MATHEMATICAL MODELLING ON SEDENTARY LIFESTYLE

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Project Submitted in Partial Fulfillment for the Degree of
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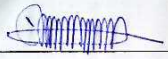
DECLARATION

I hereby declare that this project is written by me and it has not been presented before in any application for a Bachelor Degree except for quotations and summaries which have been duly acknowledged.



12/12/2019

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Date

December, 2019

CERTIFICATION

This project entitled "MATHEMATICAL MODELLING ON SEDENTARY LIFE STYLE" meets the regulation governing the Award of Bachelor of Science of Federal University Gusau and it's approved for its contribution to knowledge and literary presentation.

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DEDICATION

This project work is dedicated to Almighty Allah for his mercy on me throughout the period of my study. Also I dedicate to my parents, Alh. Ibrahim M Giwa, Haj. Hassana Ibrahim Giwa, Haj.Lubabatu Ibrahim Giwa and Haj. Hauwa'u Muh'd. May almighty Allah bless them, protect them and guide them in a right path Amin.

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ABSTRACT

Sedentary lifestyle is an issue of great concern because of its deleterious health implications in developed and developing countries. It is associated with limited physical activity, prolonged sitting at work, in cars, communities, work sites, schools, homes and public places have been restricted in ways that minimize human movement and muscular activities. People sit more and move less. This shift from a physically demanding life to reduced physical activities have exposed people to high risk of developing various health conditions such as obesity, hypertension, cardiac disorders, vitamin deficiencies, cancers to mention but a few. They are associated with unhealthy lifestyles which are preventable. This paper therefore discussed the concept of sedentary lifestyle, factors that enhance it and the various health implications associated with this unhealthy behaviour. The paper concluded that individuals, groups and communities should make concerted efforts to engage in physical activities, modify their dietary habits and avoid other risky behaviours that affect their health negatively. Suggestions made by the paper include among others that work/public places should be structured in a way that enhance active movement and recreational activities.

CHAPTER ONE

INTRODUCTION

1.1 Introduction

"Sedentary" is coined from the Latin word "Sedere" which means "to sit" hence Sedentary behaviour is a term used to characterize those behaviours that are associated with low energy expenditure.

Man was created to be active and energetic hence sedentary life style is contrary to human nature. Our grandparents were also active and engaged in vigorous muscular activities like fishing, farming, hunting, tapping and migrating from place to place hence they lived stronger, healthier and longer. Health as a quality of life is the result of diverse factors and behaviour/life style is one of the most powerful determinants of health. According to Brannon and Feist most deaths in the 20th and 21st century result from diseases that are associated with individual life style/behaviour.

A relationship between Sedentary Lifestyles and ill health was revealed as early as the 17th century by Bernadino Ramazzini, an occupational physician who discovered that sedentary life style with its associated physical inactivity has an adverse effect on human metabolism, cardiac output, physical function and well-being. Technological advancement and increase in knowledge have provided man with so many facilities that reduce physical and muscular activities such as cars, airplane, accelerators and a corresponding increase in the amount of time spent sitting down at work place, school, home and public places. Jenks, C. (2010)

Despite the well-known benefits of physical activity, many adults and children lead sedentary life styles. It has been revealed that most urban dwellers adopt sedentary life styles which have obvious negative health implications. The health belief model explained that people will be willing to adopt a positive behavioural/ lifestyle change based on six constructs; Perceived Susceptibility, Perceived Severity, perceived benefits, Perceived barriers, Cues to action and Self efficacy. This theory postulates that people's perception and belief about their vulnerability or proneness to a disease condition have great impact on their willingness to adopt a positive lifestyle. Owen. Healy, Mathew & Dunstan, (2018)

Another theory that explains lifestyles is the social theory of life style which sees life styles as the life of a people, mode of behaviour, habits, beliefs, rituals, it explains that what people do in different places and times affect them positively or negatively, National Family Health Survey (2016). According to a survey report conducted in 2016, by the United States national Health Survey, 36% of adults are totally inactive while 59% have never participated in vigorous physical activity lasting more than 10 minutes per week. This ugly trend has led to higher risk of various chronic diseases such as obesity, deep vein thrombosis, heart diseases, Type – 2 diabetes, osteoporosis, cancer, muscle and skin disorders among others with their resultant increase in morbidity and mortality. It is sad to note that many well-meaning citizens of our country and beyond are victims of these chronic diseases which would have been prevented if they had adopted more healthier life styles.

The aim of this work is therefore to investigate and modeled the concept of Sedentary Behaviour (Lifestyles), examine the factors that enhance it, identify and discuss the health implications of Sedentary Life Styles using mathematical approach. And finally, to make necessary suggestions to curb this trend

1.2 Statement of the problem

Sedentary Lifestyle as distinct class of behaviors is characterized by little or no physical movement and low energy expenditure less than 1.5 METs (Metabolic Equivalent Task) MET is used to assess the energy expenditure during activities. Running expends energy worth 8 METs, brisk walking has a value of 3-4 METs while Sedentary behaviour is any activity that expends less than 1.5 MET. Some individuals are classified as Sedentary because of physical inactivity while others are classified based on their engagement in activities that do not require high energy consumption. Researchers rely on various approaches to quantify Sedentary behaviour. This includes; Car time, Chair/Sitting time, Indoor time and Screen time.

World Health Organization (WHO) (2015), identified obesity as a worldwide public health problem affecting over 100 million people. Reduced physical activity which characterizes Sedentary Life Style leads to accumulation of excess calories and fatty acids. This is because weight maintenance depends largely on the number of calories absorbed through food intake and the number expended through physical activity and metabolism. Lucas, Ward and Brain (2008) identified Sedentary lifestyles as a major cause of obesity in both male and female workers. An individual, who is sedentric, absorbs and stores a lot of calories because of reduced energy expenditure. These unwanted calories lead to obesity.

1.3 Aim and objectives of the study

The aim of this research is to study Modeling and the Mathematical Analysis on the effect of sedentary lifestyle among the children and adult.

The objectives of the study are:

1. To propose and formulate a mathematical model for the sedentary lifestyle.
2. To determine the Equilibrium points of the model
3. To investigate the 'stability behavior of the disease free equilibrium around the model equations.

1.4 Significance of the study

A sedentary lifestyle being a type of lifestyle with little or no regular physical activity, those who sit for over 5 hours daily are at risk of losing muscle strength by 1% daily. With prolonged sitting, one begins to lose the muscle fibers that are responsible for active movements. The speed of transmission of impulses from the brain to the muscles also slows down. If muscles are not used, the fibers become gradually replaced with fat and muscle wasting eventually occur. This leads to frequent fatigue on little exertion.

Skin problems are associated with sedentary lifestyle to include-change in skin color, fat deposits around the eye folds, eczema, body odor and itching among others. These are associated with poor excretory process related to inactivity.

Sedentary Lifestyle and Cardiovascular Impact The cardiovascular system is the part of the body that contains the heart, arteries and veins. It is responsible for pumping blood

throughout the body thereby providing a rapid-transport system to distribute oxygen to the body cells and also remove carbon dioxide from the body with other waste products. The cardiovascular system consists of the heart and blood vessels. By the process of contraction and relaxation, the heart muscle pumps blood throughout the body within 20 seconds when the body is at rest cardiovascular disease as one caused by unhealthy lifestyle including smoking, poor diet and sedentary behaviour.

Sedentary Lifestyle and Cancer There is a great risk for cancers of the breast and colon cancer due to sedentary lifestyle. This is because an inactive body tissues muscle and cells can trigger the development of cancerous cells which has high morbidity and mortality rates. WHO correlated prolonged sitting time and increased risk of color cancer in men and women and endometrial cancer in women.

1.5 Scope and delimitation of the study

A sedentary lifestyle is becoming a significant public health issue. Sedentary lifestyles appear to be increasingly widespread in many nations despite being linked to a range of chronic health conditions.

Sedentary Behavior Research Network (SBRN) defined sedentary behavior as any activity involving sitting, reclining, or lying down that has very low energy expenditure.

1.6 Definition of terms

Sedentary life style: is type of lifestyle which an individual or group adopt that do not permit regular physical activity.

Sbrn: Sedentary Behavior Research Network.

Mets: (Metabolic Equivalent Task) MET is used to assess the energy expenditure during activities.

Who: World Health Organization.

Physical activities: Is define as any body movement produced by skeletal muscles result in energy expenditure.

Sedentary behavior:

Common Sedentary activities includes: Watching television and Videos, Using the construction, reads, listening to music, relaxes/resting and talking in the

CHAPTER TWO

2.1 LITERATURE REVIEW

Physical inactivity has been related to all causes of mortality, lower quality of life, and to a higher risk of obesity, diabetes, hypertension, coronary heart disease, osteoporosis, fractures, colon cancer, breast cancer, prostate cancer, psychiatric disorders, and an overall higher risk of hospitalization. Sedentary lifestyle is a term used to denote a type of lifestyle with no or inadequate participation in moderate to vigorous physical activity. It is a lifestyle that involves no participation in physical activity and longer time span of sitting down. Sedentary behaviour refers to activities that do not increase energy expenditure substantially above the resting level. Sedentary activities include sitting, reading, watching television and using computer for most part of the day with little or no vigorous physical exercise. Among unhealthy lifestyle, smoking and lack of regular physical activity are of major importance in public health because they are highly prevalent and potentially modifiable, Achalu, E.I., (2018).

The World Health Organization (WHO) (2015) reported a strong relationship between mortality rates and lifestyle practices. WHO further highlighted conditions that promote unhealthy lifestyle practices such as lack of adequate health knowledge, acquisition of misinformation about health matters and development of hazardous lifestyle. One of such lifestyle is physical inactivity or sedentary lifestyle. The World Health Organization rates inadequate physical activity as one of the three major threats to health alongside cigarette smoking and poor nutrition. Physical inactivity is estimated to cause 1.9 million deaths and 19 million disability adjusted life years globally. Appropriate regular physical activity is a

major component in preventing the growing global burden of chronic disease and at least 60% of the global population fails to achieve the minimum recommendation of 30 minutes moderate intensity physical activity daily.

A study among bank employees in India showed that 16% of the study subjects had poor knowledge regarding risk factors for coronary heart disease one of which is sedentary lifestyle while 44% were sedentary in lifestyle.

Similarly, in another study conducted among bankers in Ilorin, 23.3% had poor knowledge of sedentary lifestyle while 29.6% were sedentary.

Higher levels of sedentary lifestyle prevalence exist in Europe with highest levels in the Mediterranean Countries – Portugal (87.8%), Belgium (71.7%). Furthermore, 25 percent of adults in the United States do not engage in any leisure time physical activity, while 34 percent of the populations older than fifty years live a sedentary lifestyle. Sedentary behavior and level of physical activity of 425 university population in Flores, Argentina was studied using the self-reporting global physical activity questionnaire (GPAQ): 31% were found to be sedentary. A cross sectional study conducted in South-west Nigeria among health care workers revealed that only 20.8% of the respondents had adequate physical activity level.

Banking as a profession is characterized by sitting for most of the day and is therefore a sedentary occupation. Appropriate knowledge of bankers about sedentary lifestyle and how this knowledge can be applied in adopting physically active lifestyle to reduce the health implications of a sedentary lifestyle is considered to be therefore important. This research was conducted to assess the knowledge and practice of bankers towards sedentary lifestyle.

It is hoped that this will help to awaken their consciousness about the dangers inherent in a sedentary lifestyle and the need to be physically active.

2.2 Dangers of a sedentary lifestyle

A sedentary lifestyle can contribute to obesity, diabetes, and some types of cancer. Recent research is starting to confirm the health risks associated with a sedentary lifestyle. Studies have now consistently demonstrated that leading a sedentary lifestyle can contribute to:

1. obesity
2. type 2 diabetes
3. some types of cancer
4. cardiovascular disease
5. early death

Extended periods of inactivity can reduce metabolism and impair the body's ability to control blood sugar levels, regulate blood pressure, and break down fat.

One study analyzed data collected over 15 years and found that sedentary lifestyles were associated with an increased risk of early death regardless of physical activity levels. This shows that it is essential to reduce the amount of time spent being sedentary in addition to doing more exercise.

2.3 Mental health

A sedentary lifestyle also appears to have a negative impact on mental well-being.The combination of the physical and mental impact to health makes a sedentary lifestyle particularly problematic.

One study with 10,381 participants associated a sedentary lifestyle and lack of physical activity with a higher risk of developing a mental health disorder.

A recent review that included data from 110,152 participants found a link between sedentary behavior and an increased risk of depression.

2.4 Solutions to a sedentary lifestyle

A more active lifestyle can significantly reduce the chances of chronic health conditions, mental health disorders, and premature death.

2.5 Increasing physical activity

Research has shown that physical activity, including exercise and sports, can reduce the risk of cardiovascular disease, type 2 diabetes, obesity, and early death.

Evidence also consistently shows that exercise can improve mental health. A 2018 study Trusted Source of 1,237,194 people found that those who exercised reported fewer mental health problems than those who did not.

It is best to combine a variety of cardiovascular exercises, such as running or cycling, with strength-training exercises, which can include weight training or body-weight exercises. Going for at least three 30-minute runs and doing two 30-minute sessions of strength-training exercises per week would be sufficient to meet the minimum physical activity guidelines.

2.6 Reducing the time spent being sedentary

Physical activity is important, but spending the majority of the day being sedentary is still dangerous.

1. People can reduce the amount of time they spend being sedentary by:
2. Standing rather than sitting on public transport
3. Walking to work
4. Taking walks during lunch breaks
5. Setting reminders to stand up every 30 minutes when working at a desk
6. Investing in a standing desk or asking the workplace to provide one
7. Taking a walk or standing up during coffee or tea breaks
8. Spending more time doing chores around the house, especially DIY or gardening
9. Making excuses to leave the office or move around the building
10. Taking phone calls outside and walking around at the same time

11. spending some free time being active rather than watching television or playing video games

12. getting up and walking around during television commercials

13. taking the stairs instead of using the elevator.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Model Formulation

Sedentary lifestyle and behavioural factors have been implicated for various health risks identified in this research. Understanding the relationship between sedentary behaviour and health outcome and modifying these behaviours are fundamental in reducing the morbidity and mortality rates caused by these health complications. Since sedentary lifestyle predisposes individual (both old and young) to various non-communicable but devastating diseases, it is feasible to induce people to shift some proportion of their sedentary time into large volumes of light to moderate energy investing physical activities.

1.1.1 Model assumption

The basic assumptions governing the dynamics of the model system are as follows:

1. New born are susceptible to the infection
2. Individual goes in to the sedentary behavior after infection
3. We assume that infection is home often individual have equal chance of getting infected
4. All parent and stile variable are talent to be nonnegative

ble 1: Description of the Model Variables

ate variable	Description
t)	Susceptible at time
	Asymptomatic Infective (Sedentary Behaviour) at time.
	Symptomatic Infective (Cardiovascular Disease) at time.

le 2: Description of the Model Parameter

arameter	Description
π	Physical activity and potential cofounders (assumed)
β	Sedentary behavior transmission rate.
σ	Recovery rate of sedentary individual due to treatment
μ	Natural death rate
τ	Fraction of susceptible at high risk of infection
λ	Rate of acquiring infection by the low risk susceptible

3.2 The Schematic Diagram

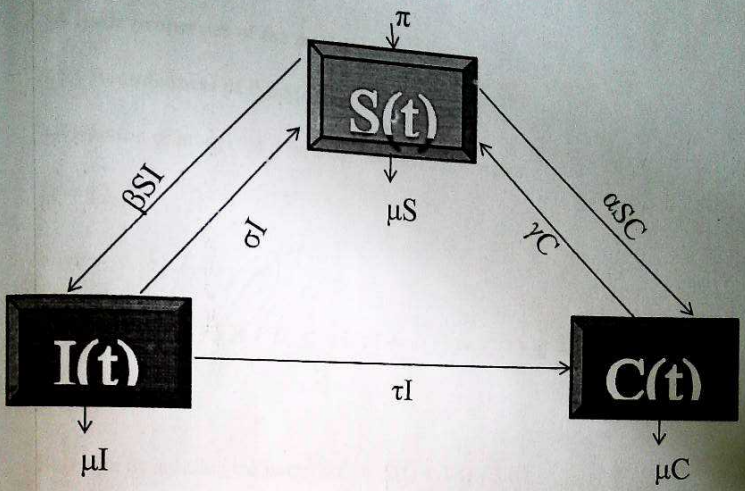

Figure 3.1: Schematic flow diagram of the model

3.2.1 Model Equation

The model diagram in fig 1 leads to the following equations

$$\frac{dS(t)}{dt} = \pi + \sigma I + \gamma c - \beta SI - \alpha SC - \mu S$$

$$\frac{dI(t)}{dt} = \beta SI - \sigma I - \tau I - \mu I \quad (1)$$

$$\frac{dC(t)}{dt} = \alpha SC + \tau I - \gamma C - \mu C$$

Or conveniently can be written as

$$\dot{S} = \pi + \sigma I + \gamma c - (\beta I - \alpha C)S - \mu S$$

$$\dot{I} = \beta SI - (\sigma - \tau - \mu)I \quad (2)$$

$$\dot{C} = \alpha SC + \tau I - (\gamma - \mu)C$$

3.3 Basic properties of the model

3.3.1 Boundedness of the Model

All solution of model (1) is bounded and remain in region

$$\Omega = \Omega_N$$

Where

$$\Omega_N = \left\{ (S, I, C) \in \mathbb{R} : 0 \leq \left[S(t) + I(t) + C(t) \leq \frac{\pi}{\mu} \right] \right\}$$

Proof:

We begin by splitting the model $N(t) = S(t) + I(t) + C(t)$

$$\frac{dN(t)}{dt} = \pi + \sigma I + \gamma C - \beta SI - \alpha SC - \mu S + \beta SI - \sigma I - \tau I - \mu I + \alpha SC + \tau I - \gamma C - \mu C$$

$$\frac{dN(t)}{dt} = \pi - \mu S - \mu I - \mu C$$

$$= \pi - \mu(S + I + C)$$

$$\frac{dN(t)}{dt} = \pi - \mu N(t)$$

$$\frac{dN(t)}{dt} + \mu N(t) = \pi - - - - - \text{(i)}$$

By using integral function we have

$$p(t) = \mu, \qquad q(t) = \pi$$

$$I.F = e^{\int p(t)\, dt} = e^{\int \mu\, dt} = e^{\int \mu t}$$

$$I.F = e^{\mu t}$$

$$N(t).IF = \int q(t).IF$$

$$N(t)e^{\mu t} = \int \pi e^{\mu t}$$

$$N(t)e^{\mu t} = \frac{\pi}{\mu}e^{\mu t} + c - - - -(ii)$$

When t = 0 $N(t) = N_0$

$$N_0e^0 = \frac{\pi}{\mu}e^0 + c$$

$$N_0 = \frac{\pi}{\mu} + c$$

$$C = N_0 - \frac{\pi}{\mu}$$

Put C in equation (ii)

$$N(t)e^{\mu t} = \frac{\pi}{\mu}e^{\mu t} + N_0 - \frac{\pi}{\mu}$$

Divide through by $e^{\mu t}$

$$\frac{N(t)e^{\mu t}}{e^{\mu t}} = \frac{\frac{\pi}{\mu}e^{\mu t}}{e^{\mu t}} + \left(\frac{N_0 - \frac{\pi}{\mu}}{e^{\mu t}}\right)$$

$$N(t) = \frac{\pi}{\mu} + \left(N_0 - \frac{\pi}{\mu}\right)e^{-\mu t}$$

$$= \frac{\pi}{\mu} + N_0e^{-\mu t} - \frac{\pi}{\mu}e^{-\mu t}$$

$$= N_0e^{-\mu t} + \frac{\pi}{\mu}(1 - e^{-\mu t})$$

Hence as N(t) $\longrightarrow \frac{\pi}{\mu}$ $as\ t \longrightarrow \infty$

$$N(t).IF = \int q(t).IF$$

$$N(t)e^{\mu t} = \int \pi e^{\mu t}$$

$$N(t)e^{\mu t} = \frac{\pi}{\mu}e^{\mu t} + c - - - -(ii)$$

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$$C = N_0 - \frac{\pi}{\mu}$$

Put C in equation (ii)

$$N(t)e^{\mu t} = \frac{\pi}{\mu}e^{\mu t} + N_0 - \frac{\pi}{\mu}$$

Divide through by $e^{\mu t}$

$$\frac{N(t)e^{\mu t}}{e^{\mu t}} = \frac{\frac{\pi}{\mu}e^{\mu t}}{e^{\mu t}} + \left(\frac{N_0 - \frac{\pi}{\mu}}{e^{\mu t}}\right)$$

$$N(t) = \frac{\pi}{\mu} + \left(N_0 - \frac{\pi}{\mu}\right)e^{-\mu t}$$

$$= \frac{\pi}{\mu} + N_0 e^{-\mu t} - \frac{\pi}{\mu}e^{-\mu t}$$

$$= N_0 e^{-\mu t} + \frac{\pi}{\mu}(1 - e^{-\mu t})$$

Hence as N(t) $\longrightarrow \frac{\pi}{\mu}$ $as\ t \longrightarrow \infty$

From (1), we note that $\frac{dN}{dt} \leq \pi - \mu N$ and it was establish that $N(t) \leq N(0)\, e^{-\mu t} + \frac{\pi}{\mu}[1 - e^{-\mu t}]$ by a standard comparism theorem (Lukshmikantham, 1989). N(t) approaches $\frac{\pi}{\mu}$ $as\ t \longrightarrow \infty$, thus the system is positively – invariant and attracting in Ω.Thus the model is mathematically and epidemiologically in Ω (Hethcote, 2000), and it is sufficient to consider solutions in Ω.

3.4 Equilibrium Point and Stability Analysis

At each of the equilibrium point of the model

$$\frac{dS}{dt} = \frac{dI}{dt} = \frac{dC}{dt} = 0$$

$\therefore$ *The S, I, C model has an equilibrium point whihc is disease free.*

$$(S_0, I_o, C_0) = \left(\frac{\pi}{\mu}, 0, 0\right)$$

3.4.1 Sedentary Free Equilibrium

At the disease free state, there is no disease in human population which implies S = I = C = 0. Thus the disease free equilibrium model is given by

$$(S_0, I_o, C_0) = \left(\frac{\pi}{\mu}, 0, 0\right)$$

With $S = \frac{\pi}{\mu}$

3.4.2 Endemic Equilibrium Point

There is endemic equilibrium point with $I' \leq 0$ as $(S', I', C',) \leq 0$

$$0 = \pi + \sigma I' + \gamma C' - \beta S' I' - \alpha S' C' - \mu S' - - - - - (i)$$

$$0 = \beta S' I' - \sigma I' - \tau I' - \mu I' - - - - - - - - - - - (ii)$$

$$0 = \alpha S'C' + \tau I' - \gamma C' - \mu C' - - - - - - - - - - (iii)$$

from Equation (iii)

$$0 = \alpha S'C' + \tau I' - \gamma C' - \mu C'$$

$$0 = \tau I' - (\gamma - \mu + \alpha S')C'$$

$$(\gamma - \mu + \alpha S')C' = \tau I'$$

$$C' = \frac{\tau I'}{(\gamma - \mu + \alpha S')}$$

From equation (ii)

$$0 = \beta S'I' - \sigma I' - \tau I' - \mu I'$$

$$0 = (\beta S' - \sigma - \tau - \mu)I'$$

$$I' = 0$$

From equation (i)

$$0 = \pi + \sigma I' + \gamma C' - \beta S'I' - \alpha S'C' - \mu S'$$

$$0 = \pi + \sigma I' + \gamma C' - (\beta I' - \alpha C' - \mu)S'$$

$$(\beta I' - \alpha C' - \mu)S' = \pi + \sigma I' + \gamma C'$$

$$S' = \frac{\pi + \sigma I' + \gamma C'}{\beta I' - \alpha C' - \mu}$$

Therefore, the (S, I, C) model has an equilibrium point which is disease free $(S_0, I_o, C_0) = \left(\frac{\pi}{\mu}, 0, 0\right)$. There is endemic equilibrium point with $I' \leq 0$ as $(S', I', C') \leq 0$

3.4.3 The Stability of the Model

To check the stability:

We used the Jacobian Stability Technique for determining the stability of the system.

$$J = \begin{pmatrix} \frac{\partial f_1}{\partial s} & \frac{\partial f_1}{\partial I} & \frac{\partial f_1}{\partial C} \\ \frac{\partial f_2}{\partial s} & \frac{\partial f_2}{\partial I} & \frac{\partial f_2}{\partial C} \\ \frac{\partial f_3}{\partial s} & \frac{\partial f_3}{\partial I} & \frac{\partial f_3}{\partial C} \end{pmatrix}$$

We have:

$$\frac{\partial f_1}{\partial s} = \mu - \alpha C - \beta I$$

$$\frac{\partial f_1}{\partial I} = \sigma - \beta S$$

$$\frac{\partial f_1}{\partial C} = \gamma - \alpha S$$

$$\frac{\partial f_2}{\partial s} = \beta I,$$

$$\frac{\partial f_2}{\partial I} = \beta S - \sigma - \tau - \mu$$

$$\frac{\partial f_2}{\partial C} = 0$$

$$\frac{\partial f_3}{\partial s} = \alpha C$$

$$\frac{\partial f_3}{\partial I} = \tau$$

$$\frac{\partial f_3}{\partial C} = \alpha S - \gamma - \mu$$

$$J_E = \begin{pmatrix} \mu - \alpha C - \beta I & \sigma - \beta S & \gamma - \alpha S \\ \beta I & \beta S - \sigma - \tau - \mu & 0 \\ \alpha C & \tau & \alpha S - \gamma - \mu \end{pmatrix}$$

At DFE $(S_0, I_o, C_0) = \left(\frac{\pi}{\upsilon}, 0, 0\right)$

$$J_{E_0} = \begin{pmatrix} -\mu & \sigma - \beta\frac{\pi}{\mu} & \gamma - \alpha\frac{\pi}{\mu} \\ 0 & (\beta\frac{\pi}{\mu} - \sigma - \tau - \mu) & 0 \\ 0 & \tau & \alpha\frac{\pi}{\mu} - \gamma - \mu \end{pmatrix}$$

Therefore $|J_{E_0} - \lambda I| = 0$

$$|J_{E_0} - \lambda I| = \begin{pmatrix} \mu - \lambda & \sigma - \beta\frac{\pi}{\mu} & \gamma - \alpha\frac{\pi}{\mu} \\ 0 & \left(\beta\frac{\pi}{\mu} - \sigma - \tau - \mu\right) - \lambda & 0 \\ 0 & \tau & \left(\alpha\frac{\pi}{\mu} - \gamma - \mu\right) - \lambda \end{pmatrix}$$

$\mu - \lambda = 0$

$\Rightarrow \quad \lambda_1 = \mu$

$\beta\frac{\pi}{\mu} - \sigma - \tau - \mu - \lambda = 0$

$\Rightarrow \quad \lambda_2 = \beta\frac{\pi}{\mu} - \sigma - \tau - \mu$

$= \beta\frac{\pi}{\mu} - (\sigma - \tau - \mu)$

$$\alpha\frac{\pi}{\mu}-\gamma-\mu-\lambda=0$$

$$\Rightarrow \quad \lambda_3=\alpha\frac{\pi}{\mu}-\gamma-\mu$$

Hence the DFE is Stable if, $\beta\frac{\pi}{\mu}<(\sigma+\tau+\mu)$

By Routh-Hurtwiz condition

The first eigenvalue of the Jacobian matrix J_1 is $-\mu$, the other two eigenvalues are negative if and only if $R_{01} < R_0 < 1$ and $R_{02} < R_0 < 1$.The Routh-Hurtwiz conditions are satisfied. All the eigenvalues of the Jacobian matrix J_1 has negative real part, so, the disease free equilibrium of the system.

CHAPTER FOUR

4.1 Result and Discussion

The model presented in Chapter 3 does not take into consideration the most commonly used strategies in the fight against Sedentary lifestyle. These strategies are educational campaigns, active case-finding and medical interventions. Also the previous model does not explicitly capture mortality due to the disease. In this chapter we incorporate a compartment of the deceased that is important in disease transmission.

The success of control strategies depends largely on resource mobilisation. In fact, the lack of knowledge on sedentary lifestyle was a limitation factor in the fight against the disease. So, the use of effective control measures with minimal cost is observed during an epidemic. Optimal control is best described using mathematical modelling. We formulate a model for the optimal control against sedentary lifestyle.

4.2 Formulation of Model

The study proposed a deterministic compartmental model approach to design a model on effect of the sedentary lifestyle. The proposed model of a disease in a human population of size N(t) is divide into three classes, S(t) susceptible, I(t) Asymptomatic infective (sedentary lifestyle) C(t) symptomatic infective (cardiovascular disease).

Two rate of transmission were considered, the rate of transmission $\beta$for sedentary behavior individuals,α for individual with cardiovascular disease. Individuals with

sedentary behavior may progress to cardiovascular class at a rateγ. Following treatment and applying other preventive measure (awareness education) both individuals with cardiovascular disease may progressed to the remove class at a rate ofσ . Let μdonate natural death in each class

CHAPTER FIVE

5.1 Summery

World Health Organization (WHO), identified obesity as a worldwide public health problem affecting over 100 million people. Reduced physical activity which characterizes Sedentary Life Style leads to accumulation of excess calories and fatty acids. This is because weight maintenance depends largely on the number of calories absorbed through food intake and the number expended through physical activity and metabolism. Lucas, Ward and Brain (2018) identified Sedentary lifestyles as a major cause of obesity in both male and female workers. An individual, who is sedentary, absorbs and stores a lot of calories because of reduced energy expenditure. These unwanted calories lead to obesity.

5.2 Conclusion

Sedentary lifestyle and behavioural factors have been implicated for various health risks identified in this seminar paper. Understanding the relationship between sedentary behaviour and health outcome and modifying these behaviours are fundamental in reducing the morbidity and mortality rates caused by these health complications. Since sedentary lifestyle predisposes individual (both old and young) to various non-communicable but devastating diseases, it is feasible to induce people to shift some proportion of their sedentary time into large volumes of light to moderate energy investing physical activities.

5.3 Recommendations

Based on the emerging evidences revealed by this research on the health risks associated with sedentary life style; the following suggestions are made:

1. Work places, schools, business centers should be structured in a way that allow individuals to have adequate time for movement and recreational activities.

2. The four key health behaviours are encouraged (involving in physical activity, avoiding smoking, reducing alcohol intake and eating healthy).

3. Individuals are encouraged to reverse from present day sugary, fatty and animal based diet to our traditional plant/vegetable based diet to reduce the health risks associated with high cholesterol diet.

4. Parents are encouraged to monitor and regulate the good intake of their children as well as time spent watching TV, video and computer game to reduce obesity with its associated health risks.

5. Proper information should be disseminated on the dangers of sedentary lifestyle through all available media of communication.

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