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Programming For Data Analytics (04638-A)
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Assignment Title:Exploratory Analysis of Africa's Demographic Transition:
Trends in Fertility, Mortality, and Life Expectancy (2010–2024)
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Abstract—This study assesses Africa's progress in population health and demographic transition between 2010 and 2024. The main objective is to understand how fertility, mortality, and life expectancy have evolved across African countries and regions, and what these changes reveal about the continent's overall health and development trajectory. Using publicly available demographic indicators from the United Nations, the analysis explores patterns and relationships through descriptive statistics and visualizations such as line, bar, and scatter plots.

The findings show clear evidence of progress across much of Africa. Fertility rates have declined steadily, life expectancy has increased for both men and women, and under-five mortality rates have dropped significantly. Regions with higher life expectancy, such as Northern and Southern Africa, also show slower population growth, reflecting a gradual demographic transition toward smaller family sizes and longer lifespans. However, maternal mortality remains uneven across regions, with several countries still facing high risks compared to global averages.

Overall, the study highlights meaningful health improvements but emphasizes the need to sustain gains in child and maternal survival while addressing persistent inequalities between regions. These insights provide valuable guidance for policymakers working toward equitable and sustainable population health outcomes in Africa.

I. INTRODUCTION

II. BACKGROUND AND PROBLEM DESCRIPTION

Africa is undergoing a complex demographic transition characterized by declining fertility rates, rising life expectancy, and gradual improvements in child and maternal survival. Over the past two decades, most African countries have experienced rapid population growth driven by high fertility and declining mortality, resulting in both opportunities and challenges for sustainable development [1]. According to the United Nations World Population Prospects (2024), Africa's population is projected to nearly double by 2050, making it home to one-quarter of the world's people [2]. This growth places significant pressure on health systems, education, and labor markets, while also reflecting improvements in survival and living conditions.

Despite this progress, large regional disparities remain. Sub-Saharan Africa continues to record some of the highest maternal and under-five mortality rates in the world, alongside persistent gaps in healthcare access and gender equality [3]. Fertility rates, while declining, remain above the global average in many regions, delaying the demographic dividend that could accelerate economic growth. Understanding these patterns, how fertility, mortality, and life expectancy interact across countries and regions is essential for formulating effective health and development policies

The central problem addressed in this study is the uneven pace of demographic transition across African regions and its implications for population health.

Objectives: The study's main objective is to assess Africa's progress in population health and demographic transition from 2010 to 2024 using United Nations data. It analyzes regional and temporal trends in fertility, mortality, and life expectancy, examines how these indicators interact across countries, and identifies both progress and remaining gaps. This analysis contributes to the understanding of Africa's demographic dynamics by linking statistical trends with health and policy relevance.

III. METHODS

A. Overview

The analysis combined quantitative summarization, visual exploration, and statistical correlation to uncover temporal and regional patterns in population health outcomes. The analysis utilized open-source Python libraries (`pandas`, `numpy`, `matplotlib`, `seaborn`) ensuring transparency and repeatability within a Jupyter Notebook environment.

B. Data Source and Transformation

Data were obtained from the United Nations *World Population Prospects 2024* database [1]. The dataset was originally in a *long format*, it was reshaped into a *wide format*, Only entries representing Africa, its subregions (Northern, Western, Eastern, Middle, Southern, and Sub-Saharan Africa) and African countries were retained. The resulting subset, contained 247 records spanning 62 entities (Africa, subregions and countries) and four observation years (2010, 2015, 2020, and 2024) and 7 key indicators each as column.

C. Data Cleaning and Validation

All numerical indicators were standardized and converted to consistent formats. Missing values were assessed, with 30% missing for maternal mortality in 2024; no imputation was done to preserve the integrity of official records, analyses used available data. Quality checks confirmed consistent temporal coverage, and outlier inspections showed no extreme anomalies, ensuring data reliability.

D. Analytical Strategy

The analysis followed three stages: subsectionAnalytical Strategy The analysis followed three stages:

1) **Descriptive Analysis:** Computed summary statistics and visualized distributions with histograms and boxplots to establish baseline demographic patterns and check for outliers.
2) **Temporal and Regional Trends:** Analyzed changes in fertility, mortality, and life expectancy from 2010 to 2024 using various charts.
3) **Relational Analysis:** Used scatter plots with trend lines to examine correlations among key indicators, including fertility, maternal mortality, life expectancy, and under-five mortality.

IV. RESULTS AND DISCUSSION

A. Descriptive Analysis of African Demographic Indicators

a) Summary statistics.: Descriptive statistics reveal that Between 2010 and 2024, the mean life expectancy across African regions was 62.7 years, with females (64.9 years) living on average 3.7 years longer than males (60.7 years). The mean total fertility rate stood at 4.3 births per woman, while population growth averaged 2.3% annually. Both maternal and child mortality remained high (376.4 and 66.8 per 100,000 and 1,000 live births respectively).

b) Distributional characteristics.: Histograms and boxplots show that life expectancy is nearly normally distributed with low dispersion, while fertility and mortality are right-skewed, reflecting Africa's transition from high- to medium-fertility regimes. Maternal and under-five mortality have heavier right tails, indicating persistent high preventable deaths. Population growth rates are tightly clustered around 2–3%, showing temporal stability.

c) Insights from the Question.: **Population Growth.** Africa's annual population growth rate declined from **2.6% in 2010** to **2.3% in 2024**, marking the beginning of a gradual slowdown after decades of rapid expansion. This pattern signals the early stages of demographic transition, where falling fertility and rising longevity reshape the continent's growth trajectory.
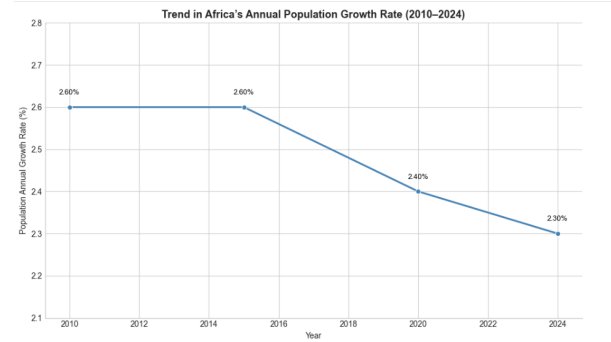

Fig. 1: Trend in Africa's Annual Population Growth Rate (2010–2024).

Fertility Decline. Across all African regions, fertility rates have continued to fall, with the continental average decreasing from approximately **4.9 to 4.2 children per woman**. Northern and Southern Africa recorded the most significant drops—now below three children per woman—while Middle and Western Africa remain higher at five or more. The decline reflects improvements in women's education, urbanization, and access to reproductive health services.
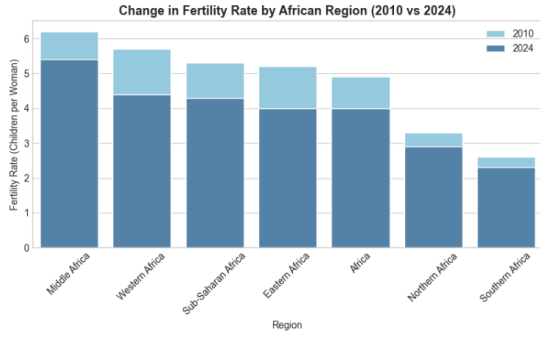
Fig. 2: Fertility Rate Comparison by Region (2010 vs 2024).

Life Expectancy Improvements. Life expectancy has improved markedly, rising from about **61.5 to 65 years** continent-wide. Northern Africa leads at over 70 years, supported by stronger health systems, while Western and Middle Africa remain below 60. These trends highlight continuing gains in population health, though disparities persist between regions.
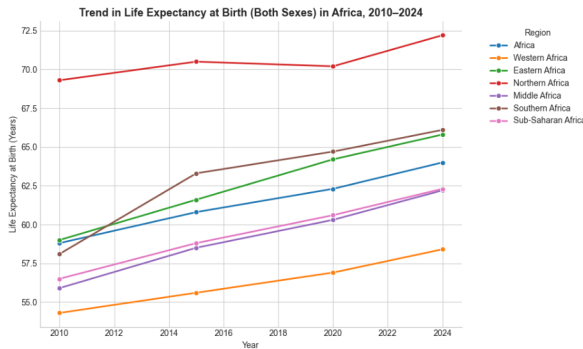

Fig. 3: Average Life Expectancy by Region (2010–2024).

Child Mortality Reduction. Under-five mortality rates have fallen sharply across the continent. Western and Middle Africa, once among the highest, saw declines exceeding 40 deaths per 1,000 live births, while Somalia and Sierra Leone achieved the largest national reductions. These improvements reflect successful child-health interventions and expanded healthcare access.
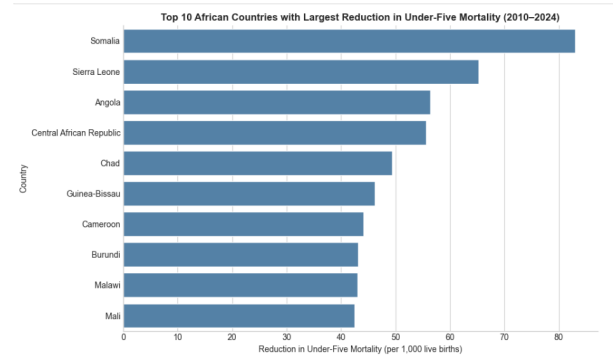

Fig. 4: Under-Five Mortality Rate Trends and Reductions (2010–2024).

Health Relationships. Inter-indicator relationships reinforce the narrative of demographic transition. Regions with higher life expectancy exhibit slower population growth , suggesting that longevity gains accompany reduced fertility. Women consistently outlive men, with the gender gap widening from **3.1 to 4.1 years**. Countries with high fertility experience markedly higher maternal mortality while low-fertility nations enjoy longer lifespans

d) Discussion: Collectively, these findings reveal a continent undergoing a gradual yet steady demographic transition. Declining fertility and mortality, coupled with increasing life expectancy, indicate real progress in public health, education, and gender equity. However, regional disparities persist: while Northern and Southern Africa are moving toward population stabilization, Middle and Western Africa remain in earlier stages, still facing high fertility and child mortality rates. Sustaining these gains requires continued investment in **maternal health, education, and healthcare infrastructure** to ensure equitable demographic progress aligned with Africa's development goals.

V. CONCLUSION

Africa is advancing through a measurable demographic transition; fertility is falling, life expectancy is rising, and population growth is beginning to slow [5], [6]. Child and maternal mortality have declined, yet remain high in several regions, underscoring persistent health inequities [7], [8]. Northern and Southern Africa are closest to stabilization, while Western and Middle Africa lag behind. These findings align with our objective to assess progress in population health and its policy relevance. Sustained gains will depend on targeted investments in maternal and child health, girls'

education, reproductive services, and robust data systems to reduce disparities and consolidate progress.

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