Shared Lifetime and Years of Shared Life Lost

Amanda Martins de Almeida[1,2*]

[1]Max Planck Institute for Demographic Research
[2]Interdisciplinary Centre on Population Dynamics, University of Southern Denmark

Abstract

The life courses of individuals intersect with those of their relatives, resulting in shared lifetimes that are shaped by mortality and fertility processes. The demographic transition has fundamentally reshaped family structures by reducing fertility and mortality, altering both the number and types of living relatives. However, the temporal dimension of kinship, that is, the amount of time individuals share with their relatives, remains largely unexplored. The present study introduces two formal demographic indicators to quantify this aspect: Shared Lifetime (SLT) and Years of Shared Life Lost (YSLL). SLT measures the expected amount of time a child and their mother are simultaneously alive, reflecting intergenerational exposure and potential for support. YSLL captures the loss of potential SLT due to the death of the mother or the child. Using age-specific fertility and mortality data from the United Nations World Population Prospects (1950 and 2023), I estimate SLT under stable population assumptions for all countries. The findings indicate a consistent rise in SLT between the years. However, substantial cross-national disparities persist: in 1950, a woman born in Germany could expect to share 42 years with her mother compared with 16 in Kenya; by 2023, both increased, but the gap remained large. These findings indicate that demographic change not only modifies kin availability but also impact the duration of intergenerational interactions. Incorporating temporal measures such as SLT and YSLL into kinship demography provides new insight into the lived experience of family ties and the intergenerational transmission of resources, care, and inequality.

1 Introduction

The demographic transition is a well-documented process in which populations shift from high mortality and high fertility to low mortality and low fertility, resulting in fewer offspring and longer lifespans. As Verdery (2015) argues, this demographic transition is accompanied by a parallel "kinship transition". The structure and size of individuals' kin networks are fundamentally shaped by demographic processes, these patterns determine the number and composition of living relatives across the life course.

Despite increasing interest among researchers in the availability and loss of kin, one important dimension has been overlooked: how much time individuals actually spend with their relatives. Time spent with relatives, especially close relatives such as mothers, has profound implications for the transmission of resources, care, and emotional support. Yet, little is known about how the duration of these relationships has changed over time or differs across countries.

Mothers, in particular, play a foundational role in their children's lives. Since every individual has only one biological mother, traditional demographic analyses of kin transitions (based on counts) offer limited insight into the experience of maternal presence. The extent to which kinship transitions involve changes in time spent with key relatives, specifically mothers, remains unexplored.

This study addresses this gap by introducing two formal demographic indicators that capture the temporal dimension of mother-child relationships across demographic contexts: Shared Lifetime (SLT) and Years of Shared Life Lost (YSLL). SLT measures the expected number of years an individual will share with their

mother, the period during which both are alive and able to interact, also known as intergenerational or multigenerational exposure (Song & Mare, 2019). YSLL, by contrast, quantifies the potential years of shared life lost due to the death of the mother or the child.

2 Analytical approach

2.1 Data

The analysis uses age-specific fertility rates and life tables from the United Nations World Population Prospects (UNWPP). The annual estimates of mortality and fertility for females from 1950 and 2023 were obtained at https://population.un.org/wpp/downloads?folder=Standard%20Projections&group=Mortality.

2.2 Measures

2.2.1 Shared Lifetime

Substantial research has been conducted to derive kinship numbers from age-specific fertility and mortality rates (Keyfitz & Caswell, 2005). Lotka (1931) and Goodman et al. (1974) demonstrated that the probability that a female of age a has a surviving mother, given a specified regime of fertility and mortality, is given by:

$$M(a) = \int_{\alpha}^{\beta} \frac{l(x+a)}{l(x)} e^{-rx} l(x) m(x)\, dx \tag{1}$$

Equation (1) does not require that the child born at age a is still alive; it gives the probability that the mother is alive, regardless of the survival status of the child. To measure the duration during which both mother and child are alive, I estimate their joint survival by incorporating child mortality. Since both mother and child are alive at time zero (when the child is born), $l_0 = 1$ for both. Therefore, the joint survival $l(a)$ is the multiplication of the probability of having a living mother ate age a, denoted by $M(a)$ and the and probability the child is alive at age a, denoted by $l_c(a)$.

$$l(a) = M(a) \cdot l_c(a) \tag{2}$$

Equation (2) provides the l_x column of a joint life table for the mother and child, beginning at 1 when both are alive at the child's birth and declining thereafter. Given this joint survival function, I construct the remaining life table columns, following the standard demographic approach (Preston et al., 2001), and assume that ${}_n a_x = 0.5$, deaths occur at the midpoint of each age interval. As the radix of the joint life table is 1, the expected Shared Lifetime (SLT) at birth is given by:

$$SLT_0 = \int_{a=0}^{\omega} l(a)\, da \tag{3}$$

The Shared Lifetime (SLT) represents the expected amount of time a child and their mother are both alive. This measure accounts for the survival of both individuals, from the perspective of the unit mother-child.

2.2.2 Years of Shared Life Lost

As shown in Section 2.1.1, there is a relationship between life expectancy and the Shared Lifetime between mother and child. I propose that $e^{\dagger}$, an index of lifespan inequality, can be used to estimate the average

number of shared years lost due to the death of either the mother or the child. This measure captures life disparity, the number of life-years lost as a result of death (Vaupel & Romo, 2003). I refer to this measure as the Years of Shared Life Lost (YSLL). $e^{\dagger}$ is defined as:

$$e_x^{\dagger} = \sum_{x=0}^{\infty} e_x \cdot d_x \tag{4}$$

Where e_x is the life expectancy at age x, and d_x is the number of deaths at age x. Years of Shared Life Lost (YSLL) is defined as:

$$YSLL = \sum_{x=0}^{\infty} SLT_x \cdot d_x \tag{5}$$

Where $SLT(x)$ is the expected Shared Lifetime at age x, and d_x is the number of deaths (mother and/or child) at age x. The YSLL quantifies the loss of potential SLT due to mortality and parallels the interpretation of $e^{\dagger}$ in lifespan inequality, but is applied to the joint survival of mother and child.

3 Results - Shared Lifetime

This section presents the results for the first indicator proposed, the Shared Lifetime (SLT), at two points in time—1950 and 2023—under the assumption of a stable population and using female-specific fertility and mortality rates. The results can be interpreted as the expected SLT at birth between a mother and daughter, if both were subject to the demographic conditions (i.e., age-specific fertility and mortality rates) of 1950 and 2023, respectively.

A woman born in Germany in 1950 is expected to live around 42 years with her mother, while, in the same year, a woman born in Kenya is expected to live approximately 16 years with her mother. As expected, an increase in the SLT was observed for all countries between 1950 and 2023, likely due to the improvement in survival rates for both mother and child. Nevertheless, disparities between countries persist. In 2023, African countries demonstrated the lowest SLT, while European countries were among those with the highest.

These results provide a significant opportunity for discussion on the potential implications of maternal time spent with the child, since this time may serve as a cumulative reserve throughout a child's life. According to Cullati et al. (2018), resources serve immediate needs, while reserves are built through accumulated resources and are drawn upon in times of adversity. Maternal support over time may therefore accumulate into reserves that buffer individuals against risks in later life. Unequal access to maternal presence could represent a mechanism through which inequality is reproduced.

The following step in this research project will consist of implementing the YSLL measure and employing the SLT and YSLL indicators within a time-varying framework. This framework will enable the estimation of the SLT and YSLL experienced by the mother and child in a non-stable population.

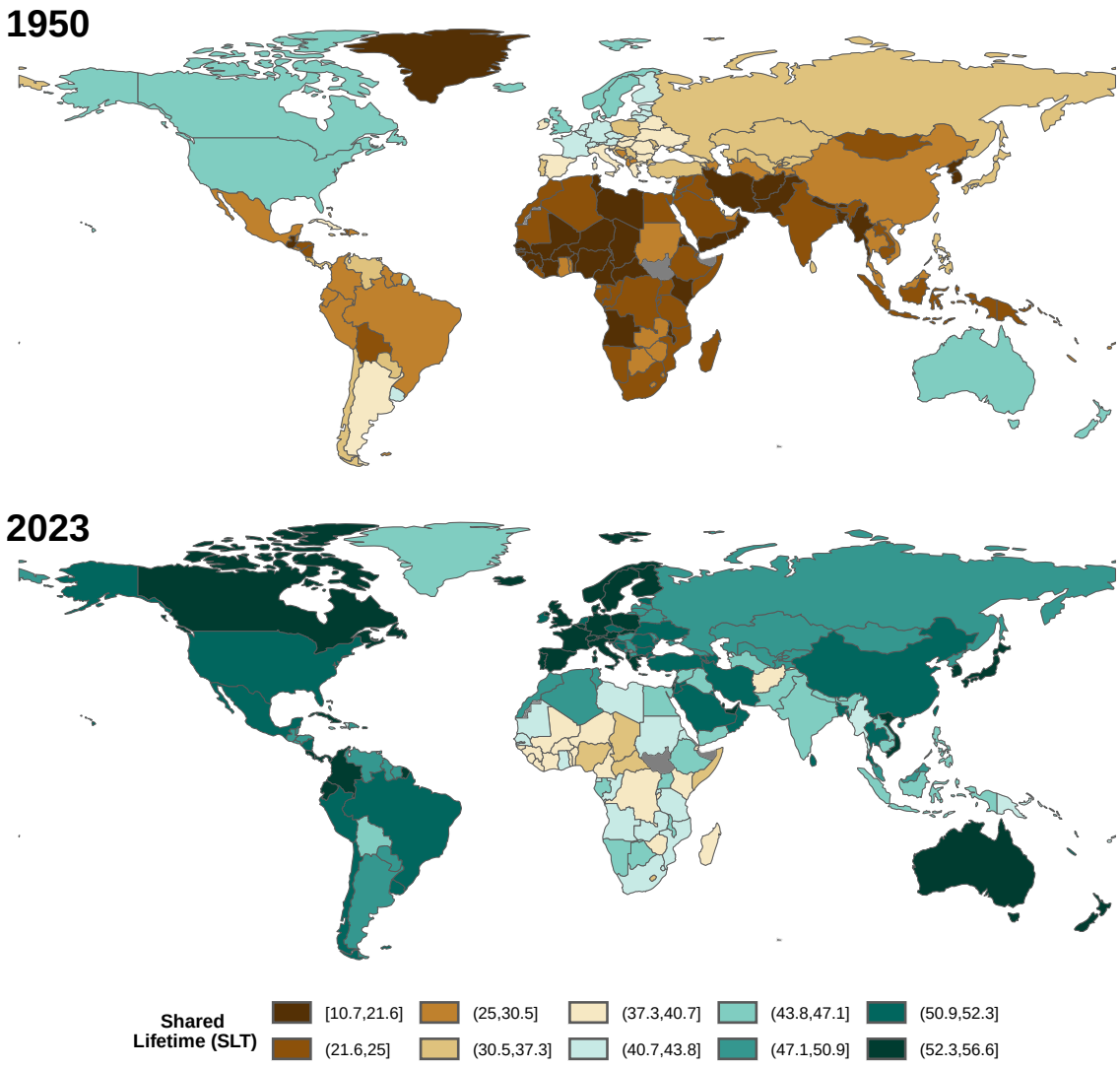

Figure 1: Shared Lifetime in 1950 and 2023.
Note: Stable population assumption.

References

Lotka, A. (1931). Orphanhood in relation to demographic factors. *9*(2), 37–109.

Goodman, L. A., Keyfitz, N., & Pullum, T. W. (1974). Family formation and the frequency of various kinship relationships. *Theoretical Population Biology*, *5*(1), 1–27. https://doi.org/10.1016/0040-5809(74)90049-5

Preston, S. H., Heuveline, P., & Guillot, M. (2001). *Demography: Measuring and modeling population processes* (Nachdr.). Blackwell.
Includes bibliographical references and index.

Vaupel, J. W., & Romo, V. C. (2003). Decomposing change in life expectancy: A bouquet of formulas in honor of Nathan Keyfitz's 90th birthday. *Demography*, *40*(2), 201–216. https://doi.org/10.1353/dem.2003.0018

Keyfitz, N., & Caswell, H. (2005). *Applied mathematical demography, 3rd edition*. Springer.

Verdery, A. M. (2015). Links Between Demographic and Kinship Transitions. *Population and Development Review*, *41*(3), 465–484. https://doi.org/10.1111/j.1728-4457.2015.00068.x

Cullati, S., Kliegel, M., & Widmer, E. (2018). Development of reserves over the life course and onset of vulnerability in later life. *Nature Human Behaviour*, *2*(8), 551–558. https://doi.org/10.1038/s41562-018-0395-3

Song, X., & Mare, R. D. (2019). Shared Lifetimes, Multigenerational Exposure, and Educational Mobility. *Demography*, *56*(3), 891–916. https://doi.org/10.1007/s13524-019-00772-8