

Numerical Solution of a Mathematical Model of the Effect of Same-Sex Marriage

*¹Oluwafemi TJ and ²Bako D

¹General Studies Department, Newgate College of Health Technology, Minna, Nigeria.

²Department of Mathematics, Federal University of Technology, Minna, Nigeria.

Abstract

Same-sex Marriage or Gay Marriage has it is also called is now becoming a global trend both in developing and developed countries. Countries like New Zealand, United Kingdom, Luxembourg, Ireland, Benin, Nigeria, Namibia, Morocco etc. have population that practice it, although in some of these countries it is hidden in few others it has been legalized, while in other countries the gays are protesting for the practice to be legalized. In this paper, a simple mathematical model to study the effect of same-sex marriage (SSM) on population growth is developed using set of ordinary differential equations and solved by using fourth order Runge-Kutta method. The population is divided into three human compartment namely Non-Gay individuals (Individuals who are involved in same-sex practice), Gay individuals (Individuals who practice same-sex marriage), Recovered individuals (Individuals who have been convinced and are not practicing same-sex marriage). We also assumed that same-sex practice is not hereditary rather people are convinced to practice same-sex marriage and people can be re-convinced after they have recovered. From the computation, the results show that as the rate of conviction to practice same-sex marriage increases, the population begins to decrease and this may eventually lead to the extinction of the human race. Hence, attention should be given to the rate at which people can convinced to practice gay marriage.

Keywords: Same sex marriage, population growth, runge-kutta method

1. Introduction

Same-sex marriage (SSM) also known as gay marriage or homosexual marriage is a kind of marriage that is a ceremonial union of two people of the same-sex. One of the characteristics of this kind of marriage is that the people (couples) cannot bear their own children. The Netherlands became the first country in the world where same-sex couples could marry when it passed a law in 2001 (Freedom to Marry, 2015) [5]. The following is a list of nations that allow same-sex marriage; Belgium, Spain, Canada, South Africa, Norway, Sweden, Portugal, Iceland, Argentina, Denmark, Brazil, France, Uruguay, New Zealand, United Kingdom, Luxembourg, Ireland, United States, Slovenia and Finland. For Mexico gay marriage is legal in some jurisdiction. (Pew Research Centre, 2015) [6].

In Africa, 38 countries do not allow gay marriage or homosexuality, these countries include: Algeria, Angola, Benin, Botswana, Burundi, Cameroon, Comoros, Egypt, Eritrea, Ethiopia, Gambia, Ghana, Guinea, Kenya, Lesotho, Liberia, Libya, Malawi, Mauritania, Mauritius, Morocco, Mozambique, Namibia, Nigeria, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, others are Somalia, South Sudan, Sudan, Swaziland, Tanzania, Togo, Tunisia, Uganda, Zambia and Zimbabwe. In Burkina Faso, Cape Verde, Central African Republic, Chad, Congo-Brazzaville, Cote d'Ivoire, Democratic Republic of Congo, Djibouti, Equatorial Guinea, Gabon, Guinea-Bissau, Madagascar, Mali, Niger, Rwanda, South Africa, there are no criminal laws against homosexuality whereas in Mauritania,

Sudan, Northern Nigeria, and Southern Somalia, those found guilty of homosexuality are sentenced to death. (Amnesty International, 2013) [1].

According to the 2011 census by Australian Bureau of statistics, there are around 33,700 same-sex Australian with 17,600 male same-sex and 16,100 female same-sex couples. New survey found that 59% of American support allowing same-sex marriage, close to double the 30% support reported in 2004 (Washington Wire, 2015) [7].

Human Population is the total number of people at a period of time. There are four basic factors that can influence the size of human population in a place namely: Natality (Birth-rate), Immigration, Mortality (Death-rate) and Emigration. Of these four factors natality and immigration are factors that increase population size. Donna (2013) [3] wrote that one of the long term effects of same-sex marriage is fall in birth-rate because the fecundity is zero. By this, it is believed there is a relationship between same-sex marriage and population growth. Therefore this paper tends to solve numerically a mathematical model of the effects of same-sex marriage on population growth.

2. Materials and Methods

2.1. Model Development

The model contains four (4) variables, namely: Non-Gay individuals (S), Gay individuals (I), Recovered individuals (R), and Total population (N). Below is the schematic representation of the model.

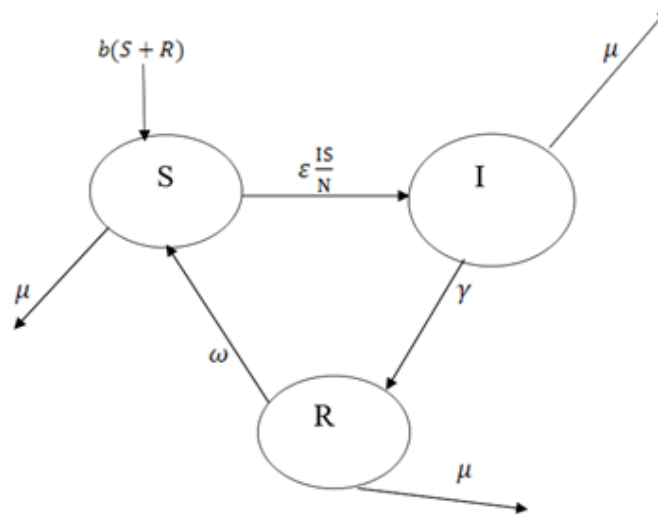


Fig 1: Schematic diagram representing the Model

The S population are generated through birth at the rate b . People become convinced to practice same-sex marriage at the rate ϵ . The effective recovery rate due to public enlightenment, health hazards and cultural pressure is γ , the rate at which the recovered becomes susceptible is given as ω . All individuals die naturally at a rate μ .

The corresponding mathematical equations are given below:

$$\frac{dS}{dt} = b(S + R) - \epsilon \frac{IS}{N} + \omega R - \mu S \tag{2.1}$$

$$\frac{dI}{dt} = \epsilon \frac{IS}{N} - (\gamma + \mu)I \tag{2.2}$$

$$\frac{dR}{dt} = \gamma I - (\omega + \mu)R \tag{2.3}$$

$$\frac{dN}{dt} = b(S + R) - \mu N \tag{2.4}$$

Where
 $S(t) + I(t) + R(t) = N(t)$ (2.5)

$S(t)$ = Non-Gay Individuals

$I(t)$ = Gay Individuals

$R(t)$ = Recovered Individuals

b = Birth-Rate

ϵ = Rate at which Gay Individuals convince the Non-Gay Individuals to become Gay

ω = Rate at which Recovered becomes Susceptible

γ = Rate at which Gay Individuals recover.

μ = Death-Rate.

The following assumptions are made on the model:

- a. People are only convinced to practice same-sex marriage.
- b. Someone that has stopped practicing same-sex marriage can later be susceptible.
- c. Same-sex is not hereditary.

3. Variables and Parameters Value

In the simulation, the effect of same-sex marriage with population growth was investigated with assumed initial values used as follow:
 $S(0) = 9999000, I(0) = 1000, R(0) = 0, N(0) = 10000000$.

The life expectancy of the population is given as sixty-two (62) years given the value of $\mu = 0.016, b = 0.027, \gamma = 0.001, \omega = 0.2, \epsilon = (0.01, 0.1)$
 The tables below are values generated

Table 1: Values of I(t), N(t), R(t), S(t) at $\epsilon = 0.01$

| t(years) | S(t) | I(t) | R(t) | N(t) |
|----------|-------------------------|----------|--------|-------------------------|
| 0 | 9.999×10^6 | 1000 | 0 | 1×10^7 |
| 50 | 1.7330×10^7 | 704.6647 | 3.3715 | 1.7331×10^7 |
| 100 | 3.0037×10^7 | 496.5621 | 2.3758 | 3.0038×10^7 |
| 200 | 9.0236×10^7 | 246.5835 | 1.1798 | 9.0237×10^7 |
| 300 | 2.7108×10^8 | 122.449 | 0.5858 | 2.7109×10^8 |
| 400 | 8.1438×10^8 | 60.8066 | 0.2909 | 8.1439×10^8 |
| 500 | 2.4465×10^9 | 30.1956 | 0.1444 | 2.4466×10^9 |
| 600 | 7.3498×10^9 | 14.9947 | 0.0717 | 7.3499×10^9 |
| 700 | 2.2080×10^{10} | 7.4461 | 0.0356 | 2.2080×10^{10} |
| 800 | 6.6332×10^{10} | 3.6976 | 0.0176 | 6.6332×10^{10} |
| 900 | 1.9927×10^{11} | 1.8362 | 0.0087 | 1.9927×10^{11} |
| 1000 | 5.9865×10^{11} | 0.9118 | 0.0043 | 5.9865×10^{11} |

From the table above, the rate of conviction to practice same-sex marriage () has no effect on the total population growth and the non-gay individuals $S(t)$. While the population of gay and recovered individuals continue to decrease.

Table 2: Values of I(t), N(t), R(t), S(t) at $\epsilon = 0.025$

| t(years) | S(t) | I(t) | R(t) | N(t) |
|----------|-------------------------|----------------------|------------|-------------------------|
| 0 | 9.999×10^6 | 1000 | 0 | 1×10^7 |
| 50 | 1.7328×10^7 | 1491.6508 | 6.6591 | 1.7330×10^7 |
| 100 | 3.0032×10^7 | 2225.0582 | 9.9333 | 3.0034×10^7 |
| 200 | 9.0208×10^7 | 4951.1622 | 22.1035 | 9.0213×10^7 |
| 300 | 2.7097×10^8 | 11017.7020 | 49.1863 | 2.7098×10^8 |
| 400 | 8.1397×10^8 | 24518.1832 | 109.4565 | 8.1399×10^8 |
| 500 | 2.4451×10^9 | 54562.6528 | 243.5838 | 2.4452×10^9 |
| 600 | 7.3453×10^9 | 1.2142×10^5 | 542.0792 | 7.3454×10^9 |
| 700 | 2.2065×10^{10} | 2.7022×10^5 | 1206.3757 | 2.2066×10^{10} |
| 800 | 6.6287×10^{10} | 6.0138×10^5 | 2684.7662 | 6.6288×10^{10} |
| 900 | 1.9913×10^{11} | 1.3383×10^6 | 5974.9378 | 1.9914×10^{11} |
| 1000 | 5.9822×10^{11} | 2.9785×10^6 | 13297.2718 | 5.9823×10^{11} |

Here, the population of all the classes i.e. (the non-gay individuals $S(t)$, gay individuals $I(t)$, recovered individuals $R(t)$ and total population $N(t)$) increases. Implying that at this rate of conviction, the population was not affected because there was increase.

Table 3: Values of $I(t)$, $N(t)$, $R(t)$, $S(t)$ at $\epsilon = 0.05$

| t(years) | S(t) | I(t) | R(t) | N(t) |
|----------|----------------------|----------------------|----------------------|----------------------|
| 0 | 9.999×10^6 | 1000 | 0 | 1×10^7 |
| 50 | 1.7323×10^7 | 5204.5998 | 20.9030 | 1.7328×10^7 |
| 100 | 2.9984×10^7 | 27063.0506 | 108.7051 | 3.0012×10^7 |
| 200 | 8.8642×10^7 | 7.2177×10^5 | 2903.0557 | 8.9367×10^7 |
| 300 | 2.3156×10^8 | 1.6960×10^7 | 68991.0942 | 2.4859×10^8 |
| 400 | 2.6716×10^8 | 1.7149×10^8 | 7.4410×10^5 | 4.3940×10^8 |
| 500 | 4.3128×10^7 | 1.9771×10^8 | 9.4801×10^5 | 2.4178×10^8 |
| 600 | 4.2724×10^6 | 6.0944×10^7 | 3.0117×10^5 | 6.5518×10^7 |
| 700 | 7.9076×10^5 | 1.4700×10^7 | 72937.2953 | 1.5564×10^7 |
| 800 | 1.7904×10^5 | 3.4435×10^6 | 17093.0753 | 3.6397×10^6 |
| 900 | 41646.1798 | 8.0402×10^5 | 3991.1913 | 8.4966×10^5 |
| 1000 | 9716.2214 | 1.8766×10^5 | 931.5578 | 1.9830×10^5 |

Here, the population of all the classes of individuals increased after which it began to decline. For the non-gay individuals $S(t)$, decrease began after 400 years, while for the remaining classes $I(t)$, $R(t)$, decline started after 500 years.

Table 4: Values of $I(t)$, $N(t)$, $R(t)$, $S(t)$ at $\epsilon = 0.1$

| t(years) | S(t) | I(t) | R(t) | N(t) |
|----------|----------------------|----------------------|------------|----------------------|
| 0 | 9.999×10^6 | 1000 | 0 | 1×10^7 |
| 50 | 1.7246×10^7 | 63120.6456 | 211.3142 | 1.7309×10^7 |
| 100 | 2.5270×10^7 | 3.3783×10^6 | 11676.6562 | 2.8660×10^7 |
| 200 | 2.7541×10^5 | 1.2929×10^7 | 64212.1086 | 1.3269×10^7 |
| 300 | 43987.0663 | 2.7783×10^6 | 13853.7097 | 2.8362×10^6 |
| 400 | 9381.1744 | 5.9269×10^5 | 2955.3396 | 6.0503×10^5 |
| 500 | 2001.2203 | 1.2643×10^5 | 630.4420 | 1.2906×10^5 |
| 600 | 426.9063 | 26971.6008 | 134.4878 | 27532.9950 |
| 700 | 91.0689 | 5753.6642 | 28.6893 | 5873.4225 |
| 800 | 19.4271 | 1227.3890 | 6.1200 | 1252.9362 |
| 900 | 4.1442 | 261.8303 | 1.3055 | 267.2801 |
| 1000 | 0.8840 | 55.8544 | 0.2785 | 57.0170 |

As seen from table (3.4) above, after 200 years the population of the non-gay individuals $S(t)$ begins to decrease, while for the gay and recovered individuals, decrease begins after 300years. After 900years, the non-gay individual was no more, same with the recovered class while for the gay population $I(t)$, the population is less than 60. Generally, it is observed that as the rate at which people get convicted to practice same-sex marriage increases, the year.

4. Conclusion

In this paper, a mathematical model to show the effect of same-sex marriage on population growth is solved using the fourth order Runge-Kutta Method. Result shows that as the conviction rate to practice same-sex marriage increases, the year in which population begin to decline increases, on the long run this may lead to the extinction of the human race in the shortest possible time

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