Changes of Proportion Never Married and Expectation of Single Life for Chinese Women: Based on Nuptiality Tables

1.Weiyi Tan
School of Public Policy and Administration, Xi'an Jiaotong University, Shaanxi Province, 710049, China
Email: tannweiyi@163.com
Tel: 0086-18874866342

2.Quanbao Jiang*
Institute for Population and Development Studies, Xi'an Jiaotong University, Shaanxi Province, 710049, China
Email: recluse_jqb@126.com
Tel: 0086-15289348290

Corresponding Author

Quanbao Jiang
Email: recluse_jqb@126.com

Abstract

There is a general trend of delay in marriage timing among Chinese women, with significant differences observed between urban and rural areas, as well as across educational levels. Using data from the 2017 China Fertility Survey and IPUMS2000, we construct nuptiality tables across cohorts to analyze the trends in marriage entry timing. We then assess how changes in first marriage conditional probabilities have impacted the proportion of women never married and the expectation of single life. Further, we decompose the differences in these measures among recent cohorts into age-specific differences between population in early birth cohorts and differences within population over cohorts, focusing on variation between urban and rural areas and educational levels. Our findings indicate a rising trend in the proportion of women never married at corresponding ages and an increased expectation of single life at age 15 across cohorts. The rise in the proportion never married and the expectation of single life is primarily attributed to changes in first marriage conditional probabilities among younger age group (20~25 years). Additionally, differences in conditional probabilities between urban and rural areas, as well as between educational levels within the younger age group (18~26 years), largely explain the disparities in the proportion never married and the expectation of single life in later cohorts between populations. Contour Decomposition results suggest that differences in first marriage conditional probability between urban and rural areas, and across educational levels in early cohorts, have significantly influenced the lifelong proportion never married and the expectation of single life at age 15 in later cohorts. Specifically, women in rural areas or with a high school education or below in age group 15~25 in early cohorts had higher first marriage conditional probabilities, experienced greater decline over cohorts, and ultimately achieved higher probabilities in later cohorts compared to women in urban areas or with a college education or above. In contrast, women in age group 26~30 exhibit opposite trends.

Keywords

Proportion never married, Expectation of single life, Contour Decomposition, Marriage delay

1 Introduction

The delay of first marriage has become increasingly pronounced among Chinese women in recent decades. In 1990, the mean age at first marriage for women in China was 22.15, rising to 24.00 by 2010 and 27.95 by 2020 (The Office of the Leading Group for the 7th National Population Census of the State Council in China, 2022). This trend of later marriages is evident across cohorts, as seen in the increase of age at the peak of the curve of first marriage frequency curve and the rightward shift in the curve of cumulative proportion of ever married women (Yu and Xie, 2015; Jiang and Dan, 2020; Wang and Zhao, 2021). Moreover, the pattern of marriage delay among Chinese women varies by urban and rural areas and educational levels. Urban women tend to marry later, as indicated by an older age at the peak of the first marriage probability curve (Guo, 2021) and a higher Singulate Mean Age at Marriage (SMAM) compared to their rural counterparts (He and Tan, 2021), with the widening of urban and rural gap over time. Additionally, statistical regression models show that the risk of first marriage in rural areas is significantly higher than in urban areas (Yu and Xie, 2015). Higher education has been identified as a positive determinant of age at first marriage (Hernes, 1972; Raymo, 2003), with its influence varying by birth cohorts (Yang and Li, 2018), urban and rural areas (Wang and Wu, 2013) and the degree of modernization (Ji, 2015).

The impact of marriage postponement on the proportion of women who remains unmarried by the end of their reproductive span has attracted considerable attention. Studies in western Europe have documented a statistical association between spinsterhood and the timing of first marriage (Watkins, 1984). Likewise, significant connections have been found between first marriage patterns and the proportion never married (PNM) in Asian countries (Smith, 1980; Retherford et al., 2001; Yoo, 2016). In China, the proportion of women never married by age 50 remained relatively low until recently. The share of never-married women at age 50 was 0.17% in 1990 and 0.97% in 2020 (The Office of the Leading Group for the 7th National Population Census of the State Council in China, 2022). However, as women born in the 1990s and 2000s reach the marriage and childbearing age, the proportion of lifelong never married women in these groups is expected to rise sharply (Feng, 2019).

The expectation of single life (ESL) is a core function in nuptiality tables, representing the average number of years of single life remaining. The effect of marriage delay on expectation of single life is reflected in changes over time (or cohorts) and ages. The expectation of single life curve typically falls sharply at the beginning and then rises steadily with age. An upward trend in expectation of single life at age 15 has been observed for Chinese women in 1982, 1990, 2000 and 2010, with the age at the bottom of the curve increasing over time (or cohorts) (Wei et al., 2014; Dan and Jiang, 2020).

Differences in first marriage conditional probabilities (FMCP) at younger ages significantly impact the proportion never married and expectation of single life. Studies on mortality have concluded that the mortality gap among children in 0~5 years is a major contributor to differences in life expectancy (GBD 2017 Mortality Collaborators, 2018; Choi et al., 2023). Similarly, in fertility, scholars found that increases in the age-specific conditional probabilities of not giving birth at early reproductive age raise the proportion of childlessness (Wang et al., 2024). Moreover, when differences in aggregated demographic measures between populations are decomposed, they are divided into differences at the initial time point (or cohort) and uneven temporal changes between the initial and final time points (or cohort) (Jdanov et al., 2024), as confirmed by studies on life expectancy in Germany (van Raalte et al., 2020). Clearly, the differences in proportion never married and expectation of single life between urban and rural areas and across educational levels depend on both the initial difference and the changes over time.

The delay in marriage has led to significant changes in the proportion never married and expectation of single life. However, due to limited data availability, few studies have focused on cohort-based changes in these measures and the analysis of age-specific contributors. In this study, we use nationally representative data from the 2017 China Fertility Survey and Integrated Public Use Microdata Series (IPUMS) from 2000. The study consists of three parts. First, we calculate proportion never married and expectation of single life for several cohorts by constructing nuptiality tables, to analyze the trends in the timing of marriage entry and differences across urban and rural areas and educational levels. Second, we develop formulas based on Stepwise Replacement to analyze the effect of changes in first marriage conditional probabilities on changes in proportion never married and expectation of single life. Third, we design formulas based on Contour Decomposition to decompose the differences in proportion never married and expectation of single life between urban and rural areas and educational levels in later birth cohorts into age-specific differences in first marriage conditional probabilities between populations in early birth cohorts and within-population probability changes over cohorts. Throughout the study, ‘first marriage conditional probability’ as FMCP, ‘proportion never married’ as PNM and ‘expectation of single life’ as ESL are used as abbreviations.

2 Data and Methods

2.1 Data

The data used in this study were collected from 2017 China Fertility Survey and Integrated Public Use Microdata Series (IPUMS) 2000 in China. The 2017 China Fertility Survey targeted the female population aged 15 to 60 (born between 1956 and 2002) residing in 31 provinces in mainland China, surveyed on July 1, 2017, with a sample size of 249,496. This survey provides robust evidence supporting research on marital status and the timing of first marriage, with data exhibiting a high degree of accuracy (Zhuang et al., 2019). We excluded samples where the age at first marriage is below 15 and those missing the year of first marriage or cohabitation (n=474, 0.19%). The status of ‘cohabitation’ was included under the status of ‘first marriage’, resulting in a final sample size of 249,472. A weighting process is applied in accordance with the sampling design. IPUMS is the world's largest collection of census microdata covering over 100 countries and providing both contemporary and historical data. The IPUMS 2000 dataset includes 5,759,928 valid female samples from China.

Data for the 1952 birth cohort come from IPUMS 2000, while data for the 1957, 1962, 1967, 1972, 1977 birth cohort are sourced from 2017 China Fertility Survey.

2.2 Methods

2.2.1 The construction of gross nuptiality tables

(1) Age-specific first marriage conditional probability

Constructing a gross nuptiality table begins with obtaining age-specific FMCP (q_i). The FMCP refers to the probability of a person entering their first marriage during an age interval $[i, i+1)$ under the condition that they have not entered their first marriage by exact age i. The equation for q_i is given by:

$$q_i = \frac{FM_i}{TP - \sum_{x=15}^{i-1} FM_x} \tag{1}$$

Where FM_i is the number of first marriages in the cohort at age i (i.e., during the age interval $[i, i+1)$), TP is the total number of persons in the cohort, and $\sum_{x=15}^{i-1} FM_x$ refers to the cumulative number of first marriage by exact age i.

A nuptiality table is then constructed based on age-specific FMCP, from which age-specific PNM and ESL can be calculated accordingly.

(2) Age-specific proportion never married and expectation of single life

Age-specific PNM (P_i) refers to the proportion of persons remaining single by the exact age i, and age-specific ESL (E_i) refers to the average number of years of single life remaining to persons single at the exact age i. According to the nuptiality tables constructed, the equations for P_i and E_i are given by:

$$P_i = \frac{l_i}{l_{15}} \tag{2}$$

$$E_i = \frac{T_i}{l_i} \tag{3}$$

Where l_i is the number of people remaining single by the exact age i and T_i is the number of person-years single at exact age i and all later ages in the nuptiality table.

2.2.2 Decomposition of differences in proportion never married between cohorts

Let $\mathbf{n}^1$ refers to the vector of q_i for cohort 1 from age 15 to $\omega-1$, and the equation for $\mathbf{n}^1$ is given by:

$$\mathbf{n}^1 = \left(q_{15}^1, \ldots, q_i^1, \ldots, q_{\omega-1}^1\right) \tag{4}$$

The PNM by exact age ω (P_ω) in cohort 1 can be expressed as $P_\omega(\mathbf{n}^1) = \prod_{i=15}^{\omega-1}(1-q_i)$.

Based on Stepwise Replacement (Andreev et al., 2002), we denote $\mathbf{n}_{[i]}^{21}$ as the vector of q_i in cohort 1 after replacement of elements from age 15 to i by corresponding q_i from cohort 2, where

$$\mathbf{n}_{[i]}^{21} = \left(q_{15}^2, \ldots, q_i^2, q_{i+1}^1, \ldots, q_{\omega-1}^1\right) \tag{5}$$

The difference $\delta_{15|x}^{2-1}$ represents the contribution of changes of q_i from ages 15 to x to the overall difference $P_\omega(\mathbf{n}^2) - P_\omega(\mathbf{n}^1)$. Therefore, the contribution of q_i for the age interval $\left[i, i+1\right)$ can be expressed as the component δ_x^{2-1}, where

$$\delta_x^{2-1} = \delta_{15|x}^{2-1} - \delta_{15|x-1}^{2-1} = \prod_{15}^{x-1}(1-q_i^2)\times[(1-q_x^2)-(1-q_x^1)]\times\prod_{x+1}^{\omega-1}(1-q_i^1) \tag{6}$$

The overall difference of PNM by exact age ω between the two cohorts is $P_\omega(\mathbf{n}^2) - P_\omega(\mathbf{n}^1) = \sum_{x=15}^{\omega-1}\delta_x^{2-1}$.

The result of the replacement by q_i from cohort 1 is different from that from cohort 2, and there is no preference for either. In order to eliminate the difference from directions, the final age-specific components are calculated as an average:

$$\delta_x = \frac{1}{2}\times(\delta_x^{2-1} - \delta_x^{1-2}) \tag{7}$$

2.2.3 Decomposition of differences in expectation of single life between cohorts

Based on Stepwise Replacement, we denote $\mathbf{m}^1$ as the vector of q_i of cohort 1 from age 15 to ω, and the equation for $\mathbf{m}^1$ is given by:

$$\mathbf{m}^1 = \left(q_{15}^1, \ldots, q_i^1, \ldots, q_\omega^1\right) \tag{8}$$

In a similar way, we denote $\mathbf{m}_{[i]}^{21}$ as the vector of q_i in cohort 1 after replacement of elements from age 15 to i by corresponding q_i from cohort 2:

$$\mathbf{m}_{[i]}^{21} = \left(q_{15}^2, \ldots, q_i^2, q_{i+1}^1, \ldots, q_\omega^1\right) \tag{9}$$

The difference $\Delta_{15|x}^{2-1}$ represents the contribution of changes of q_i from ages 15 to x to the overall difference $E_\omega(\mathbf{m}^2) - E_\omega(\mathbf{m}^1)$. Therefore, the contribution of q_i of age interval $\left[i, i+1\right)$ can be expressed as component Δ_x^{2-1}:

$$\Delta_x^{2-1} = \Delta_{15|x}^{2-1} - \Delta_{15|x-1}^{2-1} = l_x^2(E_x^2 - E_x^1) - l_{x+1}^2(E_{x+1}^2 - E_{x+1}^1) \tag{10}$$

Where l_x and E_x can be found in nuptiality tables.

The overall difference of ESL at age ω between two cohorts is $E_\omega(\mathbf{m}^2) - E_\omega(\mathbf{m}^1) = \sum_{x=15}^{\omega}\Delta_x^{2-1}$.

In order to eliminate the difference from directions, the final age-specific components are calculated as an average.

2.2.4 Decomposition of differences into between-population and within-population components between cohorts

Based on Contour Decomposition (Jdanov et al., 2017), we decompose the between-population differences of PNM and ESL in later cohort into two components: the difference in initial age-specific FMCP between populations in early cohort, and the changes in age-specific FMCP within populations between the two cohorts. These two parts jointly contribute to the between-population differences of PNM by maximum age ω and ESL at age 15 in later cohorts.

For example, in the decomposition of differences in ESL, let a/A and b/B represents two populations when a/b refer to populations in early cohort and A/B refer to populations in later cohort. $E_\omega(\mathbf{m}^{\mathrm{B}})$ refers to ESL of population B where $\mathbf{m}^{\mathrm{B}} = \left(q_{15}^{\mathrm{B}}, \dots, q_{\mathrm{i}}^{\mathrm{B}}, \dots, q_{\omega}^{\mathrm{B}}\right)$. $E_\omega(\mathbf{m}^{\mathrm{A}})$, $E_\omega(\mathbf{m}^{a})$ and $E_\omega(\mathbf{m}^{\mathrm{b}})$ are defined in a similar way. $\Delta\mathrm{AB}$ refers to the final between-population differences in later cohorts and can be decomposed into age-specific final components (Δ_i^{AB}) which can further be decomposed into age-specific initial components ($Initial_i$) and age-specific trend components ($Trend_i$).

Based on Stepwise Replacement, we denote $\mathbf{m}_{[i]}^{\mathrm{AB}}$, $\mathbf{m}_{[i]}^{\mathrm{A}(a)\mathrm{B}}$ and $\mathbf{m}_{[i]}^{\mathrm{A}(b)\mathrm{B}}$ as follows:

$$\mathbf{m}_{[i]}^{\mathrm{AB}} = (q_{15}^{\mathrm{A}}, \dots, q_{i}^{\mathrm{A}}, q_{i+1}^{\mathrm{B}}, \dots, q_{\omega}^{\mathrm{B}}) \tag{11}$$

$$\mathbf{m}_{[i]}^{\mathrm{A}(a)\mathrm{B}} = (q_{15}^{\mathrm{A}}, \dots, q_{i-1}^{\mathrm{A}}, q_{i}^{a}, q_{i+1}^{\mathrm{B}}, \dots, q_{\omega}^{\mathrm{B}}) \tag{12}$$

$$\mathbf{m}_{[i]}^{\mathrm{A}(b)\mathrm{B}} = (q_{15}^{\mathrm{A}}, \dots, q_{i-1}^{\mathrm{A}}, q_{i}^{b}, q_{i+1}^{\mathrm{B}}, \dots, q_{\omega}^{\mathrm{B}}) \tag{13}$$

Therefore, $E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(b)\mathrm{B}}) - E_\omega(\mathbf{m}_{[i-1]}^{\mathrm{AB}})$ presents the effect of the difference of probabilities between population b and B on the difference of ESL at age 15. Comparably, $E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(a)\mathrm{B}}) - E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(b)\mathrm{B}})$ is the effect of difference between group a and b, and $E_\omega(\mathbf{m}_{[i]}^{\mathrm{AB}}) - E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(a)\mathrm{B}})$ refers to the effect of difference between group a and A.

As a result, the elementary difference between group A and B at age i is given by:

$$\begin{aligned}\Delta_i^{\mathrm{AB}} &= \left[E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(b)\mathrm{B}}) - E_\omega(\mathbf{m}_{[i-1]}^{\mathrm{AB}})\right] \\ &\quad + \left[E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(a)\mathrm{B}}) - E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(b)\mathrm{B}})\right] \\ &\quad + \left[E_\omega(\mathbf{m}_{[i]}^{\mathrm{AB}}) - E_\omega(\mathbf{m}_{[i]}^{\mathrm{A}(a)\mathrm{B}})\right], i = 15, \ldots, \omega\end{aligned} \tag{14}$$

The between-population difference in ESL at age 15 in later cohort can be expressed as:

$$E_\omega(\mathbf{m}^{\mathrm{A}}) - E_\omega(\mathbf{m}^{\mathrm{B}}) = \sum_{i=1}^{\omega}(Initial_i + Trend_i) = \sum_{i=15}^{\omega}\Delta_i^{\mathrm{AB}} \tag{15}$$

In order to eliminate the directional difference, the final age-specific components are determined by averaging the two contour results.

3 Trends of the timing of marriage entry

We calculated the PNM and ESL among six cohorts to analyze trends in the timing of marriage entry for Chinese women[①]. We find a general trend of delay in marriage timing, with significant differences observed between urban and rural areas, as well as across different educational levels.

The age-specific PNM among cohorts is illustrated in Figure 1A. We observe a rightward shift in the PNM curves and a rising trend in PNM at corresponding ages across cohorts. In the 1962 birth cohort, the PNM by age 25 was 13.41%, increasing to 27.48% in the 1977 birth cohort. The PNM by age 50 also rose, from 0.77% in 1962 cohort to 1.20% in the 1977 cohort. In the 1952 and 1957 cohorts, the PNM for ages 20 to 30 was notably higher than in subsequent cohorts, likely influenced by the "Later, Longer, Fewer" family planning program started in 1973. This policy promoted a minimum marriage age of 25 for males and 23 for females, with even older in some urban areas (28 for male and 25 for female). However, in 1980, the legal minimum age at marriage was lowered to 20 for women, leading to an accelerated increase in the timing of first marriage (Coale et al., 1991). Age-specific ESL among cohorts is presented in Figure 1D[②]. ESL at age 15 rises across cohorts, from 7.86 years in the 1962 cohort to 9.39 years in the 1977 cohort. The ESL curves first decline and then rise as age increases.

PNM and ESL by urban and rural areas are shown in Figure 1B and 1E. The PNM of urban women is higher than that of rural women, and the PNM in later cohorts is higher than in earlier cohorts at corresponding ages. Similarly, ESL at age

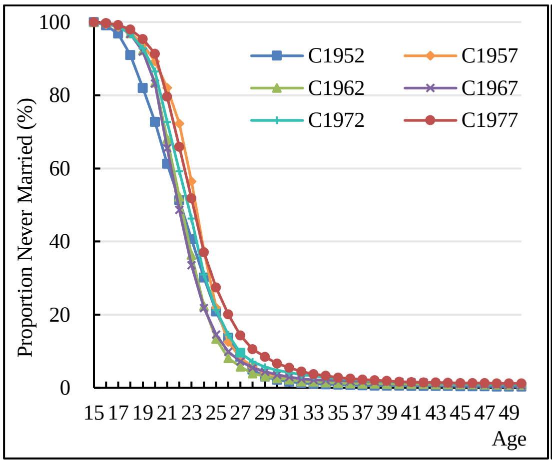
[①] Since the 1952, 1972 and 1977 cohort have not completed their marriageable ages at the time point of the survey, we use the Hernes diffusion model to fit the curves of PNM, forecast the PNM to complete the cohort, and further analyse FMCP and ESL. The outcome of the forecast of FMCP are shown in the Appendix.

[②] Since we cannot get the life expectancy at age 50 among these cohorts, and to minimize the impact of mortality on the measures, we add the life expectancy at age 50 in 2020 into nuptiality tables which is calculated from the national census in China in 2020.

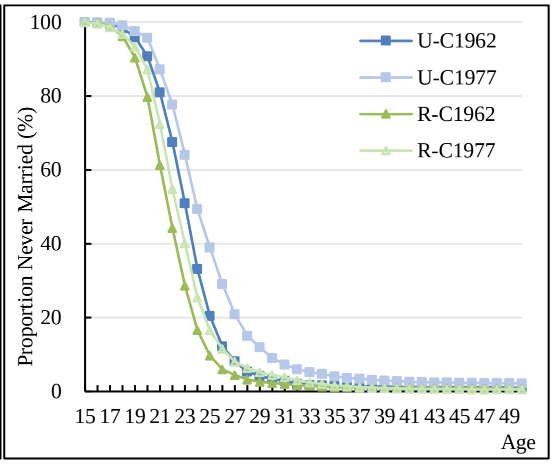
15 is higher for urban women than for their rural counterpart, and ESL at age 15 in later cohort is longer than in earlier cohorts. In the 1962 cohort, the PNM by age 25 was 20.49% for urban women and 9.69% for the rural. By the 1977 cohort, the PNM had risen to 38.97% for urban women and 15.67% for the rural women. The ESL at age 15 in the cohort 1962 is 8.80 years for urban women and 7.37 years for the rural women, while in 1977 cohort, these numbers increased to 10.85 years and 8.12 years respectively.

PNM and ESL by educational levels are depicted in Figure 1C and 1F[③]. The PNM of women with a college education or higher is greater than for those with a high school education or below, and PNM in later cohort is higher than in earlier cohorts at corresponding ages. Similarly, ESL at age 15 for women with a college education or above is longer than those with high school education or below, and the ESL at age 15 in later cohorts is longer than in earlier cohorts. In 1962 cohort, the PNM by age 25 was 12.35% for women with a high school education or below and 37.16% for women with a college education or above. However, in 1977 cohort, the PNM at age 25 is 21.38% for women with a high school education or below and 55.08% for women with a college education or above. The ESL at age 15 in the cohort 1962 is 7.72 years for women with high school education or below and 8.70 years for women with a college education or above, while in the cohort 1977, the numbers rose to 11.17 years and 12.27 years, respectively.

1A PNM



1B PNM by Urban and Rural Areas



③ Studies have shown that college education lays important impact on marriage delay for women (Acar, 2022; Vikram, 2024), hence we make comparison between ‘high school or below’ and ‘college or above’.

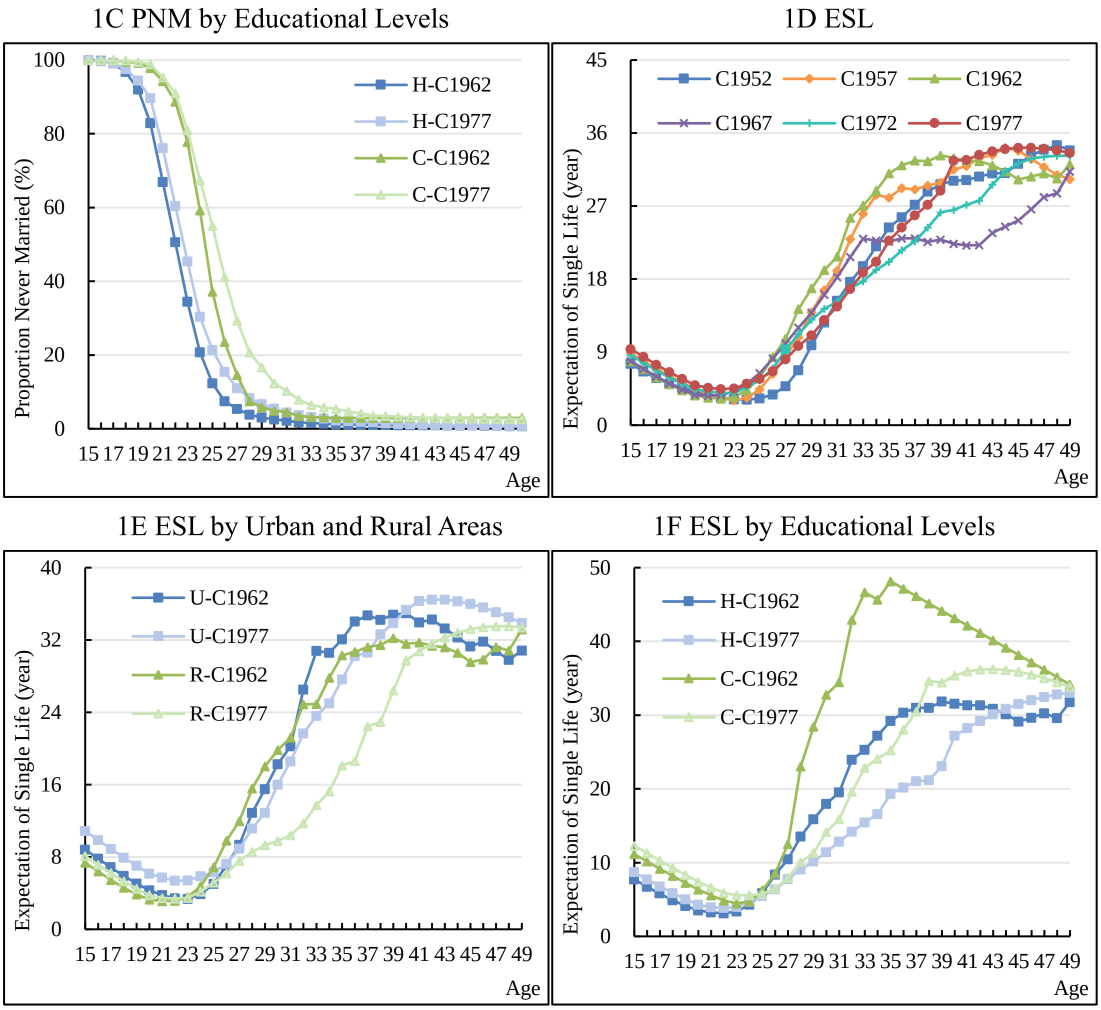


Fig.1 Proportion never married and expectation of single life

Note: U and R represent Urban and Rural areas respectively, H and C represent High school education or below and College education or above.

4 Decomposition of differences between cohorts

4.1 Differences in proportion never married

Figure 2 illustrates the effect of changes in FMCP on changes in PNM across cohorts[④]. In general, the rise of PNM among cohorts is mainly resulted from the changes in FMCP between age 20 to 30. The later the birth cohort, the greater the impact of these changes on PNM. Compared to the 1962 birth cohort, the decline in FMCP between ages 15~28, and the increase in FMCP between ages 29~44 in 1967, 1972 and 1977 cohorts, are the primary contributors to the rise in PNM across cohorts. Specifically, the PNM by age 50 in the 1977 cohort is 0.43 percentage points higher than in the 1966 cohort, where the decrease in FMCP between ages 18~25 accounts for 213.33% of this gap, while the increase in FMCP between ages 26~35 leads to

[④] Since there is no clear tendency of marriage delay in cohort 1952 and 1957, we consider cohort 1962 as the benchmark for every decomposition in this study.

-49.10% contribution of this gap.

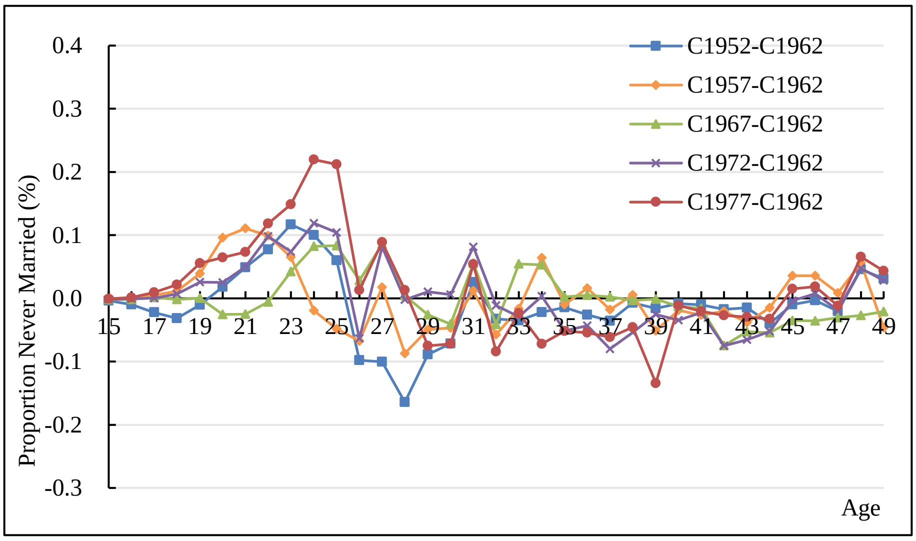


Fig 2. Decomposition of differences of proportion never married between cohorts

4.2 Differences in expectation of single life

Figure 3 presents the effect of changes in FMCP on changes in ESL across cohorts. Generally, the changes in FMCP between ages 17 to 25 are the main drivers of the increase in ESL across cohorts. Similar to the PNM, the later the birth cohort, larger the impact of changes in FMCP is on changes in ESL. Compared to the 1962 birth cohort, the decline in FMCP between ages 17~25 in the 1967, 1972 and 1977 cohorts is the primary factor contributing to the rise of ESL across cohorts. The ESL at age 15 in the 1977 cohort is 1.52 years longer than in the cohort 1966, where the decline in FMCP in age 18~25 accounts for 107.29% of this gap, while the increase in FMCP between ages 28~35 results in -7.71% contribution to this gap.

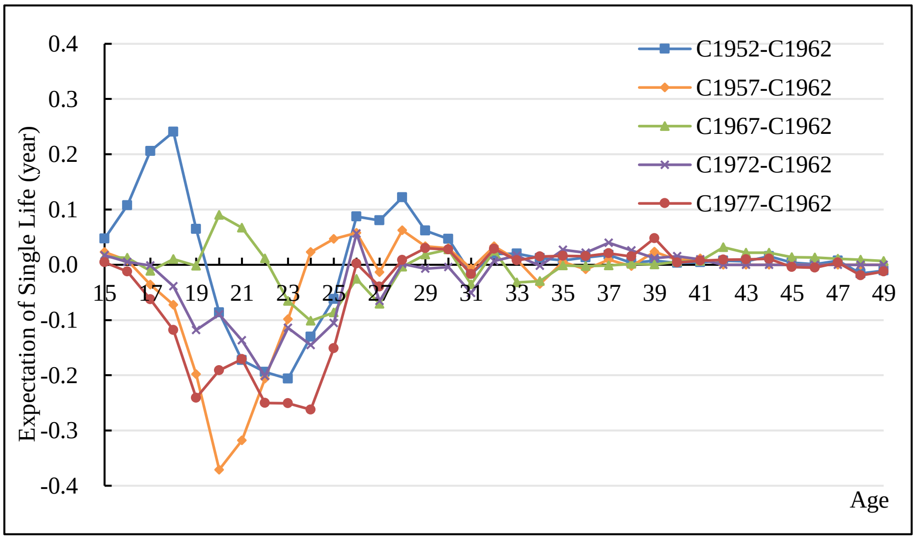


Fig 3. Decomposition of differences of expectation of single life between cohorts

5 Decomposition of differences in proportion never married between populations

Based on Stepwise Replacement, we can decompose the differences in the PNM by age 50 between two populations in later cohorts into initial age-specific FMCP differences in early cohorts and trend age-specific FMCP from early to later cohorts. By combining the initial and trend components together, we obtain the final age-specific FMCP differences in later cohorts. The sum of these age-specific differences in later cohorts will equal the total difference in PNM by age 50 between two populations in later cohorts. Take the decomposition between urban and rural areas as an example, the final component is decomposed into (a) the effect of the initial differences in FMCP in early cohort between urban and rural areas on the PNM differences by age 50, and (b) the effect of the trend differences in FMCP from early to later cohorts between urban and rural areas on the PNM differences by age 50. These two parts are presented as the 'Initial' and 'Trend' column respectively in Figure 4A. The 'Final' column represents the sum of 'Initial' and 'Trend' column. Figure 4B isolates the 'Trend' column from Figure 4A, showing the changes in FMCP for urban and rural women from the early to the later cohorts. Table 1 and 2 present the exact numbers resulting from the contour decomposition in each age group, along with the percentage share of the final difference. In addition, all differences discussed in the text, figure and table are computed as 'Urban minus Rural' and 'College education or above minus High school education or below'.

5.1 Differences between urban and rural areas

The differences in FMCP between urban and rural women aged from 18 to 32 are the main cause of the of PNM difference in the 1977 cohort. Compared to the differences in FMCP changes from the 1962 cohort to the 1977 cohort, the FMCP differences in the 1962 cohort have a greater impact on the urban and rural PNM difference in the 1977 cohort.

From 'Initial' column in Figure 4A, we can see that urban women in the 1960 cohort have lower FMCP than rural women in 17~24 age group, but higher FMCP in 25~32 age group. However, regarding the changes over time, rural women experienced a larger FMCP decline across cohorts between ages 18 to 20 than urban women, yet a smaller decline between ages 23 to 26 compared to their urban counterparts (refer Figure 4A 'Initial' column and Figure 4B). Illustrated by 'Final' column in Figure 4A, we discover that though the greater FMCP decline among rural women across cohorts partially compensates for the initial advantage (higher FMCP among rural women compared to urban women) in the 18~20 age group in the 1962 cohort, rural women in the 1977 cohort still have higher FMCP than urban women in the 18~20 age group. In contrast, for age 25 and 26, urban women experienced a greater FMCP decline across cohorts than rural women, leading to lower FMCP in the 1977 cohort compared to rural women, even though urban women had higher FMCP in the 1966 cohort at age 25~26. Table 1 shows the exact figures for the three columns in each age group and the share of difference of each age group. The PNM by age 50 for urban women in 1977 cohorts is 1.70 percentage points higher than for rural women. From an age-specific perspective, the between-population FMCP differences in the 15~24 age group in the 1977 cohort contributed to 58.17% of the total difference, while differences in the 25~34 age group contributed to 5.40% of the total difference. From a component perspective, 0.43 percentage points of the total difference (1.70 percentage points) are resulted from the between-population FMCP differences in the 1962 cohort, while 1.27 percentage points of the total difference (1.70 percentage points) are attributed to the between-population FMCP differences from the 1962 to the 1977 cohort.

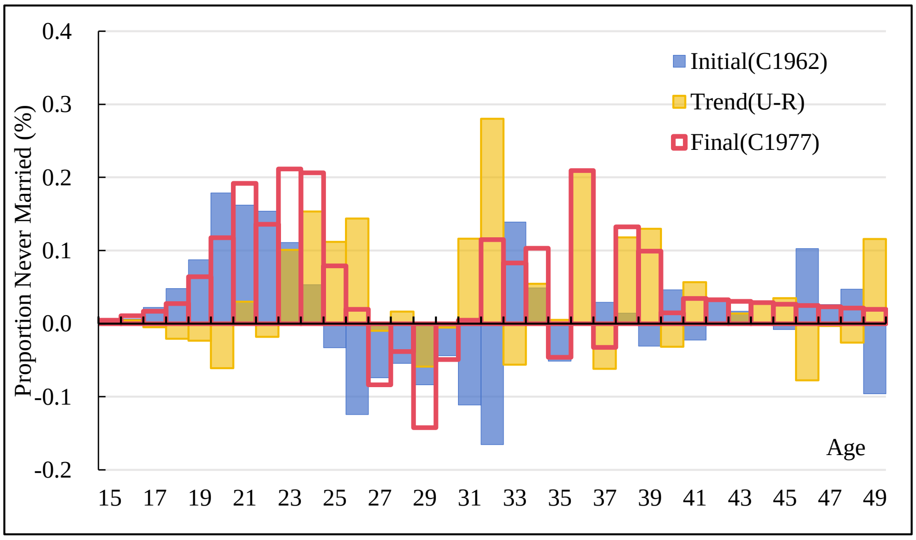


Fig 4A. Decomposition of differences of proportion never married between urban and rural areas

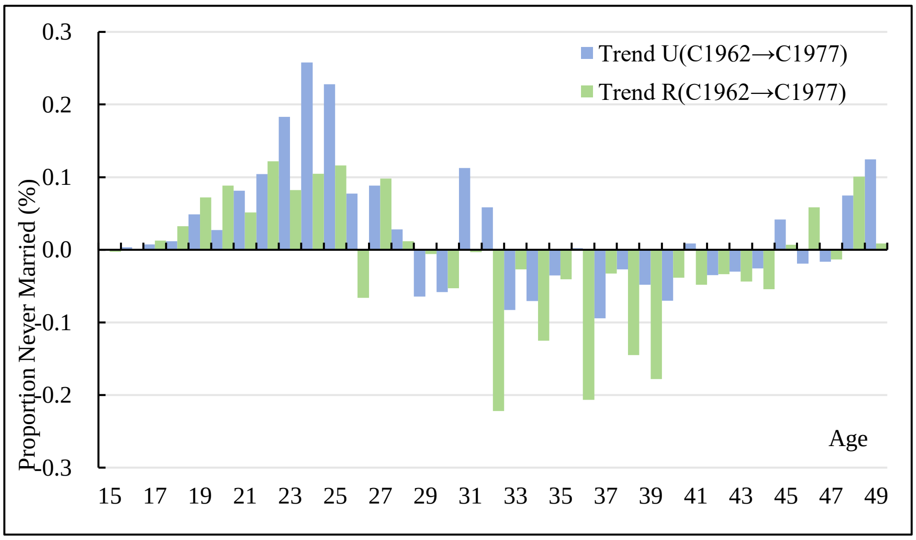


Fig 4B. Separated trend components of urban and rural areas

5.2 Differences between educational levels

The differences in FMCP between women with different educational levels from age 17 to 27 are the primary contributor to the PNM difference in the 1977 cohort. Compared to the FMCP changes between the 1962 and 1977 cohorts, the FMCP differences in the 1962 cohort have a greater impact on the PNM difference between two educational levels in the 1977 cohort.

From the 'Initial' column in Figure 5A, we discover that women with a high school education or below in the 1962 cohort have lower FMCP than women with a college education or above in the 18~22 age group, but higher FMCP than the more educated in the 25~32 age group. Regarding changes over time, women with a high school education or below experienced a larger FMCP decline across cohorts between ages 18 to 22 compared to the more educated women, yet a smaller decline in rural between ages 26 to 28 (see Figure 5A 'Initial' column and Figure 5B). As illustrated by the 'Final' column in Figure 5A, though the greater FMCP decline among women with a high school education or below across cohorts partially compensates for the initial advantage (higher FMCP for women with a high school education or below compared to the more educated) in the 18~22 age group in the 1962 cohort, women with a high school education or below in the 1977 cohort still have higher FMCP compared to the more educated. The PNM by age 50 for women with a college education or above in 1977 is 1.86 percentage points higher than for women with a high school education or below. From an age-specific perspective, the between-population FMCP differences in the 15~24 age group in the 1977 cohort contribute to 75.39% of the total difference, while FMCP differences in the 25~34 age group contribute to -7.02% of the total difference. From a component perspective, 2.26 percentage points of the total difference (1.86 percentage points) result from the between-population FMCP differences in the 1962 cohort, while -0.40 percentage points of the total difference (1.86 percentage points) are due to the between-population FMCP differences from the 1962 to 1977 cohort.

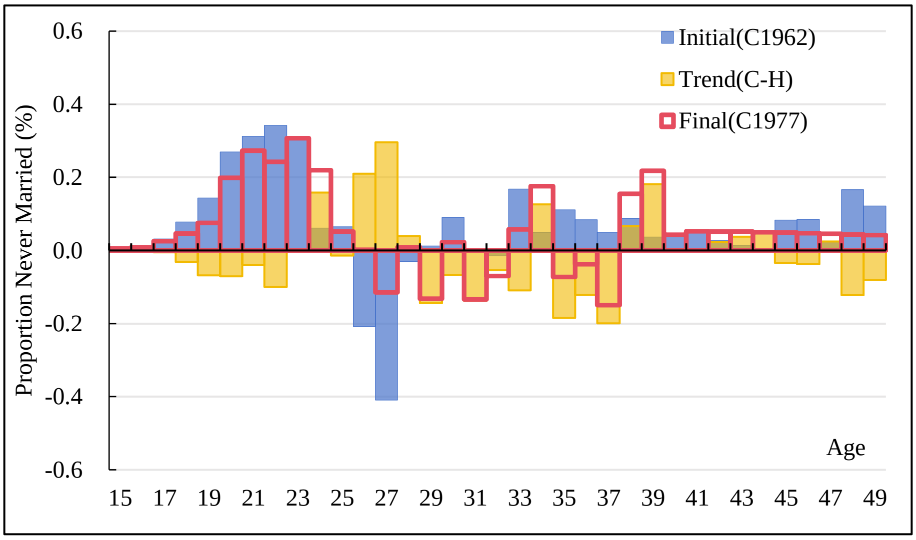


Fig 5A. Decomposition of differences of proportion never married between educational levels

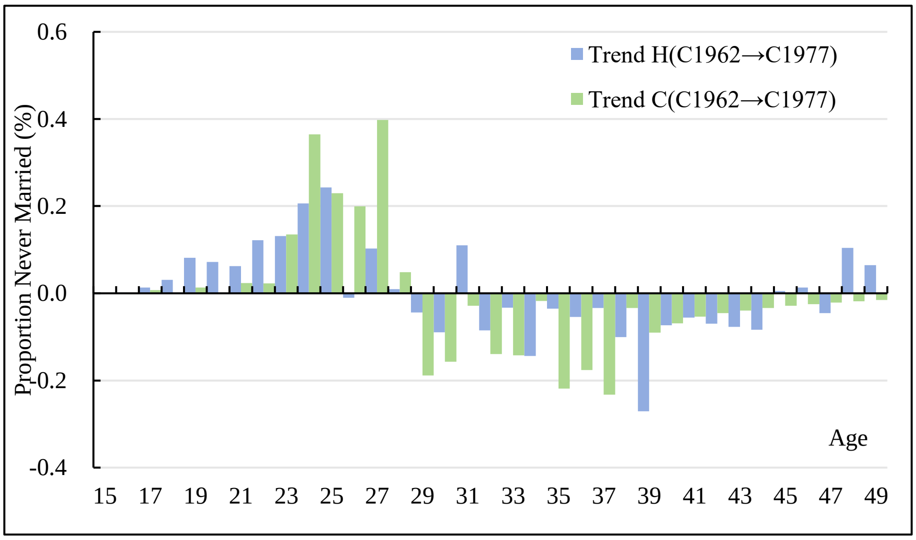


Fig 5B. Separated trend components of educational levels

Table1 Decomposition of differences of proportion never married between populations

Age group	Urban and Rural Areas (%)				Educational Levels (%)			
	Initial	Trend	Final	Percentage	Initial	Trend	Final	Percentage
15~19	0.17	-0.04	0.12	7.33	0.27	-0.11	0.16	8.69
20~24	0.66	0.21	0.86	50.84	1.29	-0.05	1.24	66.71
25~29	-0.37	0.20	-0.17	-9.73	-0.57	0.39	-0.18	-9.88
30~34	-0.13	0.39	0.26	15.13	0.30	-0.24	0.05	2.86
35~49	0.11	0.51	0.62	36.44	0.98	-0.39	0.59	31.63
Total	0.43	1.27	1.70	100.00	2.26	-0.40	1.86	100.00

6 Decomposition of differences in expectation of single life between populations

Based on Stepwise Replacement, we can decompose the differences in ESL at age 15 between two populations in later cohorts into initial age-specific FMCP differences in early cohorts and trend age-specific FMCP from early to later cohorts.

6.1 Differences between urban and rural areas

The differences of FMCP between urban and rural women from ages 18 to 26 are the main contributor to the ESL difference in the 1977 cohort between populations. Compared to the FMCP changes between the 1962 and 1977 cohorts, the FMCP differences in the 1962 cohort have a greater impact on the urban and rural areas of ESL difference in the 1977 cohort.

From Figure 6 and Table 2, we can see that the ESL at age 15 for urban women in 1977 is 2.73 years longer than that for the rural women. From an age-specific perspective, the between-population FMCP differences in the 15~24 age group in the 1977 cohort contribute to 88.43% of the total difference, while FMCP differences in the 25~34 age group contribute to 1.57% of the total difference. From a component perspective, 1.90 years of the total difference (2.73 years) result from the between-population FMCP differences in the1962 cohort, while 0.83 years of the total difference (2.73 years) are due to the between-population FMCP differences from the 1962 to the 1977 cohort.

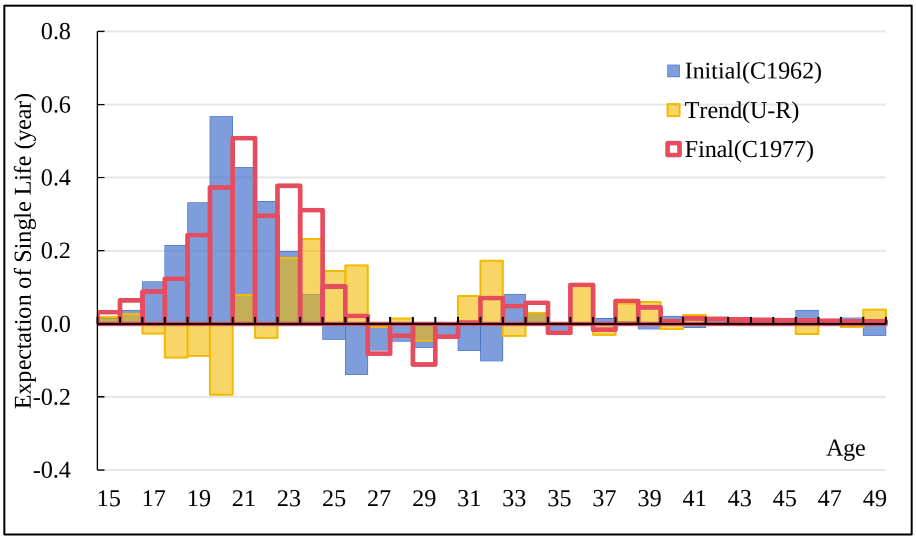


Fig 6A. Decomposition of differences of expectation of single life between urban and rural areas

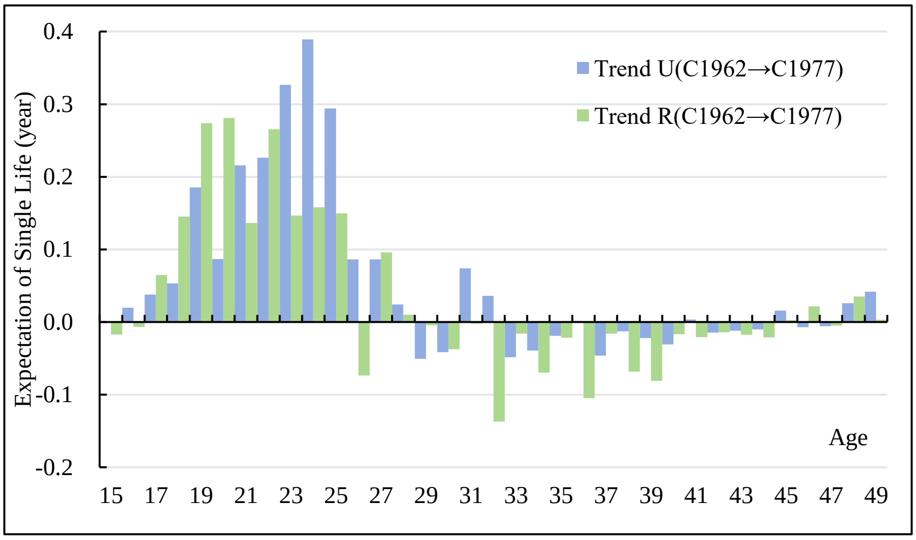


Fig 6B. Separated trend components of urban and rural areas

6.2 Differences between educational levels

The differences in FMCP between women with different educational levels from ages 18 to 27 are the primary contributor to the ESL difference in the 1977 cohort between two populations. Compared to the FMCP changes between the 1962 to 1977 cohorts, the FMCP differences in the 1962 cohort have a greater impact on the ESL difference between the two educational levels in the 1977 cohort.

From Figure 7 and Table 2, we find that the ESL at age 15 for women with a college education or above in 1977 is 3.56 years longer than for women with a high school education or below. From an age-specific perspective, the between-population FMCP differences in the 15~24 age group in the 1977 cohort contribute to 78.31% of the total difference, while the FMCP differences in age group 25~34 age group contribute to -3.42% of the total difference. From a component perspective, 4.20 years of the total difference (3.56 years) result from the between-population FMCP differences in the 1962 cohort, and -0.64 years of the total difference (3.56 years) are caused by the between-population FMCP differences from cohort 1962 to 1977.

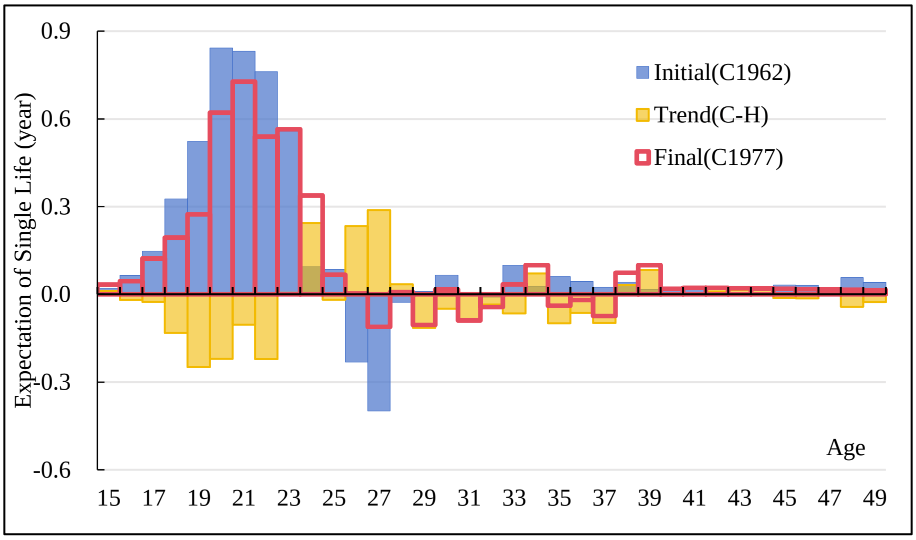


Fig 7A. Decomposition of differences of expectation of single life between educational levels

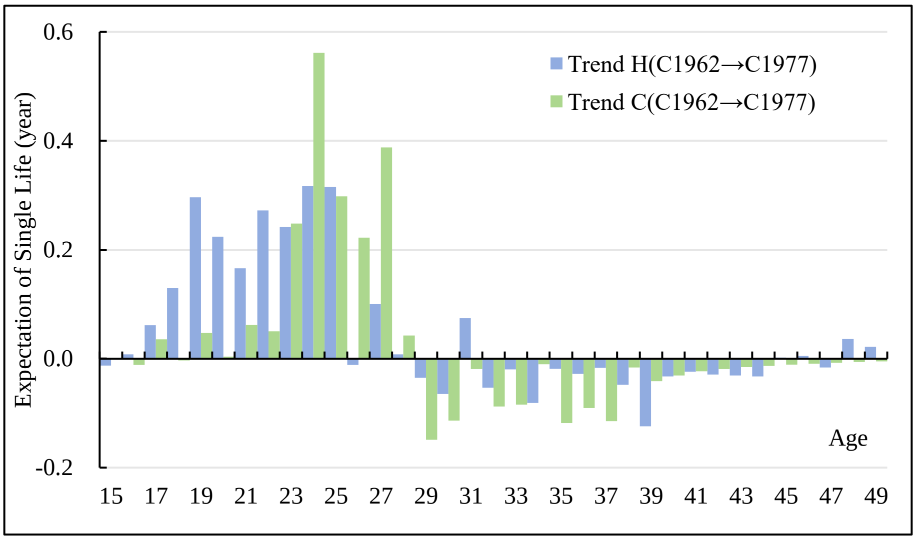


Fig 7B. Separated trend components of educational levels

Table2 Decomposition of differences of expectation of single life between populations

Age group	Urban and Rural Areas				Educational Levels			
	Initial(year)	Trend(year)	Final(year)	Percentage(%)	Initial(year)	Trend(year)	Final(year)	Percentage(%)
15~19	0.71	-0.16	0.55	20.89	1.08	-0.41	0.67	18.78
20~24	1.61	0.26	1.87	70.88	3.09	-0.30	2.79	78.31
25~29	-0.37	0.26	-0.10	-3.89	-0.56	0.42	-0.14	-3.89
30~34	-0.10	0.24	0.15	5.52	0.19	-0.17	0.02	0.47
35+	-0.02	0.19	0.17	6.59	0.41	-0.19	0.23	6.34
Total	1.84	0.79	2.63	100.00	4.20	-0.64	3.56	100.00

7 Conclusion and Discussion

In this study, we constructed nuptiality tables across cohorts to analyze trends in the timing of marriage entry, calculate the effect of changes in first marriage conditional probabilities (FMCP) on the proportion never married (PNM) and expectation of single life (ESL), and decompose differences between urban and rural areas and educational levels in later birth cohorts. We decomposed these differences into age-specific FMCP between populations in early birth cohorts and differences in FMCP changes within population over cohorts. We find the following conclusions.

There is a general trend of delayed marriage timing among Chinese women, with significant difference between urban and rural areas and across educational levels. This trend is evidenced by a rising proportion of women never married at corresponding ages and an increased expectation of single life at age 15 across cohorts. In specific, we observe a rightward shift in the curves of proportion never married and a rising trend of the proportion never married at corresponding ages across cohorts, indicating the postponement of the age at first marriage. Additionally, ESL at age 15 rises across cohorts, reflecting a slower transition into first marriage. Compared to rural and less educated women, urban women and those with higher educational levels have a higher proportion never married at corresponding ages and a longer expectation of single life at age 15. Previous studies have attributed these differences to factors such as the empowerment of urban daughters by Family Planning Policy in China (Fong, 2022), higher demand for economic resources in partner matching (Zhou, 2019), the reversal of the gender gap in educational attainment (Yang et al., 2014), the diminishing utility of marriage for women (Becker, 1973), etc.

The rise in proportion never married and expectation of single life is primarily driven by changes in FMCP within the younger age group (20~25 years). Similarly, differences in FMCP between urban and rural areas and across educational levels within younger age group (18~26 years) are the main contributor to the differences in proportion never married and expectation of single life between populations in later cohorts. This indicates that changes in FMCP during the youthful years have a significant impact on lifelong proportion lifelong never married and expectation of single life at age 15. The differences in FMCP between urban and rural areas and educational levels in younger ages are the primary contributor to the observed differences in lifelong proportion never married and expectation of single life. One probable reason is that Chinese women tend to enter marriage within a narrow age group universally, with a desired age group in willingness (Blair and Madigan, 2021) and a factual age group in action (Yu et al., 2020) for marriage entry. This suggests that the marriage behavior for young people is a key factor influencing future marriage and childbearing trends. Young population who was born or living in cities and with higher level of education are more likely to shape marriage attitudes, and consequently, marital behavior (Mao, 2024). Therefore, it is important to pay closer attention to the perspectives of young people and develop targeted policies that align with their evolving concepts and behaviors regarding marriage and childbearing.

The differences in FMCP in early cohorts between urban and rural areas and educational levels have a significant impact on the differences in lifelong proportion lifelong never married and expectation of single life at age 15 in later cohorts. Unlike traditional between-population decomposition method, Contour Decomposition not only splits the differences in aggregate demographic measures into trends of FMCP over cohorts but also reveals the impact of the past origins. Though the effect of differences in FMCP in early cohorts on later cohort measures may be compensated or counteracted by changes in FMCP over cohorts, they still have a significant impact on these measures in later cohorts.

The study also highlights changes in age-specific FMCP between urban and rural areas and educational levels. In general, women in rural areas or with high school education or below in 15~25 age group in early cohorts had higher FMCP, experienced greater decline in FMCP, and ultimately had higher FMCP in later cohorts compared to women in urban areas or with college education or above. Previous studies have suggested that urban and more educated women typically have higher socioeconomic status than rural and less educated women, leading to lower marriage utility (Lu and Wang, 2013), more stringent spouse selection (Shen and Qian, 2024), and greater freedom from traditional marriage constraint (Lavy and Zablotsky, 2015). Conversely, women in age group 26~30 display reverse trends. Women in rural areas or with high school education or below in this age group in early cohorts had lower FMCP, experienced smaller FMCP decline and finally had lower FMCP in later cohorts compared to their urban or with college education or above counterparts. This pattern supports the notions of rising years of schooling directly impacts marriage delay among women. As average years of schooling increases, women spend more time in school objectively (Marchetta and Sahn, 2016), they usually complete their education before considering marriage[5] (Thornton et al., 1995). Moreover, studies have shown that in developed urban areas in later cohorts, education is no longer the obstacle of marriage entry for women; instead, it provides an advantage in the marriage market due to their potential financial capacity (Fukuda, 2013; Park and Lee,

[5] Generally, the age at completion of high school studies in China is 18~19 years, age at college graduation is 22~23 years, and age at finishing postgraduate studies is 25~26 years.

2017). The high cost of living in cities often necessitates dual-income households, making a women's level of education an important criterion for men when selecting a spouse (He et al., 2023). This also explains why women aged 26~30 in cities or more educated in later cohorts have higher FMCP than their rural or less educated counterparts.

There are some limitations in the study. First, the marriage information used in this study is based on retrospective data, which may be subject to recall. Additionally, because of limited data, later cohorts had not fully reached marriageable ages at the time of the survey, necessitating the fitting of curves and forecasting of FMCP, which may affect the decomposition results. Finally, this study focuses solely on the first marriage of women; it is necessary to conduct further analysis on the first marriage of men in the future.

References

[1] Acar T. (2022). The role of educational attainment and educational pairings in women's marriage behavior in Turkey. *Women's Studies International Forum*, 93(3):102616.

[2] Andreev E., Shkolnikov V., Begun A. (2002). Algorithm for decomposition of differences between aggregate demographic measures and its application to life expectancies, healthy life expectancies, parity-progression ratios and total fertility rates. *Demographic Research*, 7(14):499-522.

[3] Becker G. (1973). A theory of marriage: Part I. *Journal of Political Economy*, 81(4):813-846.

[4] Blair S, Madigan T. (2021). Marriage and Fertility Preferences among Young Women in China: Changes over Time. *Journal of Family Issues*, 42(10):2353-2376.

[5] Choi M., Sempungu J., Lee E., Lee Y. (2023). Changes in contributions of age- and cause-specific mortality to the widening life expectancy gap between North and South Korea, 1990-2019: An analysis of the Global Burden of Disease Study. *SSM-Population Health*, 23:101445.

[6] Coale A.,Wang F., Riley N., Lin F. (1991). Recent Trends in Fertility and Nuptiality in China. *Science*, 251:389-393.

[7] Dan J., Jiang Q. (2020). The Transformation Trend of Chinese Women's First Marriage Pattern. *Population Journal*, 42(2):17-28. (in Chinese)

[8] Feng T. (2019). Parametric Estimates on Age Patterns of First Marriage and Proportions of Never-marrying of Chinese Female. *Chinese Journal of Population Science*, 33(6):97-110+128. (in Chinese)

[9] Fong V. (2002). China’s One-Child Policy and the Empowerment of Urban Daughters. *American Anthropologist*,104(4):1098-1109.

[10] Fukuda S. (2013). The Changing Role of Women’s Earnings in Marriage Formation in Japan. *The annals of the American Academy of Political and Social Science*, 646(1):107-128.

[11] GBD 2017 Mortality Collaborators. (2018). Global, regional, and national age-sex-specific mortality and life expectancy, 1950-2017: a systematic analysis for the Global Burden of Disease Study 2017. *Lancet*, 392(10159):1684-1735.

[12] Guo X. (2021). Prediction of the Future Situation of Marriage Squeeze in China Analysis Based on the Net Nuptiality Table of First Marriage. *Population Journal*, 43(3):14-25. (in Chinese)

[13] He G., Ge T, Yu H. (2023). Converging or Diverging? The Effect of Education on Marriage Timing and Its Regional Variation. *Journal of Social Development*. 10(3):39-61+243. (in Chinese)

[14] He H., Tan T. (2021). The Trend of Mean Age at First Marriage and the Factor-Specific Contribution Rate of Late Marriage in China.*Population Journal*,43(5):16-28. (in Chinese)

[15] Hernes G. (1972). The process of entry into first marriage. *American Sociological Review*, 37: 173-182.

[16] Jdanov D., Jasilionis D., Shkolnikov V. (2024). Two-dimensional contour decomposition: Decomposing mortality differences into initial difference and trend components by age and cause of death. *Demographic research*, 50(41):1223-1246.

[17] Jdanov D., Shkolnikov V., van Raalte A., Andreev E. (2017). Decomposing Current Mortality Differences Into Initial Differences and Differences in Trends: The Contour Decomposition Method. *Demography*, 54(4):1579-1602.

[18] Ji Y. (2015). Between Tradition and Modernity: “Leftover” Women in Shanghai. *Journal of Marriage and Family* ,77(5):1057-1073.

[19] Jiang Q., Dan J. (2020). Postponement and Recuperation of First Marriage of Chinese Women. *Chinese Journal of Population Science*, 34(5):53-65+127. (in Chinese)

[20] Lavy V., Zablotsky A. (2015). Women's schooling and fertility under low female labor force participation: Evidence from mobility restrictions in Israel. *Journal of Public Economics*, 124:105-121.

[21] Lu J., Wang X. (2013). Change of the Marital Status in Mainland China since 1990s. *Social Sciences of Beijing*, 28(3):62-72. (in Chinese)

[22] Mao Z., Ji S., Wan L. (2024). The Dynamics of Contemporary College Students' Concepts of Love,Marriage and Child-bearing in the Low Fertility Era-An Analysis Based on A National Sample of 32282 Individuals. *Youth Exploration*, 42(2):88-101. (in Chinese)

[23] Marchetta F, Sahn DE. (2016). The role of education and family background in marriage, childbearing, and labor market participation in Senegal. *Economic Development and Cultural Change*, 64(2): 369-403.

[24] Park H., Lee J. (2017). Growing Educational Differentials in the Retreat from Marriage among Korean Men. *Social Science Research*.66:187-200.

[25] Raymo J. (2003). Educational attainment and the transition to first marriage among Japanese women. *Demography,* 40(1):83-103.

[26] Retherford R., Ogawa N., Matsukura R. (2001). Late marriage and less marriage in Japan. *Population and Development Review*, 27(1):65-102.

[27] Shen Y, Qian Y. (2024). How to Find Mr/Miss Right? The Mechanism of Search Among Online Daters in Shanghai. *Journal of Family Issues*, 45(5):1087-1115.

[28] Smith P. (1980). Asian Marriage Patterns in Transition. *Journal of Family History*, 5(1):58-96.

[29] The Office of the Leading Group for the 7th National Population Census of the State Council in China. (2022). *China Population Census Yearbook 2020*. Beijing: China Statistics Press.

[30] Thornton A., Axinn W., Teachman J. (1995). The influence of school enrollment and accumulation on cohabitation and marriage in early adulthood. *American Sociological*

Review, 60(5):762-774.

[31] van Raalte A., Klüsener S., Oksuzyan A., Grigoriev P. (2020). Declining regional disparities in mortality in the context of persisting large inequalities in economic conditions: the case of Germany. *International Journal of Epidemiology*. 49(2):486-496.

[32] Vikram K. (2024). Modern Marriage in a Traditional Society: The Influence of College Education on Marriage in India. *Journal of Family Issues*, 45(5):1116-1141.

[33] Wang D, Zhao Y. (2021). A potential new pattern of pathway to adulthood is emerging in China. *Demographic Research*, 44(5):1023-1056.

[34] Wang P, Wu Y. (2013). Determinants of the Age of First Marriage: A Study Based on CGSS2006. *Chinese Journal of Sociology*, 33(3):89-110. (in Chinese)

[35] Wang T, Tan W., Han L, Jiang Q. (2024). Trends in Childlessness Proportion among Chinese Women: A Cohort Analysis. *Chinese Journal of Population Science*, 38 (4):36-49. (in Chinese)

[36] Watkins S. (1984). Spinsters. *Journal of Family History*, 9(4):310-325.

[37] Wei Y, Jiang Q., and Basten S. (2014). Observing the transformation of China's first marriage pattern through net nuptiality tables: 1982-2010. *Finnish Yearbook of Population Research*, 48:65-75.

[38] Yang J, Huang X, Liu X. (2014). An analysis of education inequality in China. *International Journal of Educational Development*, 37(4): 2-10.

[39] Yang K., Li G. (2018). The Influence of Education Acquisition on the Age of First Marriage. *Population Journal*, 40(6):5-19. (in Chinese)

[40] Yoo S. (2016). Postponement and recuperation in cohort marriage: The experience of South Korea. *Demographic Research*, 35:1045-1077.

[41] Yu J, Xie Y. (2015). Changes in the Determinants of Marriage Entry in Post-Reform Urban China. *Demography* ,52(6):1869-1892.

[42] Yu J, Zhao X., Xie Y. (2020). Marriage and Divorce in China: Trends and Global Comparison. *Population Research*, 44(5):3-18. (in Chinese)

[43] Zhou Y. (2019). Economic Resources, Cultural Matching, and the Rural-Urban Boundary in China's Marriage Market. *Journal of Marriage and Family*, 81(3):567-583.

[44] Zhuang Y., Yang S., Qi J., Li B., Zhao X., Wang Z. (2019). China fertility survey 2017: design and implementation. *China Population and Development Studies*. 2(3):259-271.

Appendix

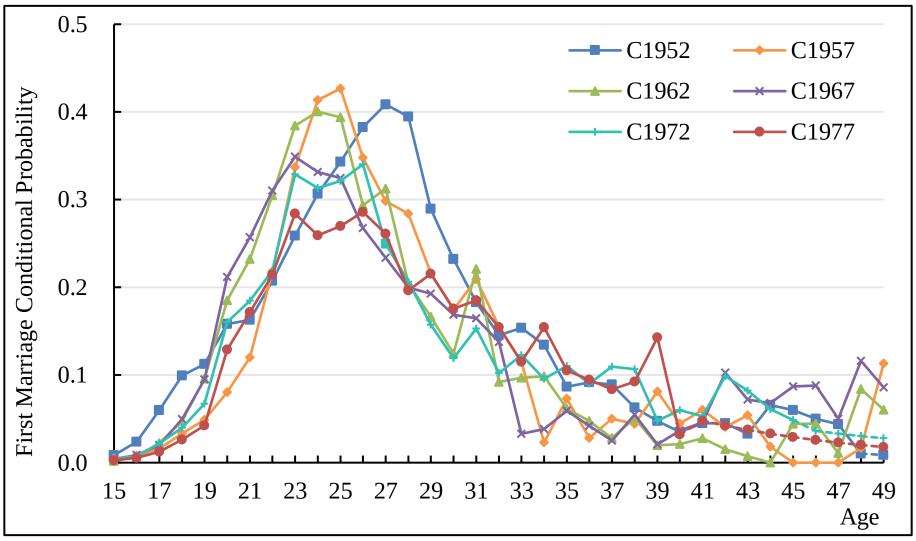


Fig.1 First Marriage Conditional Probability

Note: The solid lines show the calculated values and the dashed lines present the predicted values.

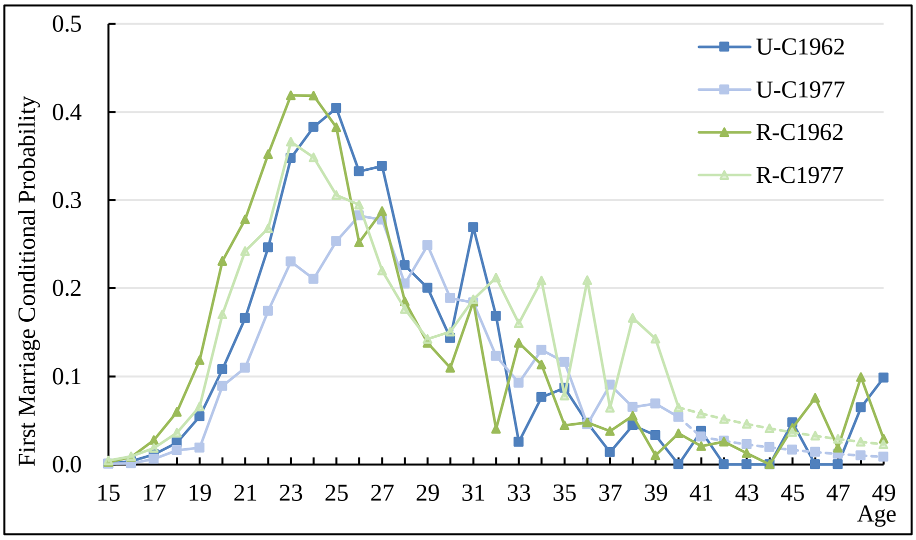


Fig.2 First Marriage Conditional Probability by Urban and Rural Areas

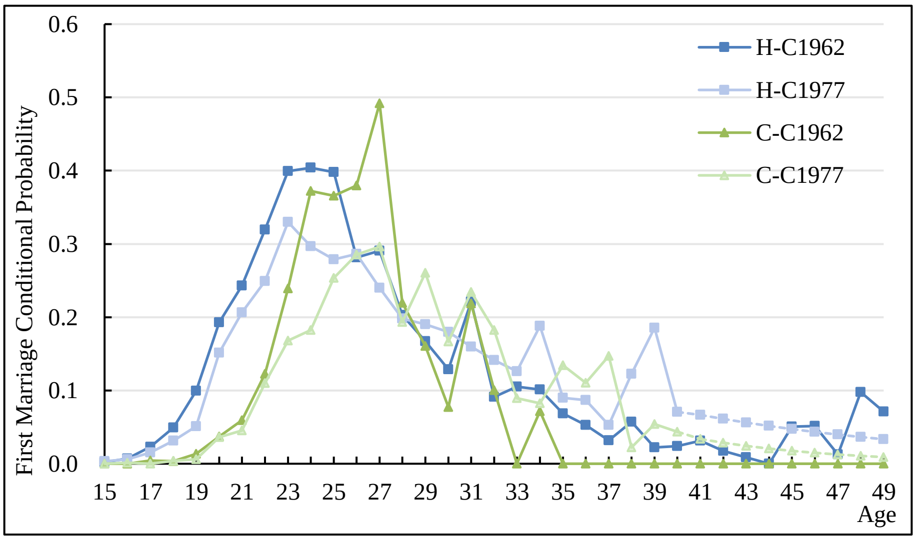


Fig.3 First Marriage Conditional Probability by Educational Levels