Australian Journal of Basic and Applied Sciences, 9(11) May 2015, Pages: 973-980

ISSN:1991-8178

Australian Journal of Basic and Applied Sciences

Journal home page: www.ajbasweb.com

Stability Analysis and Qualitative Behavior on the Dynamics Model of Alcohol Drinking

[1]Wirasak Poonpanang, [2]Purinchaya Wisutsiri and [2]Surapol Naowarat

[1,2]*Department of Mathematics, Faculty of Science and Technology, Suratthani Rajabhat University, Surat Thani, 84100,Thailand*

ARTICLE INFO

Article history:
Received 12 March 2015
Accepted 22 April 2015
Available online 22 May 2015

Keywords:
Mathematical model, Alcohol drinking, Stability analysis, Alcohol reproductive number, Peer influence

ABSTRACT

A deterministic mathematical model for the dynamics model of alcohol drinking is proposed and analyzed. The proposed model is taken into account the effect of peer influence in the model. The proposed model is analyzed using standard stability method. The alcohol free equilibrium and alcohol present equilibrium are investigated and the stabilities of the model at each equilibrium points are determined using Routh-Hurwitz criteria. Alcohol reproductive number is obtained using the next generation matrix. The graphical results shown that when the proportion of the contact rate between the potential smoking and the infected human decrease, the number of infected human will decrease and if the cost of treatment increase, the number of infected human will decrease. Computer simulations are also determined to support the analytic results of the model.

© 2015 AENSI Publisher All rights reserved.

To Cite This Article: Wirasak Poonpanang, Purinchaya Wisutsiri and Surapol Naowarat., Stability Analysis and Qualitative Behavior on the Dynamics Model of Alcohol Drinking. ***Aust. J. Basic & Appl. Sci.,*** *9(11): 974-980, 2015*

INTRODUCTION

Alcoholism, also known as 'alcohol dependence' is a disease that includes alcohol craving and continued drinking despite its negative effect on an individual's health, relationships and social standing (Merrill, 2014). As with all other drug addictions, alcoholism is taken as a treatable disease. World Health Organization estimates that about 140 million people throughout the world suffer from alcohol dependence with related problems, such as being sick, losing a job among a host of other things (Harlem-Brundtland,2001 & Rile, 2003). Alcoholism has a higher prevalence among men, although in recent decades, the proportion of female alcoholics has increased (Walter . *et al*, 2003). Alcohol consumption has health and social consequences via intoxication (drunkenness), alcohol dependence and other biochemical effects of alcohol. Overall there is a casual relationship between alcohol consumption and more than 60 types of diseases and injury. Alcohol is estimated to cause about 20-30% of esophageal cancer, liver cancer, cirrhosis of the liver, homicide, epileptic seizures and motor vehicle accidents worldwide (WHO, 2002). Alcohol is involved in nearly half of all violent deaths involving teens. Prevention and control efforts that include treatment and education program that target specific populations including children or adolescents are in need of improvement (Bhunu , 2012). The media may be the most important source of health information for the general public; it can play a special role in providing a voice for people to express their experiences of illness (Schwitzer *et al*, 2005). Jaramillo (2001) studied a model presenting an evaluation of the impact on case finding of a mass media health education campaign for TB control in Cali, Colombia. Liu *et al*. (2007) incorporated the psychological impacts of media coverage on disease transmission and emphasize the importance of refining classical mathematical models to reflect the partially self-limiting nature of infectious disease outbreaks, due to the effects of widespread news coverage and fast information flow. Web-based screening and brief interventions that include personalized feedback about their alcohol use have proven to be particularly promising for reducing hazardous drinking among university students(Palfai *et al*. 2011). Mass media (television, radio, newspapers, billboards, and booklets) have been used as a way of delivering preventive health messages as they have the potential to influence people's behavior. Further, mass media have been deployed in the effort to control and eliminate epidemic diseases. Xiang *et al*.(2011) studied a drinking model with public health educational campaigns which can be an efficient option for reducing the spread of disease. Tchuenche and Bauch (2012) and Xiana *et al*. (2011) considered the effects of awareness programs driven by media on the spread of infectious diseases; their results showed that, though awareness programs cannot eradicate infection, they help in controlling

Corresponding Author: Surapol Naowarat, Department of Mathematics, Faculty of Science and Technology, Suratthani Rajabhat University, Surat Thani, 84100,
E-mail: su1963n@gmail.com, ph: +66-842462496.

the prevalence of disease. The most successful approaches concentrate not on trying to change the drinker's behavior directly but on influencing the community environment around the nondrinker. For instance, education and persuasion may increase knowledge and change attitudes but have no effect on drinking (Misra *et al*.2011). We only consider the interaction from awareness programs between aware individual and nondrinker. Motivated by the above works, we introduce a mathematical model with the effect of awareness programs on the binge drinking in this paper. Because awareness programs are capable of inducing behavioral changes in susceptible individuals, we introduce a separate class $X(t)$ of those who are aware of risk and refrain from drinking by avoiding contact with the heavy drinkers. This newly formed aware class is assumed to be fully protected from the heavy drinkers due to media-induced isolation and individuals of this class may contact heavy drinkers only if they lose awareness (Chisodm *et al*, 2004). Furthermore, we assumed that cumulative density of awareness programs $M(t)$ increases at a rate proportional to the number of heavy drinkers. We establish some sufficient conditions for the global stability of equilibrium and give some numerical simulations to explain our main result. Our results showed that awareness programs are an effective measure in reducing alcohol problems.

The organization of this paper is as follows. In the next section, the effect of awareness programs by media on binge drinking model is formulated. In Section 3, the existence and the stability of equilibrium are investigated. Some numerical simulations are given in Section 4. We discussions are given in Section 5. Finally, we summarized the the conclusions of our study in section 6.

Model Formulartion:

The total population is divided into five compartments, namely, the susceptible compartment who do not drink or drink only moderately, denoted by $S(t)$, those who are aware of risk and avoid drinking, denoted by $X(t)$, those who drink heavily, denoted by $A(t)$, and those who are in treatment, denoted by $R(t)$. Also let $M(t)$ be the cumulative density of awareness programs driven by media. The total number of population at time t is give by $N(t) = A(t) + X(t) + A(t) + R(t)$.

The dynamics of the alcohol drinking model is depicted in the flow chart shown in Fig.1.

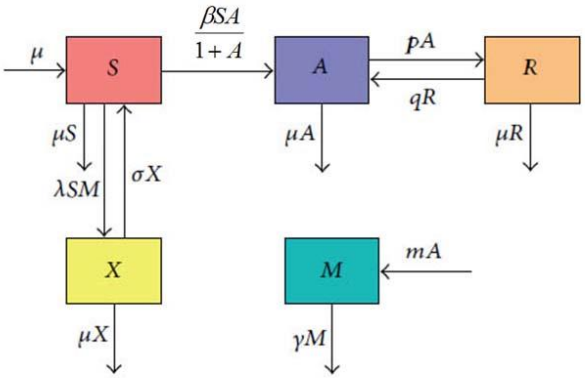


Fig. 1: Flow chart of the dynamics model of Alcohol Drinking.

The dynamical transmission model consists of system of a system of non-linear equations is given as follow.

$$\frac{dS(t)}{dt} = \mu - \frac{\beta SA}{1+A} - \lambda SM + \sigma X - \mu S, \quad (1)$$

$$\frac{dX(t)}{dt} = \lambda SM - \sigma X - \mu X, \quad (2)$$

$$\frac{dA(t)}{dt} = \frac{\beta SA}{1+A} + qR - pA - \mu X, \quad (3)$$

$$\frac{dR(t)}{dt} = pA - qR - \mu R, \quad (4)$$

$$\frac{dM(t)}{dt} = mA - \mu M, \quad (5)$$

where

μ is the rate of individuals entering into the system in a given time interval,

β is the transmission coefficient for the nondrinkers turning to heavy drinkers through peer pressure,

λ is the represents the dissemination rate of awareness among nondrinkers due to the awareness programs,

σ is the denotes the rate of transfer of aware individuals to nondrinker class,

p is the a proportionality coefficient for A going into treatment,

q is the a proportionality coefficient for R relapsing into drinkers,

m is the represents the growth rate of density of awareness programs,

γ is the represents the depletion rate of these programs due to ineffectiveness.

Model Analysis:

Equilibrium Point:

The standard method is used to analyzed the model. In this model, there are two equilibrium points, that is, Alcohol free equilibrium point and Alcohol present equilibrium point. The equilibrium point are found by setting the right hand side of equations (1)-(5) to zero.

The Alcohol Free Equilibrium (AFE):

In the absence of the drink heavily (A=0). We obtained:

$E_0(S,X,A,R,M)=E_0(1,0,0,0,0)$

The Alcohol Present Equilibrium (APE):

In case ,there are the drink heavily ,that is $A^* > 0$.We obtained:

$$S^* = \frac{B_1\pi(1+A^*)}{B_1(\beta A^* + (1+A^*)\mu) + (1+A^*)\mu wmA^*}, X^* = \frac{wmA^*(1+a)\pi}{\gamma(\sigma+\mu)(\beta A^* + \mu(1+A^*)) + \mu(1+A^*)wmA^*}, R^* = \frac{pA^*}{q+\mu}, M^* = \frac{mA^*}{\gamma},$$

A^* is the positive solution of this equation $C_0A^3 + C_1A^2 + C_2A + C_3 = 0$.,

where

$C_0 = B\mu wm$, $C_1 = B_4 + B_5 + 2B_6$, $C_2 = B_5 - B_3 + B_4 + B_5 + B_6$, $C_3 = B_5 - B_3$

$B_1 = \gamma(\sigma+\mu)$, $B_2 = \pi\beta(q+\mu)$, $B_3 = B_1B_2$, $B_4 = BB_1\beta$, $B_5 = BB_1\mu$.

The Alcohol Reproductive Number:

The alcohol reproductive number (R_0) is defined as the expected number of secondary cases produced by a single infection in a completely susceptible population. By using the next generation method and used spectral radius (Van den Driessche and Watmough,2002).We rewritten the system in matrix form

$$\frac{dX}{dt} = F(x) - V(x)$$

Where F is the matrix of new infections and V is the matrix of the transfers between the compartments in the infective equations. We obtained

$$X = \begin{bmatrix} S \\ X \\ A \\ R \\ M \end{bmatrix}, F(x) = \begin{bmatrix} 0 \\ 0 \\ \frac{\beta SA}{1+A} \\ 0 \\ 0 \end{bmatrix} \text{ and } V(x) = \begin{bmatrix} -\pi + \frac{\beta SA}{1+A} + wSM - \sigma X + \mu X \\ -wSM + \sigma X + \mu X \\ -qR + pA + \mu X \\ -pA + qR + \mu R \\ -mA + \gamma M \end{bmatrix}$$

Find the Jacobian of $F(x)$ and $V(x)$ evaluated at $E_0 = (1,0,0,0,0)$, denoted by $DF(x)=F$ and $DV(x)=V$, we obtained:

$$F = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \frac{\beta A}{1+A} & 0 & \frac{(1+A)\beta S - \beta SA}{(1+A)^2} & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}, \quad V = \begin{bmatrix} \frac{\beta A}{1+A} + wM + \mu & -\sigma & \frac{(1+A)\beta S - \beta SA}{(1+A)^2} & 0 & wS \\ -wM & \sigma+\mu & 0 & 0 & -wS \\ 0 & 0 & p+\mu & -q & 0 \\ 0 & 0 & -p & q+\mu & 0 \\ 0 & 0 & -m & 0 & \gamma \end{bmatrix}$$

Find F and V at $E_0 = (1, 0, 0, 0, 0)$

We obtained:

$$F(E_0) = \begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & \beta & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix} \text{ and } V(E_0) = \begin{bmatrix} \mu & -\sigma & \beta & 0 & w \\ 0 & \sigma+\mu & 0 & 0 & -w \\ 0 & 0 & p+\mu & -q & 0 \\ 0 & 0 & -p & q+\mu & 0 \\ 0 & 0 & -m & 0 & \gamma \end{bmatrix}$$

Find FV^{-1} obtained we:

$$FV^{-1}=\begin{bmatrix} 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \\ \frac{\beta C_{13}}{L} & \frac{\beta C_{23}}{L} & \frac{\beta\mu(\sigma+\mu)(q+\mu)\gamma}{\mu(\sigma+\mu)\left[(p+\mu)(q+\mu)\gamma-\gamma pq\right]} & \frac{\beta C_{43}}{L} & \frac{\chi C_{53}}{L} \\ 0 & 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 & 0 \end{bmatrix}$$

Find the spectral radius of FV^{-1} denoted by $\rho(FV^{-1})$

$$\rho(FV^{-1})=\begin{vmatrix} -\lambda & 0 & 0 & 0 & 0 \\ 0 & -\lambda & 0 & 0 & 0 \\ \frac{\beta C_{13}}{L} & \frac{\beta C_{23}}{L} & \frac{\beta\mu(\sigma+\mu)(q+\mu)\gamma}{\mu(\sigma+\mu)\left[(p+\mu)(q+\mu)\gamma-\gamma pq\right]}-\lambda & \frac{\beta C_{43}}{L} & \frac{\beta C_{53}}{L} \\ 0 & 0 & 0 & -\lambda & 0 \\ 0 & 0 & 0 & 0 & -\lambda \end{vmatrix}$$

where

$\rho(FV^{-1})=\mu(\sigma+\mu)((p+\mu)(q+\mu)\gamma-\gamma pq)$

We obtained

$R_0=\frac{\beta(q+\mu)}{(p+\mu)(q+\mu)-pq}$

Stability Of The Model :

Theorem 1.1:

The alcohol free equilibrium E_0 is locally asymptotically stable if $R_0<1$,and unstable otherwise.

$$J_0=\begin{bmatrix} -\mu & \sigma & \beta & 0 & -w \\ 0 & -(\sigma+\mu) & 0 & 0 & w \\ 0 & 0 & \beta-(p+\mu) & q & 0 \\ 0 & 0 & p & -(q+\mu) & 0 \\ 0 & 0 & m & 0 & -\gamma \end{bmatrix}$$

$$\det(J_0-\lambda I)=\begin{vmatrix} -\mu-\lambda & \sigma & \beta & 0 & -w \\ 0 & -D_1-\lambda & 0 & 0 & w \\ 0 & 0 & D_2-\lambda & q & 0 \\ 0 & 0 & p & -D_3-\lambda & 0 \\ 0 & 0 & m & 0 & -\gamma-\lambda \end{vmatrix}$$

$$=(\lambda+\mu)(\lambda+D_1)(\lambda^3-F_1\lambda^2-F_2\lambda-F_3)$$

where

$D_1=\sigma+\mu$, $D_2=\beta-(p+\mu)$, $D_3=q+\mu$,

$F_1=D_2-D_3-\gamma$, $F_2=D_2D_3+\gamma D_2-\gamma D_3+pq$, $F_3=\gamma D_2D_3+\gamma pq$.

Theorem 1.2:

The alcohol present equilibrium E_1 is locally asymptotically stable if $R_0>1$, and unstable otherwise.

$$J_1=\begin{bmatrix} -\frac{\beta A^*}{1+A^*}-wM^*-\mu & \sigma & -\frac{(1+A^*)\beta S^*}{(1+A^*)^2} & 0 & -wS^* \\ wM^* & -(\sigma+\mu) & 0 & 0 & wS^* \\ \frac{\beta A^*}{(1+A^*)} & 0 & \frac{(1+A^*)\beta S^*-\beta S^*A^*}{(1+A^*)^2}-(p+q) & q & 0 \\ 0 & 0 & p & -(q+\mu) & 0 \\ 0 & 0 & m & 0 & -\gamma \end{bmatrix}$$

$$\det(J_1-\lambda I)=\begin{vmatrix} -H_1-\lambda & \sigma & -H_4 & 0 & -H_6 \\ H_2 & -D_1-\lambda & 0 & 0 & H_6 \\ H_3 & 0 & H_5-\lambda & q & 0 \\ 0 & 0 & p & -D_3-\lambda & 0 \\ 0 & 0 & m & 0 & -\gamma-\lambda \end{vmatrix}$$

We obtained the characteristic equation

$\lambda^5-K_1\lambda^4-K_2\lambda^3-K_3\lambda^2-K_4\lambda-K_5=0$

where

$K_1=H_5-D_3-\gamma-D_1$, $K_2=pq-H_3H_4-H_1D_3+H_1H_5-\gamma D_3+H_5-\gamma H_1-D_3D_1+H_5D_1+D_1H_1+\gamma D_1-H_2\sigma,$

$K_3=pqH_1-H_3H_4D_3+H_5D_3+H_1H_5D_3+\gamma H_3H_4+\gamma pq+\gamma H_5D_3-\gamma H_1D_5+\gamma H_1H_5+mH_6H_3+$

$H_3H_4D_1+pqD_1+H_1D_3D_1+H_1H_5D_1+H_1H_5D_3D_1-\gamma D_3D_1+H_5D_1-\gamma H_1D_1-\sigma H_2D_3+\sigma H_2H_3-\gamma\sigma H_2,$

$K_4=\gamma pqH_1-\gamma H_3H_4D_4+\gamma H_1H_5D_3+mH_6H_3D_3-H_3H_4D_3D_1+pqH_1D_1+H_5D_3D_1-\gamma H_3H_4D_1+\gamma pqD_1+\gamma H_5D_3D_1-$

$\gamma H_1D_3D_1+\gamma H_1H_5D_1+mH_6H_3D_1-pq\sigma H_2+\sigma H_2H_5D_3-\gamma\sigma H_2D_3+\gamma\sigma H_2H_3+m\sigma H_6H_3,$

$K_5=m\sigma H_6H_3D_3+\gamma\sigma H_2H_5D_3+\gamma\sigma pqH_2+mH_6H_3D_3D_1+\gamma H_1H_5D_3D_1+\gamma pqH_1D_1-\gamma H_3H_4D_3D_1$.

From the characteristic equation, we see that $\lambda^5-K_1\lambda^4-K_2\lambda^3-K_3\lambda^2-K_4\lambda-K_5=0$ will have negative real parts if they conditions satisfied with the Routh-Hurwitz criteria (Alen,2006).Thus, $R_0>1$ if it satisfies the following condition:

n = 5: $K_i>0, i=1,2,3,4,5, a_1a_2a_3>a_3^2+a_1^2a_4, \left(a_1a_4-a_5\right)\left(a_1a_2a_3-a_3^2-a_1^2a_4\right)>a_5\left(a_1a_2-a_3\right)^2+a_1a_2^5$

Numerical Results:

The value of parameters used in the numerical simulation are given in Table 1.

Table 1: The values of parameters used in numerical simulations

Parameters	Description	Values	References
μ	Recruitment rate of the population	0.25 $year^{-1}$	Xiang, Song,and Huo,(2011)
β	Transmission coefficient	0.30 $year^{-1}$	Xiang, Song,and Huo,(2011)
λ	Dissemination rate of aware individuals	0.02 $year^{-1}$	Estimated
σ	Rate of transfer of aware individuals to susceptible class	0.001 $year^{-1}$	Estimated
p	The fraction of *A* go into treatment	0.30 $year^{-1}$	Estimated
q	The fraction of *R* who relapse into *A*	0.80 $year^{-1}$	Xiang, Song,and Huo,(2011)
m	Growth rate of density of awareness programs	0.05 $year^{-1}$	Xiang, Song,and Huo,(2011)
γ	Depletion rate of awareness programs	0.05 $year^{-1}$	Estimated

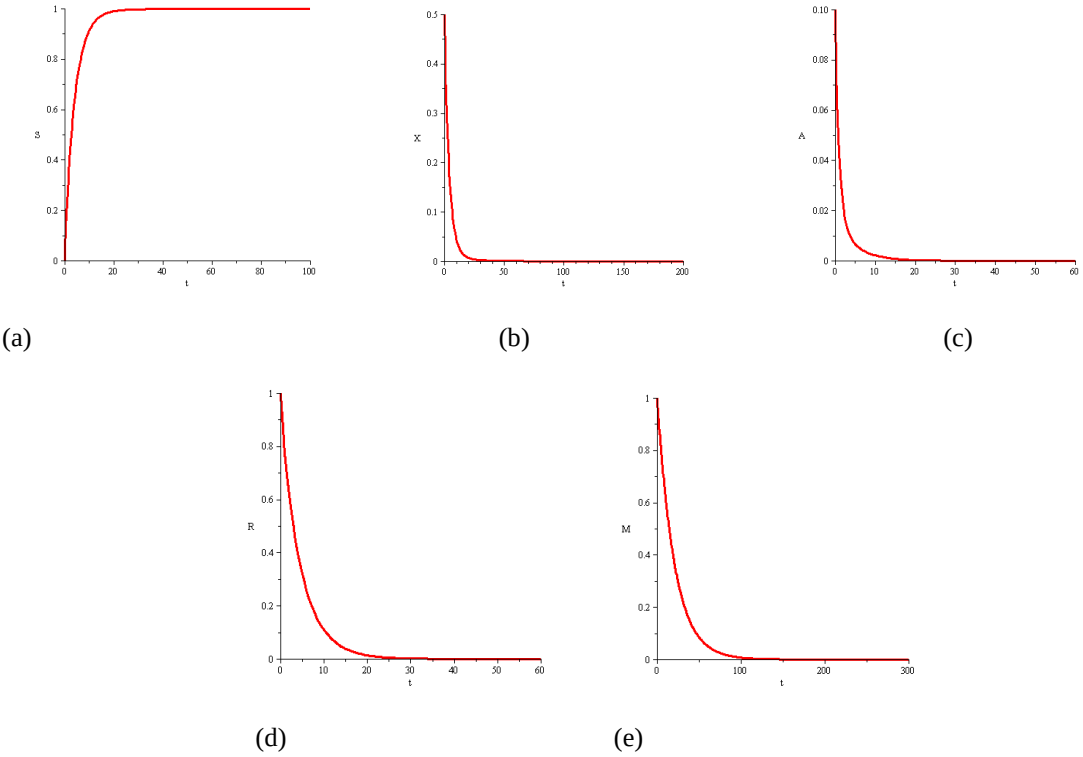
By solving the system of ordinary differential equations. The graphical results obtained from simulation are presented in the following Fig.2 and Fig 3 and Fig. 4.

Stability of the Alcohol Free state:

From the values of parameters in Table 1, we obtained the eigenvalues and alcohol reproductive number are:

$\lambda_1=-0.65, \lambda_2=-0.251, \lambda_3=-0.25, \lambda_4=-0.05, \lambda_5=-0.05, R_0=0.336<1.$

Since all of eigenvalues are negative and the alcohol reproductive is less than one ,the disease free equilibrium point will be local asymptotically stable, E_0 as shown in Fig. 2



(a) (b) (c)

(d) (e)

Fig. 2: Time series of (a) not drink or drink only moderately $S(t)$, (b) aware of risk and avoid drinking $X(t)$, (c) drink heavily $A(t)$, (d) treatment $R(t)$, (e) density of awareness programs driven by media $M(t)$

The values of parameters are in the text and $R_0 < 1$. We see that the solutions converge to the disease free state $E_0(1, 0, 0, 0, 0)$, where

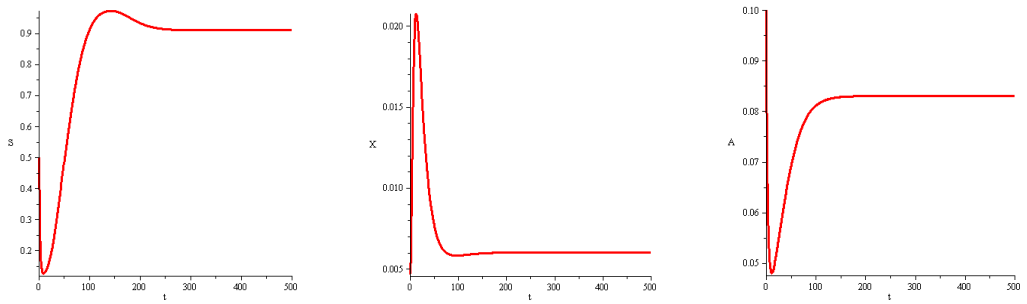
π =0.25 , μ =0.25 , β =0.30 , w =0.02 , σ =0.001 , p=0.90 , q=0.10 , m=0.05 and γ =0.05.

Stability of the basic reproductive number state:

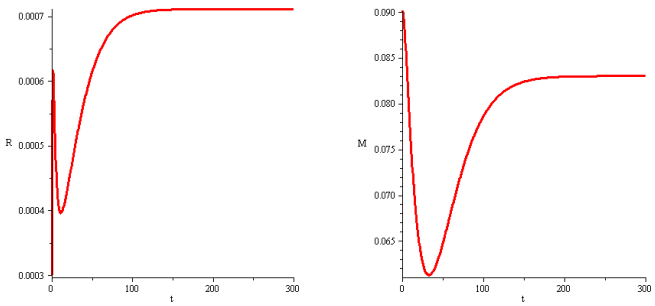
We changed the values of p=0.009 and keep the values of the other values of parameters to be those given in Table 1, we obtained the eigenvalues and alcohol present equilibrium reproductive number are:

$\lambda_1 = -1.098, \lambda_2 = -0.195 - 0.160i, \lambda_3 = -0.195 + 0.161i, \lambda_4 = -0.149, \lambda_5 = -0.012, R_0 = 1.898 > 1.$

Since all of eigenvalues are to be negative and the alcohol present equilibrium reproductive is to be greater than one, the basic reproductive number equilibrium point will be local asymptotically stable, as shown in Fig. 3



(a) (b) (c)

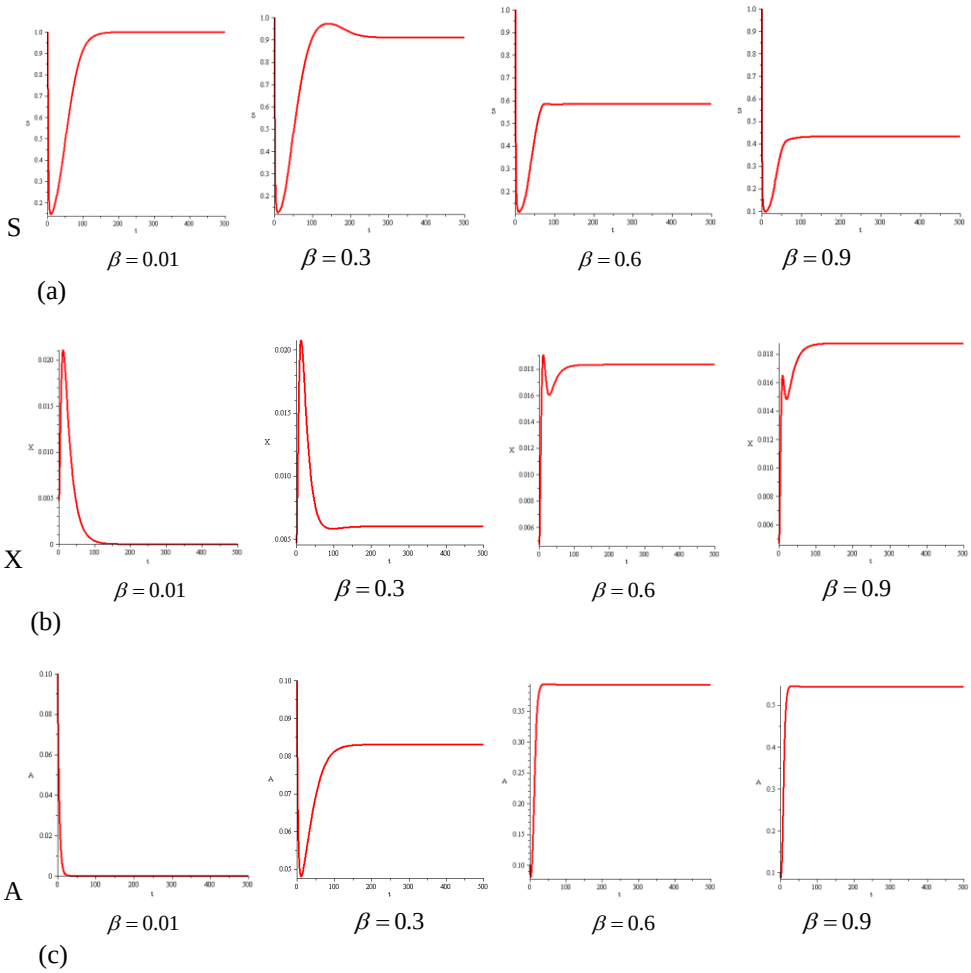


(d) (e)

Fig. 3: Time series of (a) not drink or drink only moderately $S(t)$, (b)aware of risk and avoid drinking $X(t)$, (c)drink heavily $A(t)$, (d) treatment $R(t)$, (e) density of awareness programs driven by media M(t)

The values of parameters are in the text and $R_0 > 1$. We see that the solutions converge to the alcohol present equilibrium state $E_1(0.91025, 0.00602122, 0.083017, 0.000711575, 0.0830171)$

where π =0.25 , μ =0.25 , β =0.30 , w =0.02 , σ =0.001 , p=0.009 , q=0.80 , m=0.05 and γ =0.05.



(a)

(b)

(c)

Fig. 4: Time series of (a) not drink or drink only moderately $S(t)$, (b)aware of risk and avoid drinking $X(t)$, (c)drink heavily $A(t)$,

The values of parameters are in the text and $R_0 > 1$. We see that the solutions converge to the alcohol present equilibrium state

$E_1(0.91025, 0.00602122, 0.083017, 0.000711575, 0.0830171)$, where π=0.25 , μ=0.25 , β=0.01,0.30,0.60,0.90 , w =0.02 , σ =0.001 , p=0.009 , q=0.80 , m=0.05 and γ=0.05.

Discussion:

In this study, we proposed the mathematical model of stability analysis and qualitative behavior on the dynamics model of alcohol drinking with the effect of peer influence and analyzed the analytical results by using standard modeling method. The alcohol reproductive number is obtained through the use of spectral radius of the next generation matrix. The basic alcohol number is

$$R_0 = \frac{\beta(q+\mu)}{(p+\mu)(q+\mu)-pq}$$

The alcohol reproductive number is the threshold condition for determining the stability of the equilibrium points of the model which are shown in Fig.2, Fig.3 and Fig.4. We found the value of alcohol reproductive number $R_0 = 3.56941$ if $\beta = 0.9$ and R_0 = 0.33 if $\beta = 0.3$.

Conclusion:

We can conclusion that if each individual who live in the community has knowledge, attitude. education and persuasion may increase knowledge and change attitudes but have no effect on drinking (Misra *et al*.2011) It seen that the number of drinking human will decrease if the number of contact between the not drink or drink only moderately and drink heavily decrease.

ACKNOWLEDGEMENT

The author is grateful to the Department of Mathematics, Faculty of Science and Technology, Suratthani Rajabhat University for providing the facilities to carry out the research. Surapol Naowarat would like to thanks Dr.Phananoi Rotchu for the good suggestions about the manuscript.

REFERENCES

Bhunu, C.P., 2012. A mathematical analysis of alcoholism. World Journal of Modelling and Simulation, 8 (2): 124-134.

Chisholm, D. *et al*., 2004. Reducing the global burden of hazardous alcohol use: a comparative Cost effectiveness analysis, Journal of Studies on Alcohol, 65(6): 782-793.

Harlem-Brundtland, G., 2001. European ministerial conference on young people and alcohol. http://www.who.int/director-general/speeches/2001/english/20010219 youngpeople.en.html.

Jaramillo, E., 2001. The impact of media-based health education on tuberculosis diagnosis in Cali, Colombia. Health Policy and Planning, 16(1): 68-73.

Liu, R., J. Wu and H. Zhu, 2007. Media/psychological impact on multiple outbreaks of emerging infectious diseases. Computational and Mathematical Methods in Medicine, 8(3): 153-164.

Merrill, D.B., 2014. Alcohol Use disorder. Medline Plus . http://www.nlm.nih.gov/medlineplus/ency/ article/ 000944.htm.

Misra, A.K., A. Sharma and V. Singh, 2011. Effect of awareness programs in controlling the prevalence of an epidemic with time delay. Journal of Biological Systems, 19(2): 389-402.

Misra, A., A. Sharma and J.B. Shukla, 2011. Modeling and analysis of effects of awareness programs by media on the spread of infectious diseases. Mathematical and Computer Modelling., 53(5): 1221-1228.

Palfai, T.P., Z. Zisserson and R. Saitz, 2011. Using personalized feedback to reduce alcohol use among hazardous drinking college students: the moderating effect of alcohol-related negative consequences, *Addictive Behaviors*, 36(5): 539-542.

Riley, L., 2003. WHO to meet beverage company representatives to discuss health-related alcohol issues.

http://www.who.int/mediacentre/enws/releases/2003.

Schwitzer, G. *et al*., 2005. What are the roles and responsibilities of the media in disseminating health information, *PLoS Medicine*, 2(7): article e215.

Tchuenche, J and C. Bauch, 2012. Dynamics of an infectious disease where media coverage influences transmission. *ISRN Biomathematics*. vol. 2012, article ID 581274, 1-10.

Van den Driessche, P and J. Watmough, 2002. Reproductive numbers and sub-threshold endemic equilibria for compartment models of disease transmission.Math.Biosci., 180: 29-48.

Walter, H. *et al*., 2003. Gender specific differences in alcoholism: implications for treatment. Archives of Women's Mental Health, 6(4): 253-258.

WHO., 2001. http://www.who. int/director-general/speeches/2001/English/20010219 young people.

WHO., 2014. Report of Alcohol in developing societies summary, http://www.who.int.

Xiang, H., N. Song and H. Huo, 2011. Modelling effects of public health educational campaigns on drinking dynamics. Abstract and Applied Analysis., (2014): 1-8.