Original Article

Understanding the Link between Fertility Decline and Child Survival in Ethiopia: Implications from Decomposition and Regression Models

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Abstract

Background: Despite significant declines over the past two decades, Ethiopia continues to experience high rate of child mortality. While socioeconomic factors and high-risk fertility behaviors are well-established determinants, the independent effect of fertility decline remains underexplored. This study examines the impact of fertility decline- measured by the number of children ever born and the general fertility rate- on child survival in Ethiopia.

Methods: Two data sources and analytic approaches were used: (1) decomposition analysis of United Nations data (2000–2020) to assess the contribution of fertility decline to reductions in under-five deaths and (2) a Probit regression model using the Ethiopian Demographic and Health Survey data to estimate the effect of the number of children ever born on the survival probability of under-five children, adjusted for women's reproductive and other characteristics. Using complex survey analysis in Stata, the regression is done among 37,780 single and second -or higher- order births of under-five children pooled from five surveys (2000–2019).

Results: Between 2000 and 2020, Ethiopia's general fertility rate declined from 208.5 to 135.5 per 1,000 women, while under-five mortality dropped from 141 to 45 per 1,000 live births. The decline in the general fertility rate contributed to 16.3% of the nearly 659,000 averted under-five deaths. At the micro level, each additional child was associated with a 1% (marginal effect =0.01, P=0.00) increase in survival probability, and children born to mothers with 2–4 children had approximately 4% (marginal effect = 0.04, P=0.00) higher survival compared to those with eight or more children.

Conclusion: Lower fertility enhances child survival. Beyond reducing early childbearing and short birth intervals, promoting birth limitation and scaling up of the long-acting contraceptives are vital for further reducing child mortality. [*Ethiop. J. Health Dev.* 2025; 39(2)]

Keywords*: child survival, under-five mortality, fertility rate, Ethiopia.*

Introduction

In 2022, global under-five mortality declined to 4.9 million deaths. Sub-Saharan Africa contributed 57% of these deaths.[1] While child mortality has declined significantly, many developing countries still face high mortality rates and require substantial efforts to meet the Sustainable Development Goals (SDGs), which aim to end preventable child deaths by 2030.[2]

Beyond socioeconomic and health system factors, fertility behaviors, including maternal age at birth, birth intervals, and parity, play a crucial role in child survival.[3-10] Children of higher birth orders and those born into large families are more likely to experience fetal and neonatal complications, undernutrition, and limited access to essential healthcare.[11-14] Becker's Quantity-Quality trade-off theory suggests that having more children intensifies sibling competition, leading to malnutrition, increased morbidity, reduced medical care, and higher child mortality.[15] Empirical evidence also showed similar effects.[16-19] Avoidance of high-risk fertility behaviors is therefore an essential contributor to improving child survival. A study using Bangladesh-Matlab longitudinal data found that declining fertility between 1976 and 1985 was associated with significant reductions in child mortality.[18] Analysis of DHS data found that childbirth between the ages of 18-39 years, an inter-pregnancy interval of at least 36 months, and avoiding more than three childbirths can reduce under-five mortality by one-third.[20]

Ethiopia, the second-most populous country in Africa, has made significant progress in reducing child mortality. However, child survival remains a major public health concern, with 178,000 under-five deaths happening in 2022. [1] This high mortality burden is attributed to both elevated fertility rates and increased risks associated with high-risk fertility behaviors (HRFB), low socioeconomic status, and an underdeveloped healthcare system. Many studies in Ethiopia have examined factors associated with child mortality, including HRFB.[10, 16, 21-29] However, these studies focus on factors affecting mortality rate rather than survival probabilities, and use socio-demographic variables and HRFB, mainly birth-spacing and maternal age. Evidence looking into the effect of lower fertility rates on child survival is rare. This study fills this evidence gap by measuring the contribution of lowering birth rates to child survival in Ethiopia.

Method

Study Setting and Data Source: Ethiopia is currently a federal state comprising 12 administrative regions and two city administrations. More than three-fourths of its population resides in rural areas with limited access to healthcare and basic social services. The country is experiencing rapid population growth with slightly declining fertility and mortality rates.[30] This study used two analytical approaches from two data sources. The data for macro-level decomposition analysis came from the 2024 World Population

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Prospects data repository of the United Nations PopulationDivision(https://population.un.org/wpp/)[31] The micro-level regression analysis used data from the five rounds (2000, 2005, 2011, 2016, and 2019) of the Ethiopian Demographic and Health Survey (EDHS) obtainedfromhttps://dhsprogram.com/data/dataset_admin/index.cfm. The EDHS were nationally representative cross-sectional surveys that employed a two-stage probability sampling method based on predetermined Enumeration Areas (EAs) stratified by region and urban-rural residence.

Study Sample: The population for the regression analysis comprises 48,782 records of children aged 0-59 months obtained from the Kids' Recoded (KR) file of the pooled EDHS data. First-order and twin births were excluded due to higher mortality risks, and the regression was done among 37,780 under-five children.

Variables: the survival status of all under-five children at the time of the interview, coded as 0 = deceased and 1 = alive, was the main outcome variable for the micro-regression analysis. The main exposure variable, the number of children ever born (nCEB) (reversed from its highest to lowest values to assess the impact of lower fertility on child survival). The analysis was adjusted for birth spacing**,** maternal age at delivery, child sex, place of delivery, residence, region, and the mother's educational status.

Statistical Analysis: for the macro-level decomposition analysis, the decline in under-five deaths from 2000 to 2020 was decomposed into changes in the general fertility rate (GFR) and under-five mortality rate (U5MR). The decomposition follows the formula U5D=LB*U5MR=GFR*WRA*UMR adopted from Anrudh K. Jain.[32] The details of the formulas and indicators for the decomposition were given in Table 1.

For the regression analysis, the probability of survival of under-five children was estimated using ordinary probit regression, which is represented by:

$$P(Y=1|X_i) = \Phi(X_i\beta). \ldots\ldots\ (1)$$

Where $\Phi(\cdot)$ is the cumulative distribution function (CDF) of the standard normal distribution; X_i is the vector of explanatory variables which include number of children ever born, birth interval, maternal age at delivery, maternal educational status, residence, sex of child, and type of pregnancy; β\beta is the vector of coefficients estimated using the maximum likelihood estimation; and P(Y=1) is the probability that a child is alive if $Y^* > 0$, or died if $Y^* \leq 0$, where Y^* is a latent variable estimated as $Y^* = \beta_0 + \beta_1 X_i + \varepsilon_{i.}$ Since child survival and fertility rates have bidirectional causality, where improved child survival may lower fertility, and reduced fertility may enhance survival, the nCEB may be endogenous and can be correlated with the error term (ε_i) and produce biased estimates. To diagnose this, we run an instrumented (ivprobit) model [33] using current maternal age as an instrument for nCEB. The Wald test of exogeneity ($\chi^2(1) = 0.3$, $p = 0.6$) indicates the absence of significant endogeneity. Similarly, the correlation between the structural error and the first-stage error (rho = -0.01) is small and statistically insignificant, further supporting the assumption of exogeneity. A table of these estimates, including the model coefficients from ivprobit, was given as supplementary material. Then the coefficients with 95% confidence intervals, and marginal effects with p-values from the standard Probit model were used to measure the effect of CEB on child survival. Given the complex survey design, the analysis was conducted using 'svy linearized'.

Results

Trends in death and survival of under-five children

Over the last two decades, both fertility and mortality have been reduced. Despite the increase in the number of reproductive women and total number of births, the GFR reduced from 208.5 in 2000 to 135.5 in 2020, and the under-five mortality rate reduced from 141 to 50 per 1000 live births in the same year (Table 1).

Table 1: **Decomposition of the changes in the number of under-five deaths into changes in the general fertility rate and the under-five mortality rate, Ethiopia 2000-2020.**

Scenarios and indicators	**2000.0**	**2020.0**
WRA: Number of women aged 15-49 years	14, 737,831.5	29,237,828.5
LB: Number of Live Births	3,073,321	3,961,198
GFR: General fertility rate	208.5	135.5
U5MR: Under-five mortality rate per 1 000	141	50
U5D: Number of deaths of under-five children	422,897	194,814
Scenarios	**Formulas**	**Values**
U5D2020 under constant fertility and mortality: both GFR and U5MR remain constant	U5D1= WRA2020*GFR2000*UMR2000	858,482.3
U5D2020 under constant fertility: U5MR declined, but GFR did not	U5D2= WRA2020*GFR2000*UMR2020	307,077.7
U5D2020 under constant mortality: GFR declined, but U5MR did not	U5D3= WRA2020*GFR2020*UMR2000	557,748.6
U5D2020: Both GFR & U5MR declined (estimated)	U5D4= WRA2020*GFR2020*UMR2020	199, 505.7
U5D reduced due to a decline in mortality rate only	U5Dmr=U5D1- U5D2	551,404.6
U5D reduced due to a decline in the fertility rate only	U5Dgfr=U5D1- U5D3	300,733.8
U5D reduced due to a decline in both fertility and mortality rates	U5Dmr+gfr=U5D1- U5D4	658, 976.6

U5D reduced due to the overlap between declining fertility and mortality rates	U5Dmr*gfr= (U5Dmr+U5Dgfr) - U5Dmr+gfr	193,161.8
UMD decline due to the *net effect* of the decline in U5MR	U5MRnet= U5Dmr- U5Dmr*gfr	358, 242.8
UMD decline due to the *net effect* of the decline in GFR	GFRnet= U5Dgfr - U5Dmr*gfr	107, 572.0
Percentage contribution of decline in U5MR	(U5Dmr- U5Dmr*gfr)/ U5Dmr+gfr*100	54.4
Percentage contribution of the decline in GFR	(U5Dgfr- U5Dmr*gfr)/ U5Dmr+gfr*100	16.3
Percentage decline due to the interaction of the decline GFR&MMR	(U5Dmr*gfr)/U5Dmr+gfr *100	29.3

Source: Author's estimations using data from the 2024 World Population Prospects

The number of under-five deaths also reduced by 54% (241,882 deaths). The data from the EDHS also showed an increasing trend in the survival probability of under-five children from 88% in 2000 to 95% in 2019 (Figure 1).

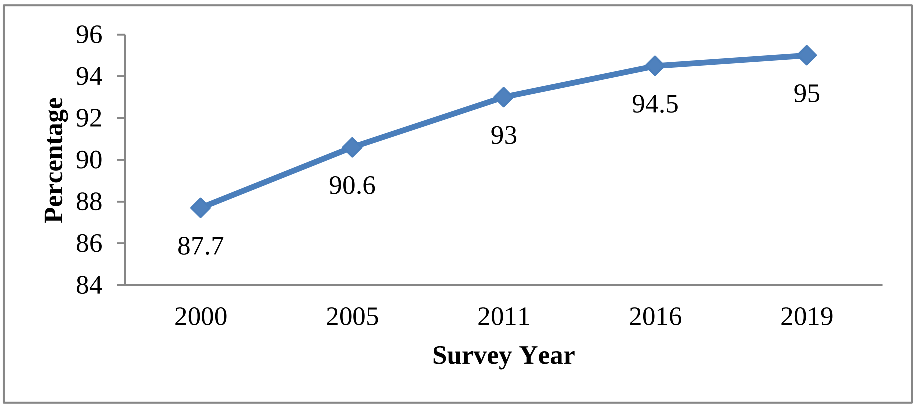

Figure 1: **Trends in the proportion of under-five children survived to the date of interview in each survey, Ethiopia, EDHS 2000-2019**

Macro-level analysis: descriptive decomposition of changes in the number of under-five deaths

To assess the net effect of fertility decline on the reduction of under-five deaths, a decomposition analysis was conducted using data from 2000 to 2020. As shown in Table 1, the number of WRA doubled from 14.7 million in 2000 to 29.2 million in 2020. Without changes in fertility and mortality rates, this could have increased the LB to over 4.1 million and the under-five deaths to 858,482. However, declines in the GFR and the U5MR and their interaction effects reduced an estimated 658,976.6 deaths (358,242 due to U5MR, 107,572 due to GFR, and the rest 193, 161.8 due to their interaction or other factors). The percentage decomposition from these estimates indicates that the decline in GFR contributed to 16.3% of the total under-five deaths averted by 2020.

Micro-level analysis of determinants of survival status of under-five children

Overall, 92% of children under the age of five in the sample were alive at the time of the survey. As shown in Table 2, the proportion of surviving children varies by place of residence, region, educational status, wealth status, child sex, and place of delivery. The survival rate was 93.5% among children of mothers with only one child, but dropped to 89% for those born to mothers with eight or more children. Similarly, while 95% of children born with a 4–5 year birth interval survived, only 86.6% of those born less than two years apart did. Survival was also higher (92.4%) among children of mothers aged 20–34 years compared to 89% among those born to mothers under 20.

Table 2: **Child survival status by women's background characteristics, EDHS 2000-2019**

Variable	**Survival Status of under-five children**	
Residence	**0=Died**	**1=Alive**
Urban	6.3 (5.3,7.3)	93.7(92.6,94.6)
Rural	8.5 (8.1,8.9)	91.5(91.1,91.9)
Region		
Tigray	6.6 (5.8, 7.4)	93.4(92.6,94.2)
Afar	9.8 (8.6, 11.0)	90.2(88.9,91.3)
Amhara	9.0 (8.2,9.8)	91.0(90.2,91.8)
Oromia	8.3 (7.6,9.0)	91.7(90.1,92.4)
Somalia	8.3 (7.3,9.4)	91.7(90.5,92.7)
Benshangul Gumuz	9.2 (7.9,10.5)	90.8(89.4,92)
SNNP	8.1 (7.3,8.9)	91.9(91.1,92.7)
Gambela	8.2 (6.9,9.6)	91.8(90.4,93.0)

Harari	7.2 (6.1,8.3)	92.8(91.6,93.4)
Addis Ababa	4.3 (3.3,5.2)	95.7(94.6,96.6)
Dire Dawa	7.7 (6.2,9.2)	92.3(90.7,93.7)
Educational status		
No education	9.0 (8.6,9.5)	91.0(90.5,91.4)
Primary	6.6 (5.8,7.3)	93.4(92.6,94.2)
Secondary+	4.6 (3.4,5.7)	95.4(94.1,96.5)
Wealth quintile		
Poorest	8.0 (7.3,8.8)	92.0(91.2,92.7)
Poorer	8.3 (7.5,9.2)	91.7(90.8,92.5)
Middle	9.2 (8.3,10.1)	90.8(89.9,91.6)
Richer	8.3 (7.5,9.1)	91.7(90.9,92.5)
Richest	7.0 (6.2,7.9)	93.0(92.1,93.8)
Children ever born		
1	6.5 (5.6,7.4)	93.5(92.5,94.3)
2-4	7.7 (7.1,8.2)	92.3(91.8,92.9)
5-7	8.5 (7.7,9.2)	91.5(90.7,92.2)
8+	11.0 (9.8,12.2)	89.0(87.7,90.1)
Birth order		
1	9.3 (8.5,10.2)	90.7(89.8,91.5)
2-4	7.7 (7.1,8.2)	92.6(92.0,93)
5-7	8.5 (7.7,9.2)	92.0(91.3,92.7)
>=8	11.0 (9.8,12.2)	89.7(88.4,90.9)
Maternal age at birth		
<19 years	10.9(9.8,12.0)	89.1(88.0,90.2)
20-34 years	7.6(7.2,8.0)	92.4(92.0,92.8)
35+years	8.9(8.0,9.9)	91.1(90.1,92.0)
Preceding birth interval (years)		
<2	13.4(12.3,14.6)	86.6(85.4,87.7)
2-3	7.0 6.7,7.5)	93.0(92.5,93.4)
4-5 years	5.0 (4.3,5.8)	95.0(94.2,95.7)
>=5	5.3 (4.2,6.7)	94.7(93.3,95.8)
Place of delivery		
Health facility	5.8 (4.9,6.6)	94.2(93.4,95.0)
Home/other	8.7 (8.2,9.1)	91.3(90.8,91.2)
Child sex		
Female	7.2 (6.7,7.8)	92.8(92.3,93.1)
Male	9.2 (8.7,9.7)	90.8(90.3,91.3)
Type of pregnancy		
Single	7.8 (7.4,8.1)	92.2(91.8,92.6)
Multiple	28.9 (24.33.3)	71.1(66.4,75.4)

SNNP = Southern Nations and Nationalities, Secondary+= secondary or higher educational level

Table 3 presents the crude and adjusted regression coefficients along with 95% confidence interval (CI), and marginal effects (maef) with p values. The multivariable regression was adjusted for women's age at delivery, birth interval, sex of child, mother's educational status, household wealth quintile, region of residence, and survey year. Place of residence and place of delivery were excluded due to their correlation with other predictors. Controlling for reproductive and social characteristics, reducing the nCEB by one child resulted in 1% (maef = 0.01, p = 0.00) higher probability of survival up to the date of interview among those children born five years preceding the survey. Compared to mothers with eight or more children, those with 2–4 children have a 4% (maef=0.04, p=0.00) higher probability of survival. A one-year increase in the preceding birth interval raises survival probability by 1%. Increasing the interval from under two years to 3–5 years improves survival by 8% (maef = 0.08, p = 0.00). Children born to mothers aged 20 or older have a 4% higher probability of survival than those born to mothers under 20 (maef = 0.04, p = 0.00).

Table 3: **Probit regression of survival status of under-five children using fertility behaviors and other maternal characteristics, EDHS 2000-2019**

Variables	β (95%CI)	Adjusted β (95%CI)	Marginal effect (maef)	P value of maef
Number of children ever born Categorized (8+=ref)				
5 to 7	0.15 (0.7,9.23)	0.12 (0.03,0.21)	0.02	0.01
2 to 4	0.29 (0.21,0..36)	0.26 (0.17,0.35)	0.04	0.00
Number of children ever born(reversed order)	0.05 (0.04, 0.06)	0.07 (0.05,0.08)	0.01	0.00
Birth interval Cat (<2 year=ref)				
2-3years	0.36 (0.30,0.43)	0.39 (0.33,0.46)	0.06	0.00
4-5years	0.54 (0.45,0.69)	0.53 (0.43,0.62)	0.08	0.00
5+ years	0.51 (0.38,0.64)	0.45 (0.31,0.59)	0.07	0.00
Single Years of the preceding birth interval	0.09 (0.07,0.11)	0.07 (0.05,0.10)	0.01	0.00
Maternal age at delivery(<20=ref)				
20-34 years	0.26 (0.16,0.36)	0.23 (0.12,0.35)	0.04	0.00
35+ years	0.17 (0.05,0.29)	0.25 (0.10,0.41)	0.04	0.00
Single years of maternal age at delivery	0.0 (-0.1,0.0)	0.01 (0.01,0.02)	0.00	0.00
Women's educational status (no education=ref)				
Primary	0.16 (0.07,0.22)	0.07 (-0.01,0.20)	0.02	0.00
Secondary+	0.28 (0.09,0.46)	0.21 (0.01,0.42)	0.02	0.05
Women's Single Years of Education	0.03 (0.02,0.05)	0.01 (-0.01,0.02)	0.00	0.2
Sex of child (male=ref)				
Female	0.01 (0.05,0.16)	0.11 (0.05,0.16)	0.01	0.00
Survey Year (2000=ref)				
2005	0.16 (0.09,0.24)	0.15 (0.08,0.23)	0.02	0.00
2011	0.28 (0.20,0.36)	0.26 (0.18,0.34)	0.04	0.00
2016	0.40 (31,0.49)	0.40 (30,0.50)	0.05	0.00
2019	0.45 (0.32,0.58)	0.47 (0.33,0.60)	0.06	0.00

Discussions

This study examines the role of fertility decline, measured by the number of children ever born and the general fertility rate, in Ethiopia using both macro-level decomposition and micro-level regression analyses, providing valuable insights that address gaps in the current literature on fertility's impact on child survival. The macro-level decomposition showed that reductions in the general fertility rate accounted for 16.3% of the nearly 659,000 under-five deaths averted between 2000 and 2020. While declines in the under-five mortality rate contributed more significantly to improvements in child survival, reductions in fertility also played a substantial role. This effect likely operates by both reducing the number of births, and hence potential deaths, and minimizing exposure to HRFBs known to increase child mortality risk.

At the micro-level, regression analysis controlling for key socioeconomic and biological factors confirmed that lower actual fertility improves child survival. Compared to children of mothers with eight or more children, those from mothers with 2–4 children had a 4% higher likelihood of survival. Notably, these effects persist even after adjusting for HRFBs, underscoring the independent contribution of family size to child health outcomes. Other studies in Ethiopia have also found that a higher number of children significantly increases the risk of under-five mortality.[28, 34, 35] This finding is consistent with international evidence showing a significant association between fertility rate and child survival [18, 36, 37], and aligns with the demographic transition theory, which posits a synergistic decline in both fertility and mortality [38]

The positive effect of a lower fertility rate on child survival, independent of other HRFBs, can be explained by the maternal depletion [39, 40] and parental investment theories.[41] Women with many births, even if adequately spaced, may suffer from nutritional depletion, affecting fetal and newborn health. Moreover, having more children often reduces maternal healthcare utilization, childcare practice, resource allocation, and investment per child, resulting in higher malnutrition and mortality.[42-44]. Studies in Ethiopia showed that a smaller number of children or family size is associated with improved vaccine uptake [45], reduced risk of respiratory infections [46], and better healthcare seeking for under-five diarrheal illness.[47]

In line with prior studies, this analysis also confirmed that increasing the preceding birth interval by one year raises child survival probability by 1%, and children born after a 4–5 year interval have an 8% higher probability of survival than those born within two years. Similarly, children born to mothers aged 20 or older had a 4% higher survival probability than those born to mothers under age 20. The mechanisms of effect between high-risk fertility behaviors and child survival are well established by prior studies [4, 17, 20, 25, 48-53], including associations with prematurity, low birth weight, chromosomal abnormalities, inadequate breastfeeding, and sibling competition.

The findings have strong programmatic relevance. Although Ethiopia has made remarkable progress in reducing under-five mortality, the current rate remains unacceptably high. Persistent challenges such as a high fertility rate, inadequate childcare practice [54], recurrent drought, conflicts, and development lag [55] can pose barriers to achieving the sustainable development targets. Moreover, there is a higher prevalence of HRFBs. According to the EDHS data used in this analysis, 43.5% have five or more children (44.5% in 2000 and 38.5% in 2019), 21% give birth within less than two years of the previous birth, and 13.7% give birth before the age of 20. Other studies also show that there is a high prevalence of HRFB in the country.[56]

Family planning programs are known to avoid such HRFB, thereby reducing the risk of mortality.[57-59] Ethiopia has already recognized family planning as a high-impact strategy for improving child survival and well-being.[60, 61] However, progress in reducing cumulative cohort fertility and high parity has been limited.[62] Family planning measures should not only focus on reducing HRFB but also should aim at limiting the total number of children, reducing exposure to mortality risk (fewer births mean fewer deaths).

This study fills methodological and evidence gaps by using aggregate-level decomposition and micro-level regression to assess fertility decline on child survival. Nationally representative data from urban and rural areas strengthen the validity of findings. However, child survival was measured only up to the interview date, limiting age-specific analysis. Also, the number of children ever born as an exposure variable does not capture completed fertility or parity-specific mortality. Future research should use longitudinal or cohort data to address these limitations.

Conclusion

This study provides clear evidence that reducing the number of births both at the individual and population levels significantly contributes to improving child survival in Ethiopia. The observed mortality-reducing effect of lower fertility, independent of birth spacing, maternal age, and other maternal characteristics, highlights the importance of strengthening family planning initiatives that promote fertility-limiting behaviors. Expanding access to and uptake of long-acting contraceptive methods, particularly among high-parity women, should be prioritized as part of a broader strategy to reduce under-five mortality and accelerate progress toward national health and development goals.

Ethical Clearance

The EDHS was conducted after obtaining ethical clearance from the Ethiopian Health and Nutrition Research Institute Review Board, the Ministry of Science and Technology, the Institutional Review Board of ICF International, and the CDC. Data were collected after taking informed consent, and all information was kept confidential by the central statistical agency and the DHS program. After requesting a written statement of purpose, data was accessed from the DHS program website.

Competing interest

The authors declare that they have no financial or other competing interests.

Author contributions

TB and MM conceived the research idea. TB prepared the proposal, conducted the analysis, and prepared the main manuscript. WM and MM secured funds for data analysis, supervised the research process, and reviewed the results and manuscripts. All authors read and approve the final manuscript.

List of abbreviations

EDHS=Ethiopian Demographic and Health Survey
HRFB=High risk fertility behaviors
Maef= *Marginal effect*
nCEB=Number of Children Ever Borne

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