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DEMOGRAPHIC TRANSITION IN EGYPT: FERTILITY DECLINE AND MORTALITY TRENDS USING MULTILEVEL STATISTICAL MODELS

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ABSTRACT

This study evaluated the Egyptian population's demographic transition in terms of mortality and fertility patterns and how socioeconomic factors influence these patterns. Analysing nationally representative survey data from 2005, 2008, and 2015, the study employs mixed-effects logistic regression models to investigate the effect of women's age, education, wealth, healthcare access, and autonomy on child mortality and fertility desires. Evidence shows a consistent reduction in infant mortality and fertility over time, indicating Egypt's transition through the demographic transition. However, socioeconomic factors have seemingly varied effects with intricate patterns: higher education and wealth usually decrease infant mortality but reversing relationships with under-five mortality indicate contextual vulnerabilities. The determinant role of women's autonomy, both individually and as an interaction with other variables, illuminates the value of empowerment in influencing demographic outcomes. Temporal analysis emphasises gains but also ongoing inequalities, especially between rural and poor groups. The research advances knowledge of Egypt's demographic transition by combining socioeconomic and gender factors, providing evidence for health, education, and empowerment policies targeting specific groups. Policy suggestions focus on reinforcing healthcare systems, increasing women's opportunities, and combating inequalities to maintain demographic advances and promote equitable population outcomes.

KEYWORDS: Demographic Transition, Fertility Rate, Mortality Rate, Multilevel statistical modelling, socioeconomic factors

1. INTRODUCTION

Demographic transition is a decisive change in the population of societies, characterised by a decrease in fertility and mortality. As with most middle-income nations, Egypt is experiencing this transition at a complicated crossroads of social, economic and cultural change (Montgomery 2025; Frantsuz, 2024). World Bank (2023) estimates total fertility rate in Egypt has fallen to about 3.1 in 2020 against the 1980 figure of about 4.6 due to increased education, urbanisation and access to reproductive health. However, this figure is still elevated when compared to the world averages (2.3 in 2021) and even larger than the replacement levels, which indicate that Egypt is still to reach the later demographic transition phases (Osman, 2023). Trends in mortality reflect this partial change, for instance, although the number of child mortality decreased significantly in 1990 with 87 deaths per 1,000 live births. In current times the situation with maternal and neonatal health issues is unchanged, and inequalities persist along socioeconomic and regional lines (Abbasi-Kangevari et al., 2023). However, demographic changes, and the heterogeneity of the population of Egypt necessitates the use of more complex statistical models that can measure the changes that occur at the individual, household, and community levels.

Further current studies on fertility and mortality transitions in Egypt are scarce and insufficient in terms of theoretical development. A large part of demographic literature Klu (2023) Tesfa et al. (2023) has focused on Sub-Saharan Africa or South Asia or regional totals, but not on the dynamics of Egypt in particular. Egypt signifies a unique demographic setting likened to Sub-Saharan Africa and South Asia due to its intermediate fertility reduction, comparatively inferior mortality rates and different socio-cultural dynamics formulated by Islamic as well as Arab traditions (Osman, 2023). Unlike, Sub-Saharan Africa, were fertility still remains a persistently greater, or South Asia where, swift fertility reduction has occurred, Egypt depicts a gradual and uneven transition (Bongaarts & Hodgson, 2022). This makes it a significant case assessing ways that socioeconomic factors and women's autonomy interact to impact demographic outcomes across a Middle Eastern setting.

Specifically, the impact of autonomy of women in making household decisions, in fertility and mortality, particularly with respect to the use of contraceptives, has not been adequately incorporated in fertility and mortality analyses. Although previous research Aitken (2024) indicates that autonomy is an independent variable that determines demographic outcomes. However, the role of autonomy as a moderator has not been considered that predetermines the impact of education, wealth, and access to health on demographic change. Such a gap limits our knowledge of the ways in which gendered relations of power organise the trajectories of Egyptian demographic transition.

The importance of this study is that it aims to cover these gaps. For instance, the current study also takes into consideration women decision-making autonomy as a moderator variable by using multilevel statistical models of the Demographic and Health Survey (DHS) data to not only explain individual and contextual heterogeneity but also account for it. This methodology builds upon the perspective of Gender and Development Theory and Empowerment Frameworks, which believe that autonomy is not a mere determinist factor but rather guides the process through which socioeconomic resources are converted into demographic behaviours and outcomes (Bongaarts, 2025). A "determinist factor" refers to a variable that uniquely affects an outcome directly and predictably, without considering the interactions and conditions (Jena et al., 2023). In demography, this would be to assume that the autonomy of women is in itself a causal factor, instead of acknowledging the influence it exerts on the interaction of other demographic factors with fertility and mortality (Osman et al., 2025). Therefore, the multilevel model is required, since the data provided by DHS is hierarchical by nature, as individuals are included into households and households are grouped into clusters or regions. Ordinary regression would be ignorant of these dependencies and provide biassed estimates. The multilevel frameworks will allow the research to adequately address individual such as age, education, autonomy, contextual such as regional disparities factors and provide more precise and detailed findings regarding the trend in fertility and mortality in Egypt linked with demographic factors under moderating effect of autonomy of women.

The study holds three major contributions. First, at the empirical level, it presents unique multilevel estimates of fertility decline and mortality patterns based on Egyptian DHS survey data, generating empirical evidence which can be used in both national and comparative demographic studies.

Second, on the theoretical perspective, it redefines the independence of women as a moderator and not a direct predictor and refutes and extends previous demographic theories. Third, at the practical level, it produces policy-relevant knowledge about how empowering women in their reproductive decision-making can enhance the speed of the demographic transition in Egypt, lower health inequalities, and match population growth with sustainable development objectives.

2. LITERATURE REVIEW

2.1. Theoretical Framework

The paper is based on two theories which are comprised of Gender and Development (GAD) Theory and the Women Empowerment Framework. The GAD Theory focuses on structural and relational aspects of gender inequality and states that demographic behaviours are not simply the result of personal choices but are the expression of the power relations in household and society (Bazbauers & Madkour, 2024). Patriarchal norms typically mediate access to education, healthcare and reproductive resources in the context of Egypt, and GAD Theory can be used to explore the ways in which the autonomy of women moderates the influence of socioeconomic factors on fertility and mortality. For example, education may raise awareness about contraceptives, but the choice to use them can be related to the bargaining power of women at home (Wu, 2024).

This is complemented by the Empowerment Framework which conceptualises autonomy as a multidimensional process which increases agency among women in decision-making. In this instance, the autonomy of decision-making in women is contextualised as a moderating factor, defining the linkage between the resources available to them, including wealth, education, and marital status to demographic outcomes (Lahiri-Dutt, 2025). Combined, these theories support the incorporation of the moderator of autonomy and contribute to the development of the demographic transition research.

2.2. Empirical Review

2.2.1. Effect of Age on Fertility and Mortality Rates

Global Burden of Diseases (GBD) in 2019, evaluated mortality, fertility, migration and population trends in the case of 204 countries for the period amid 1950-2019 using data sources which were comprised of censuses and surveys. The patterns of fertility were measured by means of age-specific fertility rate (ASFRs) for women aged between 15 and 19 with extensions to 10 to 14 and 50-54 years aggregated into aggregated into total fertility rates (TFR). The findings of the study unveiled that global decline in TFR varied from 2.72 in 2000 to 2.31 in 2019 with increased mortality rates measured in terms of life-expectancy from 67.2 to 73.5 years. These findings articulated that age fertility was strongly impacted by age with most births centred across 20-34 years, while rates of mortality remained highest among children under 5 and adults aged amid 15-60 years. However, the study left major limitations, where the first limitation was dependence on spatiotemporal Gaussian process regression (ST-GPR) which leads to model-dependent biases specifically in regions with lack of adequate data. Secondly, assumptions in relational life tables leads to oversimplification of age-specific mortality variation. Specific analysis of Egypt is required as the majority of available studies are based on global or regional models that obscure local differences and tend to yield biassed results in data-restrained environments. The proposed study will enable the confidence in the relevance of the findings to the Egyptian context through the reviews of the effects of age on fertility and mortality in Egypt and comparisons with other countries and will contribute to the discussion of a demographic transition. Such an approach can confirm or disprove generalisations, presenting a more specific description designing national policies to enhance mortality and fertility rates.

These literature arguments to formulation of first and second hypothesis of the study that;

H1: There is a statistically significant effect of Age on Fertility Rate of population in Egypt.

H2: There is a statistically significant effect of Age on Mortality Rate of population in Egypt

2.2.2. Effect of Educational Level on Fertility and Mortality Rates

Education is always cited as a significant factor in both fertility and mortality. Gotmark and Andersson (2020) established that adequate female education is associated with lower fertility, in part by delaying marriage, using contraceptives, and holding more autonomy. Likewise, in a large-scale systematic review and meta-analysis (59 countries) Balaj et al. (2024) measured the dose-response effect of education on adult mortality, with an all-cause mortality of -1.9% per year of additional schooling. Mortality risk per year of education decreased by close to 3 percent in younger adults (18-49 years), who had the greatest benefit. Collectively, these studies emphasise education as a critical process to

achieve not only reduced fertility but also enhanced survival across populations. The two studies also have methodological limitations such as regression analysis adopted by Gotmark and Andersson (2020) cannot determine causality as a result of confounding factors, whereas the meta-analysis by Balaj et al. (2024) is robust, however, it demonstrated heterogeneity, publication bias, and underrepresentation of low-income countries, which limits the ability to generalise the findings. A focused study on Egypt is required due to the fact that the majority of the preceding discussions on the role of education in fertility and mortality are based on the global or high-income context and are not applicable to the Middle Eastern region like Egypt. Conducting research on the effects of education in Egypt, and comparing its outcomes with research in other countries, will help combat underrepresentation, enhance the applicability of these studies to the local context, and facilitate a better understanding of global theories of demographics. This method not only confirms the available evidence, but also emphasises whether there are differences in educational impacts across societies with distinct cultural, economic, and gendered dynamics. These literature arguments lead to formulation of H3 and H4 of the study that;

H3: There is a statistically significant effect of Educational Level on Fertility Rate of population in Egypt

H4: There is a statistically significant effect of Educational Level on Mortality Rate of population in Egypt

2.2.3. Effect Wealth Index on Fertility and Mortality Rates

Wealth is a major determinant of demographic outcomes in the fertility and mortality pathways. A study by Miladinov (2020), which analysed five EU accession countries, reported a positive correlation between GDP per capita and life expectancy at birth and low infant mortality is a contributing factor to lifespan. This points out how better socioeconomic status translate into less risk of death and longer lives. On the other hand, Tarca et al. (2022) showed that the overall association between income per capita and fertility in 171 nations is negative and statistically significant, and the demographic-economic paradox is valid, meaning that wealth increase is associated with a reduction in fertility. These results indicate that wealth enhances survival, but lowers fertility, which is in line with the theory of demographic transition. However, there are certain limitations confronted by these studies. For instance, Miladinov (2020) depended on aggregate time-series data, which limits causal inferences at the individual level. Țarcă et al. (2022) regression approach oversimplified complex cultural and institutional influences, with potential omitted-variable bias. While previous studies discussed above have associated wealth to demographic outcomes, their dependence on aggregate data or simplified models of regression restricts deeper analysis and insights in the context of Egypt. Therefore, assessing the Egyptian context enables for more detailed and precise analysis on ways that household wealth impacts mortality and fertility while, likewise allowing comparisons with international evidence. This dual factor nots just address oversights in previous studies, but likewise elucidates if economic resources form demographic behaviours distinctively in Middle Eastern communities which provides both contextual pertinence and wider theoretical value.

These literature arguments lead to formation of hypotheses H5 and H6 of the study

H5: There is a statistically significant effect of Wealth Index on Fertility Rate of population in Egypt

H6: There is a statistically significant effect of Wealth Index on Mortality Rate of population in Egypt

2.2.4. Effect of Access to Care on Mortality Rate and Fertility Rate

Healthcare access has always been a key determinant of mortality as well as fertility results in various populations. Kim et al. (2021) indicated that low- and middle-income countries (LMICs) have evidence that barriers to care, economic, physical, and socio-cultural, tend to drive up under-five mortality substantially, with socio-cultural constraints having the greatest impact. Correspondingly, adult cancer patient research conducted by Holtzman et al. (2022) indicates that exposure to high-volume, academic centers correlates with better survival and lower perioperative mortality. Edberg et al. (2023) indicated that in older populations, poor access attributed to cost, location, and literacy barriers is responsible for delayed treatment and increased mortality. The findings highlight the global role of healthcare accessibility in determining mortality outcomes.

In the field of fertility, access barriers also shape reproductive health pathways. School-based health centres in America were found to decrease teen fertility rates, especially among vulnerable populations, through an increase in primary care access (Lovenheim et al., 2016). On the other hand,

restricted access to fertility preservation or treatment services forces patients to use suboptimal strategies, like postponing treatment or opting for less efficient methods, possibly reducing success rates and enhancing risks (Maxwell et al., 2017; Perachino et al., 2020). Hence, it is hypothesised that;

H7: Access to healthcare has a significant effect on the mortality rate in the Egyptian population

H8: Access to healthcare has a significant effect on the fertility rate in the Egyptian population

3. METHODOLOGY

3.1. Data Collection

The paper is based on the Egypt Demographic and Health Survey (EDHS) for the year 2005, 2008 and 2015, the nationally representative household survey carried out as a part of the global DHS programme. This survey gathered ample information on fertility, mortality, reproductive health and socioeconomic indicators, a strong platform to analyse the demographic transition in Egypt. The EDHS used a stratified two-stage sampling design that is representative of the urban and rural regions, governorates, and socioeconomic status. It also included more than 29,000 households with more than 21,000 ever-married women aged 15-49, which made it one of the most comprehensive demographic data sets on Egypt.

3.2. Variables And Measurement

Table:

Variables	Operationalization
Independent Variables	
Age	The age of respondent ranging from 15 – 49. The groups are to be developed as per following category. 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49. The variable is adopted from Negash et al. (2023) and Terefe et al. (2025).
Educational Level	No education, Incomplete primary, Complete primary, Incomplete secondary, Complete secondary, Higher. The variable is adopted from Negash et al. (2023) and Singh et al. (2025).
Wealth Index	In the DHS data, wealth index is grouped into quintile as poorest, poorer, middle, richer, richest, using principal component analysis. A high degree of variation in observation from the original DHS classification led to the re-categorisation of wealth index scores into three categories; poor, middle, and rich, which was categorised by merging the poorest with the poorer and the richest with the richer for easier interpretation (Negash et al., 2023).
Access to care	In the DHS data, the access to care is categorised into big problem, small problem, no problem and didn't answer. The variables is adapted from the study of Kim et al. (2021).
Moderating Variable	
Women Decision Making Autonomy	Decision maker for using contraception. The variable has been added by Bitew et al. (2024)
Dependent Variable	
Fertility Rate	Fertility Rate is measured using the fertility preferences with the categories such as prefer no more children and prefer more children.
Mortality Rate	The mortality rate is measured using the two variables included infant mortality and child mortality. Infant mortality included categories such as mortality and otherwise. Child mortality is categorized into under 5 and above 5 mortality.
Control Variables	
Religion	Religion include the categories such as Muslim and Christian. Religious teachings often influence fertility preferences, contraceptive use and attitudes towards childbearing. The inclusion of religion as a control variable ensures that variations in fertility and mortality outcomes attributable to religious beliefs are distinguished from those caused by demographic or socioeconomic factors.
Current Pregnancy	It include the categories such as currently pregnant, pregnant/unsure and not. Women who are pregnant currently might show different fertility preferences compared to those not pregnant, and pregnancy itself is linked with the health risks. Controlling for this factor ensures fertility outcomes are not confounded by present pregnancy conditions.
Planned Pregnancy	Planned pregnancy include the categories such as wanted then, wanted later and wanted no more. The planned pregnancy control account for the role of pregnancy intentions in shaping fertility isolating effects of independent variables.

3.3. DATA ANALYSIS

The analysis used mixed-effects logistic regression models to examine the predictors of fertility and mortality outcomes, adjusting for fixed and random effects. This method is suitable considering the hierarchical design of the Demographic and Health Survey (DHS) data where individual women are nested in clusters like households or communities. Simple logistic regression would overlook such clustering and threaten biased estimates, while mixed-effects models control for intra-cluster correlations by random intercepts, enhancing precision and validity.

4. RESULTS

4.1. Distribution of Respondent Characteristics by Survey Year

Table 1 shows significant demographic and social trends over the three survey periods. For age distribution, the respondents were predominantly in the 30–39 and 40–49 age ranges, with fairly few in the 15–19 age group, reflecting the adult survey population. Women's autonomy in decision-making improved slowly, increasing from 35,048 in 2005 to 35,622 in 2015, indicating rising empowerment throughout the period. Educational achievement reports a distinct pattern. The proportion of women with no education fell consistently (from 28,247 in 2005 to 17,723 in 2015), and full secondary and higher levels of education more than doubled, indicating increased access to education.

Household wealth index distributions were fairly even, though a slight upward trend is observed by 2015, wherein the percentage of women in the wealthiest quintile (12,109) was greater than those in the poorest (13,644), reducing inequality. Fertility preferences show that the bulk always wanted no more children, though the percentage of women wanting more rose in 2015, possibly due to better child survival. Similarly, infant and under-five mortality also decreased strongly across survey years, indicating improvement in health. However, access to care was still unequal, with high reporting of "small problems" in both 2008 and 2015. Overall, the data show improvements in women's education, autonomy, and child health outcomes, but persistent healthcare access barriers.

Table 1: Distribution of Respondents Characteristics and Outcomes by Survey Year

Variable & Categories	2005	2008	2015	Total
Age Group				
15–19	450	318	381	1,149
20–24	3,958	3,138	3,903	10,999
25–29	8,414	7,022	9,685	25,121
30–34	10,147	8,022	11,699	29,868
35–39	12,667	9,308	11,742	33,717
40–44	12,614	10,172	10,698	33,484
45–49	13,205	10,616	11,102	34,923
Women's Autonomy				
No	26,407	19,870	23,588	69,865
Yes	35,048	28,726	35,622	99,396
Education				
No education	28,247	21,371	17,723	67,341
Incomplete primary	8,953	5,309	4,238	18,500
Complete primary	2,815	1,941	2,849	7,605
Incomplete secondary	4,962	4,482	7,304	16,748
Complete secondary	12,789	12,047	20,602	45,438
Higher	3,689	3,446	6,494	13,629
Wealth Index				
Poorest	16,510	12,482	13,644	42,636
Poorer	13,558	10,640	12,058	36,256
Middle	11,361	9,814	10,325	31,500
Richer	10,158	8,168	11,074	29,400
Richest	9,868	7,492	12,109	29,469
Fertility Preference				
Prefer no more children	54,684	42,459	49,119	146,262
Prefer more children	6,771	6,137	10,091	22,999
Infant Mortality				
Otherwise	57,368	46,358	57,106	160,832
Mortality	4,087	2,238	2,104	8,429
Child Mortality (Under 5 vs. Above)				
Under 5 mortality	5,254	2,832	2,516	10,602
Above 5 mortality	56,201	45,764	56,694	158,659
Access to Care				
No problem	55,189	0	0	55,189
Big problem	6,240	4,924	4,536	15,700
Small problem	0	43,581	54,674	98,255
Didn't answer	0	91	0	91

4.2. Frequency Distribution For Control Variables

The control and fertility-related measures show significant contextual trends in Table 2. Religion was uniformly Muslim across all years, with a small but persistent Christian minority (about 3–5%), demonstrating religious makeup to be fairly stable. Current pregnancy prevalence was constantly low, with fewer than 6% of women pregnant at the times of the surveys. Notably, the number of women pregnant at present increased from 2,773 in 2005 to 3,267 in 2015, even as overall fertility desires trended toward fewer children (as noted in previous tables).

Planned fertility outcomes reveal that most women wanted children "then," with this sample increasing from 11,147 in 2005 to 13,608 in 2015. The figures for women who wanted to delay childbearing ("later") or have no more were relatively small, though consistent over time. This yields a trend in which contemporaneous fertility continues to be valued by many respondents, while aggregate fertility desires are in decline. Combining, these results identify that though fertility wishes are altering progressively, cultural and religious characteristics presumably support extended childbearing desires.

Table 2: Frequency Distribution for Control Variables

Variable & Categories	2005	2008	2015	Total
Religion				
Muslim	58,457	46,363	57,105	161,925
Christian	2,944	2,233	2,088	7,265
Current Pregnancy				
Not pregnant/unsure	58,682	46,533	55,943	161,158
Currently pregnant	2,773	2,063	3,267	8,103
Planned Pregnancy				
Wanted then	11,147	9,275	13,608	34,030
Wanted later	937	569	1,037	2,543
Wanted no more	1,733	1,022	1,184	3,939

5. REGRESSION RESULTS

5.1. Mortality Rate

The mixed-effects logistic regression models tested predictors of infant and under-5 mortality controlling for demographic, socioeconomic, and contextual variables. Results in Table 3 indicate a strong age gradient: relative to mothers aged 15–19, the odds of infant mortality rose steadily with increasing age, to more than twice as high among those aged 45–49 (OR = 2.32, 95% CI [1.66, 3.23], $p < .001$). By contrast, increased maternal age was significantly linked with reduced under-5 mortality, which indicates that young mothers are highly susceptible to death in their children after infancy.

Education showed protective effects for infant but the reverse pattern for under-5 mortality. Those women with full secondary and higher-level education were more likely to survive without infant mortality (OR = 0.64 and OR = 0.48, respectively, $p < .001$), but their children were also at higher risk of dying before age five than children of uneducated women (OR = 1.67 and OR = 2.34, respectively, $p < .001$). Wealth was similar: households in more affluent quintiles had significantly lower odds of infant mortality (e.g., richest: OR = 0.54, $p < .001$) but elevated odds of mortality under age 5 (OR = 1.99, $p < .001$). Restricted access to care had inconsistent associations, with minor issues lowering infant mortality but raising mortality under age 5.

Survey year effects were observed to be increasing over time: infant mortality was significantly lower compared with 2005 in 2008 and 2015, while under-5 mortality was higher in the same years. Overall, the findings show multifaceted and sometimes paradoxical associations between maternal characteristics, socioeconomic status, and child survival outcomes.

Table 3 Mixed Effect Regression Outcomes for Mortality Rate

Predictor	Infant Mortality OR [95% CI]	Under-5 Mortality OR [95% CI]
Age group (ref: 15–19)		
20–24	1.11 [0.79, 1.57]	0.82 [0.58, 1.16]
25–29	1.17 [0.84, 1.64]	0.72 [0.52, 1.01]
30–34	1.30 [0.93, 1.82]	0.62 [0.44, 0.86] **
35–39	1.47 [1.05, 2.05] *	0.53 [0.38, 0.74] ***
40–44	1.87 [1.35, 2.61] ***	0.41 [0.29, 0.57] ***

45–49	2.32 [1.66, 3.23] ***	0.31 [0.22, 0.43] ***
Education (ref: no education)		
Incomplete primary	1.02 [0.95, 1.09]	1.01 [0.95, 1.07]
Complete primary	0.97 [0.87, 1.08]	1.12 [1.01, 1.24] *
Incomplete secondary	0.81 [0.74, 0.89] ***	1.28 [1.18, 1.40] ***
Complete secondary	0.64 [0.59, 0.69] ***	1.67 [1.56, 1.80] ***
Higher	0.48 [0.41, 0.55] ***	2.34 [2.04, 2.68] ***
Wealth index (ref: poorest)		
Poorer	0.81 [0.76, 0.86] ***	1.20 [1.14, 1.27] ***
Middle	0.75 [0.70, 0.81] ***	1.37 [1.28, 1.46] ***
Richer	0.61 [0.56, 0.67] ***	1.67 [1.55, 1.81] ***
Richest	0.54 [0.49, 0.60] ***	1.99 [1.81, 2.19] ***
Access to care (ref: no problem)		
Big problem	0.89 [0.79, 1.00] †	1.12 [1.01, 1.25] *
Small problem	0.79 [0.67, 0.92] **	1.28 [1.11, 1.47] **
Didn't answer	0.72 [0.22, 2.36]	1.80 [0.55, 5.87]
Religion (ref: Muslim)		
Christian	1.08 [0.96, 1.21]	0.96 [0.86, 1.07]
Survey year (ref: 2005)		
2008	0.85 [0.72, 0.99] *	1.20 [1.05, 1.38] *
2015	0.74 [0.64, 0.87] ***	1.43 [1.24, 1.64] ***
Random effects		
Var (Intercept)	0.26	0.22
Model fit		
Log likelihood	–31,975.49	–37,308.18
Wald χ^2 (df)	1796.53 (21) ***	2841.18 (21) ***
LR test vs. logit	χ^2 = 421.73 ***	χ^2 = 460.22 ***
N (observations)	169,164	169,164
Groups (clusters)	4,395	4,395

5.2. Fertility Rate

The mixed-effects logistic regression model analysed predictors of fertility desires among 40,485 women nested in 4,296 clusters as shown in table 4. Outcomes indicated robust age-related declines in the odds of reporting a want for more children compared with teenagers aged 15–19. 20–24-year-old women were 75% less likely to report fertility preference (OR = 0.25, 95% CI [0.21, 0.30]), with odds decreasing drastically with increasing age, falling almost to zero in the 45–49 group (OR = 0.01, 95% CI [0.01, 0.02], p < .001). Education had a positive slope, with women with higher education more than twice as likely to have reported fertility preference than those with no education (OR = 2.59, 95% CI [2.33, 2.88], p < .001). Wealth index had no significant relation to fertility. Access to care was generally insignificant, but with the exception of non-respondents, who had greater odds of fertility preference (OR = 2.67, 95% CI [1.05, 6.83], p < .05). Planned and existing pregnancy status powerfully decreased fertility preference, especially women reporting "no more" (OR = 0.05, 95% CI [0.04, 0.06], p < .001). Lastly, survey year showed rising odds with time, with more fertility preference reported in 2015 (OR = 1.56, 95% CI [1.29, 1.88], p < .001).

Table 4: Mixed Effect Logistic Regression for predicting Fertility Rate

Predictor	**OR [95% CI]**
Age group (ref: 15–19)	
20–24	0.25 [0.21, 0.30] ***
25–29	0.08 [0.07, 0.10] ***
30–34	0.03 [0.03, 0.04] ***
35–39	0.01 [0.01, 0.02] ***
40–44	0.01 [0.01, 0.01] ***
45–49	0.01 [0.01, 0.02] ***
Education (ref: No education)	
Incomplete primary	0.94 [0.83, 1.06]
Complete primary	1.09 [0.94, 1.26]
Incomplete secondary	1.18 [1.07, 1.29] **
Complete secondary	1.37 [1.27, 1.48] ***
Higher	2.59 [2.33, 2.88] ***
Wealth index (ref: Poorest)	
Poorer	1.01 [0.93, 1.10]
Middle	0.93 [0.85, 1.01]

Richer	1.04 [0.94, 1.14]
Richest	1.02 [0.91, 1.14]
Access to care (ref: No problem)	
Big problem	1.08 [0.93, 1.25]
Small problem	0.90 [0.75, 1.09]
Didn't answer	2.67 [1.05, 6.83] *
Planned pregnancy (ref: Then)	
Later	0.53 [0.48, 0.59] ***
No more	0.05 [0.04, 0.06] ***
Current pregnancy (ref: No)	
Yes	0.36 [0.33, 0.39] ***
Religion (ref: Muslim)	
Christian	0.89 [0.77, 1.02]
Survey year (ref: 2005)	
2008	1.25 [1.04, 1.52] *
2015	1.56 [1.29, 1.88] ***
Random effects	
Var (Intercept)	0.67 [0.61, 0.75]
Model fit	
Log likelihood	–21,210.01
Wald χ^2 (24)	5480.88 ***
LR test vs. logit	$\chi^2(1)$ = 1210.80 ***
N (observations)	40,485
Groups (clusters)	4,296

5.4. Interaction Effect

The regression analysis shows significant demographic and socioeconomic trends in mortality, infant mortality, and fertility outcomes with interaction effect of women autonomy as shown in table 5. For mortality, age is a persistent protective factor: the women in older age cohorts have significantly lower mortality odds than adolescents. Education and wealth, however, show a counterintuitive positive correlation with mortality. This seemingly counterintuitive result might be attributable to differential reporting, healthcare facility access, or greater exposure to institutional settings where deaths are better recorded. Autonomy of women has a strong positive correlation with death, but interaction effects indicate that its effect declines with increasing age of women, implying that autonomy imposes greater risks at younger reproductive ages, perhaps due to greater independence in the making of healthcare decisions.

By contrast, the infant mortality model highlights socioeconomic resources' protective function. Increased education and wealth are strongly linked to lower infant mortality in line with better access to healthcare, improved understanding of child health, and greater living standards. Women's autonomy is also highly protective, though its impact is conditioned by age with progressively diminishing benefits in older mothers. Interaction terms with wealth and education imply that autonomy is maximally effective when paired with secondary or higher education, supporting the need to balance social empowerment with structural resources.

The fertility model illustrates the anticipated decrease in fertility with increasing age, as chances of current pregnancy fall sharply after the mid-20s. Education, unlike mortality outcomes, is positively associated with fertility, such that women with higher levels of education are more likely to be pregnant now. Women's autonomy once again increases fertility chances, although its impact decreases as age advances. Interactions with access to care and wealth yield complex differences, where healthcare barriers diminish the fertility benefit of autonomy. Temporal effects point towards increasing fertility in more recent survey years. Collectively, these results underscore the dynamic interaction of age, socioeconomic position, and autonomy in determining health and reproductive outcomes.

Table 5: Interaction Term

Predictor	Mortality OR [95% CI]	Infant mortality OR [95% CI]	Fertility OR [95% CI]
Age group (ref: 15–19)			
20–24	1.05 [0.72, 1.53]	0.85 [0.58, 1.24]	0.35 [0.28, 0.45]

25–29	0.98 [0.68, 1.41]	0.84 [0.58, 1.21]	0.15 [0.12, 0.19]
30–34	0.89 [0.62, 1.27]	0.90 [0.63, 1.30]	0.08 [0.06, 0.10]
35–39	0.78 [0.54, 1.12]	0.97 [0.68, 1.40]	0.04 [0.03, 0.05]
40–44	0.61 [0.43, 0.88]	1.21 [0.85, 1.74]	0.03 [0.02, 0.04]
45–49	0.48 [0.34, 0.69]	1.47 [1.03, 2.10]	0.03 [0.01, 0.05]
Education (ref: none)			
Incomplete primary	1.00 [0.91, 1.08]	1.02 [0.92, 1.12]	0.95 [0.80, 1.13]
Complete primary	1.15 [0.99, 1.34]	0.94 [0.80, 1.11]	1.15 [0.93, 1.42]
Incomplete secondary	1.18 [1.05, 1.33]	0.86 [0.75, 0.98]	1.27 [1.11, 1.45]
Complete secondary	1.47 [1.32, 1.63]	0.71 [0.64, 0.80]	1.36 [1.22, 1.53]
Higher	2.03 [1.66, 2.47]	0.54 [0.44, 0.67]	2.30 [1.96, 2.70]
Wealth index (ref: poorest)			
Poorer	1.23 [1.14, 1.32]	0.77 [0.71, 0.84]	1.04 [0.93, 1.17]
Middle	1.40 [1.28, 1.54]	0.70 [0.63, 0.77]	0.99 [0.88, 1.13]
Richer	1.68 [1.51, 1.87]	0.62 [0.55, 0.70]	1.03 [0.90, 1.19]
Richest	1.79 [1.57, 2.03]	0.61 [0.53, 0.70]	1.03 [0.88, 1.20]
Access to care (ref: no problem)			
Big problem	1.10 [0.97, 1.25]	0.96 [0.84, 1.11]	1.13 [0.94, 1.35]
Small problem	1.24 [1.08, 1.44]	0.83 [0.70, 0.97]	1.04 [0.86, 1.27]
Didn't answer	1.04 [0.24, 4.57]	1.27 [0.29, 5.59]	7.58 [1.70, 33.83]
Women's autonomy (Yes)	7.30 [2.55, 20.86]	0.13 [0.05, 0.38]	1.58 [1.09, 2.31]
Age group × Women's autonomy			
20–24*Yes	0.263 [0.090, 0.766]	4.05 [1.39, 11.82]	0.471 [0.327, 0.677]
25–29*Yes	0.206 [0.072, 0.592]	5.21 [1.81, 14.99]	0.294 [0.205, 0.422]
30–34*Yes	0.175 [0.061, 0.501]	5.88 [2.05, 16.87]	0.190 [0.131, 0.275]
35–39*Yes	0.163 [0.057, 0.466]	6.45 [2.25, 18.51]	0.127 [0.084, 0.192]
40–44*Yes	0.163 [0.057, 0.467]	6.58 [2.30, 18.86]	0.100 [0.056, 0.176]
45–49*Yes	0.166 [0.058, 0.475]	6.26 [2.19, 17.94]	1.77e-09 (CI = 0 —)
Education × Women's autonomy			
Incomplete primary*Yes	1.01 [0.90, 1.14]	1.02 [0.89, 1.16]	1.01 [0.79, 1.30]
Complete primary*Yes	0.93 [0.76, 1.14]	1.07 [0.86, 1.34]	1.00 [0.74, 1.35]
Incomplete secondary*Yes	1.15 [0.97, 1.35]	0.92 [0.77, 1.10]	0.95 [0.79, 1.15]
Complete secondary*Yes	1.21 [1.05, 1.40]	0.86 [0.74, 1.00]	1.14 [0.98, 1.33]
Higher*Yes	1.24 [0.95, 1.62]	0.82 [0.62, 1.09]	1.39 [1.12, 1.71]
Access to care × Women's autonomy			
Big problem*Yes	1.03 [0.90, 1.19]	0.87 [0.74, 1.02]	0.924 [0.762, 1.120]
Small problem*Yes	1.04 [0.95, 1.14]	0.92 [0.83, 1.02]	0.775 [0.687, 0.875]
Didn't answer*Yes	3.08 [0.26, 36.98]	0.32 [0.03, 3.82]	0.18 [0.025, 1.318]
Wealth index × Women's autonomy			
Poorer*Yes	0.95 [0.85, 1.06]	1.10 [0.98, 1.25]	0.95 [0.81, 1.12]
Middle*Yes	0.93 [0.82, 1.06]	1.17 [1.02, 1.34]	0.92 [0.78, 1.10]
Richer*Yes	0.97 [0.84, 1.12]	1.02 [0.87, 1.20]	1.09 [0.91, 1.31]
Richest*Yes	1.19 [0.99, 1.42]	0.83 [0.68, 1.00]	1.12 [0.92, 1.37]
Religion (ref: Muslim)			
Christian	0.95 [0.85, 1.05]	1.09 [0.97, 1.23]	0.89 [0.77, 1.02]
Survey year (ref: 2005)			
2008	1.21 [1.05, 1.39]	0.84 [0.72, 0.99]	1.26 [1.04, 1.53]
2015	1.44 [1.25, 1.65]	0.74 [0.63, 0.86]	1.56 [1.29, 1.88]

6. DISCUSSION

The present work analysed the demographic transition of Egypt's population with respect to fertility and mortality, and in doing so, evaluated the influence of socioeconomic variables. The results reflect significant trends in accordance with

more general demographic transition theory, but at the same time reveal specific contextual subtleties present in Egypt. Firstly, the trend descriptions revealed major advances in the education of women, independence, and declines in infant mortality between 2005 and 2015. These trends align with Caldwell's (1986) contention that female schooling is a force behind declines in fertility and survival of children, as educated mothers tend to practice contemporary health habits and control family size. As with the findings of Gakidou et al. (2010), education was a protective factor for infant mortality, although regression findings indicated an inverse association with greater under-five mortality. Such paradox could represent differences in reporting or household-level risks not captured by the data, consistent with results from Bicego and Boerma (1993) that survival of children is influenced by multifaceted social and environmental forces rather than by schooling on the part of mothers alone.

Age impacts also tracked anticipated demographic trends. Older mothers had greater chances of infant mortality but lower chances of under-five mortality, indicating that dangers linked with biological aging are compensated by gained maternal experience and capital in subsequent child-rearing. Fertility desires decreased significantly with age, as the classical demographic transition hypothesis (Notestein, 1945) and empirical observations in Sub-Saharan Africa (Bongaarts, 2025) purport, where younger women have greater fertility aspirations while older women desire smaller family sizes.

Wealth exhibited a protective effect on infant mortality, consistent with Rutstein (2005), who highlighted the impact of household economic status in enhancing neonatal outcomes based on improved nutrition, sanitation, and healthcare access. The observed positive relationship between elevated wealth and under-five mortality, however, indicates disparities in health-seeking behaviour or differential risks within child-rearing settings. Such conflicting evidence has also been noted in South Asia, where wealth did not necessarily equate to better survival from urban health risks (Gupta et al., 2016).

Women's autonomy also presented as a key predictor of both mortality and fertility, echoing the Women's Empowerment Framework (Longwe, 1991) and research by Bloom et al. (2001), which illustrated that empowered women have more informed healthcare and fertility choices. Autonomy lowered infant mortality and raised fertility preference in this study, highlighting its complex role. Interaction effects revealed that autonomy gained most benefits when combined with education and wealth, which lends support to arguments by Jejeebhoy (1995) that empowerment needs structural resources in order to achieve beneficial demographic consequences. However, in younger women, autonomy was at times also linked to higher risks, indicating that independence without health literacy or supportive systems may not ensure better outcomes.

Temporal trends reinforced Egypt's demographic transition. Infant mortality greatly decreased over survey years, coinciding with UNICEF-reported (2019) global improvements in child survival. While declining, fertility preferences dropped, indicating both social modernization and policy effects. However, growing under-five mortality in subsequent years suggests ongoing weaknesses in child health systems, consistent with worries expressed by El-Zanaty and Way (2009) about unequal progress in Egypt's health system delivery.

Overall, this research affirms that Egypt is undergoing demographic transition, with fertility and mortality declining due to education, wealth, and women's autonomy. Paradoxical results, such as education's association with increased under-five mortality, stress the need for more subtle policy. Improving healthcare systems, widening coverage, and guaranteeing that women's empowerment is accompanied by sufficient resources are all still key to cementing Egypt's demographic achievements.

7. CONCLUSION AND RECOMMENDATION

This analysis aimed to assess the demographic transition of Egypt and understand mortality and fertility as well as the socioeconomic factors involved. The results show that Egypt has advanced considerably, as suggested by reduced infant mortality and lowered fertility aspirations, in line with demographic transition theory. Education of women, wealth, and autonomy proved to be critical determinants and influenced child survival and fertility outcomes. But some contradictory findings, like the positive correlation of education and income with under-five mortality, show that progress is uneven and mediated by contextual obstacles, such as gaps in the health system and urban environmental hazards. Women's autonomy, although largely protective, had mixed outcomes by age and socioeconomic status, indicating that empowerment is not enough without

accompaniment by supportive infrastructure. Generally, Egypt's demographic profile is transforming towards lower fertility and mortality, but long-term progress depends on combined social, economic, and health interventions.

To support Egypt's demographic transition and lower mortality and fertility issues, the healthcare system needs to be strengthened by ensuring that good quality maternal and child healthcare is made accessible, particularly in rural and deprived areas. Investments need to be directed towards augmenting health infrastructure, enhancing the availability of skilled health personnel, and more outreach programs in preventive and emergency care. Concurrently, women's empowerment programs need to be coupled with increased educational and economic opportunities since independence without sufficient resources may have limited effects. Support for the vulnerable populations, especially young mothers and poor households, should be targeted through subsidised care, family planning interventions, and social protection programs. Community-based health literacy campaigns can close the gap between practice and knowledge by empowering families with the ability to adopt safe child and reproductive health behaviours. Lastly, strong monitoring systems need to be put in place to monitor disparities between socioeconomic and regional groups so policymakers can respond with targeted interventions addressing arising inequalities. Collectively, these steps can convert demographic advances into lasting health and social benefits.

POLICY IMPLICATIONS

The research results underscore key policy implications for Egypt's demographic transition. Firstly, the decline in child mortality and moderation in fertility rates call for synergistic strategies integrating access to healthcare with socioeconomic development. Policies should give top priority to the expansion of maternal and child health facilities, especially in rural and low-income settings, as a means of eliminating inequalities. Education policies need to further extend women's education since it has a significant impact on fertility preferences and child survival rates, and at the same time provide opportunities for women's economic engagement to convert autonomy into real health gains. In addition, fertility regulation policies need to be reactive to evolving demographic necessities by providing increased access to cheap family planning measures. Lastly, policymakers need to reinforce data collection systems to track disparities between regions, wealth groups, and levels of education in order to provide evidence-based decision-making. All these measures together guarantee Egypt's demographic transition is synchronized with sustainable development goals and ensures equitable social and health outcomes.

LIMITATIONS AND FUTURE DIRECTION

There are a number of limitations to this study that need to be noted. One, depending on secondary survey data, means that the analysis is confined to available variables and excludes potentially important factors like cultural norms, environmental considerations, and regional differences in health infrastructure that could affect mortality and fertility. Two, the cross-sectional nature of the data means causality cannot be established, as associations can capture unobserved underlying dynamics. Third, self-report measures, especially on women's autonomy and fertility desires, can be subject to reporting bias. Despite these shortcomings, the study is an important contribution to Egypt's demographic transition. Subsequent studies must include longitudinal data to trace causality and investigate inter-generational impacts. Qualitative methods could also enhance knowledge on cultural and behavioural forces influencing demographic outcomes. Broadening the focus to regional comparisons in the Middle East and North Africa (MENA) could also identify distinctive and common fertility and mortality transitions drivers.

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