A Simple Model for a Complex Issue: Understanding the Dynamics of Adult HIV and AIDS Situation in Canada

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ABSTRACT

System dynamics models can facilitate the understanding of complex and dynamic biomedical systems such as in HIV/AIDS. Untangling the dynamics among various population stocks (e.g., susceptible population, infected population, HIV population, AIDS population) can be used to investigate the effective points of interventions in the HIV/AIDS cycle. With that in mind, the authors have developed a system dynamics model that can be used to examine various policy decisions for the prevention and the treatment of HIV/AIDS. The specific objectives of their study was to examine the growing number of AIDS-related deaths in Canada. They used the authors’ dynamic simulation model to evaluate the impact of various HIV/AIDS policy intervention scenarios centred on the reduction of the number of AIDS deaths in Canada. Their analysis suggests that more lives will be saved if effective preventive and treatment programs are implemented simultaneously. A simultaneous implementation of these programs will also result in a much smaller HIV-infected and AIDS populations.

Keywords: Acquired Immunodeficiency Syndrome (AIDS), Canada, Human Immunodeficiency Virus (HIV), Preventive Care, System Dynamics, Treatment Care

1. INTRODUCTION

The HIV/AIDS epidemic, a disease which primarily affected men who have sex with men (MSM), to one that increasingly affects other groups, including injecting drug users (IDU) and heterosexuals, in Canada has changed in recent years. As a result, there are more adults living with HIV and AIDS (StatsCan, 2004). Recent data has shown a somewhat surprising and disturbing trend; that occurrences of HIV and AIDS are being diagnosed in adults at an increasing rate and in particular in women who have contracted the disease through heterosexual contact (Gahagan et al., 2008; StatsCan, 2008). This alarming trend of HIV/AIDS related cases among adults in Canada requires efforts to address and mitigate the impact of HIV/AIDS through research. We, therefore, are interested to understand the dynamics of HIV/AIDS in the adult population of Canada.

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The major risk factors of HIV/AIDS infection in adults are heterosexual contract, injecting drug users (IDU) and, blood and blood products. Heterosexual contact remains the main risk factor for HIV and AIDS infection among women. Heterosexual contact is defined by three main categories: sexual contact with a person who is either HIV infected or at an increased risk for HIV infection, origin from a country where HIV is endemic, and sex with the opposite gender as the only identified risk. These numbers do not include those who are infected with either HIV or AIDS, but are unaware of their infection or choose not to be tested.

A good understanding of the infection mechanisms and their correct modelling and analysis is a fundamental step towards successfully preparing and evaluating alternative policies that aim to eradicate or minimize the occurrence of the disease. Traditional analytical techniques (see for example, classic OR models in Brandeau and Zaric (2009) and Kaplan and Brandeau (1994) discrete even simulation (Davies et al., 2003), and a network epidemic model in (Zanakis et al., 2007) barely capture the dynamics of underlying structural variables e.g., susceptible population, HIV infected population, AIDS population)(Gilbert & Troitzsch, 1999). On the other hand, system dynamics models have been successfully used to study the dynamics of complex systems such healthcare systems (e.g., epidemiology of HIV/AIDS (Dangerfield et al., 2001; Atun et al., 2007)), epidemic intervention policies (Tebbens & Thompson, 2009), and modelling for public health (Homer & Hirsch, 2006). The objective of this study, therefore, is to demonstrate the development and application of a system dynamics simulation model to better understand the dynamics of the adult HIV and AIDS situation in Canada. Specifically, utilizing the developed dynamic model, we will explore the impact of various HIV/AIDS policy intervention scenarios centred on the reduction of AIDS deaths - a raison d’être of any HIV/AIDS prevention and treatment care program.

2. THEORETICAL REVIEW

2.1. Background

The Acquired Immunodeficiency Syndrome (AIDS) is caused by Human Immunodeficiency Virus (HIV). HIV attacks the immune system which results in a chronic, progressive illness leaving infected people vulnerable to opportunistic infections and cancers. The time from HIV infection to AIDS diagnosis can last more than 10 years.

The first case of AIDS in Canada was reported in 1982. In 2003, 19,344 AIDS cases were reported to Health Canada but the total number of AIDS cases that have occurred in Canada since the epidemic began is estimated to be close to 20,000 (PHAC, 2006). The HIV/AIDS epidemic in Canada has changed from the early epidemic, which affected primarily men who have sex with men (MSM), to the current epidemic, which increasingly affects other groups such as IDU users, aboriginal people and women (Guenter, 2005; StatsCan, 2004). According to Health Canada, the number and percentage of women living with HIV/AIDS epidemic is increasing (PHAC, 2006, 2008). The HIV/AIDS infected women is of more concerned because of the possible transmission to their infants. The study also stated that the HIV/AIDS epidemics among adults who are 15 years old and older in Canada are increasing. Therefore, understanding the dynamics of adults (15-59 age group) HIV/AIDS situation in Canada has become increasingly important. The need to understand the long term dynamics of prevention and treatment policy decisions becomes even more pronounced. This study aims to attempt this challenge through the development and application of a dynamic model, based on system dynamics methodology (Forrester, 1961), which is calibrated to the data about adult HIV/AIDS population in Canada.
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