appendix Figure 2-B
% Females Primary School or Less in 2000 by Birth Cohort: Born in the Central Region



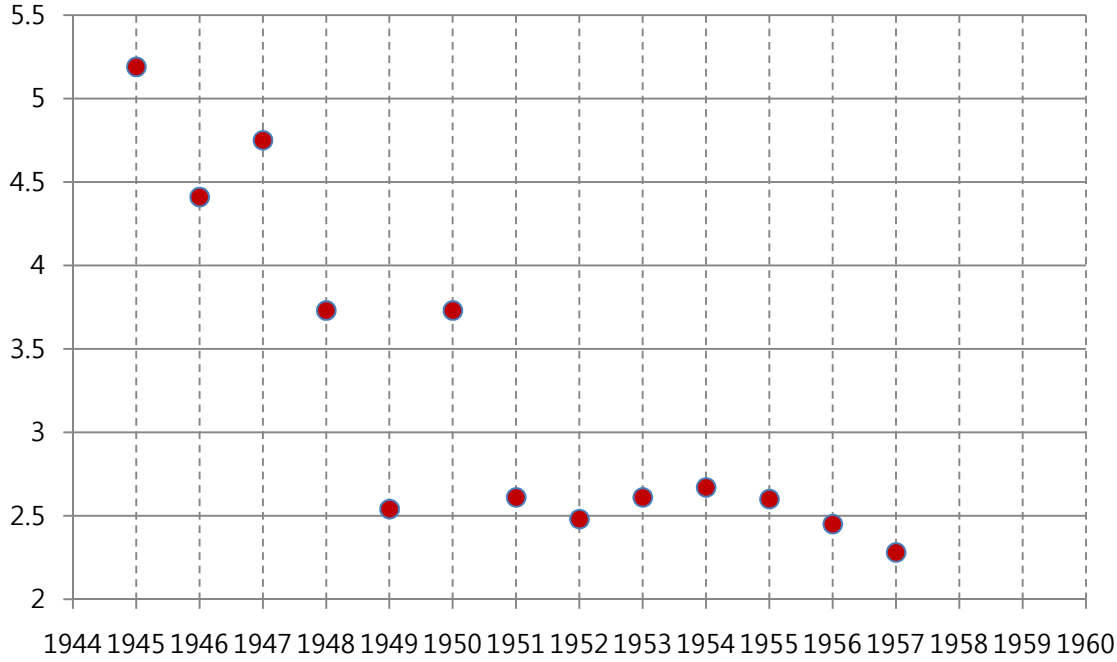
Appendix Figure 3-A
% Males with Disability in 2005 by Birth Cohort:
Residing in the Central Region



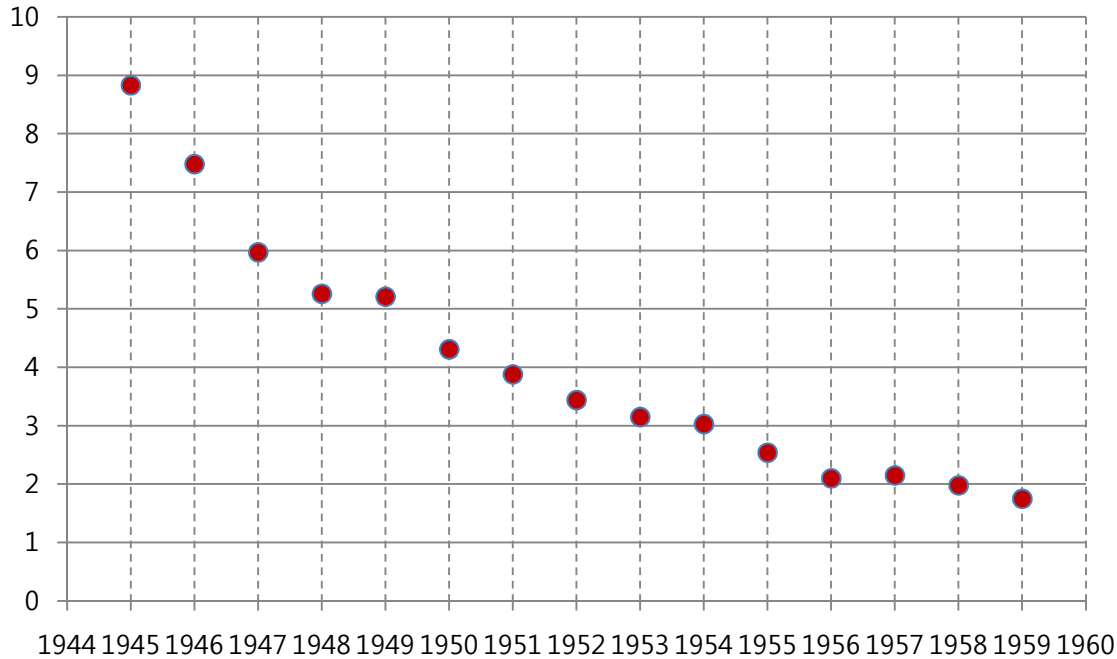
Apendix 3-B
% Females with Disability in 2005 by Birth Cohort:
Residing in the Central Region



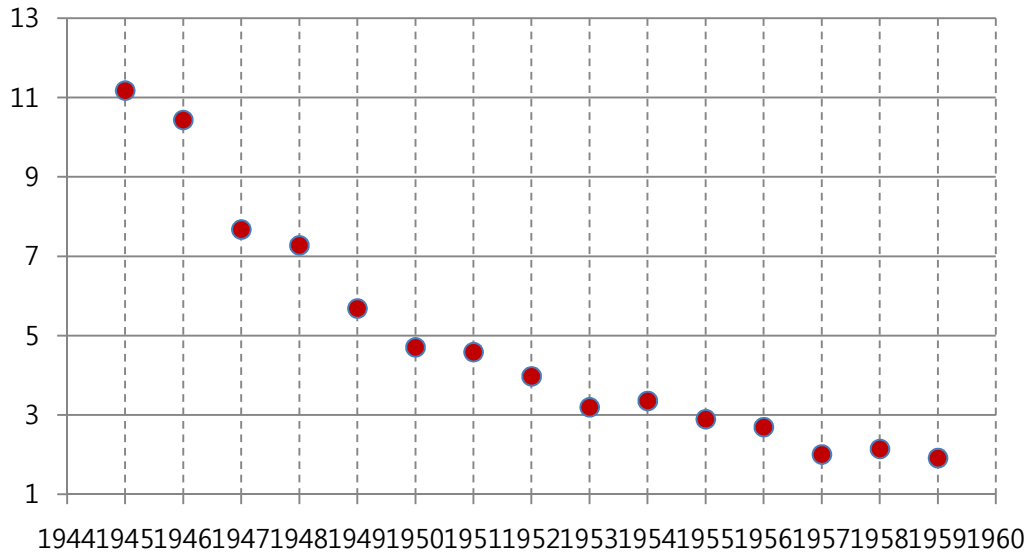
Appendix Figure 4-A
% Males with Limited Activity in 2005 by Birth Cohort:
Residing in the Central Region



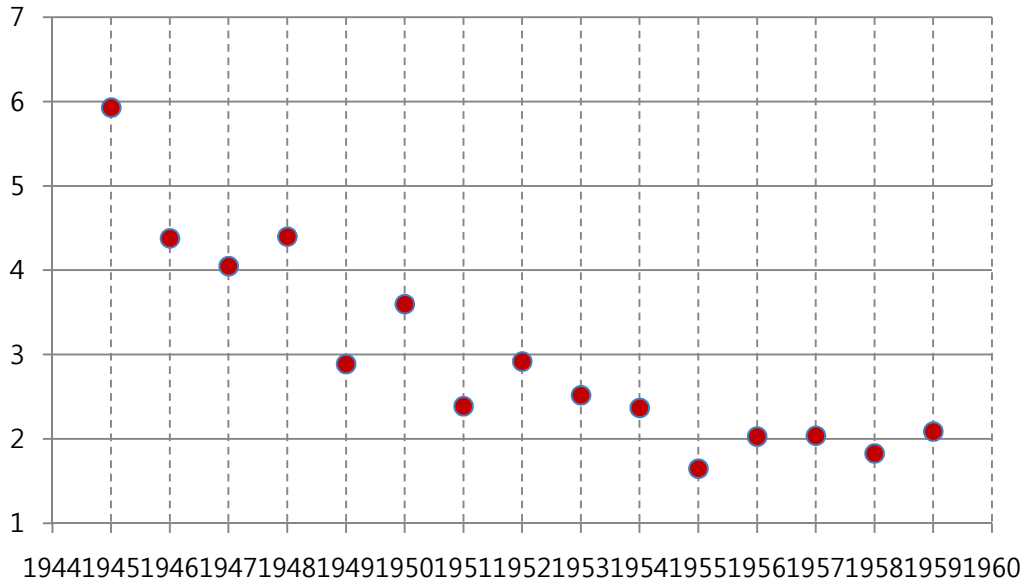
Appendix Figure 4-B
% Females with Limited Activity in 2005 by Birth Cohort:
Residing in the Central Region



Appendix Figure 5-A
% Married Women with Disability/Limited Activity in 2005 by Own Birth Year (Central Region)



Appendix Figure 5-B
% Married Women with Disability/Limited Activity in 2005 by Husband's Birth Year (Central Region)



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