

PROJECTION OF MATERNAL MORTALITY FOR JAMAICA USING A MACHINE LEARNING TECHNIQUE

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ABSTRACT

This research article employs annual time series data on MMR for Jamaica from 1985 to 2023 to predict future trends of MMR over the period 2024 to 2035. The forecast evaluation criteria of the applied model indicate that the ANN (12, 12, 1) model is stable. The neural network model projections revealed that MMR is likely going to increase and remain high throughout the out of sample period. Therefore, we encourage the government to address local causes of preventable maternal mortality.

Keywords: ANN, Forecasting, Maternal Mortality Ratio

INTRODUCTION

The maternal mortality ratio (MMR) is defined as the number of women who die from pregnancy-related causes per 100,000 live births (Bourne et al. 2022). The majority of maternal deaths in Jamaica are due to numerous preventable causes such as underutilization and deficiencies in antenatal care, incompetency of clinical staff and delays in taking action when signs of complications develop before, during, and after delivery (Jamaica, 2022). The most common causes of death in 1981-1983 were hypertensive diseases of pregnancy (26%), hemorrhages (20%), ectopic pregnancy (10%), pulmonary embolism (8%), and sepsis (8%) (Jamaica, 2022). Jamaica has experienced increased cases of deaths due to non-communicable diseases and non-obstetric causes (McCaw-Binns et al. 2022; Jamaica MOH, 2022) which is similar to the regional counterparts (Razzaghi et al. 2019). Non-communicable diseases (NCDs) such as diabetes mellitus (DM) and hypertension are known risk factors for maternal morbidity and mortality. Obesity may be classified as an indirect cause posing risks to maternal health (Chakhtoura et al. 2019; Riley et al. 2018; Caughey et al. 2018; Kanguru et al, 2017)5-8. The leading causes of death in Jamaica in 2014 were hypertensive disorders in pregnancy (19%) and hemorrhage (18% PAHO, 2017).

The objective of this paper is to model and forecast MMR for Jamaica using a machine learning approach. The results of the study will inform policy and allocation of resources to the maternal and child health program in order to further reduce preventable maternal deaths across the country.

LITERATURE REVIEW

Author(s)	Objective(s)	Methodology	Key finding(s)
Cuestas et al. (2026)	To analyze whether the proportion of Indigenous and Afro-Colombian populations at the municipality level (admin level 3) is associated with high levels of maternal mortality rates in Colombia between 2017 and 2020	Ecological study	-Maternal mortality rates increased between 2017 and 2020, and the increase was concentrated in municipalities in remote areas -municipalities with a higher proportion of Indigenous and Afro-Colombian populations have higher probabilities of presenting high rates of maternal mortality, and when these populations are living in rural areas, maternal mortality increases even more
Marks & Castro (2026)	To examine how MWHs have been implemented across Latin America, analyzing their evolution, the specific needs they address in different countries, and their impact on maternal and neonatal health outcomes throughout the region	Systematic review	The evolution of MWHs suggests that they address a spectrum of needs beyond their original purposes, such as providing culturally responsive maternal support and psychosocial and early childhood support
Yue et al. (2026)	to perform an umbrella review to summarize the current evidence to provide a reference for clinicians and future research	Systematic literature review	This review offers a thorough overview of the current evidence linking SLE, SS and APS to pregnancy and assisted reproductive outcomes. It identifies existing gaps and proposes future research directions
Bayas (2025)	to develop and evaluate a model to improve access to maternal and child health services to reduce maternal mortality in a public hospital in Ecuador	Quantitative approach	the proposed model demonstrated a significant and positive effect on access to maternal and child health services, as evidenced by differences between pretest and posttest scores in the experimental group
Cresswell et al. (2025)	To obtain updated evidence on causes of maternal death is needed to accelerate progress	Systematic review	Globally, the most common cause of maternal death was hemorrhage (27%; 80% uncertainty interval 22–32), followed by indirect obstetric deaths (23%, 18–30), and hypertensive disorders (16%, 14–19). The proportion of

			hemorrhage deaths varied substantially by region and was highest in sub-Saharan Africa and Western Asia and Northern Africa.
Goicochea et al. (2025)	to identify and analyze maternal complications associated with adolescent pregnancy, with a particular focus on the Latin American context	Mixed methods approach	adolescent pregnancy in Latin America and the Caribbean entails significant medical risks and negatively affects the integral development of adolescents, a situation that is aggravated by the lack of access to health services, education and by factors such as poverty
Quiroz-Acuña et al. (2025)	To assess maternal mortality trends in LAC women from 1997 to 2019, providing key insights to address this issue.	ecological observational time-series study	Despite overall progress, regional differences in maternal mortality persist across Latin America and the Caribbean. These variations highlight the importance of strengthening maternal health systems, improving access to skilled birth attendance, and ensuring quality prenatal and postnatal care
Silvana et al. (2025)	To describe the factors influencing the reduction of maternal mortality during the 2022–2024 management period at Tartagal Hospital (HT)	Participatory Action Research (PAR) with a qualitative-quantitative analysis. Twelve meetings and interviews were conducted with the healthcare team, along with 10 validated surveys administered to obstetric inpatients (10/12/24), and an analysis of hospital databases	intercultural, comprehensive, and territory-based management of pregnancy and childbirth led to a reduction in maternal mortality beginning in 2022. Teamwork and intersectoral collaboration optimized available resources, consolidating a sustainable and effective model for maternal health. However, the greatest challenge lies in maintaining and increasing funding to ensure the continuity of this policy
Salazar Flórez et al. (2025)	to examine the trends in maternal mortality in Colombia and its social disparities based on the area of residence from 2014 to 2021	Ecological study	Maternal mortality rates have increased in recent years, with a more pronounced rise in remote rural areas than in settlements and municipal centers
Nigenda and Serván-Mori (2024)	To discuss the relationship between the availability of human resources for health and the maternal mortality	used secondary data from a global source to show patterns in the relationship between these two aspects and identify gaps in the	Although variations in maternal mortality rate cannot be explained solely through the provision of health personnel, it is important to consider that it is critical to find new modalities

	ratio for the period 1990–2021 in Latin America	Latin American and Caribbean regions	on how human resources for health could integrate and create synergies with other resources to increase systems capacity to deliver care according to conditions in each country
Castañeda-Orjuela et al. (2023)	to examine changes in maternal mortality and identify correlates and predictors of excess maternal mortality in Colombia during the pandemic	Analysis of data from the national epidemiological surveillance databases of Colombia (Sivigila)	The COVID- 19 pandemic had considerable impact on maternal health, not only by leading to increased deaths, but also by increasing social health inequity
Rodríguez Hernández et al. (2023)	to analyze the inequalities and inequities in Maternal Mortality (MM) for Chocó (Colombia) between 2010–2018	Mixed method study	The Maternal Mortality Ratio was 224/100 000 live births. The Gini coefficient was 0.35, indicating inequality in the distribution of the number of MM with respect to live births
Bourne et al. (2022)	To assess Jamaica's maternal mortality rate trend from 2000 to 2019. Objectives: 1) To explore the trend of maternal ratio and 2) To determine the causes of maternal mortality. To establish some preventative measures for maternal mortality ratio.	Descriptive statistics, changes in percentages, and graphs were used to examine the incidence of maternal mortality ratio. Data collected from The World Health Organization and Statistical Institute of Jamaica was stored, retrieved, and analyzed using the Statistical Packages for the Social Sciences (SPSS) version 28.0 and Microsoft Excel	The findings annually have been varied. However, a significant improvement since the year 2000. These findings show that the most annual change since 2000 was 53.05%, and the most minor was - 25.03%
Critto et al. (2022)	To examine the effects of a pandemic influenza virus on cause-specific maternal mortality time series, using Argentinian vital statistics	-conducted a population-based natural experiment from national vital records of maternal deaths between 1980 and 2017 -applied Join-point regression models	Over this 38-year study, the MMR decreased by 58.6% (69.5 to 28.8 deaths/100,000 live births), transitioning from direct obstetric causes (67.0 to 21.1/100,000 live births; 68.4% decrease) to indirect causes (2.6 to 7.7/ 100,000 live births; 196.2% increase)
Schuurmans et al. (2021)	-To determine the prevalence of maternal death, stillbirth and low birthweight in women with (pre-)	-conducted a retrospective cohort study of pregnant women admitted to Centre de Référence	Of all admissions, 10 991 (34.9%) were women with (pre-)eclampsia. Caesarean section significantly increased the risk of maternal death in the women

	eclampsia and complicated pregnancies or deliveries in Centre de Références des Urgences Obstétricales, an obstetric emergency hospital in Port-au-Prince, Haiti	des Urgences Obstétricales between 2013 and 2018 using hospital records. Risk factors investigated were age group, type of pregnancy (singleton, multiple), type of delivery and use of antenatal care services	with a complicated pregnancy and women with (pre-)eclampsia, but reduced the risk of stillbirth in such women
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METHODOLOGY

The Artificial Neural Network (ANN) approach, which is flexible and capable of nonlinear modelling; will be applied in this study. The ANN is a data processing system consisting of a large number of highly interconnected processing elements in architecture inspired by the way biological nervous systems of the brain appear like. Since no explicit guidelines exist for the determination of the ANN structure, the study applies the popular ANN (12, 12, 1) model based on the hyperbolic tangent activation function. This paper applies the Artificial Neural Network (ANN) approach in predicting annual maternal mortality ratio (MMR) for Jamaica.

Data Issues

This study is based on annual MMR in Jamaica for the period 1985 – 2023. The out-of-sample forecast covers the period 2024 – 2035. All the data employed in this research paper was gathered from the World Bank online database.

Findings of the study

ANN Model Summary

Table 1: ANN model summary

Variable	J
Observations	27 (after adjusting endpoints)
Neural Network Architecture:	
Input Layer Neurons	12
Hidden Layer Neurons	12
Output Layer Neurons	1
Activation Function	Hyperbolic Tangent Function
Back Propagation Learning	
Learning Rate	0.005
Momentum	0.05
Criteria:	
Error	0.016107
MSE	6.449886
MAE	2.160952

Residual Analysis for the Applied Model

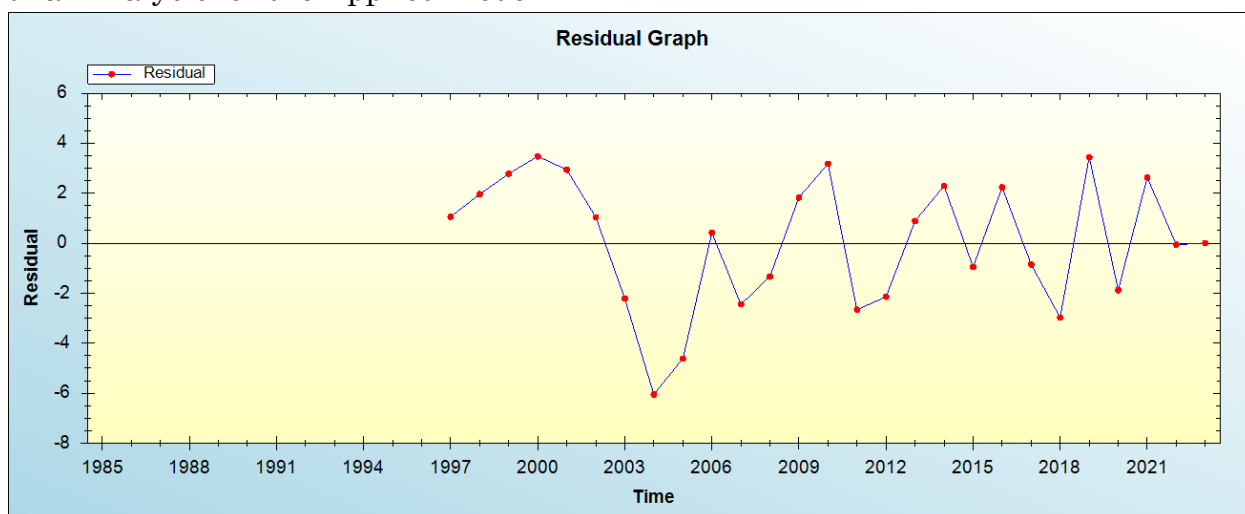


Figure 1: Residual analysis

In-sample Forecast for J

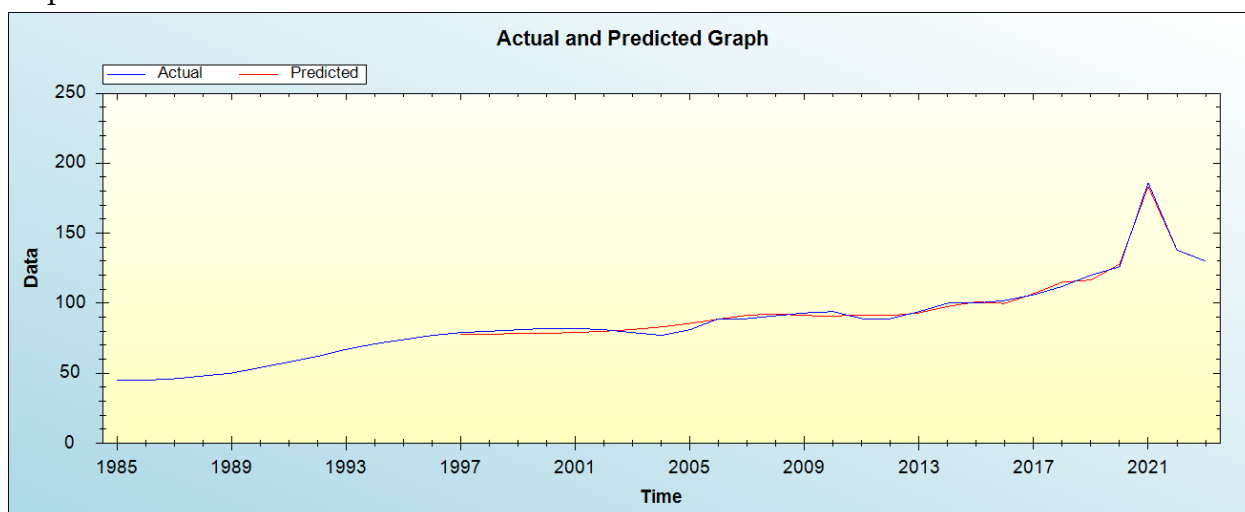


Figure 2: In-sample forecast for the J series

Out-of-Sample Forecast for J: Actual and Forecasted Graph

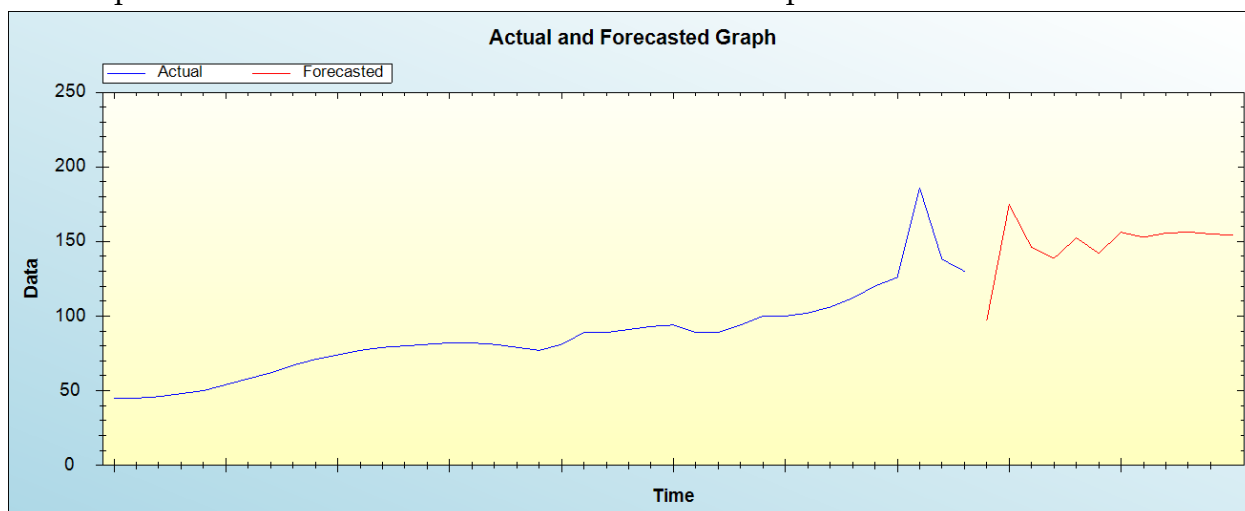


Figure 3: Out-of-sample forecast for J: actual and forecasted graph

Out-of-Sample Forecast for R: Forecasts only

Table 2: Tabulated out-of-sample forecasts

Year	Forecasted MMR
2024	97.2168
2025	174.7323
2026	145.9258
2027	138.6786
2028	152.3641
2029	142.0788
2030	156.1321
2031	152.8150
2032	155.5469
2033	156.3198
2034	154.9570
2035	154.2350

The main results of the study are shown in table 1. It is clear that the model is stable as confirmed by evaluation criterion as well as the residual plot of the model shown in figure 1. It is projected that annual MMR is likely to increase and remain high over the out of sample period.

RECOMMENDATIONS & CONCLUSION

Maternal mortality ratio indicates the quality of maternal healthcare services offered during the antenatal, childbirth and puerperium periods. Existence of numerous gaps in the continuum of care contributes significantly to high maternal mortality rates in low-middle income countries. In this study we modelled and forecasted MMR and the findings indicate that MMR is likely to increase and remain high over the out of sample period. Therefore, health authorities in Jamaica are encouraged to address major drivers of maternal mortality and conduct routine quality improvement activities.

REFERENCES

1. Caughey A.B., and Turrentine M (2018). ACOG PRACTICE BULLETIN: Gestational Diabetes Mellitus. *Obstetrics and Gynecology*. 131(2): E49–64.
2. Chakhtoura N., Chinn J.J., Grantz K.L., Eisenberg E., Artis Dickerson S., Lamar C (2019). Importance of research in reducing maternal morbidity and mortality rates. *Am J Obstet Gynecol*. 221(3):179–82.
3. Jamaica (2022) Maternal Mortality Rate 2000-2022. Macro Trends. [cited 2022 Oct 11]. Available from: <https://www.macrotrends.net/countries/JAM/jamaica/maternal-mortality-rate>
4. Kanguru L., McCaw-Binns A., Bell J., Yonger-Coleman N., Wilks R., and Hussein J (2017). The burden of obesity in women of reproductive age and in pregnancy in a middle-income setting: A population-based study from Jamaica. *PLoS One*. 12(12): e0188677.
5. McCaw-Binns A., Campbell L., Harris A., James L.A., and Asnani M (2022). Maternal mortality among women with sickle cell disease in Jamaica over two decades (1998–2017).

- EClinical Medicine [Internet]. 2022; 43:101238. Available from: <http://www.thelancet.com/article/S2589537021005198/fulltext>
6. MOH Jamaica (2022). Non-Communicable Diseases. Ministry of Health and Wellness Jamaica. Available from: <https://ncdip.moh.gov.jm/non-communicable-disease/>
 7. PAHO (2017). Health in the Americas+ [Internet]. Scientific and Technical Publication. Available from: <https://iris.paho.org/handle/10665.2/34321>
 8. Paul Andrew Bourne., Chardonnay Forbes., Kacia Hayles., KeshannaYoung., Sasha- Lee Bailey., Shenique Walch., James Fallah., Calvin Campbell., Clifton Foster., Caroline McLean., Tabitha Muchee., and Barbara Biira (2022). Maternal Mortality in Jamaica: A Quantitative Analysis using time-series data, 2002-2021, Academic Journal of Health sciences 2023/38 (2): 110-115
 9. Razzaghi H., Martin D.N., Quesnel-Crooks S., Hong Y., Gregg E., Andall-Brereton G., Gawryszweski V., and Saraiya M (2019). 10-year trends in noncommunicable disease mortality in the Caribbean region. Rev Panam Salud Publica. 43: e37. doi: 10.26633/RPSP.2019.37
 10. Riley L., Wertz M., and McDowell I (2018). Obesity in Pregnancy: Risks and Management. Am Fam Physician. 97(9):559-561.