Mortality, Fertility, and Economic Development:

An Analysis of 201 Countries during 1960-2010.

Summary

Background Rapid reductions in fertility and mortality during the last half-century caused a major favorable shift of population age structure in many countries, which has proven to be conducive to economic development. The efficient utilization of the economic opportunities that result from a favorable demographic transition is known as the demographic dividend. Given the well established relationship between favorable population age structure and spurred economic development, our aim is to estimate the contribution to the change in the dependency ratio from the decline of each component of demographic transition, fertility and mortality, during 1960-2010.

Methods We applied the cohort component method (CCM) to the data from 201 countries in the World Population Prospects: 2012 version (WPP) released by the United Nations (UN).

Findings The results of our study demonstrate large regional and country-level variations in the contributions from fertility and mortality declines to the change in dependency ratios during 1960-2010. The child dependency ratio would be 122% and 104% higher than the observed level in 2012 in Asian and Latin America and the Caribbean, respectively, had the fertility not declined. It would only be 13% higher if there was no fertility decline in SSA.

Interpretation The dependency ratio in SSA countries is still very high, mainly due to minimal reductions in fertility rates. SSA can accelerate the catch-up process by putting more effort into measures to reduce fertility, such as family planning. This will lead to a more favorable dependency ratio and consequently open the window of opportunity for a demographic dividend in SSA, which, if properly utilized, will spur economic development for the coming few decades.

Key words: fertility decline, reproductive health, dependency ratio, demographic dividend

Introduction

Rapid reductions in fertility and mortality during the last half-century caused a major favorable shift of population structure in many countries, which has proven to be conducive to economic development. Countries with a high proportion of working age population are better able to use their resources for economic development due to reduced expenditures related to caring for children and the elderly. The efficient utilization of the economic opportunities that result from a favorable demographic transition is known as the demographic dividend.

Over two centuries ago, Malthus argued that unconstrained population growth would lead to catastrophic consequences because the amount of many production factors, such as land, is fixed.[1] Later, Solow proposed that even reproducible factors would be swamped by rapid population growth.[2] The variation of population growth rates is an important factor in explaining differences in long-term economic performance across countries. The implications of these two theories and many others are quite pessimistic for countries with sustained high fertility rates. The solution is to lower fertility and restrict population growth. In this framework, fertility decline results in a smaller total population, which in turn increases the ratio of fixed and reproducible factors to labor. Fertility decline also encourages investments in human capital, which has been recognized as another important production factor.[3, 4]

Moreover, fertility change leads to behavior change. Lower fertility means that women spend less time on the bearing and care of children, which translates into a higher female labor participation rate.[5]

In addition to the impacts on the density of production factors and individual-level behaviors, fertility also has a significant impact on population age structure. Lower fertility implies fewer children and a lower child dependency ratio. Holding other factors such as labor participation rate constant, a larger proportion of working age population automatically means more output per capita.

R. Lee and A. Mason refer to the demographic dividend discussed above as the first dividend and argue that a second dividend is also possible.[6] If people have reasonable expectations about the future consequences of declining fertility, i.e. a smaller working age population by the time they retire, they will begin to save and invest from an early age. This boosts the accumulation of assets in society and consequently has a positive impact on economic development. This is called the second demographic dividend.[6] Unlike the first dividend, which only lasts for a limited period of time, the second dividend can continue indefinitely with effective polices in place.

Many empirical studies identified a strong correlation between favorable population age structure and rapid economic growth.[7-9] It is estimated that as much as one-third of the economic growth in the "East Asia Miracles" was derived from demographic dividends.[8]

The relationship between economic growth and the ratio of children to working age population is illustrated in Figure 1. The vertical axis is the change in GDP per capita based on purchasing

power parity (PPP) and measured in constant 2011 international dollars. The horizontal axis is the average ratio of children (younger than 15 years) to working age (15-64 years old) population during 1990-2010. We used 1990, instead of 1960 as in subsequent sections, as the starting year since that is the first year with PPP converted GDP data in the World Bank database. Change and average for those two decades, instead of a cross section, are plotted so as to mitigate the impact of short-term fluctuations. All low- and middle-income countries (totally 85) in those four regions are included. The relationship between the economic growth and average ratio of children to working age population during the past two decades is consistent with findings in previous literature, and justifies our investigation of dependency ratio with the purpose to examine the relationship between mortality, fertility, and economic development. We run a simple regression model of the change in GDP per capita on the average ratio. The goodness of fit of the model is satisfactory with $R^2 = 0.54$. The slope of the linear fitted line is -102, i.e. one unit increase in the ratio is associated with a reduction of 102 international dollars in GDP per capita.

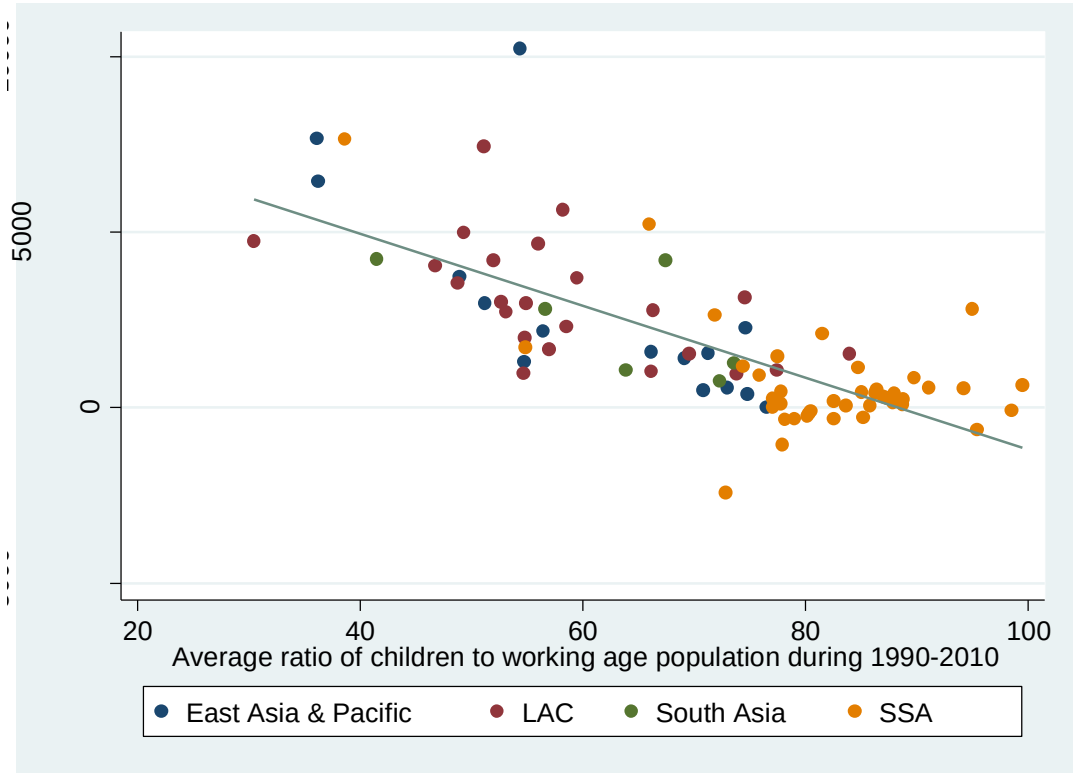

Figure 1: Change in GDP per capita and average ratio of children to working age population in Asia, LAC, and SSA during 1990-2010

Over the past few decades, SSA has stood as an outlier in both demographic transition and economic development. This study aims to investigate the reasons why SSA has not experienced the dramatic reduction in dependency ratio observed in other regions around the world. We want

to answer the question of whether SSA is any different in its opportunities to take advantage of a demographic dividend for economic development.

This paper is organized as follows. We begin with a brief discussion of indicators used to measure population age structure and fertility, which is then followed by the introduction of data and methods. Then we move on to the decomposition results for 201 countries. We also present graphical depictions of 50 years of regional fertility and dependency ratios to visualize a still ongoing transition process. In the last section we finish with a discussion and conclusion.

Summary measures of population age structure and fertility

Three types of dependency ratios are used to summarize the population age structure. Child dependency ratio only considers children under 15 years old as dependents and is defined as the ratio of the number of children aged 0-14 years over the working age population (i.e. aged 15-64 years). On the other end of the spectrum, aged dependency ratio only considers elders as dependents and is defined as the ratio of the number of people older than 65 years over the working age population. Total dependency ratio takes both children and elders into account and is equal to the sum of child and aged dependency ratios. As discussed above, numerous studies on demographic dividend have identified close associations between dependency ratios and economic development.

Some literature on the demographic dividend uses another indicator, support ratio, to measure the population age structure, which is defined as the ratio of producers to consumers. Child support ratio is the ratio of working age population to children younger than 15 years; aged support ratio has the same numerator but uses people older than 65 years as the denominator. Clearly support ratio is simply the inverse of dependency ratio. This study uses the dependency ratio since it has been widely accepted in the demography and health economics literature. Given the monotonic relationship between a dependency ratio and a support ratio, the conclusions derived using the former indicator equally apply to the latter indicator. There have been many recent debates regarding the cut-off ages for young and old dependents. We follow tradition and use 15 and 65 years as cutoffs for child and aged dependency ratio, respectively.

Total fertility rate (TFR) is the most commonly used measure of fertility. It is the number of children a woman would have over her lifetime if she were to experience the observed period age-specific fertility rates.[10] TFR is widely used due to its simplicity in calculation and intuitiveness in interpretation.

Data and methods

Data sources

We obtained data on the fertility, mortality, and population age structure for 201 countries during 1960-2010 from World Population Prospects (WPP), the 2012 Revision. It is the 23rd round of

official United Nations population estimates and projections, published in June 2013 by the Population Division of the Department of Economics and Social Affairs of the United Nations Secretariat.[11] This update incorporated the data from the 2010 round of population census in many countries and from a few recent demographic surveys. We conducted a decomposition analysis for 201 countries and 10 regions, with our interest mainly on SSA countries. Most figures and tables below are based on 186 countries in 5 regions that are of interest to this study.

Cohort component method (CCM)

The aim of this study is to estimate the contribution of fertility and mortality decline to the changes in dependency ratios by answering the following hypothetical question: what would the dependency ratio be in 2010 had there been no fertility and/or mortality decline during 1960-2010?

We use fertility and mortality "decline" in this paper because the fertility and mortality in most parts of the world have been declining during the past five decades. However, there are a few exceptions where the fertility and/or mortality actually increased during this period. Our analysis framework and results are valid for either direction of change. Declining fertility implies a lower dependency ratio while increasing fertility results in a higher ratio.

There are three determinants of population change in a country: births, deaths, and net international migration. Our projection considers the changes to population growth brought about by births and deaths, which usually account for an absolute majority of the change in a population. Due to the lack of quality data, we do not include international migration in the projection model. Migration is important only in countries with a large flow of migrant workers. Even in those countries, the flow of migrants is typically temporary and the impact on population projection is usually minimal.

Cohort component method (CCM) is a demographic projection method used by the UN to generate WPP reports. It uses a transition matrix to predict the population by age from one period to the next. Following WPP 2012, our projections were made for five-year intervals. The fundamental formula for the CCM is,

$$P_{t+5} = M_{t,t+5} * P_t$$

where P_t is a column vector whose elements are the age-specific population at calendar time t; P_{t+5} is the population vector for time $t + 5$. Our study used five-year age groups for ages up to 85, i.e. 0-4, 5-9, …, 80-84, 85+. $M_{t,t+5}$ is a transition matrix constructed from the age-specific fertility and mortality. Its elements are used to determine the births and deaths in each age group. The first row of matrix $M_{t,t+5}$ is the age group specific fertility rates divided by 2.05 to reflect the fact that P_t is counting both genders while only females are concerned in calculating the

number of births. Other elements of the transition matrix are survivorship for respective age groups.[1]

From 2010 the UN adopted a Bayesian hierarchical component to account for the uncertainty in the population projection. But the CCM component remains the same in the projection as before. The adoption of the Bayesian method changes the uncertainty in the projection of the future population, but does not affect the estimates of the past. Given the retrospective nature of the present study, our analyses did not incorporate the Bayesian component.

All of the 201 countries included in the WPP 2012 dataset are used in this study. We also conducted decomposition analyses at the regional level for 10 regions. In particular, population projections for the following three scenarios were made using Stata 13:

1. What would the dependency ratio be in 2010 if there had been neither fertility nor mortality reduction during 1960-2010?
2. What would the dependency ratio be in 2010 if there had been no fertility reduction during 1960-2010?
3. What would the dependency ratio be in 2010 if there had been no mortality reduction during 1960-2010?

Role of funding source

The funders of the research played no role in the research design, data analysis, results interpretation, and report writing. All authors had full access to all data in the research and had final responsibility for the decision to submit for publication.

Results

Globally, child and total dependency ratios declined significantly during 1960-2010 but with large country-level and regional variations. The declines in SSA are the smallest among the 5 regions showed in Figure 1---the median change in both child and total dependency ratios are close to zero. On the other hand, Asia and Latin America and Caribbean (LAC) have experienced quite dramatic changes in both fertility and dependency ratios, with median changes in the range of 30-40. This is consistent with the differences in economic growth across those regions during the same period.

The decompositions of the contribution from fertility and mortality declines to the change in dependency ratio were conducted at both region- and country-level. Table 1 shows the results from region-level decomposition and Tables A.1 and A.2 in the appendix have detailed results from country-level analyses. The results in Table 1 can be considered as the regional averages weighted by the population size of each country, while table A.2 are the un-weighted averages.

[1] We acknowledge Dr. Germán Rodríguez for making the Stata code to implement CCM available online.

The contribution of fertility decline to the change in the dependency ratio is smaller in SSA than in any other region. Table 1 shows the dependency ratios in 2010 and the contribution to the changes in dependency ratio from fertility and mortality decline in 10 regions. The child dependency ratio is 81 in SSA 2010 and it would have been 92 if there had been no fertility decline during 1960-2010, i.e. the child dependency ratio would be 13% higher without fertility decline. In Asia, the corresponding numbers are 38 and 84. In other words, the child dependency ratio in Asia 2010 would have been 122% higher than the observed value if no fertility decline occurred during 1960-2010. The fertility decline in LAC also dramatically reduced the region's child dependency ratio. Because most European countries had completed demographic transition by 1960, the fertility decline during 1960-2010 was minimal, which explains the marginal contribution of fertility reduction to the change in the child dependency ratio in the region.

Table 1: The contribution of fertility and mortality decline to the change in dependency ratio (DR) during 1960-2010 in 10 regions

	UN WPP 2012			CCM estimates under constant fertility and mortality						CCM estimates under constant fertility					
Region	Total DR	Child DR	Age DR	Total DR	% diff.	Child DR	% diff.	Aged DR	% diff.	Total DR	% diff.	Child DR	% diff.	Aged DR	% diff.
Sub-Saharan Africa (50)	87	81	6	86	-1	81	0	5	-16	97	12	92	13	6	-2
Northern Africa(7)	57	50	8	90	57	85	71	5	-30	106	84	100	102	6	-28
Asia(51)	48	38	10	80	69	75	101	5	-51	91	91	84	122	8	-25
Latin America and the Caribbean(38)	54	43	10	87	62	81	87	6	-40	96	78	88	104	7	-28
Europe(40)	47	23	24	56	20	38	68	18	-26	60	29	39	74	21	-13
Australia/New Zealand(2)	48	28	20	65	35	54	88	12	-41	70	45	54	88	17	-17
Melanesia(5)	69	64	5	87	26	84	31	3	-40	94	35	89	39	5	-15
Micronesia(3)	56	48	8	94	68	89	85	5	-38	100	79	94	95	6	-23
Northern America(2)	49	29	20	66	36	55	89	11	-43	70	44	55	91	15	-25
Polynesia(3)	59	50	10	100	68	96	93	4	-63	104	76	100	100	5	-49
World(201)	52	41	12	75	43	67	66	7	-38	83	59	73	81	9	-20

Note: the number of countries in each region is in the parenthesis.

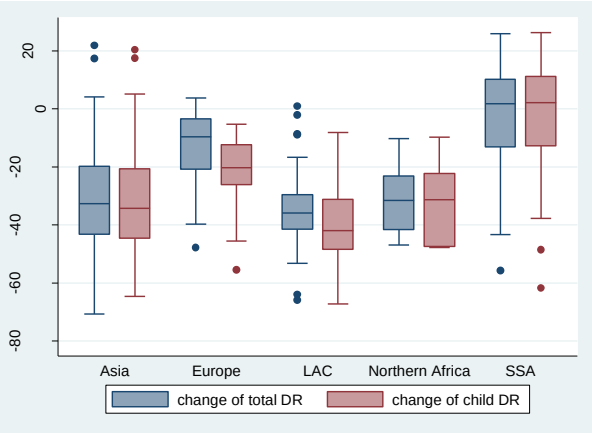

Figure 2: The change in child and total dependency ratios during 1960-2010 by regions in 186 countries in 5 regions

Overall, Figure 1 shows that both child and total dependency ratios have declined quite dramatically in Asia and LAC during the past five decades. However, SSA countries have experienced little changes in both ratios. The median change in total and child dependency ratios are close to 0. The remarkable variation in the change of dependency ratios warrants an investigation of the contributions from fertility and mortality decline to the changes in dependency ratio.

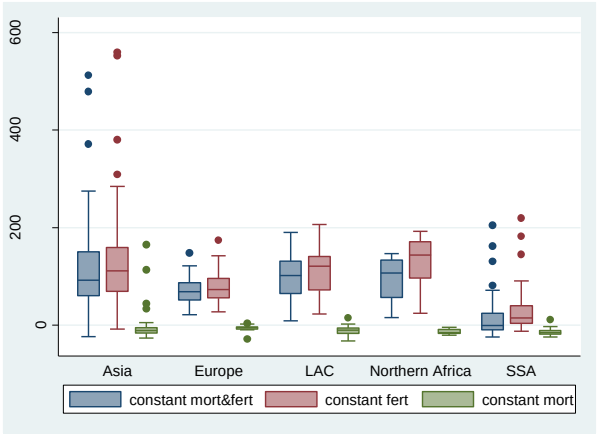

Figure 3: The percentage change in child dependency ratio in three fertility and mortality scenarios compared with UN data by regions in 186 countries in 5 regions

Our main results are illustrated in Figure 2. We simulated how much higher the child dependency ratio would be if mortality and/or fertility have been constant during 1960-2010. The percentage change in child dependency ratio is positive and large in the constant fertility scenario in Asia and LAC. The interpretation is that fertility decline has remarkably reduced the child dependency ratio in those two regions during 1960-2010. On the other hand, the percentage change in child dependency ratio is negative in the constant mortality scenario, but the size of the change is marginal. The combined effect of mortality and fertility changes is positive in all of those five regions, but the size is larger in Asia and LAC than in SSA. Given the focus of the present study on SSA and its comparison with Asia and LAC, the changes in Europe and North America will not be examined in detail.

In the following sections, we look at the relationship between initial fertility and the contribution of fertility decline to the changes in child and total dependency ratios. Figure 3 shows a clear positive relationship between initial fertility and the contribution of fertility decline to dependency ratios. The three outlier countries are Bahrain, United Arab Emirates, and Qatar. Their percentage changes are extremely large because their dependency ratios are very small in 2010 and would have been much higher had there been no fertility decline.

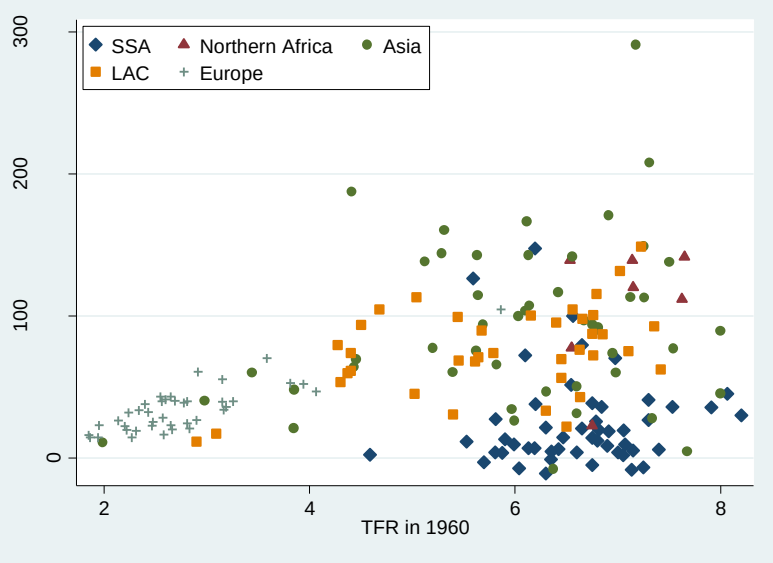

Figure 4: The relationship between total fertility rate in 1960 and the contribution of fertility decline to the change in total dependency ratio in developing countries during 1960-2010

Except for most SSA and several Asian countries, a higher TFR in 1960 is associated with a larger contribution of fertility decline to the change of dependency ratio. Most high-fertility Asian countries have experienced significantly reduced their TFR, which consequently resulted in a favorable change in dependency ratios. A similar change was not observed in high-fertility SSA countries during the same period.

Discussion

SSA: On the same trajectory as other regions but left behind in achieving a favorable DR

During the past five decades, fertility has rapidly declined around the world, with the exception of many SSA countries. Figure 4 show the historical trajectory of TFR and child dependency ratio during eth past four decades. The UN WPP data are for five-year interval, and in the figure we assigned the interval value to the middle point of the interval. For example, the TFR for the period 1970-1974 was assigned to the calendar time 1972.5. This is a common practice that facilitates graphical illustration without any substantial impact.

There are two immediate observations from Figure 4. First, both TFR and child dependency ratios were much higher in SSA than in other regions throughout the period 1960-2010. This is expected and consistent with our analyses above. Second, the relationship between TFR and child dependency ratio, shown as the slopes of the curves, are nearly identical across regions, although they were at different stages of demographic transition during the period. The coefficient in Asia is slightly larger than in other regions probably because its mortality also declined faster during this period.

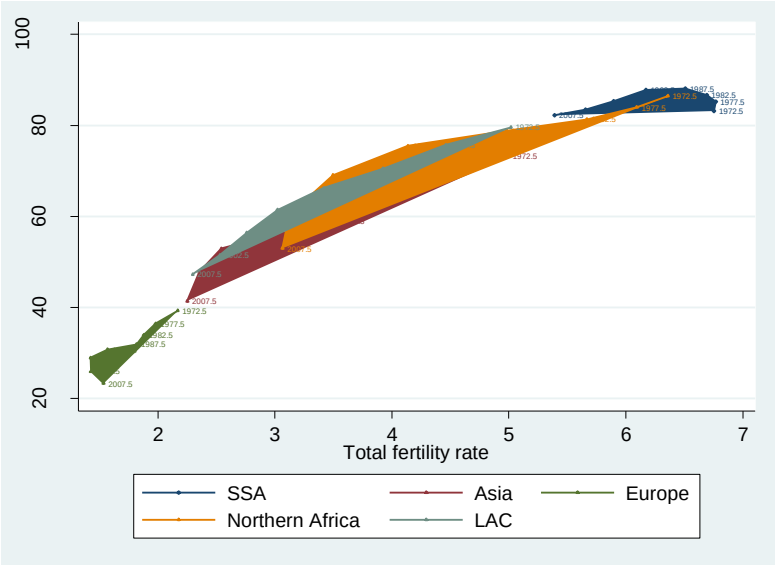

Figure 5: the relationship between child dependency ratio and TFR in five regions

The implication of second observation from Figure 4 is encouraging. While it stands as a cross-sectional outlier, SSA is not different from other regions from a longitudinal perspective. Overall it is on the same trajectory as are other regions in terms of achieving favorable dependency ratios through a rapid reduction in fertility. SSA is at an early stage of demographic transition that started in other regions a few decades ago.

The main reason that fertility decline has contributed so little to the reduction of the dependency ratio in SSA during the past few decades is that fertility only declined marginally. The TFR in SSA reduced from 6.64 in 1960 to 5.39 in 2010. During the same period, the TFR in LAC dropped from 5.95 to 2.30, and the change is from 5.76 to 2.25 in Asia.

Given the almost identical relationship between TFR and dependency ratio, shown in Figure 4, SSA needs to accelerate its fertility decline in order to achieve a favorable dependency ratio. Satisfying unmet need for family planning and providing full and voluntary access to a range of contraceptive methods have proven to be effective measures to reduce fertility. In order to capitalize on the demographic dividend, governments of SSA countries should also encourage investments in human capital and ensure adequate employment.

Limitations

Although this paper used widely recognized population data from the UN and applied well-established demographic projection methods, it still has a few limitations. First, we assessed the changes of fertility, mortality, and dependency ratios for 1960-2010, which is quite a long period of time during which many countries may have experienced some short-term demographic and socioeconomic fluctuations. Our current analysis cannot account for the impacts of those short-term shocks on the dependency ratios. Second, due to the lack of age-specific data for international migration, we are not able incorporate international migration into our projections. Although the impact is minimal in general, it can be large in some countries or during certain periods. These limitations warrant further investigation in future studies.

Panel: research in context

Systemic review

In PubMed we located about 500 articles published in English during Jan 1, 1990-Sep 1, 2014 that included terms “fertility decline” or “mortality decline” in the title or abstracts. However, only 7 articles had “demographic dividend” in the title or abstracts. Admittedly, many studies in the field of demographic dividend are published in the economic literature which may or may not be included in the PubMed database. However our search result does indicate that the demographic dividend perspective, which is appealing to policy makers, has not penetrated the health literature, despite the reliance on reproductive health interventions and has not been fully utilized as evidence of the importance of improved reproductive, maternal and child health.

Interpretation

This study is the first to retrospectively assess the contribution of fertility and mortality declines to the change in national dependency ratios over the past five decades. Contrasting SSA countries to Asian and LAC countries sheds new light on the historical relationship between fertility and the dependency ratio. Benefitting from a favorable dependency ratio has enabled many Asian and LAC countries to realize the demographic dividend and transform their mostly rural agrarian economies into largely urban industrialized ones. During this period of development, tens of millions of people worldwide have been lifted out of poverty and the health of as many substantially improved.

The implication of our study for policymakers is that expanding and intensifying the provision of effective reproductive, maternal, and child health interventions, particularly contraceptive access and nutrition enrichment, can accelerate ongoing fertility and mortality declines favorable not only to population health but also resulting in population age structures favorable to economic productivity and poverty alleviation.

Conclusion

This study fills an important gap in the current literature of population welfare and reproductive and family health in LMICs. Assessing the contribution of fertility decline to the change in population age structure (measured by the dependency ratio) provides a strong argument for expanding reproductive, maternal and child health interventions to reducing fertility and mortality levels. Our study has estimated the contribution of fertility decline, by far the more dominant factor, to the change in dependency ratios in 201 countries over the past five decades. Lower dependency ratios both for countries as a whole and individual households offer the opportunity to reallocate scarce resources toward better education, health care and nutrition, Improved health benefits for youth also confer improved physical and cognitive performance with social and economic consequences that can disrupt poverty conditions.

The past half-century was characterized by rapid demographic transition and historically unprecedented economic growth in most parts of the world, with the exception of most SSA countries. The population age structures in Asia and LAC experienced dramatic changes during 1960-2010. At the same time, countries in these regions transformed from mostly rural agrarian economies with high fertility and mortality to largely urban industrialized economies with low fertility and mortality. Most SSA countries have lagged in their demographic transitions and economic development.

Based on a decomposition of 201 countries, we found that fertility decline played a large role in changing the population age structure and lowering the dependency ratios during 1960-2010. Over this period, fertility decline contributed greatly to the reduction of the child dependency ratio in Asia and LAC. However, the contribution in SSA has been marginal. The difference in the demographic transitions in these regions is consistent with the variation in economic development among them.

Yet from a longitudinal perspective, SSA is on the same trajectory of demographic transition, although with quite a long lag compared to other regions. SSA is about 50 years behind LAC in terms of the TFR and child dependency ratio. The nearly identical relationship between TFR and child dependency ratio across regions suggests that SSA can achieve a favorable dependency ratio if its fertility transition can be accelerated; this will open the window for a demographic dividend. Proven measures to reduce unintended fertility, such as satisfying unmet need with expanded contraceptive access, should be actively promoted, along with increased gender equity and nutrition.[12]

Contribution

QL led the statistical analysis and wrote the first draft of the paper. QL, AT, and SA contributed in conceptualizing the research and interpreting the results. LL helped to revise the report. All authors have read and approved the final version of the paper.

Declaration of interests

We declare no competing interests.

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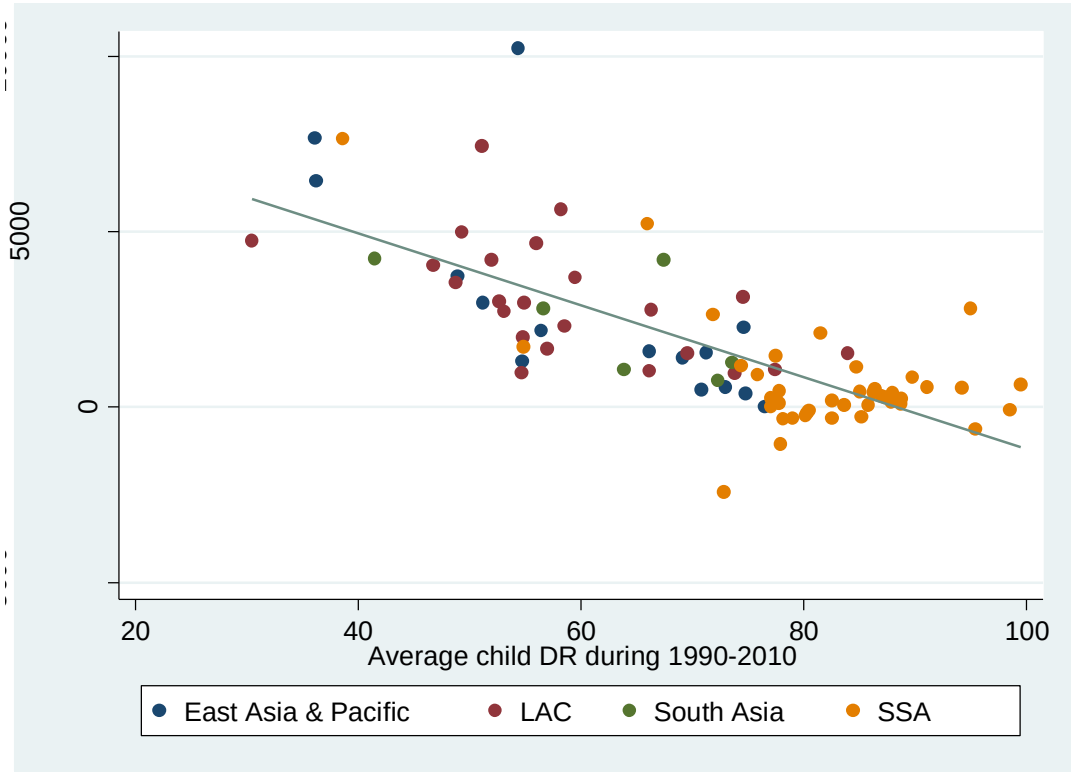

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