Illegal Drugs Diffusion in the Philippines: Exploring the Use of SIR Model

Joy M. Mirasol, Ph.D.
Bukidnon State University
ORCID No. 0000-0001-7710-1940

Marlon S. Frias, Ph.D.
Bukidnon State University
ORCID No. 0000-0001-8891-3805

Christian J. Inovejas
Bukidnon State University
ORCID No. 0000-0002-9774-7236

Joan M. Recente
Bukidnon State University
ORCID No. 0000-0001-6104-0610

Abstract

The study deals with the issue of illegal drugs spread or diffusion in the country. It attempts to use a mathematical model to explain how the drug spread/diffusion is described and analyzed. It specifically (a) determines the patterns and themes found in the simulated and actual interactions of actors/variables to produce optimal interactions and scenarios; (b) predicts, using the SIR model, whether illegal drug spread/diffusion will continue to proliferate or will it fade; and (c) recommends policies based on the patterns and scenarios developed in the study. Findings showed that using the SIR model there were three possible scenarios whereby the drug diffusion in the country might be explained. Using existing data and applying the SIR model result showed that drug spread/diffusion in the country was decreasing. The study recommends that the concerned authorities may use the SIR model, in conjunction with other qualitative methods, in determining and predicting drug diffusion in the country. Further, it may employ alternative or supplementary policies to address (a) drug prevention activities that protect the susceptible population, (b) causes of drug infection/use, and (c) effective drug rehabilitation to prevent relapses.

Keywords: Drug abuse, drug diffusion, drug spread, epidemiological model, SIR model

Introduction

The scourge of substance abuse is recognized as a worldwide phenomenon. It has wreaked havoc on individuals, families, societies, and governments. The World Health Organization has considered this a serious threat to public health. In response to this threat, the Philippines has become one of the United Nations member states who adopted the Political Declaration and Plan of Action on International Cooperation towards an integrated and balanced strategy to counter the drug menace (UNODC, 2009). The country has participated in International Drug Control Conventions for the Adoption of a Single Convention on Narcotic Drugs of 1961 as amended by the 1972 Protocol, the Convention on Psychotropic Substances of 1972, and the United Nations Convention against Illicit Traffic in Narcotic Drugs and Psychotropic Substances of 1988 (UNODC, 2013). These conventions address the universal call for prevention and combat against the spread and traffic of illegal narcotic substances.

Under the administration of President Rodrigo Duterte, the Philippine government has embarked on a "War on Drugs" to put a stop to the spread of this deadly menace. The resulting action by the government has produced varied reactions from the different sectors of society. Two conflicting views emerge as to how the government handles the drug-related problems in the country. Issues on extra-judicial killing and human rights violations arise, questioning the punitive approach of the government led by police officers in arresting individuals allegedly committing drug-related offenses. Given the intent to destroy the structure of the supply and network of hard-hitting drug pushers and suppliers, the war on drugs mechanism resulted in an increase in drug-related deaths and intensified violations of human rights. According to the Philippine Drug Enforcement Agency (PDEA), in a matter of three months (July 2016 to September 2018), a total of 4,948 suspected drug users and dealers died during anti-illegal drug operations. However, the data excluded the thousands of others killed by unidentified gunmen. According to the Philippine National Police, around 22,983 deaths were recorded since the "war on drugs" on Duterte's administration has been implemented. These deaths were classified as homicides under investigation (Human Rights Watch, 2020).

On the contrary, the "war on drugs" has received a high level of popular support from across the class spectrum in the Philippines. The population support was evident in Duterte's approval rating of 86% during the nationwide survey on presidential performance and trust ratings from September 25 to October 1, 2016, by Pulse Asia Research (Xu, 2016). Despite the pros and cons of the "war on drugs" approach, President Duterte vowed to continue the anti-drug campaign until the end of his term.

The drug problem in the country is a complex and multi-faceted problem that includes not only criminal justice issues but also public health issues. In 2015, global estimates of drug use reported that about 255 million are users of illicit drugs, and 29.5 million are drug users diagnosed with health disorders due to addiction. A minimum of 190,000 cases of deaths were also related to drugs, and most were due to drug overdoses (UNDOC, 2017). In the Philippines, the Philippine Drug Enforcement Agency (PDEA) reported currently four million drug users (PADS, 2018). There is an increasing trend of cases of admission to treatment and rehabilitation centers from 2012-2016 (2,744 to 6,079) and a sudden drop in the number of cases in 2017 (4,045) (PADS, 2018). The decrease may be attributed to the prevention and other interventions implemented from international, national, and local agencies and institutions.

Literature Review

Drug abuse in the Philippines has reached epidemic proportions, hence, considering it as one of the top priorities on the government's agenda, as evident by the "war on drugs" government program. Hambre (2004) suggested that an immediate need for an epidemiologic study of the extent of drug abuse is necessary considering the importance of the study to policy formulation, treatment, and prevention of the problem. As a social problem, mathematical models based on mathematical epidemiology concepts and the mathematical theory of infectious diseases (Bailey, 1975) have been developed to address this problem. The works of Bailey (1975), Anderson and May (1991), Murray (2004), Brauer and Castillo-Chavez (2000), and Diekmann and Heesterbeek (2000) documented the valuable applications of mathematical and statistical methods in understanding epidemiological realities.

The term epidemic is usually applied to the spread of infectious disease, but Mushanyu et al. (2015a) argue that drug abuse is assumed to have mechanisms similar to epidemic diffusion. Several researchers have introduced mathematical models describing drug abuse spreading like an infectious disease. The SIR model is one of the most common mathematical models used and adopted in understanding the dynamics of substance (i.e., drug) abuse. It is one of the simple compartmental mathematical models assigning the populations into three, the susceptible, infectious, and recovered (Kermack & McKendrick, 1927). Other mathematical models related to the behavior and dynamics of drug abuse are variations of the SIR model. The Classic SIS model is a variation of the SIR model involving the susceptible and infected group. However, in this model, the infected individuals return to the susceptible class on recovery because the disease confers no immunity against re-infection (Hethcote, 1989). An exponential model based on the SIR model was developed by Mackintosh and Stewart (1979) to illustrate how heroin spreads in epidemic function. From the heroin and methamphetamine epidemic, mathematical models were developed modeling the substance abuse (Nyabadza & Hove-Musekwa, 2010) and examining the trends of two types of (drug use) rehabilitation, the in-patient and out-patient forms of rehabilitation (Mushanyu et al., 2015a). Other drug-related mathematical models include the dynamic model of drug initiation as to its implications for treatment and drug control (Behrens et al., 1999); modeling multiple relapses as a common phenomenon in drug epidemics, particularly in the recovery process (Mushanyu et al., 2015b); and the ordinary differential equations (ODE) modeling for opiate addiction involving the susceptibles, heroin users, and the heroin users undergoing treatment (White & Comiskey, 2007). In the study of Liu and Zhang (2011), the distributed delays are incorporated into the ODE heroin epidemic model, developing various differential equations to analyze the heroin dynamics involving the susceptibles, drug users not in treatment, and drug users in treatment. Given the documented literature related to drug epidemics, all mathematical models presented are patterned after the classical SIR Model of Kermack and McKendrick (1927), hence, making it an appropriate model to use in understanding the drug dynamics in the Philippines.

Theoretical Framework

As a framework of the study, the SIR Model developed by Kermack and McKendrick (1927) is used to explore the dynamics of drug diffusion in the country. The framework showed the interaction of various actors that include the S (susceptible actors), I (infected actors), and R (recovered actors). Simulated interactions and interactions using the actual data are compared to predict the patterns and themes in drug use in the country.

Figure 1. The SIR theoretical framework showing the interaction of the different actors.

Objectives

Specifically, this study explores the following objectives:

1. Determine the patterns and themes that can be found in the simulated and actual interactions in terms of the following:
    1.1. Optimal values of interactions; and
    1.2. Optimal scenarios;
2. Simulate and apply the SIR model to determine whether illegal drug diffusion will continue to proliferate or fade; and
3. Recommend policies based on the patterns and themes developed in the study.

Methodology

Ethical Considerations

The study utilized data that are publicly available over the internet. It does not have human participants as respondents. It, however, attempted to explain the phenomenon of illegal drug spread/diffusion using an epidemiological model (SIR). It intended to capture this phenomenon to provide a way of predicting whether the drug spread/diffusion is increasing or decreasing. The society/government/health or any law enforcement agency may use this technology to develop policies that can effectively address the illegal drug scourge in the country.

Simulation

The study modeled and simulated the interaction of various actors in the drug spread in the Philippines. It specifically followed these steps in the conduct of the study:

1. Determine the various actors (S.I.R.) in the drug trade and anti-drug activities in the country;
2. Develop a mathematical model of the interaction of the various actors and their relation;
3. Develop a computer program incorporating the mathematical model;
4. Describe the pattern of interaction produced using simulated and actual data;
5. Analyze the various scenarios as to its relevance to the existing social phenomenon

Data Requirements on Drug-Related Incidents in the Philippine Context

This study utilized data from the following sources:

1. Reports from the PNP and PDEA on the number of arrested and killed individuals that were related to drugs from July 1, 2016-January 31, 2019 based from Philippine Drug Enforcement Agency.
2. Facility-based reported cases related to drugs by the Dangerous Drugs Board from 2010-2017 (Dangerous Drug Board).
3. Estimated number of drug addicts as published by PDEA, 2016 (PDEA Annual Report, 2016).
4. The assumption that the total Philippine population as of 2016 is 103,242,900 (PSA)

Data Limitation

The study relied mainly on publicly accessible data provided by government institutions. These data may have limitations as to the scope (national) as there may be information that is unreported or inaccessible to the study.

Model Building

The SIR model (Kermack & McKendrick, 1927) is a simple mathematical model of epidemics. An epidemic is when the number of people infected with a disease is increasing in the population. In the SIR model, there are three variables considered. These are S (susceptible), I (infected or infectious), and R (recovered or immune). The S refers to the people who are not infected with the disease. In this study, this refers to individuals who are non-users of illicit substances. They are, at the same time, susceptible to potential drug use in the future. The I (infected or infectious) are the individuals who are already into drug use/abuse. These people may entice non-drug users to try them into the habit of drug use/abuse. R refers to the recovered or immune. This refers to the individuals who have been to substance use/abuse and are rehabilitated/recovered. In this model, they have recovered from the disease and are immune, so they can no longer be infected with the disease.

In this study, the epidemic refers to the spread of drug use/abuse. We consider a population of size N. This can be expressed as follows:

$$N = S + I + R \qquad 1$$

The population consists of individuals who belong to three classes, namely, susceptible to drugs (S), infected with drugs (I), and recovered or rehabilitated from drugs (R). Susceptible (S) individuals are not yet addicted to drugs but will likely be exposed to drugs. The infected (I) individuals, on the other hand, are those who are already addicted to drugs, while recovered (R) individuals are those who are rehabilitated from drug addiction and are immune to being addicted again.

The variables *S, I,* and *R* represent the number of people at a particular time. These variables change over time since individuals infected with drugs can influence people from susceptible class. This may cause a decrease in the number of susceptible and an increase in the number of those infected. The number of infected individuals may also decrease due to police operations and government effort in terminating drug spread in society. They may be convicted, rehabilitated, or left dead if they resist arrest and fight back against the government authorities. To represent the variables as a function of time, we have these following notations:

$S(t)$ = number of susceptibleindividuals at time t; (2)
$I(t)$= number of infected/addicted individuals at time t; (3)
$R(t)$ =number of recovered/rehabilitated/dead individuals at time t; (4)

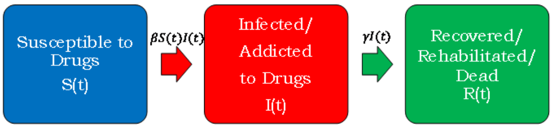

Figure 2. The SIR model for drug diffusion

From these quantities, we can write

$$N = S(t) + I(t) + R(t)\,, \quad for\ all\ t \qquad (5)$$

These quantities are counts representing the number of people from each class at a particular time *t*. Figure 1 shows the SIR model. The boxes represent the three classes with the corresponding variables. The arrows represent the transition rates between classes. Between *S(t)* and *I(t)*, the transition rate is β, which is also called the rate of addiction. The quantity *βS(t)I(t)* is the number of individuals from the susceptible class, influenced by those in the infected/addicted class. The transition rate between the infected class and the recovered class is *γ*. This rate is also called the recovery rate from drug addiction. The quantity *γI(t)* is the number of individuals from *I(t)*, which are moving to *R(t)* for a particular time *t*. These individuals are either recovered from addiction, rehabilitated, or dead.

Assumptions of the SIR Model

The following are the underlying assumptions of the SIR model of drug diffusion:

1. Individuals are born into the susceptible class.
2. The population size *N* is constant.
3. Infected individuals spread the disease to susceptible and remain in the infected class (the infected period) before moving into the recovered class.
4. Individuals in the recovered class are assumed to be immune for life.
5. The interaction between the *S* and *I* will result in a proportion of *S* to *I*, which will lead to an increase in *I* and decrease in *S*. Thus, a negative rate of change of *S* with respect to time.
6. The recovered or rehabilitated individuals have developed immunity or do not relapse.

Interaction among Variables

The dynamics of the drug diffusion described can be expressed by the following set of ordinary differential equations:

$$\frac{dS}{dt} = -\beta S(t)I(t) \qquad (6)$$

$$\frac{dI}{dt} = \beta S(t)I(t) - \gamma I(t) \qquad (7)$$

$$\frac{dR}{dt} = \gamma I(t) \qquad (8)$$

Where β is the rate in which individuals from susceptible compartment become a drug user or become infected *I(t)*. The coefficient *γ*, on the other hand, is the rate in which addicted individuals will be recovered/rehabilitated from the use of a drug for a particular time *t*.

Difference Equations

From equations (6)-(8), a series of difference equations are expressed to describe how the system changes between two succeeding times, say *t* and *t* +1. The three variables are expressed as follows:

$$S(t+1) = S(t) - \beta S(t)I(t) \quad (9)$$
$$I(t+1) = I(t) + \beta S(t)I(t) - \gamma I(t) \quad (10)$$
$$R(t+1) = R(t) + \gamma I(t) \quad (11)$$

For each class, the number of individuals at a particular time, say (t+1), is equal to the number of individuals in the previous time (t) plus the rate of change, for each time, shown in equations (9)-(11). Time (t) represents any arbitrary time period. For this model, we treat t as a time period of 1 day.

In equation (6), the observed values are the counts/numbers of susceptible, infected, and recovered. To generalize this system of equations, the system is converted to a fraction of its population by dividing it by its total population. Thus:

$$1 = s(t) + i(t) + r(t) \quad for\ all\ t \quad (12)$$

where$s(t) = S(t)/N$ = fraction susceptible class' population at time t
$i(t) = I(t)/N$ = fraction of infected class' population at time t
$r(t) = R(t)/N$ = fraction of recovered class' population at time t

Similar with equations, the difference equation becomes:

$$s(t+1) = s(t) - \beta s(t)i(t) \quad (13)$$
$$i(t+1) = i(t) + \beta s(t)i(t) - \gamma i(t) \quad (14)$$
$$r(t+1) = r(t) + \gamma i(t) \quad (15)$$

Parameters of the Drug Diffusion Model

There are many questions about the behavior of the model that need to be answered. These may be answered using ordinary calculus. To analyze the behavior of the model, it is necessary to examine the parameters of the model. Consider the differential equation:

$$\frac{dI}{dt} = \beta S(t)I(t) - \gamma I(t) \quad (16)$$

$$= [\beta S(t) - \gamma]I(t) \quad (17)$$

Consider also the initial population of susceptible S(0) and infected I(0). One of the questions that needs to be answered is: Will the spread of drugs in our society continue to proliferate, or will it fade?

From the equation above, dI/dt>0if S_0>γ/β. This means that the number of people infected with drugs will grow and eventually will become a major problem in our society. If S(0)<γ/(β), then dI/dt<0. This means that the population of those infected with a drug will shrink, and the problem in drug spread in our country will fade.

Next is the definition of another quantity, which is important in analyzing SIR models. This quantity is called the basic reproductive ratio:

$$R_0 = \frac{\beta}{\gamma} \quad (18)$$

This ratio is interpreted as the expected number of new cases of infection from a single observed infection in a population. If R_0>1, then more people are getting addicted to drugs than are recovering from it. However, if R_0<1, then there is an exponential decrease in drug addiction. For example, in the drug spread problem, if the rate of infection/addiction (β) is 0.5, and the rate of recovery (γ) is 0.20. Then,

$$R_0 = \frac{\beta}{\gamma} = \frac{0.5}{0.20} = 2.5 \quad (19)$$

This means that for each individual addicted to drugs, it will produce/influence 2.5 new cases of addiction. This will, in turn, reduce the number of population from susceptible class and increase the number of infected/addicted to drugs.

Another important quantity to describe the behavior of infected individuals is the effective reproduction number, R_e, which is defined as:

$$R_e = \left(\frac{s(0)}{N}\right)\frac{\beta}{\gamma} = s(0)\cdot\frac{\beta}{\gamma}$$ (20)

The effective reproduction number R_e is the threshold value that tells us whether an infectious disease will quickly die out or whether it will invade the population and cause an epidemic. The behavior of $i(t)$ using the value R_e are the following:

1. If $R_e \leq 1$, then $i(t)$ decreases monotonically to zero as $t \to \infty$.
2. If $R_e > 1$, then $i(t)$ starts increasing, reaches its maximum, and then decreases to zero as $t \to \infty$. We call this scenario of increasing numbers of infected individuals an epidemic.

Results and Discussion

This section presents the patterns and scenarios that can be found in the interactions among variables. Further, this section discusses the optimal values of the interaction and optimal scenarios based on the interactions.

Patterns and Scenarios of Simulated Interactions

This section presents the simulation of the drug diffusion model, and these three cases are considered: (1) $\beta > \gamma$, (2) $\beta < \gamma$, and (3) $\beta = \gamma$.

Scenario 1:

Addiction rate is greater than the recovery rate:

$s(0) = 0.7$, $i(0) = 0.3$, $r(0) = 0$, $\beta = 0.5$, and $\gamma = 0.2$

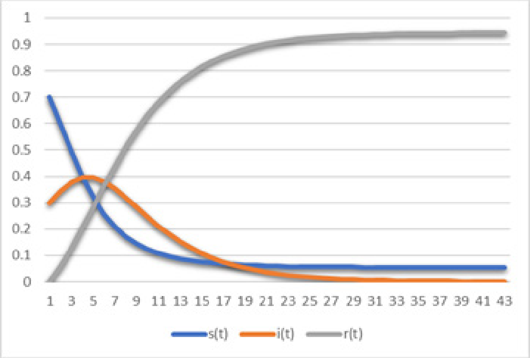

Figure 2. Simulation of drug diffusion model with β=0.5 and γ=0.2.

$$\frac{ds}{dt} = -0.5s(t)i(t) \tag{21}$$

$$\frac{di}{dt} = 0.5s(t)i(t) - 0.2i(t) \tag{22}$$

$$\frac{dr}{dt} = 0.2i(t) \tag{23}$$

Since $\frac{ds}{dt} \leq 0$ for all t, the number of susceptible individuals is decreasing or remains constant. Setting $\frac{ds}{dt} = 0$, we get:

$$-0.5s(t)i(t) = 0 \Leftrightarrow s(t) = 0 \text{ or } i(t) = 0 \tag{24}$$

This means that $s(t)$ will remain constant if any of the two values, *s(t)* or *i(t)*, becomes zero depending on which runs out first. Next, if the following formula isset $\frac{di}{dt} = 0$, the following is derived:

$$0.5s(t)i(t) - 0.2i(t) = 0$$
$$i(t)[0.5s(t) - 0.2] = 0 \Leftrightarrow i(t) = 0 \text{ or }$$
$$s(t) = 0.4$$

Note that if:

$$s(t) > 0.4,\ \frac{di}{dt} > 0 \tag{25}$$

$$s(t) < 0.4,\ \frac{di}{dt} < 0 \tag{26}$$

Above, it is observed that the fraction of infected individuals initially starts increasing until the remaining fraction of susceptible individual is 40% of the population, then its starts decreasing when the fraction of susceptible individuals is less than 40%. It is also observed that the fraction of infected individuals reduces to 0 faster than the susceptible. This makes the susceptible leveling off to 5.4% of the population and remains constant thereafter.

Next, the following is computed:

$$R_0 = \frac{0.5}{0.2} = 2.5$$

This value is the expected number of susceptible individuals influenced by each infected/addicted individual. This value is alarming since the number of infected individuals will accumulate exponentially, and thus, it will result in an epidemic. This behavior of infected individuals can be predicted from the very start by computing the effective reproduction number:

$$R_e = 0.7 \times \frac{0.5}{0.2} = 1.7$$

Observe that,

$$\frac{di(0)}{dt} = \beta s(0) i(0) - \gamma i(0)$$

$$= \gamma \left(\frac{\beta}{\gamma} s(0) - 1 \right) i(0)$$

$$= \gamma (R_e - 1) i(0)$$

Substituting the values of R_eand γ, the following is derived:

$$\frac{di(0)}{dt} = 0.2(1.7 - 1) i(0)$$

$$= 0.14\, i(0)$$

This result means that the fraction of infected individuals will initially grow by 14% of their population.

Scenario 2:

Recovery rate is greater than addiction rate: $s(0) = 0.7, i(0) = 0.3, r(0) = 0, \beta = 0.3, and\ \gamma = 0.8$

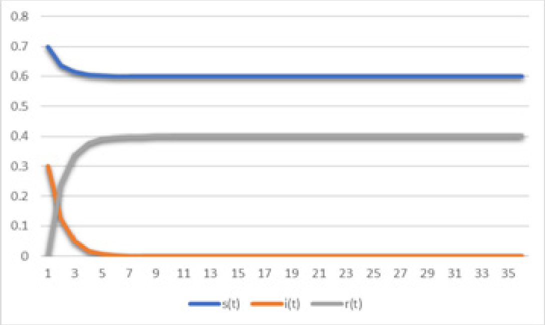

Figure 3. Simulation of drug diffusion model with β=0.3 and γ=0.8

$$\frac{ds}{dt} = -0.3 s(t) i(t) \qquad (27)$$

$$\frac{di}{dt} = 0.3 s(t) i(t) - 0.8 i(t) \qquad (28)$$

$$\frac{dr}{dt} = 0.8 i(t) \qquad (29)$$

Based on the figure, the number of susceptible individuals starts decreasing exponentially until the number of infected individuals runs out. The s(t) and r(t) then remain constant since there are no longer individuals who will infect others. This can also be explained by the effective reproduction number, which is computed as:

$$R_e = 0.7 \times \frac{0.3}{0.8} = 0.2625$$

This value is less than 1, and so there will be no epidemic.

Scenario 3:

Addiction and recovery rates are equal: $s(0) = 0.7, i(0) = 0.4, r(0) = 0, \beta = 0.6,$ and $\gamma = 0.6$

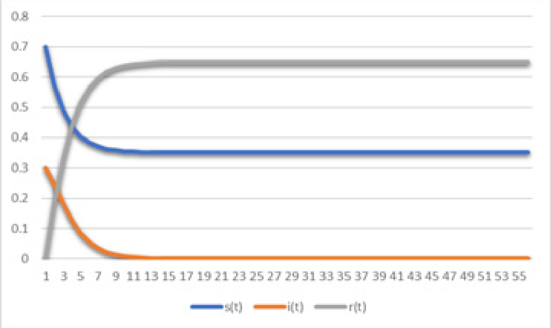

Figure 4. Simulation of drug diffusion model with

$\beta = 0.6$ and $\gamma = 0.6$.

Scenario three is similar to scenario two, where susceptible individuals start decreasing exponentially until the number of infected individuals reaches zero. This will lead to susceptible individuals to remain constant over time, and the disease will die out, and the epidemic will not occur.

Drug Diffusion in the Philippine Context

To determine the actual drug diffusion in the Philippines, actual data are used to determine the current scenario and predict the pattern of diffusion.

Infected Cases (I)

Table 1 shows the facility-based drug-infected cases reported by the Dangerous Drugs Board (DDB Database).

Table 1
Reported Cases by Type of Admission (Facility-Based) 2010-2017

Type of Admission	2010	2011	2012	2013	2014	2015	2016	2017
New Admission	2,021	2,394	2,192	2,618	3,388	4,325	4,688	3,256
Re-admission	486	425	404	446	772	1,077	1,126	633
Out-patient	238	221	148	202	232	-	265	156
Total	2,745	3,040	2,744	3,266	3,392	5,402	6,079	4,045

Data show that the number of infected individuals increased over time. The increase, on the average, is about 8.9% over time.

Rehabilitated/Recovered Cases (R)

According to Philippine National Police (PNP) and Philippine Drug Enforcement Agency (PDEA) (Database: July 1, 2016, to January 31, 2019), there were 5,176 drug personalities killed in anti-drug operations in the country. There were also 170,689 drug-related arrests. Of these arrests, 295 were employees, 263 were elected officials, and 69 were uniformed personnel. These figures mean that, on average, 5,673 individuals were rehabilitated/recovered per month or 68,076 individuals per year.

Parameter Estimations in the Philippine Context

Based on the reported cases above, the rate of drug infection in the Philippines, assuming the population is $103{,}242{,}900$ as projected by the PSA in 2016, is estimated to be $\beta = \frac{3{,}839}{103{,}242{,}900} = 0.00003718$ while the recovery rate is $\gamma = \frac{68{,}076}{103{,}242{,}900} = 0.00065938$.

In 2016, PDEA reported that there were 4.7 million individuals who were infected/addicted to drugs. This suggests that, on the population of 103,242,900, 4.6% of the population were the infected individuals, while 95.4% are the susceptible ones. For this analysis, 2016 was set as the initial time (t=0), and the proportion of recovered/rehabilitated individuals is 0% (r = 0%).

Using the estimated parameters, we obtained $\frac{\gamma}{\beta} = \frac{0.00065938}{0.00003718} \approx 17.7348$. Observed that $s(0) = 0.954 < 17.7348$, which means that the proportion of drug infected individuals will shrink, and the drug problem will fade.

$$R_0 = \frac{0.00003718}{0.00065938} \approx 0.0564$$

$$R_e = 0.954 \times \frac{0.00003718}{0.00065938} \approx 0.0538$$

Table 2 shows a summary of the computed values of parameters of the drug diffusion in the Philippines. It further shows that the behavior of variables implies that the drug diffusion in the Philippines is decreasing and will continue to decrease over time.

Table 2.
Indicators Showing the Drug Diffusion Behavior

Parameter	Value	Criteria	Remarks
The ratio of γ and β	$s(0) = 0.954, \frac{\gamma}{\beta} = 17.7353$	$s(0) < \frac{\gamma}{\beta}$	The drug spread will decrease
Basic Reproduction Ratio (R_0)	0.0564	$R_0 < 1$	The drug spread will decrease
Effective Reproduction No. (R_e)	0.0538	$R_e < 1$	The drug spread will decrease

Policy Recommendations

The study investigates how illegal drug diffusion can be simulated using the SIR model (differential equation). The simulation seeks to provide assessment and predictive mechanisms for the diffusion of illegal drug use/abuse in the country. Institutions dealing with the illegal drug problem may be able to use this model in situating and predicting the extent of illegal drug use/abuse at any given time.Though the SIR model can situate and predict scenarios based on available quantitative data, it may not be able to fully explain the experiences of individuals who directly experience the phenomenon. Hence, for further studies, future researchers may use the SIR model in conjunction with other qualitative research methods to complement the qualitative aspect of the phenomenon.

Mechanisms may be provided for academic researchers to be allowed access to government databases on the proliferation of illegal drugs and other related information, specifically on (1) population who are infected, (2) population who are rehabilitated, and (3) population who are not infected.

Concerned authorities may also consider alternative or supplementary strategies that strengthen its capacity on rehabilitation programs to ensure that rehabilitated/recovered individuals will not relapse.

Implications

Though the SIR model showed that illegal drug diffusion is decreasing, there is still a need to clarify what causes interactions and factors that produce such a result. Hence, factors like (a) the arrests/jailing of the drugs suspects, (b) alleged killing of drug suspects, or (c) the rehabilitation of the drug suspects, (d) and other related factors can be scrutinized to determine which have contributed significantly to the observed decrease in the diffusion of illegal drugs.These require community-based data and information to fully enrich the said discussions.

Conclusion

With the SIR model, the study has developed three (3) cases/models showing patterns of decrease/increase/stable. It showed the three possible scenarios whereby the drug diffusion in the country maybe be observed. Using available data for the SIR model, the simulation for actual data showed that illegal drug spread/diffusion in the country is decreasing. However, due to the limitation of data (facility-based and government-provided), the incorporation of community – based data is still to be desired.

The government may adopt policies that utilize the SIR model in conjunction with other research tools in determining and predicting drug spread in the country. Further, it may also address the sustainability of this effort to further decrease the infection by (a) enhancing drug prevention activities to protect the susceptible population, (b) conducting qualitative studies on the causes of drug infection/use, (c) effective drug rehabilitation to prevent relapses (d) and access of researchers to drug-related data and information.

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