Diverse pathways to permanent childlessness in Singapore: A latent class analysis

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Abstract: The proportions of adults reaching midlife without having children have been rising rapidly across the globe, particularly in Asia. However, little is known about the pathways to permanent childlessness within the region's childless population. This study utilized latent class analysis (LCA) to typologize pathways to childlessness based on dynamic characteristics of multiple life domains (i.e., partnership, education, and occupation) among 489 childless Singaporeans aged 50 and above from a 2022 nationwide survey. Additionally, we utilized multinomial logistic regressions to examine the sociodemographic correlates of pathway profiles and Shannon's entropy index to assess the heterogeneity in pathways to childlessness among successive cohorts. Results revealed five distinct profiles of pathways to childlessness: *the Never-Married Semi-Professionals, the Low-Flex Blue-Collars, the Highly Educated Professionals, the Ever-Married Semi-Professionals*, and *the Flexible Blue-Collars*. These pathway profiles were significantly associated with sociodemographic characteristics such as gender and family background. Women's pathways to childlessness were more standardized and heavily influenced by partnership characteristics, compared to those of men. The childless from privileged family background were less likely to follow pathways characterized by disadvantageous education and occupational status. There were also rising trends of voluntary childlessness among married childless individuals and increasing heterogeneity in pathways to childlessness across successive birth cohorts. In sum, our findings are consistent with some of the predictions of the Second Demographic Transition theory, suggesting that Singapore may be experiencing a demographic transition characterized by rising childlessness, decoupling of marriage and childbearing, and de-standardization of the life course.

Keywords: Childlessness, Latent class analysis, Singapore

1. Introduction

Permanent childlessness has been rising rapidly across the globe. At present, the percentages of women who have never had a child by their late 40 s have increased substantially in the United States and many European countries, reaching 20 % for those born in the late 1960s and early 1970s (Livingston, 2015; Sobotka, 2017). In high-income Asian countries, the proportions are even higher: over 20 % in Singapore, 31 % in Japan, and 35 % in Hong Kong (Frejka et al., 2010; Yeung & Hu, 2018). These trends have continued unabated among younger cohorts approaching the end of their reproductive careers. Approximately, 28 % among women born in the late 1970s in Singapore, and above 37 % among women born in the early 1980s in Japan, South Korea, and Taiwan are childless (Sobotka, 2021). These figures imply that populations reaching midlife without having their own child will grow significantly in the foreseeable future, suggesting a "fertility crisis" as predicted by the Second Demographic Transition (SDT) (Lesthaeghe, 2010, 2014). To better understand factors underlying the fertility crisis, researchers and policymakers have paid attention to pathways through which individuals become childless (Hagestad & Call, 2007; Keizer et al., 2008). Previous research typically used variable-centered

approaches (e.g., logistic regression analyses) to estimate how individual characteristics influenced the likelihood of being childless versus being a parent. These studies identified several life domains that were most pertinent to childlessness, including partnership, education, and occupation (e.g., Bloom & Trussell, 1984; Hashmi & Mok, 2013; Keizer et al., 2008; Ritchey & Stokes, 1974). However, such approaches have a few shortcomings. For example, the associations are often confounded by interdependencies among different life domains and by unobserved characteristics such as value orientation (McQuillan et al., 2012). Moreover, contrasting childless individuals with parents, past research treated the childless as an undifferentiated group, thus overlooking the within-group heterogeneity in various pre-conditions of childlessness (Hagestad & Call, 2007; Mynarska et al., 2015). Due to these shortcomings, it remains unclear how various life domains—namely, partnership, education, and occupation during one's reproductive years—are of distinct significance to pathways to childlessness. Thus, there remain some ambiguities regarding who and what should be targeted when addressing the fertility crisis (Frejka et al., 2010).

In recent years, scholars have recognized childlessness as "dynamic, context-dependent processes" that span over multiple life domains (Gemmill, 2019; Mynarska et al., 2015). They have adopted person-centered approaches (e.g., sequence analysis) to explore the within-group diversity among childless populations, with an emphasis on categorizing pathways based on the (dis)similarities in childless individuals' life trajectories, such as union histories (Chaloupková & Hašková, 2020; Gemmill, 2019; Jalovaara & Fasang, 2017; Mynarska et al., 2015). Nevertheless, several research gaps remain. First, the interdependency among various life domains that influence childlessness has not yet received full attention. For instance, while sequence analyses could shed light on heterogeneous partnership trajectories, they have not yet considered education and occupation pathways in a simultaneous manner (Chaloupková & Hašková, 2020; Jalovaara & Fasang, 2017). Next, these studies focused on describing the sequential ordering of life events but did not pay adequate attention to the nuanced characteristics of each life domain. For example, Mynarska and colleagues (2015) utilized sequence analysis to understand the life course trajectories of childless women in Italy and Poland based on dichotomously-coded statuses of partnership (partnered vs. unpartnered), education (in school vs. not in school), and employment (employed vs. non-employed) in person-months from age 15 to 37. While the study provided one of the most comprehensive findings, data and methodological limitations prevented the researchers from incorporating key characteristics of each life domain, such as infertility, educational attainment, occupational status, and work flexibility, all of which are relevant to childbearing decisions (e.g., Livingston, 2015; Matthews & Matthews, 1986; Nisén et al., 2018; Thomas et al., 2022).

Importantly, a few exceptions notwithstanding (e.g., Chen, 2022; Koropeckyj-Cox & Call, 2007), permanent childlessness has been theorized primarily based on the experience of childless individuals in western settings. Less is known about the dynamic processes leading individuals down the path of permanent childlessness in Asia, where dramatic demographic and socioeconomic changes have taken place during the last half century (Lesthaeghe, 2010, 2014; Raymo et al., 2015). Singapore provides an illustrative case. The city state's fertility rates declined from 4.66 in 1965 to 2.1 in 1975 and further plummeted to a record low of 0.97 in 2023. Approximately a quarter of Singaporean women born during 1966–1970 never had a child in their lives (Jones, 2012; Yeung & Hu, 2018). However, whether various trends giving rise to childlessness align with the SDT framework remains unsettled. While evidence suggests that marriage remains the gatekeeper of childbearing in Singapore, it is unclear whether voluntary childlessness within marriage has been rising, reflecting the "disconnection between marriage and procreation" as suggested by the SDT (Lesthaeghe, 2010, p. 211; Zaidi & Morgan, 2017). Furthermore, additional research is warranted to address whether individuals' pathways to childlessness have become less standardized and more individualized over time, constituting the

de-standardization of the life course (Brückner & Mayer, 2005).

In this study, we utilize latent class analysis (LCA) to describe the diverse pathways to permanent childlessness among Singapore's childless middle-aged and older populations. We choose LCA over sequence analysis to incorporate detailed characteristics of multiple life domains and to overcome our data constraints. Specifically, we construct a typology of pathways to childlessness based on a nationally representative sample of 489 Singaporeans aged 50 and above who have never had a child in their lives. The dataset contains rich information on partnership, educational, and occupational histories during respondents' prime reproductive years. Next, we use multinomial logistic regressions to examine the sociodemographic correlates of the derived pathway profiles. Finally, we examine cohort variations in the prevalence of voluntary childlessness within marriage, as well as the overall heterogeneity of pathways to childlessness.

The remainder of the article proceeds as follows. The Background section compares variable- and person-centered approaches and reviews past research on the determinants of childlessness, with an emphasis on the context of Singapore. The Data and Methods section describes our data source, variable measurements, and analytical strategies. The Results section provides descriptive statistics, the typology of pathways to childlessness, and estimations of the sociodemographic correlates. The last section discusses our empirical findings and implications for the SDT and policies.

2. Background

2.1. Variable-centered and person-centered approaches

To investigate the reasons why individuals are childless, past studies typically utilized variable-centered approaches to explain relationships between various life domains and childlessness (e.g., Bloom & Trussell, 1984; Hashmi & Mok, 2013; Ritchey & Stokes, 1974). Partnership, education, and occupation have been found to be the most salient life domains to childbearing behaviors (Heaton et al., 1999; Keizer et al., 2008). Nevertheless, past research recognized several disadvantages of the variable-centered approach, including estimations being confounded by interdependencies among multiple life domains and by unobserved characteristics, as well as the overlooked within-group heterogeneity (Howard & Hoffman, 2018; Muthen & Muthen, 2000; Mynarska et al., 2015).

Recent studies have adopted person-centered approaches for a more holistic study of childlessness, focusing on identifying subgroups within the childless population based on (dis)similarities in observed characteristics (Chaloupková & Hašková, 2020; Gemmill, 2019; Jalovaara & Fasang, 2017; Mynarska et al., 2015). Unlike variable-centered approaches, person-centered methods recognize that the life domains most significant to childlessness—such as partnership, education, and occupation—are specific to individuals and vary in importance across subgroups. Their objective is to uncover patterns of partnership, educational, and occupational characteristics among childless individuals rather than merely estimating associations between these life domains and childlessness. Person-centered approaches, therefore, can better capture the "dynamic, context-dependent processes" of becoming childless and identify subgroups to whom various pathways to childlessness are of distinct importance (Gemmill, 2019).

Sequence analysis, a widely-used person-centered approach, has been adopted by life course researchers to identify clusters of life course trajectories (e.g., partnership) preceding permanent childlessness in some European settings, including the Czech Republic (Chaloupková & Hašková, 2020), Finland (Jalovaara & Fasang, 2017), Italy and Poland (Mynarska et al., 2015). This method, while well-suited for examining the sequential ordering of life events, is limited by its stringent requirement for complete time-stamped data for each life course event. Consequently, other nuanced variables relevant to childbearing decisions but without time-stamped information (e.g., infertility status,

level of educational attainment, occupational characteristics) are often left out from sequence analysis.

Latent class analysis (LCA) is another person-centered approach that classifies individuals into subgroups based on unobserved heterogeneity empirically derived from a set of manifest variables (Hagenaars & McCutcheon, 2002; Muthen & Muthen, 2000). While LCA is limited in analyzing the chronological order of life events, it is highly capable of incorporating a broad range of observed characteristics, with or without time-stamped information. While LCA has been applied to study various life course behaviors such as transitions to adulthood (Oesterle et al., 2010) and family formation (Amato et al., 2008), to the best of our knowledge, it has not yet been used to examine pathways to childlessness.

In this study, we employ LCA to identify latent pathways to childlessness based on various manifest indicators related to partnership, education, and occupation. As much as our data allows, we incorporate a wide range of time-sensitive variables, such as marital timing and occupational characteristics during prime reproductive years, to represent the dynamic pathways to childlessness. For the remaining Background section, we review the literature on key determinants of childlessness to justify our variable selection.

2.2. The determinants of childlessness

2.2.1. The partnership domain

Partnership is one of the most salient determinants of childlessness. *Singlehood* is consistently identified as a key reason for remaining childless through midlife (Heaton et al., 1999; Keizer et al., 2008; Koropeckyj-Cox & Call, 2007). This is particularly true in Asian societies where marriage is the primary gatekeeper of parenthood, as evidenced in Asia's extremely low rates of nonmarital childbearing (Jones, 2012; Raymo et al., 2015). The absence of partnership during one's prime reproductive years almost guarantees childlessness for both Asian men and women (Raymo et al., 2015). Furthermore, other aspects of partnership can also influence childbearing behaviors. For example, *infertility* may cause married couples to become childless involuntarily, especially when adoption is costly and uncommon (Matthews & Matthews, 1986). *The timing and continuity of marriage* are also important (Hagestad & Call, 2007; Keizer et al., 2008). Scholars attributedfrtility decline at least partially to the postponement of marriage and the increasing prevalence of marital disruption by divorce (Cohen & Sweet, 1974; Rowland, 2007). The SDT theory further predicts that the traditionally strong relationship between marriage and childbearing would be challenged, given the value shifts toward self-actualization following higher educational attainment and career prioritization among both men and women (Lesthaeghe, 2010; Zaidi & Morgan, 2017). In some western contexts, scholars have observed a decoupling between marriage and childbearing, whereby nonmarital childbearing has become increasingly common, and parenthood within marriage is no longer the default (Hacker, 2016; Klüsener, 2015; Schnor & Jalovaara, 2020).

2.2.2. The educational domain

Educational attainment is another pertinent determinant of childlessness, with divergent effects across genders (Bloom & Trussell, 1984; Chen, 2022; Nisén et al., 2018). For women, higher education is often linked to a greater likelihood of childlessness. For men, however, studies have generally found positive associations between educational attainment and the number of children (Nisén et al., 2018; Trimarchi & Van Bavel, 2017), with a few exceptions of negative or non-significant relationships (Ritchey & Stokes, 1974; Keizer et al., 2008). Scholars have proposed a few mechanisms to explain the gendered patterns. First, in a marriage market dominated by homogamy and female hypergamy, highly-educated women and less-educated men tend to encounter the "marriage squeeze" and face a greater likelihood of remaining single, thereby missing the reproductive window (Jones, 2012; Jones et al., 2012). Second, while education improves economic prospects for both

genders, the unequal division of childcare responsibilities may result in women bearing a higher opportunity cost of childbearing (Ho & Myong, 2022; Joshi, 1998). Moreover, evidence from western settings and a few Asian countries demonstrates that education does not necessarily induce progressive value orientation to the same extent among women and men, resulting in asymmetric gender ideology (Deole & Zeydanli, 2021; Du et al., 2021). Highly educated women with progressive gender ideology tend to challenge the centrality of motherhood, whereas it is not necessarily the case for highly educated men.

Recent research, nevertheless, reveals a complex relationship between education and female fertility. For example, Chen (2022) found that in China, each additional year of women's education induced by the country's higher education expansion from 1999 to 2007 decreased the likelihood of childlessness by 3 % points. South Korea and Scandinavian countries have observed new dynamics of educational disparities in women's marriage and fertility rates, such that singlehood and childlessness concentrate among the least-educated women (Raymo & Park, 2020; Jalovaara et al., 2019).

2.2.3. The occupational domain

Work/occupation is an important life domain associated with childlessness in a multi-faceted manner. Employment often represents a rational trade-off, offering financial stability conducive to childbearing, but at an increased opportunity cost (Adda et al., 2017; Heaton et al., 1999; Matysiak, 2009). Due to persistent gendered division of unpaid work, women are more likely affected by this trade-off, as evidenced in the well-documented positive association between employment and childlessness among women (Matysiak & Vignoli, 2008), in contrast to a mostly negative one among men (Heaton et al., 1999; Ritchey & Stokes, 1974).

In addition to employment, other characteristics of occupational pathway are noteworthy, including *occupational status, work flexibility,* and *family-related benefits*. Facing high opportunity cost of childbearing, women may self-select into low-paying or low-status occupations in anticipation of future motherhood, and those already in high-status occupation may opt out of motherhood (Adda et al., 2017). Furthermore, work flexibility and access to family leave policies may alleviate work-family conflicts, thus reducing the opportunity cost of childbearing for women. A recent systematic review found that access to family leave benefits increased fertility levels, especially when the benefit was generous (Thomas et al., 2022).

Recent research has revealed new dynamics in the occupational pathway to childlessness. For instance, employment is increasingly viewed not as a barrier to motherhood, but rather as a precursor, especially among women in younger cohorts. Matysiak (2009) reported that Polish women born between 1966 and 1981 were more likely to pursue motherhood after achieving stable employment. In the United States, McQuillan et al. (2008) found a positive association between the perceived importance of work success and motherhood among women born from 1965 to 1985. These findings challenge the traditional view of the incompatibility between women's employment and motherhood. This shift underscores the need for a nuanced understanding of how the occupational pathway contributes to childlessness, particularly in contexts like Singapore, where both demographic trends and gender roles in the labor market are in flux (Jones, 2012; Jones et al., 2012).

2.3. The Singapore context

Childlessness is a pressing social and demographic issue in Singapore, a developed country in Southeast Asia with one of the world's lowest fertility rates and fastest-growing older-aged populations (Jones, 2012; Malhotra et al., 2019; Teerawichitchainan et al., 2024). Both the number and proportion of childless individuals have been rising among cohorts born from the early 1940s to the late 1960s, whose reproductive careers are now complete (Yeung & Hu, 2018). Currently, approximately one out of five individuals in their 50 s and above is

childless. The rising trends in permanent childlessness among these cohorts are at least partially explained by Singapore's various anti-natalist campaigns implemented during the 1960s and the mid-1980s as well as by rapid economic and social development during the last half century (Jones, 2012; Palen, 1986). In the following paragraphs, we review changing patterns of partnership, educational attainment, and labor force participation as potential contributors to the rising childlessness in Singapore.

First, changes in partnership pathways are characterized by the increasing prevalence of forgone, postponed, and disrupted marriages. Between 2000 and 2020, the proportion never-married among individuals in the 50–54 and 55–59 age groups rose from 8.8 % to 13.2 % and from 6.6 % to 12.6 %, respectively (Department of Statistics, 2000, 2020). Age at first marriage has been rising steadily across cohorts, and the proportion divorced nearly doubled from 3.0 % to 5.6 % among men presently aged 50–59 and from 5.2 % to 8.9 % among women in the same age group, with slightly lower figures but similar magnitudes of change for older age groups (Department of Statistics, 2000, 2020; Jones, 2012).

Second, the expansion of educational opportunities in Singapore has contributed to delayed or forgone marriages, yet with pronounced gender differences (Jones, 2012). From 2000 to 2020, the highest proportions of never-married individuals were consistently among least-educated men and highly-educated women. However, while the figures more than doubled from 8.6 % to 18.1 % among men aged 50–59 with below-secondary degrees, there was a negligible decline from 20.8 % to 19.3 % among highly-educated women in the same age group (Department of Statistics, 2000, 2020). This is potentially due to a substantial increase in transnational marriages between Singaporean women and foreigners, which challenges the presumed negative effects of higher education on women's fertility via singlehood in Singapore (Jones, 2012; Jones et al., 2012).

Third, Singapore has witnessed a rapid decline in male-female differences in labor force participation rates in recent decades. Nevertheless, the gender gaps and pervasive work-family conflicts persist (Wong, 1980). In 1987, 78.6 % of men aged 15 years and over (who were 50 years or older in 2022, corresponding to the age range in our sample) were economically active, a decline from 88 % in 1957 (Department of Statistics, 1957, 1987). In contrast, women's labor force participation rates more than doubled from 21.6 % to 47 % during the same period, though still much lower than men's. Additionally, Singaporean workers reported the lack of work flexibility and limited access to family-related benefits as key contributors to work-family conflicts, which in turn may adversely affect their childbearing decisions (Call et al., 2008; Tan, 2021).

Taking stock of the literature, we expect pathways through which Singaporeans reached middle and older adulthood without bearing children to be heterogeneous and associated with sociodemographic characteristics such as gender, cohort, and family backgrounds. Specifically, given the ongoing importance of partnership to childbearing, we anticipate deriving a distinct pathway profile characterized by singlehood during one's prime reproductive years, as well as a pathway typifying individuals who are married yet childless.

Informed by the changing dynamics of education and fertility, we expect to derive pathway types stratified by education and occupational status. Given the norms of homogamy and female hypergamy, we expect to find clusters of childless men with lower socioeconomic status and women with higher status being squeezed out of the marriage market. We also expect to find a group of highly educated childless individuals with mostly postponed or forgone marriages, reflecting the conflicts between higher education and marriage. Furthermore, considering the detrimental impact of work-family conflicts on fertility, we expect to identify pathway types among childless Singaporeans that are characterized by limited work flexibility and access to family-related benefits during their prime reproductive years. Lastly, as predicted by the SDT, we expect to observe increasing trends in voluntary childlessness within

marriage and greater heterogeneity in the pathways to childlessness across successive cohorts.

3. Data and methods

3.1. Sample

We used data from the Childless Aging in Singapore (CAS) Study, a nationwide survey of 1500 Singaporeans aged 50 and above, which included an oversampling of 500 childless individuals. The survey was conducted during January-June 2022 through in-person interviews, each lasting about one hour. Respondents were randomly selected from a list of nationally representative households, provided by the Singapore Department of Statistics, featuring a broad range of dwelling types and diverse socioeconomic characteristics of Singapore's community-dwelling populations aged 50 and above. Since only 1.8 % of older Singaporeans are institutionalized, the impact on the national representativeness of the survey should be minor at most (Chan et al., 2018). Furthermore, the survey collected comprehensive data on respondents' partnership histories, educational attainment, and occupational characteristics during their prime reproductive years (e.g., the age of 20 s and 30 s), making it well-suited for latent class analysis of pathways to childlessness.

The survey's overall response rate of 46 % was influenced by Singapore's stringent Covid-19 safety measures up until August 2022, which disproportionately impacted older individuals, a major demographic within the CAS sample (Aravindhan et al., 2023). Although the pandemic has notably affected survey response rates–a phenomenon extensively documented (Krieger et al., 2023)—there continues to be substantial discussion about the impact of response rates on survey validity, particularly concerning non-response bias (Hendra & Hill, 2019; Rindfuss et al., 2015). Despite these challenges, the response rate of the CAS is in line with other nationally representative surveys of older persons conducted pre-pandemic in Singapore, such as the 51 % achieved by THE SIGNS-I Study (Chan et al., 2018). Moreover, the robustness of the CAS is further affirmed by a comparison of the sample distribution to that of the 2020 Population Census of Singapore across socio-demographic characteristics, as detailed in Supplementary Table A1.

To derive our analytic sample, we first focused on the 500 childless individuals born in 1972 or earlier, corresponding to ages 50 and above in 2022. We then dropped 7 childless respondents who had outlived all their children, aligning with our focus on adults who have never had a child in their lives. Next, we excluded 4 respondents with missing data on key variables required for LCA, such as partnership, educational, and occupational characteristics. For multinomial regression analyses, we further removed 32 cases due to missing sociodemographic variables, resulting in a final sample of 457 childless individuals aged 50 and above. We applied sampling weights in all analyses to make our sample of childless individuals representative of the childless population in Singapore. Given the negligible percentages of first-time parenthood after age 50 (Khandwala et al., 2017), we consider this sample as representative of those who are permanently childless.

3.2. Measures

Pathway indicators. We selected a rich set of variables to describe the three life domains (partnership, education, and occupation) during the respondents' prime reproductive years (e.g., in their 20 s and 30 s). First, partnership is characterized by marital timing, marital continuity, and self-reported infertility. The timing of the first marriage is categorized as a) *never-married*, b) *early or on-time marriage*, and c) *late marriage*, defined based on gender-specific terciles of marital timing in the entire sample. Early and on-time marriages (below age 24 for women and 27 for men, and aged 24–28 for women and 27–31 for men, respectively) are combined due to limited observations among the

childless. Late marriage refers to marriage after age 28 for women and 31 for men. Marital disruption is a categorical variable indicating whether the respondent was a) *never-married*, b) *continuously married*, or c) experienced a *disrupted marriage* (divorce) before age 40. Since no childless respondent in our sample experienced widowhood before age 40, the category of disrupted marriage refers to divorce exclusively. Self-reported infertility is a dichotomous variable (1 =*yes*, 0 =*no*) indicating whether the respondent answered affirmatively to the following questions: "Have you or your spouse ever had pregnancy that did not end in a live birth?"; "Have you and/or your spouse ever sought professional intervention for issues related to difficulties in conceiving?"; "Have you and/or your spouse ever been diagnosed by a doctor with infertility?"; or gave a negative response to the question, "Was it physically possible for you or your spouse to have a baby when you were younger (in reproductive years)?".

The educational domain is characterized by the respondent's educational attainment: *low* (primary school or lower), *middle* (secondary school), and *high* (post-secondary or beyond).

The occupational domain includes occupational status, job flexibility, and family leave during the respondent's 20 s and 30 s. First, the survey separately asked respondents about their main occupations during two time periods, first in their 20 s and subsequently in their 30 s. For each period, respondents were asked if they had never worked, and for those who worked, the occupation held for the longest duration according to Singapore Standard Occupational Classification (SSOC) 2020. We recoded them as separate indicators for the 20 s and the 30 s: *non-employed*, *blue-collared* (e.g., craftsmen, machine operators, assemblers, cleaners), *semi-professional* (e.g., associate professionals, technicians, clerical support workers, service and sale workers), and *professional* (e.g., professionals, managers, officials, and legislators). Next, job flexibility refers to whether the respondent reported having flexible work arrangements during their prime reproductive years (from age 20 s to 30 s) such as options to work from home or take a half day off. This variable was dichotomously coded by *low* vs. *moderate or high job flexibility*, the latter including those who have never worked. Family leave is a dichotomous variable indicating whether or not the respondent had access to generous family leave during his/her prime reproductive years, such as being able to take childcare leave for a few months, with the non-employed grouped with those having generous family leave.

Sociodemographic characteristics. We included several sociodemographic variables exogenous to pathways to childlessness: gender (1 =*female*, 0 =*male*), birth cohort, ethnicity (1 =*Chinese*, 0 =*non-Chinese*), nativity status (1 =*foreign-born*, 0 =*native-born*), number of siblings, father's education (*low, middle,* and *high,* coded similarly to the respondents' education). Additionally, we included childhood economic well-being denoting how financially well-off the respondent's family was during his/her childhood on a scale from 1 (*way below average*) to 5 (*way above average*), childhood health on a scale from 1 (*poor*) to 5 (*excellent*), and parental relationship before the respondent reached age 16 on a 1 (*very poor*) to 5 (*very good*) scale. These variables were included in multinomial regressions as correlates to the identified pathway types.

3.3. Analytical strategies

We employed LCA to derive pathways to childlessness. LCA is a person-centered approach that identifies latent, unobserved heterogeneity (e.g., pathways to childlessness) from observed characteristics (e.g., partnership, education, and occupation characteristics). The approach allows researchers to distinguish qualitatively different subgroups within populations that share certain outward characteristics—in this case, childlessness (Hagenaars & McCutcheon, 2002; Muthen & Muthen, 2000). It is particularly suitable for our study, as our data includes detailed partnership histories but lacks time-stamped data on education, occupation, job flexibility, and access to family leave.

Our analytical approaches proceeded as follows. In the first step, to identify the optimal number of latent classes, we compared multiple fit statistics, including Bayesian Information Criterion (BIC), sample-size adjusted BIC (SABIC), and entropy. BIC and SABIC are widely considered the most reliable fit statistics in LCA, with lower values indicating better model fit (Weller et al., 2020). Entropy is a measure of how accurately the model defines its classes; a value above 0.8 is acceptable, and close to 1 is ideal. We also considered sample size requirements, with the overall sample size ideally above 300 cases and each latent class containing more than 50 cases or 5 % of the total sample (Nylund-Gibson & Choi, 2018). We then assigned labels to each identified latent classes based on their distinguishing features.

In the second step, following the LCA, we conducted multinomial logistic regressions to examine the sociodemographic correlates of the identified pathway types.

Finally, we used the Shannon's entropy index to evaluate the degree of heterogeneity in pathways to childlessness across cohorts (Shannon & Weaver, 1998). The index quantifies the amount of uncertainty in a distribution of categories—in this case, the degree of diversity in pathway types. It has been utilized by previous research to study the degree of heterogeneity in partnership, fertility, occupation, and other life course transitions (Fulda, 2016; Pelletier et al., 2020; Widmer & Ritschard, 2009; Wang & Zhao, 2021). The index is calculated by:

$$H(X) = -\sum_{i=1}^{n} \frac{p(x_i)\ln(p(x_i))}{\ln(n)}$$

where $p(x_i)$ is the probability of the discrete value x_i in X, n is the number of unique values in X, Σ denotes the sum of the normalized values. Shannon's entropy ranges from 0 (no heterogeneity), indicating that there is only one type of pathway to become childless, to 1 (maximum heterogeneity), when all five types of pathways are equally distributed among childless individuals. We calculated the index for each cohort to assess variations over time.

4. Results

4.1. Descriptive statistics

Table 1 summarizes the descriptive statistics of childless respondents, stratified by gender. Among them, 187 (40.9 %) were men, and 270 (59.1 %) were women. They were born between 1935 and 1971 and on average 62.63 years old (SD=7.84) in 2022. They had an average of 4.53 siblings. Over 80 % were of Chinese ethnicity (Singapore's majority ethnic group), and nearly 90 % were native-born. All rated on scales from 1 to 5, mean scores for economic well-being, health, and parental relationships during childhood were 2.77 (SD=0.83), 4.35 (SD=0.71), and 4.09 (SD=0.88), respectively. Nearly three quarters of the respondents (72.9 %) reported that their fathers had primary education or less. There were no significant gender differences in these sociodemographic characteristics.

Partnership characteristics of childless individuals were marked by a high prevalence of singlehood, late marriage, and self-reported infertility. Over 75 % of childless individuals had never been married. Among those married, 61.5 % were married late and 21.1 % experienced marital disruption. Furthermore, about half (50.5 %) of married childless individuals reported infertility. Childless women were overrepresented among those who married late. Next, results show pronounced gender differentials in educational attainment. Among childless men, 38.5 % had primary education or less, 30.5 % had secondary education, and 31 % had post-secondary education. In contrast, among childless women, these figures were 17.8 %, 35.2 %, and 47 %, respectively.

Regarding the occupational domain, non-employment during prime reproductive years was rare, with only 2.8 % of respondents not working in their 20 s and 2.2 % in their 30 s. Women generally reported higher occupational status than their male counterparts. Approximately 64.1 % of childless women worked as semi-professionals in their 20 s,

Table 1
Sample Description of Childless Individuals (N = 457).

	All	Male	Female	T/χ² test
LCA indicators				
Timing of first marriage				*
Never	76.15 % (348)	75.40 % (141)	76.67 % (207)	
Early/on-time	9.19 % (42)	12.83 % (24)	6.67 % (18)	
Late	14.66 % (67)	11.76 % (22)	16.67 % (45)	
Marital disruption before age 40				ns
No	94.97 % (434)	93.58 % (175)	95.93 % (259)	
Yes	5.03 % (23)	6.42 % (12)	4.07 % (11)	
Self-reported Infertility				ns
No	81.84 % (374)	81.82 % (153)	81.85 % (221)	
Yes	18.16 % (83)	18.18 % (34)	18.15 % (49)	
Education				***
Low	26.26 % (120)	38.50 % (72)	17.78 % (48)	
Middle	33.26 % (152)	30.48 % (57)	35.19 % (95)	
High	40.48 % (185)	31.02 % (58)	47.04 % (127)	
Occupation in 20 s				***
Non-employed	2.84 % (13)	3.21 % (6)	2.59 % (7)	
Blue-collared	31.07 % (142)	47.06 % (88)	20.00 % (54)	
Semi-pro	53.39 % (244)	37.97 % (71)	64.07 % (173)	
Professional	12.69 % (58)	11.76 % (22)	13.33 % (36)	
Occupation in 30 s				***
Non-employed	2.19 % (10)	2.14 % (4)	2.22 % (6)	
Blue-collared	26.48 % (121)	41.18 % (77)	16.30 % (44)	
Semi-pro	58.21 % (266)	43.85 % (82)	68.15 % (184)	
Professional	13.13 % (60)	12.83 % (24)	13.33 % (36)	
Job flexibility in 20 s & 30 s				ns
Low	48.58 % (222)	47.06 % (88)	49.63 % (134)	
Moderate or high	51.42 % (235)	52.94 % (99)	50.37 % (136)	
Family leave in 20 s & 30 s				*
No	55.80 % (255)	62.57 % (117)	51.11 % (138)	
Yes	44.20 % (202)	37.43 % (70)	48.89 % (132)	
Sociodemographic characteristics				
Age	62.63 (7.84)	62.49 (7.62)	62.73 (8.01)	ns
Year of birth	1959.37 (7.84)	1959.51 (7.62)	1959.27 (8.01)	ns
Race				ns
Non-Chinese	17.07 % (78)	20.32 % (38)	14.81 % (40)	
Chinese	82.93 % (379)	79.68 % (149)	85.19 % (230)	
Nativity status				ns
Native born	89.50 % (409)	89.84 % (168)	89.26 % (241)	
Foreign born	10.50 % (48)	10.16 % (19)	10.74 % (29)	
Num of siblings	4.53 (2.72)	4.55 (2.89)	4.52 (2.6)	ns
Father's education				ns
Low	72.87 % (333)	75.40 % (141)	71.11 % (192)	
Middle	19.91 % (91)	19.25 % (36)	20.37 % (55)	
High	7.22 % (33)	5.35 % (10)	8.52 % (23)	
Childhood economic well-being	2.77 (0.83)	2.72 (0.82)	2.81 (0.83)	ns
Childhood health	4.35 (0.71)	4.35 (0.69)	4.34 (0.73)	ns
Parental relationship	4.09 (0.88)	4.1 (0.87)	4.08 (0.88)	ns
N	457	187	270	

Notes: Samples include 457 childless individuals with no missing value for variables in the table. Gender differences were assessed by t-tests for continuous variables and χ² tests for categorical variables. *** if $p < 0.001$; ** if $p < 0.01$; * if $p < 0.05$, "ns" (not statistically significant), otherwise.

increasing to 68.2 % in their 30 s, compared to 38 % and 43.9 % of men for the same periods. Additionally, slightly over half (51.4 %) of respondents reported having moderate or high job flexibility, and 44.2 % had access to generous family leave during their prime reproductive years, with women having greater access than men.

4.2. Typology of pathways to childlessness

We employed LCA to derive a typological structure underlying the various pathways to childlessness. Based on fit statistics (reported in Supplementary Table A2) and theoretical interpretability, we selected a five-class LCA model with the lowest BIC score and a high entropy of 0.93. Table 2 presents the distribution of childless individuals' partnership, educational, and occupational characteristics during their 20 s and 30 s across the five latent classes. We assigned them labels based on key features of each latent class, ordered by size as follows: the Never-Married Semi-Professionals (N = 201, 41.1 %), the Low-Flex Blue-Collars (N = 99, 20.3 %), the Highly Educated Professionals (N = 69, 14.1 %), the Ever-Married Semi-Professionals (N = 62, 12.7 %), and the Flexible Blue-Collars (N = 58, 11.9 %).

The Never-Married Semi-Professionals, comprising 41.1 % of childless respondents, is the largest group among all five. This group is predominantly characterized by singlehood and semi-professional occupations during their prime reproductive years. A vast majority (92.5 %) attained secondary or post-secondary education, with very few having only primary or lower education. Less than half (43.8 %) reported having moderate or high job flexibility, and a similar proportion (44.3 %) had access to generous family leave.

The second largest group, *the Low-Flex Blue-Collars*, represents 20.3 % of the sample and is characterized by blue-collared occupations with limited flexibility and access to generous family leave. Almost all individuals were blue-collared workers in their 20 s, with a small portion (8.2 %) transitioning to semi-professional roles in their 30 s. The majority reported low job flexibility (75.8 %) and lacked access to generous family leave (90.2 %). In terms of education, 72.7 % had primary education or less. Their partnership pathways, in which 76.8 % had never been married, were close to the sample average (76.2 %). Among those who were married, slightly over half (52.2 %) were married late, 13 % experienced divorce, and 52.2 % reported infertility.

The third group, *the Highly Educated Professionals* (14.1 %), consists of childless individuals who were highly educated (e.g., having post-secondary education) and predominantly worked in professional occupations during their 20 s and 30 s. More than half reported having moderate or high job flexibility (59.4 %) and access to generous family leave (55.1 %). Their partnership pathways did not differ much from the sample average.

The fourth group, *the Ever-Married Semi-Professionals,* (12.7 %), consists of individuals who had all been married during their prime reproductive years but remained childless. A substantial proportion of them were married late (67.7 %) and reported infertility (62.9 %), and 21 % experienced divorce before age 40. Their educational and occupational characteristics resembled those of the Never-Married Semi-Professionals. Approximately 87.1 % had secondary or post-secondary education, and 82.3 % and 98.4 % held semi-professional occupations during their 20 s and 30 s, respectively. Two-thirds (67.7 %) reported moderate or high job flexibility, but only 37.1 % had access to generous family leave.

The last and smallest group was labelled *the Flexible Blue-Collars* (11.9 %). While many individuals (72.4 %) in this group reported having blue-collar occupations in their prime reproductive years, 25.9 % had never worked during their 20 s and 30 s. Over three-quarters (77.3 %) had never been married during their prime reproductive years. Among those married, 41.7 % were married late or divorced, and 33.3 % reported infertility. Regarding education, 69.0 % had low education, 29.3 % had middle education, and only one individual was highly educated. Though similar to the Low-Flex Blue-Collars in educational and occupational characteristics, this group differs notably as all its employed members had moderate or high job flexibility and access to generous family leave.

4.3. The uneven and stratified distribution of pathways to childlessness

Table 3 presents the marginal effects and robust standard errors from multinomial logistic regressions that examine the sociodemographic correlates of pathway types. These correlates include gender, birth cohort, race, nativity status, sibship size, father's education, childhood economic well-being, childhood health, and parental relationship during the time when the respondent grew up. In the supplementary

Table 2
Distributions and Probabilities of Pathway Indicators across Latent Classes.

	The Never-Married Semi-Professionals	The Low-Flex Blue-Collars	The Highly Educated Professionals	The Ever-Married Semi-Professionals	The Flexible Blue-Collars
Timing of first marriage					
Never	0.96	0.77	0.77	0.00	0.77
Early/on-time	0.01	0.11	0.09	0.32	0.12
Late	0.03	0.12	0.15	0.69	0.10
Marital disruption before age 40					
No	1.00	0.97	0.97	0.77	0.91
Yes	0.01	0.03	0.03	0.23	0.09
Self-reported Infertility					
No	0.92	0.83	0.85	0.33	0.83
Yes	0.08	0.17	0.15	0.67	0.17
Education					
Low	0.08	0.72	0.00	0.12	0.70
Middle	0.46	0.27	0.00	0.42	0.28
High	0.46	0.01	1.00	0.46	0.02
Occupation in 20 s					
Non-employed	0.00	0.00	0.00	0.00	0.27
Blue-collared	0.02	0.99	0.02	0.14	0.71
Semi-pro	0.97	0.01	0.16	0.83	0.02
Professional	0.01	0.00	0.83	0.04	0.00
Occupation in 30 s					
Non-employed	0.00	0.00	0.00	0.00	0.24
Blue-collared	0.01	0.92	0.00	0.02	0.61
Semi-pro	0.99	0.09	0.08	0.98	0.15
Professional	0.00	0.00	0.93	0.00	0.00
Job flexibility in 20 s & 30 s					
Low	0.55	0.76	0.40	0.34	0.00
Moderate or high	0.45	0.24	0.60	0.66	1.00
Family leave in 20 s & 30 s					
No	0.56	0.90	0.45	0.64	0.00
Yes	0.44	0.10	0.55	0.36	1.00
N = 489	201	99	69	62	58
Distribution	41.1 %	20.2 %	14.1 %	12.7 %	11.9 %

Notes: Latent classes are reordered by size

Table 3
Marginal Effects and Robust Standard Errors from Multinomial Logistic Regressions Predicting Pathway Types by Sociodemographic Characteristics.

	The Never-Married Semi-Professionals	The Low-Flex Blue-Collars	The Highly Educated Professionals	The Ever-Married Semi-Professionals	The Flexible Blue-Collars
Female	0.17 ***	-0.19 ***	-0.03	0.08 *	-0.03
	(0.04)	(0.04)	(0.04)	(0.04)	(0.03)
Year of birth	0.00	-0.01 *	0.01 **	-0.00	-0.00
	(0.00)	(0.00)	(0.00)	(0.00)	(0.00)
Chinese	0.01	-0.06	0.05	0.07	-0.08
	(0.07)	(0.06)	(0.05)	(0.07)	(0.04)
Foreign-born	-0.18 *	0.03	0.12 **	0.09	-0.05
	(0.08)	(0.07)	(0.04)	(0.06)	(0.08)
Siblings	-0.01	0.02 **	-0.03 ***	0.01	0.01
	(0.01)	(0.01)	(0.01)	(0.01)	(0.01)
Father's education (ref = low)					
Middle	0.01	-0.05	0.14 *	0.00	-0.10 **
	(0.07)	(0.06)	(0.05)	(0.06)	(0.03)
High	-0.05	-0.24 ***	0.16 *	0.26 *	-0.13 ***
	(0.09)	(0.03)	(0.08)	(0.11)	(0.03)
Childhood economic well-being	0.04	-0.08 *	0.00	0.02	0.01
	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)
Childhood health	-0.01	0.04	0.04	-0.05	-0.02
	(0.04)	(0.04)	(0.03)	(0.03)	(0.02)
Childhood parental relationship	0.02	0.02	-0.02	-0.02	0.00
	(0.03)	(0.03)	(0.02)	(0.03)	(0.02)

Notes: Each cell reports marginal effects with robust standard errors in parentheses, derived from multinomial logistic regressions. N = 457. Wald Chi-squared= 2646.45 at Df of 40. Pseudo R-squared= 0.143. *** if $p < 0.001$; ** if $p < 0.01$; * if $p < 0.05$.

materials, we reported the descriptive statistics of sociodemographic characteristics by latent class in Supplementary Table A3, and relative risk ratios from the multinomial logistic regressions in Supplementary Table A4.

First, pathways to childlessness differed significantly by gender.

Holding all other variables constant, we calculated the probabilities of belonging to each type of pathway by gender (calculation not shown here). Men displayed greater heterogeneity in their pathways to childlessness than women. Net of covariates, their probabilities of each pathway type, except for the Flexible Blue-Collars, were relatively

evenly distributed: 28.1 % through the Ever-Married Semi-Professionals, 23.0 % through the Highly Educated Professionals, 21.2 % through the Low-Flex Blue-Collars, 20.7 % through the Never-Married Semi-Professionals, and 7 % through the Flexible Blue-Collars. In contrast, women's pathways were more skewed: most commonly via the Ever-Married Semi-Professionals (37.8 %) and the Never-Married Semi-Professionals (34.7 %) pathways, followed by the Highly Educated Professionals (16.1 %), the Low-Flex Blue-Collars (6.7 %), and the Flexible Blue-Collars (4.7 %). Gender comparisons further revealed that women were significantly more likely than men to become childless via the Ever-Married Semi-Professionals and the Never-Married Semi-Professionals pathways—both associated with relatively advantageous socioeconomic status and polarized partnership characteristics (presence vs. absence of marriage). Men were overrepresented in the Low-Flex Blue-Collars pathway.

Aside from gender, nativity status and sibship size were also significant demographic correlates. While we did not find any statistically significant variations by ethnicity, we observed that childless individuals with larger sibship size tended toward the Low-Flex Blue-Collars pathway and away from the Highly Educated Professionals pathway. Additionally, compared to their native-born counterparts, foreign-born childless individuals were 12.1 % more likely to be categorized in the Highly Educated Professionals pathway and 18.4 % less likely to be in the Never-Married Semi-Professionals pathway. This observed pattern may be partially attributed to the selectivity of Singapore's immigration policy, which favors highly educated and married individuals (Yeoh & Huang, 2011).

Family background, including father's education and childhood circumstances, also influenced the pathways to childlessness. Individuals from more privileged backgrounds—such as those with higher paternal education or better financial conditions during childhood—were more likely to follow the Highly Educated Professionals pathway and less likely to follow socioeconomically disadvantaged pathways such as the Low-Flex Blue-Collars and the Flexible Blue-Collars. No significant associations were found between pathway types and childhood health or parental relationship.

4.4. Cohort variations and the second demographic transition

To explore demographic changes over time, we further examined cohort variations using multinomial regression, as summarized in Table 3, and visualized the changing prevalence of pathway types across cohorts in Fig. 1. Results show that childless individuals in younger birth cohorts were more likely to belong to the Highly Educated Professionals and less likely to follow the Low-Flex Blue-Collars pathway. Holding all sociodemographic characteristics constant, an individual born in 1971 (the youngest cohort in our analytic sample) had a 46.7 % chance of being categorized as Highly Educated Professionals, which was 3.3 times and 1.8 times higher than those born in the 1950s and 1960s, respectively. Conversely, the likelihood of following the Low-Flex Blue-Collars pathway was only 8.5 % for the youngest cohort, which was 51.7 % and 30.6 % lower than those born in the 1950s and 1960s, respectively. We did not observe any significant cohort variations in the other three groups, namely, the Never-Married Semi-Professionals, the Ever-Married Semi-Professionals, and the Flexible Blue-Collars.

Next, we looked specifically into the prevalence of voluntary childlessness within marriage across cohorts. We considered childless individuals who were married and did not report infertility during their prime reproductive years as being voluntarily childless. After omitting cohorts earlier than 1950 due to their small number of observations, the study found a significantly increasing trend in voluntary childlessness across the 1950–1971 cohorts, as visualized in Fig. 2. Coefficients of both the slope (0.01) and the Pearson correlation (0.65) were significant at the 0.05 significance level. These results suggest that voluntary childlessness within marriage has become increasingly prevalent among childless Singaporeans, corroborating the decoupling of marriage and childbearing under the SDT.

Lastly, we evaluated the overall degree of heterogeneity in pathways to childlessness by cohort, excluding those born before 1950 due to their small number of observations. As illustrated in Fig. 3, the Shannon's entropy index increased across the 1950–1971 cohorts, with the coefficient (0.04) of the slope being significantly different from zero. The increasing degree of heterogeneity suggests that pathways to childlessness have become less standardized and more diverse among younger cohorts, reflecting a plurality of life course options to become childless. Thus, the de-standardization of the life course under the SDT is validated.

5. Discussion

Using latent class analysis (LCA), this study uncovered diverse pathways to permanent childlessness among middle-aged and older Singaporeans born before 1972 (age 50 and over in 2022). We identified five distinct pathway profiles: the Never-Married Semi-Professionals,
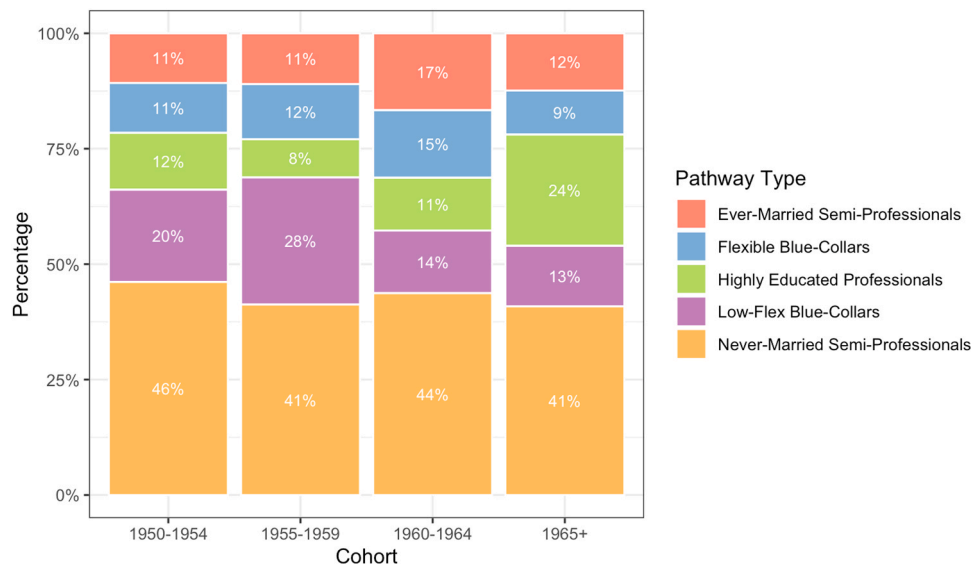

Fig. 1. Changes in the Prevalence of Pathway Types Across Cohorts Notes: Due to small sample sizes in each birth year, respondents were categorized into four cohort groups: 1950–1954, 1955–1959, 1960–1964, and post-1965. Percentages, calculated by each cohort group, may not sum up to exactly 100 % due to rounding.
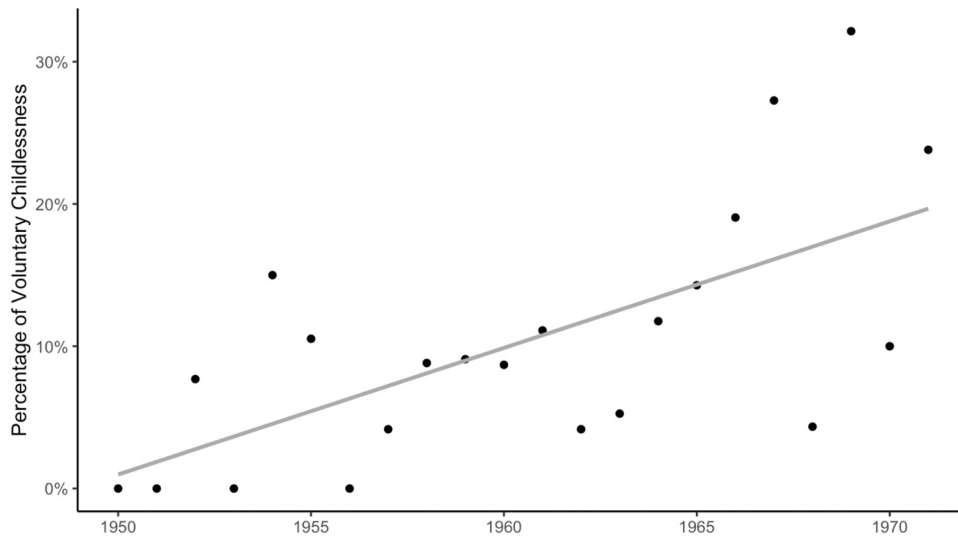
Fig. 2. The Percentage of Voluntarily Childless Individuals across Cohorts Notes: Childless individuals who were ever married and did not report infertility during their prime reproductive years were considered as being voluntarily childless. X-axis denotes cohort, and the y-axis denotes the cohort-specific percentage of voluntary childlessness. Cohorts earlier than 1950 were omitted due to limited sample size (less than 10 individuals per cohort). The regression line was identified by a bivariate regression predicting the percentage by cohort and had a slope of 0.01, significantly different from zero at the 0.05 significance level.
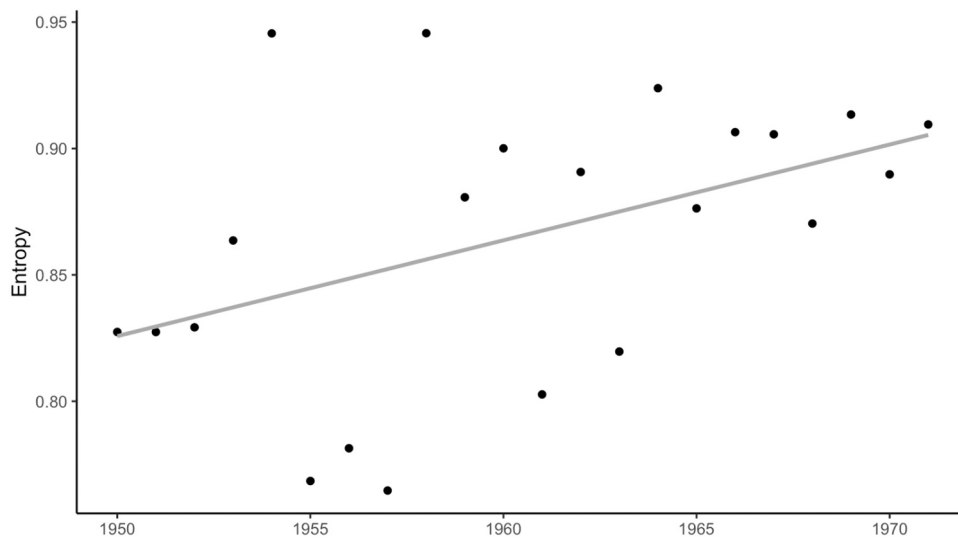
Fig. 3. The Degree of Heterogeneity in Pathways to Childlessness across Cohorts Notes: Shannon's entropy index is defined by $H(X) = -\sum \frac{p(x_i)\ln(p(x_i))}{\ln(n)}$ where $p(x_i)$ is the probability of taking the discrete value x_i in X, n is the number of unique values in X, Σ denotes the sum of possible values after normalization.

the Low-Flex Blue-Collars, the Highly Educated Professionals, the Ever-Married Semi-Professionals, and the Flexible Blue-Collars. These profiles were significantly associated with respondents' sociodemographic characteristics such as gender, nativity status, sibship size, and family background. Notably, we also found evidence consistent with the SDT which highlights not only an increase in voluntary childlessness within marriage across successive cohorts but also a growing heterogeneity in pathways to childlessness in Singapore.

Our findings provide new insights into the dynamic process regarding how Singaporeans reached midlife and late adulthood without having their own children. Evidence shows that the three life domains—partnership, education, and occupation—were interdependent and of distinct significance to childless individuals across different pathway profiles. Individuals in the Ever-Married and Never-Married Semi-Professionals pathways were distinguished from the rest by not only their relatively advantageous socioeconomic status but also their polarized partnership pathways through either singlehood or marriage.

The childless in the remaining three pathways—the Low-Flex Blue-Collars, the Highly Educated Professionals, and the Flexible Blue-Collars—differed from one another by educational and occupational characteristics.

With these findings, the study highlights that the rising prevalence in childlessness is a multi-faceted phenomenon influenced by life events from multiple domains. Specifically, partnership remains crucial in determining childlessness. Consistent with past research, our findings indicate that forgone, delayed, or disrupted marriages, as well as infertility, are key characteristics of the partnership domain among childless individuals in Singapore (Heaton et al., 1999; Keizer et al., 2008; Koropeckyj-Cox & Call, 2007). By examining the within-group heterogeneity, the study further points out that the Never-Married Semi-Professional pathway was the most prevalent, and women were more likely than men to have this pathway profile. This further corroborates with findings indicating that the absence of marriage remains a key determinant of childlessness, particularly for childless women.

Nevertheless, there has been a significant increase in voluntary child-lessness within marriage among younger cohorts, suggesting new dynamics in the partnership pathway to childlessness that aligns Singapore with the decoupling hypothesis of the SDT framework.

Moreover, by simultaneously considering educational and occupational domains, the study reveals changing socioeconomic characteristics of pathways to childlessness. First, the Highly Educated Professionals have become more prevalent across successive cohorts, accompanied by a decline in the Low-Flex Blue-Collars. This echoes several key factors behind the rising trends in childlessness, including career prioritization over family and childbearing obligations (Les-thaeghe, 2010; Yeung & Hu, 2018), as well as the growing incompatibility between higher education and marriage, especially on-time marriage (Matysiak, 2009; Matysiak & Vignoli, 2008; Raymo et al., 2015). Second, the socioeconomic characteristics of pathways to childlessness differed by gender (Nisén et al., 2018; Trimarchi & Van Bavel, 2017). Men were more likely than women to follow the Low-Flex Blue-Collars pathway, and on average, had much lower education and occupational status than childless women. Given Singapore's prevailing norms of homogamy and female hypergamy, these men were likely squeezed out of the marriage market, thus failing to find a partner and remaining childless (Jones, 2012). Third, the socioeconomic differentials among childless individuals were deeply rooted in their family background and childhood experience. Those from less privileged families were overrepresented in relatively disadvantageous pathways to childlessness, such as the Low-Flex Blue-Collars and the Flexible Blue-Collars. Lastly, the study finds that the majority of Low-Flex Blue-Collars and slightly under half of childless individuals in other pathway profiles did not have moderate to high job flexibility or access to generous family leave, suggesting that pathways to childlessness may be partially driven by the lack of such structural support in workplace.

We further examined cohort variations to unveil temporal changes in pathways to childlessness. In addition to the decoupling between marriage and childbearing as well as the changing prevalence of the Highly Educated Professionals and the Low-Flex Blue-Collars pathways, we also found that these pathway profiles have overall become increasingly heterogeneous across successive cohorts, thus supporting the de-standardization of the life course. Now with a plurality of life course options such as voluntarily opting out of childbearing within marriage, younger cohorts in our sample follow less standardized and more individualized pathways to childlessness.

These new dynamics in pathways to childlessness—namely, the decoupling of marriage and childbearing and the de-standardization of the life course—further illuminates the diversity of demographic transitions in Asian countries that share the commonality of sustained low fertility rates. In South Korea, while the connection between marriage and childbearing has remained largely intact (Choi & Qian, 2023; Lim, 2021), the country has shown signs of a de-standardized life course similar to our findings in Singapore (Park & Koropeckyj-Cox, 2022). Life course trajectories during the transitions to adulthood have become increasingly varied among Koreans born between 1970 and 1985. In contrast, the life course in Japan and China has remained relatively standardized—a notable difference from predictions of the SDT theory. Rindfuss and colleagues (2010), for example, indicated that young Japanese responded to demographic transitions in a fairly orderly manner, closely adhering to traditional familial expectations such as childbearing within marriages. In China, scholars have found that partnership and fertility-related life trajectories remained largely homogenous and to some extent, increasingly standardized, amidst the recent decline in marriage and birth rates (Van Winkle & Wen, 2023; Wang & Feng, 2023; Wang & Zhao, 2021). Taking the evidence together, we conclude that compared with other Asian countries with comparably low fertility rates, Singapore appears to align more closely with the SDT.

The study is not without limitations. First, due to the lack of detailed time-stamped data, we chose LCA, which allows for the inclusion of a broader spectrum of observed characteristics, irrespective of whether they have time-stamped information. However, LCA does not capture the sequential ordering, timing, and duration of life events as comprehensively as sequence analysis. This limitation hinders our ability to fully investigate the chronological order of partnership, education, and occupation, as well as to explore the extent to which prioritizing higher education and career advancement might postpone marriage.

Moreover, our study did not consider cohabitation as a determinant of permanent childlessness for multiple reasons. First, our survey data lack information on respondents' cohabitation history. Next, cohabitation is relatively rare in Singapore, particularly among middle-aged and older Singaporeans. According to wave 7 (2020) of the World Value Surveys (WVS-7), only 0.7 % of Singaporeans cohabited at the time of the survey. These estimates are comparable to figures in other Asian countries (Raymo et al., 2015; Yu & Xie, 2015; Yeung & Hu, 2018). Given that cohabitation may become more common (albeit still low) among younger cohorts (1.8 % among Singaporeans aged 30–49 in WVS-7), future research could consider examining the contribution of cohabitation in the pathways to permanent childlessness.

Furthermore, while our study included a comprehensive set of partnership, education, and occupation indicators in the LCA, we acknowledge that several other factors crucial to understanding childlessness trajectories were not incorporated in our analyses. For instance, our survey data lacks information regarding job instability and temporary unemployment during one's reproductive years, which has been shown to negatively impact fertility intentions (Alderotti et al., 2021; Fang et al., 2013). Additionally, health factors such as chronic illnesses may also influence pathways to childlessness for both men and women (Hanson et al., 2017; Winters & Walsh, 2014). A more holistic understanding of the diverse, interdependent pathways to childlessness will benefit from the inclusion of these factors.

Despite these limitations, our study has important implications for future research and policies. First, the rise in voluntary childlessness within marriage calls for a deeper investigation into the underlying motivations and potential barriers, which are crucial for developing targeted policies to incentivize marital childbearing. Second, the heterogeneity in pathways to childlessness suggest that fertility-promoting policies may need to adopt a gender-sensitive and multi-pronged approach, addressing issues in partnership, education, and the labor market simultaneously. For men, particularly those with lower socioeconomic status who are likely to follow the Low-Flex Blue Collars pathway, policies enhancing their educational and occupational opportunities could indirectly facilitate their entry into the marriage market and increase their likelihood of becoming fathers. For women, especially those in the Never-Married Semi-Professionals and the Highly Educated Professionals pathways, policies harmonizing their career and motherhood aspirations could be key to increase childbearing.

In brief, our study provides evidence on the diversity of pathways to permanent childlessness in Singapore—an Asian setting with one of the world's highest childlessness rates among its middle-aged and older populations and lowest fertility rates. While conventional pathways to childlessness, such as singlehood and women's trade-offs between career and childbearing, remain prevalent, new diverse pathways have emerged among younger cohorts. A noteworthy finding is the rise in voluntarily childless married couples and the growing plurality of pathways that younger birth cohorts may follow to become childless, both aligning with the SDT framework. This study represents an initial exploration of new dynamics in the pathways to childlessness in Singapore. We call for future research to address the limitations identified in our study. This includes the adoption of sequence analysis to capture the sequential ordering, timing, and duration of life course events more precisely, contingent upon data availability. Future studies may also examine cohabitation and other sociodemographic factors that are pertinent to childlessness and investigate the fertility intentions of younger generations who have yet to complete their reproductive careers. Additionally, we recommend that future research delves deeper into the unique experiences of childless individuals, addresses the

specific needs and concerns of various subgroups, and develops multi-faceted policy measures that are sensitive to this diversity.

CRediT authorship contribution statement

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Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.alcr.2024.100628.

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