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Forecasting Modelling of Adolescent Pregnancy Crisis in Malaysia Using Runge-Kutta Fourth Order Method

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Abstract

Despite the significant dangers that countries suffer when adolescent pregnancy is neglected, this major problem usually receives little attention. In recent decades, the number of teenage girls who get pregnant has increased worldwide. Therefore, this issue has become many countries' main public health concern. This paper aims to use MATLAB to estimate Malaysian teen pregnancy data for the next few years and to find missing data for a particular year. Since the Runge-Kutta is used to forecast the prevalence of adolescent pregnancy in Malaysia, the comparison reveals that the two sets of data are distinct. Therefore, the order four Runge-Kutta method is insufficient to approximate incomplete data for adolescent pregnancy. Although the results show that adolescent pregnancy has decreased over time, we must continue to treat this issue seriously. It is necessary to educate teenagers about sex education and safe pregnancy. Educating the young about the risk of having pregnancies in their early years is also necessary. Additionally, it is necessary to provide special consideration to those who did not grow up in a good environment and belong to a family unit that does not function in a healthy way according to social norms.

Keywords: adolescent pregnancy, Malaysia, Runge-Kutta, teenage girls

INTRODUCTION

Adolescent pregnancy is one of the prominent community issues in many countries all over the world. Adolescence is a crucial time for teenage girls, which is marked by important changes in their physiological, social, behavioural, and sexual [1]. World Health Organization identified that over 16 million adolescent females around the world between the ages of 15 and 19 give birth every year [2]. Over 20% of adolescent girls worldwide give birth before 18. Adolescent pregnancy is a global issue with unfavourable health consequences for youth, relatives, and the community. Evidence suggests that 14 out of every 1,000 Malaysian teenage girls, or 18,000 in total, are pregnant each year [3]. Adolescent pregnancies include social and health consequences such as growing attention to domestic abuse. It may be exacerbated by pregnancy, psychological disorders, drug use, sexually transmitted infections (STIs), financial stress, and destitution. Any sexual activities among teenagers that raise the risk of unintended pregnancies are considered risky sexual behaviour [4]. Girls still growing physically are more vulnerable to complications during pregnancy and delivery. Nine percent to 86 percent of women with obstetric fistula develop the disorder as teenagers, with severe, frequent lifelong implications [5]. There is an increased possibility of negative perinatal and neonatal effects for young mothers [6]. It is believed that a mix of biological and socioeconomic variables contribute to the association between adolescent pregnancy and a significant increase in child mortality, moderated by well-being behaviour [7]. Presently, the investment plans in maternity care for adolescent girls do not correspond to the needs that have disastrous effects on pregnant adolescent girls and their unborn children. One of the main causes of death among adolescent girls around the world is difficulties during labour and birth. Thus, one of the negative effects of unaddressed maternal health needs is adolescent pregnancy [8]. Teenage girls' diet and nutrition intake are also important due to malnutrition's high prevalence and serious effects, such as micronutrient deficiencies. Infections or mortality can result from malnutrition in a variety of aspects. Pregnant teenagers' lives are at threat due to the baby's increased nutritional needs and those necessary for adolescence to grow up [9]. This issue can be worsened if we do not consider this a major problem among adolescents. It will affect the next generation with uncountable problem health.

The rising number of these problems happened because of having sex before marriage. As we know, Malaysia is a living country with a multiethnic that allows professing various religions. Abortion in many religions is prohibited because most of the results will harm the pregnant mom and the chance of death is higher. In Islamic teachings, the fetus baby also has the right or chance to live in the world. Besides that, the factors of adolescent pregnancy are not just because of less exposure to sex education but also lack of parental supervision [10]. These are quite general factors, and they can be called primary factors too. This sad truth is happening around us, and the growing numbers of adolescent pregnancies are very alarming if they cannot be controlled. Parents play the main role in preventing this problem from worsening. Numerous variables, including poorly coordinated policies, social and emotional learning for teenagers, parent awareness and attitudes, inadequate health service delivery, and poverty, have been raised as factors influencing the low use of maternal healthcare services among pregnant adolescents [11]. Teenage girls that got pregnant usually missed out the antenatal care. They also do not go to the hospital to report their pregnancy because they are afraid they will get rejected by their families. The bad side of adolescent pregnancy is that it can affect the growth of a girl, preventing the girl from reaching her full potential and failing to apply her basic human rights. Therefore, they can negatively affect a girl's life, such as financial problems, limited income-earning, no academic success, and embarrassment in socialising. Adolescent pregnancy can lifelong affect the girl's life and can happen in the next generation.

This study will use the Runge-Kutta method to examine the adolescent pregnancy population in Malaysia from 2017 to 2021, the missing data population, and the prediction population for 2023.

Table 1: Populations of adolescent pregnancy over three years with 2-step size

Year (x)	Population
2017	11,024
2019	10,349
2021	13,550
2023	Prediction using Runge-Kutta 4

Based on Table 1 above, the population over three years with 2 step size between 2017 and 2019 had diminished to less than 1000 population while in 2019, and 2021 grew by more than 3000 population respectively. It shows that inconsistent graphs will be proven later in the Runge-Kutta graph and discussion part.

In 2010, there were more than 5.5 million young people in Malaysia between intervals of 10 and 19, with 19.4 percent of the overall population. With such a large number of teenagers, it's critical to examine the situation of adolescent pregnancy using local statistics. Our goals and objectives are to identify missing data from statistics on adolescent pregnancy for a specific year and to forecast data for the future few years in Malaysian adolescent pregnancy cases using MATLAB. In this study, we will use an analytical method that uses the already stored data or historical data. The data will be collected from 2017 to 2021 and the prediction year 2023 will be using the Runge-Kutta method. We choose the Runge-Kutta method for this assignment because the Runge-Kutta method is a multilevel method. This method also has greater steadiness even though this method is classified as a fully explicit method.

MATERIAL AND METHODS

Our goals and objectives are to identify missing data from statistics on adolescent pregnancy for a specific year and to forecast data for the future few years in Malaysian adolescent pregnancy cases by using MATLAB. Runge-Kutta is a powerful and extensive approach for solving differential equations that require the initial value of the problems. In addition, the Runge-Kutta can approximate a high-order accurate numerical method from any function [12].

The Runge-Kutta Methods are an ODE solver family that includes the Euler and Trapezoid Methods and more advanced higher-order methods. In this project, we introduce a few one-step approaches and apply them to model trajectories of major applications. The evaluation is the main computing effort in using the Runge-Kutta procedures. The local truncation error in second-order approaches is $O(h^2)$ and the value is two function evaluations per step. The order four Runge-Kutta technique needs four evaluations to be done, and the local truncation error is $O(h^4)$.

Even though Euler's method and the Runge-Kutta have the same objective, which is to determine the approximation of a differential equation's values, the Runge-Kutta order four technique is used for calculating four evaluations every step. In contrast, Euler's method is used for calculating one evaluation. As a result, if the Runge-Kutta technique of order four is effective, the accuracy results of Range-Kutta are superior to Euler's method approach with a one-quarter step size. It is similar if the Runge-Kutta technique of order four is superior to second-order Runge-Kutta methods. Since it needs two evaluations for each step, it should provide a bigger precision with step size (fix) than a second-order approach with a step size half of it. Whereas Euler's Method, computes a slope at an interval. As a result, the Runge-Kutta approach is appropriate for this study.

Up to this point, the step size h has been handled as a fixed in the ODE solver implementation. There is no reason why h cannot be altered during the solution process. A useful reason to adjust the step size is for a solution that alternates between periods of sluggish and quick change. Making the fixed step size small enough to precisely measure the quick changes may result in the rest of the solution being solved slowly but steadily slowly. For this project, we will use the Runge-Kutta method of an order of four. For analysis statistics, we put the data in the table as shown in a problem statement for easy reading. Then, we continue using the Runge-Kutta Method to estimate our solution.

Runge-Kutta Order four

$$w_0 = \alpha, \tag{1}$$
$$k_1 = hf(t_i, w_i), \tag{2}$$
$$k_2 = hf\left(t_i + \frac{h}{2}, w_i + \frac{1}{2}k_1\right), \tag{3}$$
$$k_3 = hf\left(t_i + \frac{h}{2}, w_i + \frac{1}{2}k_2\right), \tag{4}$$
$$k_4 = hf(t_{i+1}, w_i + k_3), \tag{5}$$
$$w_{i+1} = w_i + \frac{1}{6}(k_1 + 2k_2 + 2k_3 + k_4), \tag{6}$$

for each $i = 0,1,\ldots,N-1$. The truncation error for this method is$O(h_4)$, and it has five continuous derivatives, $y(t)$.

This method's success arises from its simplicity and ease of programming. It is a one-step approach that requires only an initial condition to begin. Yet, it is significantly more accurate as a fourth-order method than the Euler or Trapezoid Methods. Then for Ordinary Differential Equation for Runge-Kutta will be using population growth.

$$\frac{dN}{dT} = aN - bN^2 \tag{7}$$

$$N(0) = N_0 \tag{8}$$

where
$N_0 =$ Initial population
$N =$ Population
$a =$ Birth date $= 0.1$ (fixed)
$b =$ Death rate $= 0.00008$ (fixed)

Ordinary Differential Equation (ODE) depicts the death rate owing to all causes, such as disease, and is widely used to estimate the population increase of any species. Population ecologists model population dynamics using a range of mathematical methodologies (how populations change in size and constitution over time). Some of these models reflect expansion without compromising the environment, while others contain "ceilings" imposed by resource constraints. Population mathematical models can be implied to characterise distinctness and, more crucially, anticipate potential population developments.

The solution of modelling problems frequently involves using ordinary differential equations (ODEs). By identifying the approximation solution that, if it exists, is close to the precise solution, numerical methods are one of the essential mathematical tools for solving the ODEs that emerge in diverse modelling situations. Using multistage approaches at the midpoint of an interval, Runge-Kutta methods (RK) are numerical techniques that integrate ODEs and can effectively produce results with smaller error margins. Figure 1 below refers to the flowchart diagram of the mathematical model to estimate the population of Malaysian adolescent pregnancy cases.

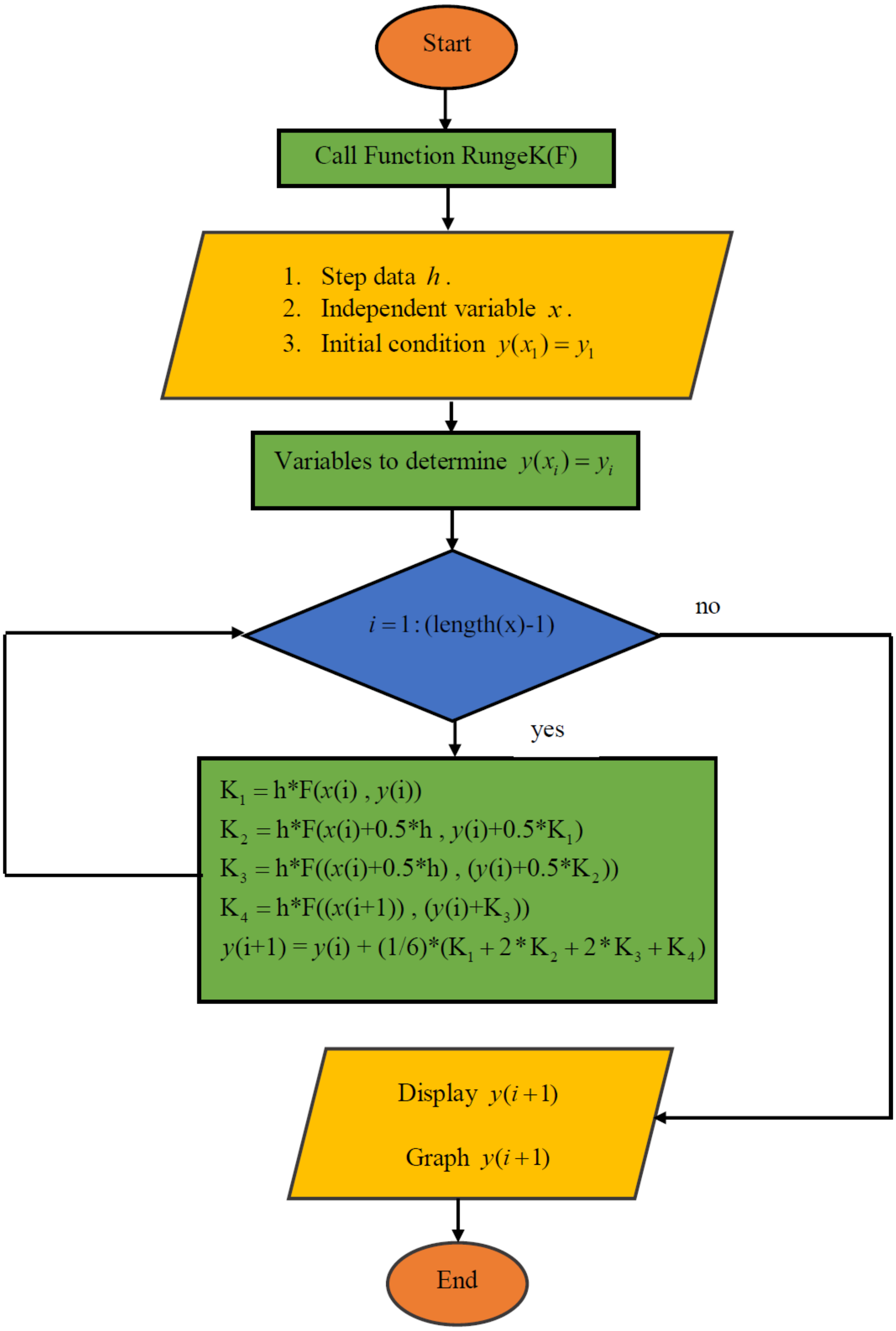

Figure 1: Flowchart of the mathematical model to estimate the population of Malaysian adolescent pregnancy cases

RESULTS AND DISCUSSION

Task 1: Find missing data in 2018.

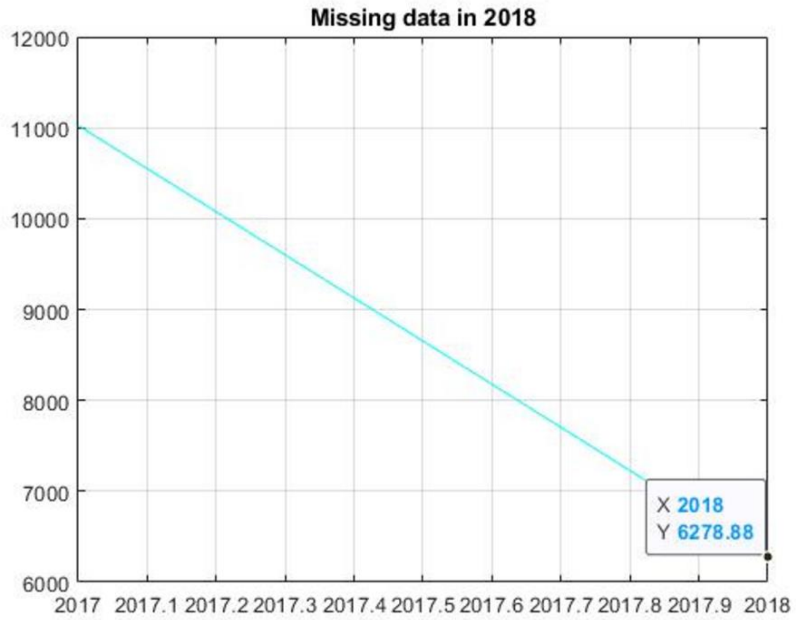

Figure 2: Plotting the missing data on the adolescent pregnancy population in 2018

Task 2: Forecasting Adolescent pregnancy population 2023 starting from 2017 with h = 2.

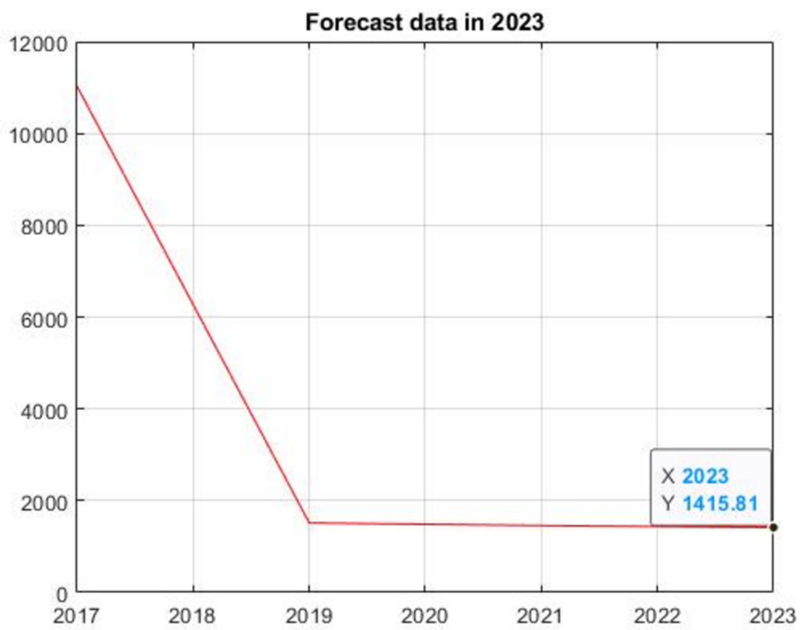

Figure 3: Forecasting the adolescent pregnancy population in 2023

Task 3: We combine data from 2017 until 2023 with h = 2.

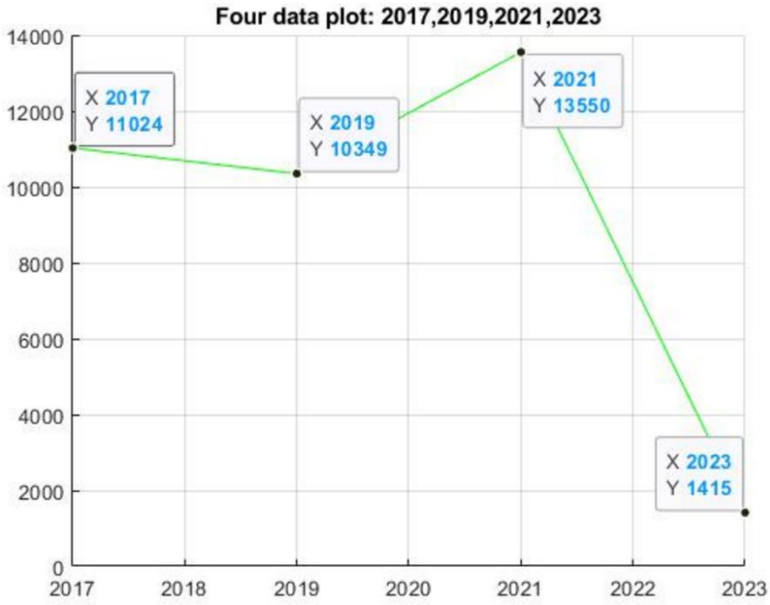

Figure 4: Plotting the missing data on adolescent pregnancy from 2017-2023

Based on Figure 2, the missing data from 2018, we can see that the graph is slightly decreasing. This means that the number of adolescent pregnancies that year is decreasing from 2017 to 2018. For figure 3, which is the forecasting adolescent pregnancy population in 2023 starting from 2017 with h = 2, we can see that the graph is decreasing from 2017 to 2019. Then, the graph remains in a horizontal line from 2019 to 2023. This means that the adolescent pregnancy population from 2019 to 2023 remain unchanged. According to figure 4, we can see the pattern for each year. The pattern of the graph is not consistent. According to the Minister of Health (MoH) data, the adolescent pregnancy population in Malaysia in 2018 was 10,501. However, in figure 2 above, the estimates obtained using the Runge-Kutta method for the adolescent pregnancy population in Malaysia in 2018 are only 6278.88. Compared with the two values, the difference occurs because the Runge-Kutta is used to predict the population of adolescent pregnancy in Malaysia. Absolute error for the population in 2018:

$$|\text{Exact value} - \text{Approximated value}| = |10501 - 6278.88| = 4222.12$$

Referring to the error, we can conclude that RK4 is insufficient to approximate missing data for adolescent pregnancy. The absolute error for the population in 2018 is quite bigger to accept. However, this method is still powerful for certain differential equations, especially for only first-order ordinary differential equations where the lower step size means more accuracy. The data in 2023 is expected to fall dramatically over the year. It can cause a population drop due to low fertility, putting pressure on future population reduction. Furthermore, the spread of Covid-19 around the world may cause this graph's decline over the year. COVID-19, a highly contagious new coronavirus disease, has negatively impacted healthcare systems worldwide. Thus, this factor is the major of falling data in 2023.

CONCLUSION

This report aims to identify missing data from statistics on adolescent pregnancy for a specific year and to forecast data for the next few years in Malaysian adolescent pregnancy cases using MATLAB. For these two tasks, we use Runge-Kutta of order four to find the missing data from statistics on adolescent pregnancy in 2018 and forecast data in 2023 in the Malaysian adolescent pregnancy population. After that, we plot the graphs of missing data in 2018, forecast data in 2023, and four data plots in 2017, 2019, 2021, and 2023. And then, we make a comparison between the prediction of missing data in 2018 by using Runge-Kutta of order four and the data that we get from the MOH (Ministry of Health). The comparison shows that the two datasets are different because the Runge-Kutta is used to predict the population of adolescent pregnancy in

Malaysia. The Runge-Kutta method is not sufficient to approximate missing data for adolescent pregnancy. However, based on the results, we can conclude that adolescent pregnancy has dropped over time. Although the adolescent pregnancy rate for the next year is declining, we must take this matter seriously. Teenagers around the world must be educated on issues like early motherhood and pregnancy. Additionally, a number of political, economic, and social reasons must not constrain the distribution of support and knowledge. Next, healthcare professionals also play an important role by offering young people supportive, nonjudgmental, youth-appropriate services. Based on this project, we may build numerical trajectories for various parameter values using credible ODE solvers to demonstrate the variety of phenomena available to this model. Differential equation models can anticipate behaviour and shed light on systems in scientific research when used in this manner.

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