Available online at http://scik.org
Commun. Math. Biol. Neurosci. 2020, 2020:39
https://doi.org/10.28919/cmbn/4749
ISSN: 2052-2541

MATHEMATICAL MODELING OF THE DYNAMICS OF HEALTH RISKS ASSOCIATED WITH ALCOHOLISM IN TANZANIA: A LITERATURE REVIEW

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Abstract. In this paper, a number of alcohol related studies have been reviewed in light of the strength and challenges of the models developed for their applicability in Tanzanian drinking context. The aim of this paper is to provide a meaningful reference of the current state of the art regarding to modeling the health risks epidemics associated with alcoholic behavior in the community. It also discusses and identify current open problem reflecting on more realistic community and suggesting new research perspectives in the mathematical modeling of alcoholism and its related risks. The peer influence and social cultural practices appear to be two equally important influential aspects of model formulation with opposing effects on the spread of alcoholism. The study also reveals that, different levels of alcohol consumption has differing health effects. In this regard, the study proposes development of an advanced infection models to represent the influence of external motivations on the spreading of alcohol abuse by introducing different population segments with distinct exposition towards and resistance to the influence of drugs as an open relevant problem.

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Received June 3, 2020

Keywords: alcoholism; mathematical models; health risks.

2010 AMS Subject Classification: 93A30.

1. INTRODUCTION

Alcoholic beverages have long been used and considered as integral part of most cultures around the world [1, 2]. They have been used as part of entertainment by means of bringing people together in so many ways. Unfortunately, alcohol drinking is an addictive behavior in which a drinking individual accelerates to the state physical alcohol dependency after using the drink for sometimes without personal control initiatives. Unless stated otherwise, this state of addiction to the consumption of alcoholic drinks which eventually accelerate to alcohol dependency is referred to as alcoholism throughout this paper.

Alcohol drinking behaviors is one of the health risk factors for some lifestyle diseases [3, 4]. It is one among the major global risk factors in the Global Burden of Diseases (GBD) [4, 5]. Health challenges associated with alcoholism include malnutrition, chronic pancreatitis, liver cirrhosis, different types of cancer, and damage to the central and peripheral nervous system [2, 6, 7, 8, 9]. In support of this, Wiessing and collaborators identified social problems and crimes as direct and indirect indicators of prevalence of drugs and substance abuse in the community [10].

The effects of alcohol on human health and social well-being can be addressed in two perspectives: the health risks and injuries associated with alcohol use; and its extended impacts to the family and community through violence, and economy instability. Cancer and cardiovascular diseases (CVDs) combined contribute at least 40% of all alcohol-related deaths that accounting to more than one million deaths per year globally [6]. This statistics has continually been increasing from time to time. For instance, recently WHO [11] reported that, alcohol associated health risks resulting from harmful use of alcoholic beverages is responsible for three million deaths every year. This may be translated into six deaths occurring every single minute daily.

Alcoholism in the community may be influenced by several factors including; age, genetic disposition, ethnic groups, sex, mental health, social environment, and stress [8]. The key

determinants of alcohol related health risks are: the volume of alcohol consumed, the patterns of drinking and quality of alcohol consumed [2, 12].

Despite the health challenges emanating from alcoholism, most cultures promote drinking practices that are positive while discouraging those associated with adverse behaviors. This idea gets some literature supports in which many alcohol drinkers borrow a lief. According to Grönbaek [13], alcohol consumed at a desired level has some health benefits such as prevention of thrombosis. The study also identify alcohol as a source of income in rural communities [13]. However, the recent studies put this stand into challenges, it is finally established that there are health challenges regardless of the amount of alcohol consumed [4]. That is to say, there is no safe level of alcohol consumption which is free from health risks as it was believed for quite sometimes.

In Tanzanian settings, alcoholic beverages are available in terms of standard bottled beers, spirits, wines and locally made brews. Most of locally made illegal spirits are not freely sold in the market but they have been long existed in the free black markets in different communities. Since local brews are produced from the locally available ingredients, they are readily available at a comparatively lower prices than modern/standard beers and spirits, posing a greater health risks to low earned income population [14]. Although, the legally acceptable age for alcohol use in Tanzania is 18 years, it was observed that in many places of the country people of underage have access to alcohol especially the locally made brews and spirit [15]. This is supported by a recent survey conducted among secondary school students that revealed at least 64% had easy access to alcohol [15].

The drinking threshold to be referred to as an alcoholic is estimated to be a maximum of 21 standard bottles per week for men and 14 drinks per week for women [2, 12, 13]. In Tanzanian context, the standard bottle of a beer carries between 250mls to 500mls while spirits and wines takes different volumes depending on the packages applied. However, a very small fraction of the Tanzanian population are non-drinkers while majority endure in drinking. This implies that a broader public health message of the beneficial effects regarding to alcohol use does not seem to be interesting topic in most societies.

Different scholars have made an attempt to address the problem of alcoholism in different ways. Mathematical approach by means of model development, simulation and analysis regarding the question of alcohol epidemic have been employed in an attempt to provide insight on effects of alcohol consumption on health and socio-economic aspects of the society. The aim of this review paper is twofold: first is to provide a meaningful reference of the current state of the art regarding to modeling of health risks epidemic associated with alcoholism behavior in the community. Secondly, is to discuss and identify current open problems reflecting on more realistic community and suggesting new research perspectives in the mathematical modeling of alcoholism and its related risks.

2. THE DYNAMICS OF ALCOHOLISM

2.1. The effects of Religious beliefs. Religious beliefs have gained popularity in recent times over different parts of the world. It is one of the popular social cultural practices with such a greater influence which assumes the roles of the control agent of addictive substances including alcoholism. According to Koening and collaborators [16], religiosity has positive effects on both physical and mental health. This fact has propelled researches regarding to the direct or indirect roles of religious on health [18]. However, an increased number of individuals that are actively participating in their religious might have contributed to the increased interest of researching on the relationship between religious and health [17]. In the recent study [15], it was revealed that religiosity is one among the reasons for some people to abstain alcohol drinking. This was also true for some individuals who are non alcohol drinkers. Since the definition of religiosity is debatable, in this study, we borrow the definition of religiosity from [16], that is, any organized set of beliefs and measurable practices within a community of people who accept an authoritative doctrine. Based on the above literature, for the model to be realistic it is clear that religious beliefs and/or any other influential social cultural beliefs make an important component in the formulation of alcohol dynamic models.

2.2. The effects of peer influence. Peer influence has been closely associated with the spread of alcoholic behaviors in the community. Different cultures in Tanzania, for instance, praises alcohol drinking habits through cultural songs and other cultural practices. Available literature

reveals that, at least 64% of American adults consider themselves drinkers and 20% admitted to have occasionally over consumed alcohol. Over consumption and abuse of alcohol among American college and university communities is reported to be as higher as 33%. Peer influence and social pressure is also recorded as the main agent to the increase of the scenes of alcohol abuse in university communities [19].

Mundt and collaborators [20], formulated and analyzed a stochastic actor - based model for peer selection and influence effects on adolescent alcohol use with the aim of disentangling selection associated with the dynamic interplay of adolescent friendship and alcohol use. In this study, they analyzed data from Add Health, a longitudinal survey of selected students enrolled between 1995 and 1996 in the U.S. The study findings revealed that, peer selection plays a major role in alcohol use behavior among adolescent friends.

Walsh and collaborators [21] examined parental, peer, and school predictors of alcohol drinking among Israeli−born adolescents and first and second generation adolescent immigrants from the Former Soviet Union (FSU) and Ethiopia in Israel. In this study, they used Pearson's Chi-Square and logistic regression models to examined the differences between the groups for drinking and group specific predictors of drinking respectively. The influence of both, parents through parenting and peer pressure measured by the amount of time spent together, play greater roles in shaping individuals drinking behaviors. For example, the study found out that, first generation FSU and both Ethiopian groups had greater time with friends with lower levels of parental monitoring and they reported to have higher levels of binge drinking and drunkenness than Israeli - born adolescents. It reveals further that, time spent with peers consistently predicted immigrant alcohol use. It was suggested further that, drinking patterns must be understood in relation to country of origin and immigration experience of a particular group.

A recent study conducted in Tanzania reveals that, most of alcoholic drinkers had their first drinking experience at the social event [15]. This experience in the initiation stage may be closely associated to the influence of peer pressures and provision of free and easy access to the alcoholic beverages in an exciting moments. It was reported further that, between 31% - 66% of the drinkers population took the standard bottled beers during their first time drinking while 36% - 45% of the school girls had the locally made brews as their first alcoholic drink

[15]. This implies that exposure to drinking context is yet another important pulling factor to alcoholic behaviors. In Tanzania and many other African countries, local brewery activities are performed by women with the assistance from their daughters. The practice will automatically set good exposure for girls to the drinking context than the case may be in the boys.

Generally, drinking habits at younger ages, is unacceptable behavior in many communities. For example, the study conducted by DGC in 2007 reported that, at least 76% of the European population were against alcohol advertisements targeted the young citizens in all member states [22]. It is therefore important to consider peer influence in the model formulation. The peer influence inters in the system as a changing agent in molding individuals behavior towards alcohol drinking.

2.3. Application of the theory of reasoned action (TRA). Different studies have indirectly proved that alcohol drinking habit obeys the theory of reasoned action (TRA) rooted in Socio - psychology. TRA explains how and why individual's attitude influences behavior. Darwin [29] is considered to be the father of this phenomenon, by pioneering the study about the attitude towards behavior. The study defines the attitude as the expression of physical and emotion. The great psychologist later looked at attitude as the source of emotion of cognitive with the behavior component, both verbal or non verbal [30].

The theory of reasoned action or behavior is applicable to many kinds of behaviors today, especially in socio-psychology. It focus on intention variable determined by the attitude, subjective norm and other important norms. The individual's behavior is determined by attitude toward behavioral outcome and public opinions on the behavior. According to the theory, every behavior is influenced by intention which is the function of attitude of behavior and subjective norm [31]. A behavior, for that matter, is the transition of intention into an action or practice. On another hand, attitude towards a behavior is result of thorough assessment made by an individual regarding to the belief about cost and benefits of the behavior and its consequences. Similarly, subjective norm is influenced by the the combination of personal belief towards public opinions, and the motivation to conform to the group norms.

Regarding to alcohol drinking behavior, no one drinks alcohol accidentally. An individual will consciously consume alcohol whenever expectations of getting positive consequences of

drinking outweigh those of not drinking, its converse is also true [32]. An individual's decision on whether or not to take an alcoholic drink is determined by various factors including, but not limited to, past experiences with drinking, current life situation. These factors, modulated by individual's neurochemical reactivity to alcohol, will help to form expectations of effective change from drinking alcohol [32]. However, parental influence over individual's behavior may not go unappreciated. For instance, in survey conducted by Francis and collaborators [15], parental influence was mentioned as one among the main reasons some people did not engage in the drinking behaviors. That, if alcohol drinking is not something the parents feel proud of, then no one under their guidance would be expected to drink while hunting the approval of the parents. The same is true for other behaviors. This stand is also backed up by [21] in which parenting and peer pressure proved to be very influential towards behavioral change. People tend to learn or unlearn different behaviors from different individuals around them, especially those who deserve their respect befitting a role model.

3. Modeling Basics

In epidemiological studies, transmission of infectious agents in the host population is key process deserving the descriptive analysis when the model compartments is used to study a particular infectious disease [33]. Mathematical models may be extended to describe behavioral dynamics and transmission where people already in the behavior may act as transmission agent in the host population provided a desired amount of interactions between them is allowed. When a behavior associated with health risk factors emerge in any community, the total population in the community can be partitioned into a number of categories depending on the risk levels or defined patterns individuals exhibit. Mathematical modeling of alcohol drinking epidemic and its consequences on human health has been an interesting topic for many researchers. The similarity between the spreading nature of alcoholic behavior and that of infectious diseases has attracted modelers to use mathematical modeling as an essential tool for simulating the behavior and provide valuable control analysis. Most models developed in relation to alcoholism and its consequences fall in the category of SIR with or without significant modification.

In both studies Bhunu [8], and Huo & Liu [9] separately, used an extension of the basic *SIR* model approach to model the spread of alcoholism in the community. While remaining

conventional on *SIR* model, Bhunu [8] considered deterministic models by splitting alcoholic population into two classes based on different consumption levels (see system (1)). According to Bhunu [8], the following model reflects the problem of alcoholism epidemic

$$\begin{aligned} S'(t) &= \Lambda - (\lambda + \mu) S \\ D'(t) &= \lambda S - (\mu + \rho + \gamma) D \\ A'(t) &= \rho D - (\mu + \nu + \delta) A + \sigma R \\ R'(t) &= \gamma D + \delta A - (\gamma + \mu) R \end{aligned} \tag{1}$$

with $\lambda = \dfrac{\beta c (D + \theta A)}{N}$ and non-negative associated parameters and state variables at all times. The study aimed at gaining insight on the growth of alcoholism as a health and social problem. Analytical and numerical methods were used for analysis of the model. It was found out that it is easy for moderate drinkers to quit alcohol drinking than alcoholics. Thus, any effort geared to encourage and support moderate drinkers to quit drinking will be effective that using the same efforts to alcoholic population.

Two years later, Wang and collaborators [35] authored a different study with deterministic *SATQ* type mathematical model to investigate the optimal control strategies in alcoholism. This is another *SIR* like model with slight modification to accommodate treatment intervention. In this study, using the model system (2), the spread of alcoholism is studied with two control strategies u_1, and u_2, to gain insights about health and social phenomenon. The following is the model system presented in the said study.

$$\begin{aligned} S'(t) &= \mu N - (1 - u_1) \frac{\beta S A}{N} - \mu S \\ A'(t) &= (1 - u_1) \frac{\beta S A}{N} + \xi T - (u_2 + \mu) A \\ T'(t) &= u_2 A - (\mu + \xi + \delta) T \\ Q'(t) &= \delta T - \mu Q \end{aligned} \tag{2}$$

where $0 \leq u_i \leq 1$, $\{i = 1, 2\}$. It considered the closed environment with the total population in four compartments: the susceptible compartment, $S(t)$, with individuals who either do not drink or drink moderately without affecting the physical health; the alcoholism compartment, $A(t)$, with individuals who binge drink and affect the physical health seriously; the treatment compartment, $T(t)$, with individuals who have been receiving alcohol related treatments after

alcoholism; and the quitting compartment, $Q(t)$, which refers to the individuals who recover from alcoholism after treatment and stay off alcohol hereafter. However, grouping moderate drinkers population and susceptible population together is challenged by the recently published scientific study affirming that alcohol consumption at whatever level poses health challenges and that there is no healthy drinking of alcohol [4]. Just like in Bhunu [8], this study also ignored the contribution of the social cultural practices in the control of alcoholism problem in the community.

In a different study, Huo & Liu [9] considered a relapse alcoholic model on weighted network by dividing the total population into susceptible, S; infections, I; and recovery, R; making a simple *SIRS* model. In that regard, the following model were formulated and analyzed

$$\begin{aligned} S_k'(t) &= b\,(1-S_k(t)-I_k(t)-R_k(t))\,S - kS_k(t)\Theta(t) + \sigma R_k(t) - \mu S_k(t) \\ I_k'(t) &= kS_k(t)\Theta(t) + \beta R_k(t) - \alpha I_k(t) - \mu I_k(t) \\ R_k'(t) &= \alpha I_k(t) - \beta R_k(t) - \sigma R_k(t) - \mu R_k(t) \end{aligned} \tag{3}$$

with initial conditions

$$\Omega^* = \left\{(S_k(t), I_k(t), R_k(t)) \in \mathbb{R}_+^{3n} | 0 \le S_k(t) \le 1, 0 \le I_k(t) \le 1, 0 \le R_k(t) \le 1, k = 1,2,\ldots,n\right\}$$

and

$$\Theta(t) = \sum_i \lambda_{ik} \frac{\varphi(i)}{i} P(i|k)\, I_i(t).$$

The model system (3) was used to study the peer influence on individual's drinking dynamics. The analysis results looked at interaction between susceptible and alcoholism, and reculperator recurrence drinking alcohol as the determinant of alcoholic problem. Thus, reducing the sequence of interaction between susceptible and alcoholism, and stopping reculperator recurrence drinking alcohol may be an effective control to eliminate alcoholic problem in the community.

While both, Bhunu & Huo suggested some workable intervention programs, they did not seem to have considered the effects of social cultural beliefs which plays an influencing roles in molding peoples' behaviors [15, 34]. Also, they partially agree with the multilevel risk of alcohol consumption and its relationship between health and social outcomes suggested by Jernigan [3]. The multilevel risks of alcohol consumption can be meaningful when extended beyond two classes.

In Mushayabasa [36], an *SIR* like mathematical model to investigate the role of optimal intervention strategies on controlling excessive alcohol drinking and its related adverse health effects in the community was proposed and analyzed. The study considered the transmission process as the social contract between heavy and light alcohol consumers within an unchanging shared drinking context. Two models − an autonomous system with constant parameters in relevant alcohol drinking components and alcohol related treatment model − incorporating peer influence were proposed and analyzed qualitatively. The study considers the model with the total drinking population in four different population compartments depending on individuals' alcohol consumption level as follows.

$$\begin{aligned} S'(t) &= \mu N - g(H)\frac{S}{N} - \mu S + (1-p)\,\psi A \\ H'(t) &= g(H)\frac{S}{N} - (\phi + \varepsilon + \mu)\,H \\ A'(t) &= (1-f)\,\phi H - (\psi + \mu)\,A \\ R'(t) &= f\phi H + p\phi A - \mu R \end{aligned} \tag{4}$$

Susceptible, $S(t)$, contains light alcohol consumers; heavy, $H(t)$, contains heavy alcohol consumers; $A(t)$ contains individuals receiving alcohol related treatment and consume alcohol occasionally; and recovered, $R(t)$, which contains both individuals on treatments and those who have successfully completed treatment and permanently quit alcohol consumption. In his study, optimal control results suggested that, effective control of high-risk alcohol drinking can be achieved if more resources and efforts are devoted on weakening the intensity of social interactions between light and heavy drinkers. It was suggested further that, time dependent interventions have the potential to eliminate the problem of excessive alcohol use. Having alcoholic population in three classes depending on their consumption level answers the multilevel risks challenges appeared in the previous literature. However, the study considered only drinkers population and left the non drinkers population out of the system. As observed in the previous literature, the study also ignored the contribution on social cultural beliefs in controlling the problem.

Xiang and collaborators [37] worked on global property of a drinking model with the public health campaigns. To describe the problem, the drinking population is subdivided into five groups: susceptible drinkers, $S(t)$, who moderately consume alcohol but may develop alcohol

related problems and refuses public health education; educated drinkers, $E(t)$, who consume alcohol in moderation and accept the public health education; alcoholics, $A(t)$, who have drinking problems or addictions; and temporarily recovered drinkers, $R(t)$, former alcoholics who have entered treatment and are abstaining from alcohol; quit drinkers, $Q(t)$, who permanently quit drinking. The following model was established

$$\begin{aligned} S'(t) &= q\mu\Lambda - \beta SA - \beta SA + (p+\mu)S \\ E'(t) &= (1-q)\mu\Lambda + pS - \beta\sigma EA - (\mu+\varepsilon)E \\ A'(t) &= \beta SA + \beta\sigma EA + \delta R - (\mu + a_1 + \gamma)A \\ R'(t) &= \gamma A - (\delta + \xi + \mu + a_2)R \\ Q'(t) &= \xi R + \varepsilon E - \mu Q \end{aligned} \tag{5}$$

With the help of Lyapunov function, global stability of equilibria of the model system (5) is derived. The basic reproduction number, $\mathscr{R}_0$, ware obtained by means of the next generation matrix and the global stability of model has been proved by using the Lyapunov function. The study analysis revealed that, the public health educational campaigns of drinking individuals can slow down the drinking dynamics. Some numerical simulations are also used to support this conclusions. Again this work is not free from the challenges of ignoring the influence of social cultural beliefs existing in the society.

A non - linear $SHTR$ model [38] studied the dynamics of drinking epidemics where the susceptible compartment (S) of the model took non drinkers population and the compartment (H) recruited heavy alcohol drinkers with no considerations of the light alcohol drinkers.

$$\begin{aligned} S'(t) &= b - \alpha SH - \mu S + \eta R \\ H'(t) &= \alpha SH - (\mu + \delta_1 + \phi)H \\ T'(t) &= \phi H - (\mu + \delta_2 + \gamma)T \\ R'(t) &= \gamma T - (\mu + \eta)R \end{aligned} \tag{6}$$

with initial conditions $S(0) \geq 0, H(0) \geq 0, T(0) \geq 0$, and $R(0) \geq 0$. In this study, the conditions for existence and stability of drinking free and endemic equilibria points were established by using Lassalle's invariance principle of Lyapunov function. Analytical results were later confirmed by some numerical simulations putting forward three useful methods of combating the drinking epidemics. These include: reducing the contact rate between non drinkers and heavy

drinkers; increasing the number of drinkers that go into treatment; and educating to refrain from drinking. The authors also seem to have generalized the concept of alcoholism without considering multilevel risks phenomenon based on one's drinking patterns and frequency.

A risk - structured model for the spread of drug abuse presented by system (7) was used to estimate an epidemic threshold value (abuse reproduction number) [39].

$$
\begin{aligned}
S_H'(t) &= \rho\Lambda - \frac{\beta_1 U S_H}{N} - (\mu+\omega_1) S_H + \omega_2 S_L \\
S_L'(t) &= (1-\rho)\Lambda - \frac{\eta_1\beta_1 U S_L}{N} - (\mu+\omega_2) S_L + \omega_1 S_H,\ 0<\eta_1<1 \\
U'(t) &= \frac{\beta_1 U (S_H+\eta_1 S_L)}{N} + \frac{\beta_2 U (R_H+\eta_2 R_L)}{N} - (\mu+\sigma+\delta+\rho+\rho_h+\rho_l) U \\
T'(t) &= \sigma U - (\mu+\gamma_h+\gamma_l) T \\
R_H'(t) &= \gamma_h T + \rho_h U - \frac{\beta_2 U R_H}{N} - (\mu+\varepsilon_1) R_H + \varepsilon_2 R_L \\
R_L'(t) &= \gamma_l T + \rho_l U - \frac{\eta_2\beta_2 U R_L}{N} - (\mu+\varepsilon_2) R_L + \varepsilon_1 R_H,\ 0<\eta_2<1
\end{aligned}
\tag{7}
$$

with initial conditions $S_H(0)=S_{H0}>0, S_L(0)=S_{L0}>0, U(0)=U_0\geq 0, T(0)=T_0\geq 0, R_H(0)=R_{H0}\geq 0, R_L(0)=R_{L0}\geq 0$ and positive model parameters. In this complex model, the question of multilevel risks has been addressed and the model solution revealed that public health education on skills to handle the risky situation may be the best approach to protect individuals from initiating or re-initiating into drug abuse. However, just like any other previous studies, the study did not consider the importance of social cultural influences in molding human behavior.

4. Discussion and Conclusion

In light of the above literature, it is clear that mathematical modeling approach towards solving different problems have continually attracted most researchers. This is also true for health problems and its associated risks as the consequences of alcoholism. However, the field of drugs abuse and substance addiction like other fields is not without challenges. Based on the fact that, the field of drug abuse and addiction largely depend on behavioral criteria than physical and biological personalities: defining, quantifying and measuring the phenomena of studies of drug abuse has been recorded as one among the great challenges facing the drug abuse epidemiologists [40].

It is well known that even the best models have some imperfections in one way or another [41]. It is therefore utmost important to continue reviewing and improving the models available

from time to time, in order to increase their usefulness. Motivated by above literature, the studies reviewed provide the stepping stone towards developing a more relevant model. In light of the above literature, the open problem which comes out clearly includes: developing a complex and more relevant models the dynamics of health related risks associated with alcoholism and its control strategy addressing the main aspects raised above as the challenge to most of the studies. Such models are expected to take into account the influence of external motivations on the spreading of alcohol abuse by introducing different population segments with distinct expositions, towards and resistance to the influence of drugs.

Since different levels of alcohol consumption has different health effects, alcohol drinking population is anticipated to be considered in three categories depending on their alcohol drinking habits as follows;

(1) **Low risk population:** involving the population proportion who drink alcohol once in while mainly when they are involved in some special events, they are also known as occasional drinkers.

(2) **Moderate risk population:** involving the population proportion who drink alcohol on regular basis but have not developed symptoms of alcohol dependency.

(3) **High risk population:** these include the population proportion who consume alcohol frequently and at large amount, they may or may not have developed symptoms of alcohol dependency but they have crossed the threshold of alcoholism.

Inclusion of the influence of external motivations with positive and negative influential effects, and a clearly defined alcohol drinking population will make this study even more peculiar and it will distinguish itself from most of the models developed over the subject.

CONFLICT OF INTERESTS

The author(s) declare that there is no conflict of interests.

REFERENCES

[1] R. C. Ellison, M. Martinic, The harms and benefits of moderate drinking: Findings of an international symposium. Elsevier Monograph Series. 2007.

[2] WHO, The Global Status Report on Alcohol and Health 2014, World Health Organization, 2014.

[3] D. Jernigan, Comparative quantification of health risks, Citeseer (2004), 959.

[4] M.G. Griswold, N. Fullman, C. Hawley, et al. Alcohol use and burden for 195 countries and territories, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016, The Lancet. 392 (2018) 1015–1035.

[5] C.J.L. Murray, ed., The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020; summary, Harvard School of Public Health [u.a.], Cambridge, 1996.

[6] WHO, The global burden of disease 2004, World Health Organization, 2004.

[7] WHO, Harmful use of alcohol, World Health Organization, 2009.

[8] C.P. Bhunu, A mathematical analysis of alcoholism, World J. Model. Simul. 8 (2012), 124–134.

[9] H. Huo, Y. Liu, The analysis of the SIRS alcoholism models with relapse on weighted networks, SpringerPlus 5 (2016), 722.

[10] L. Wiessing, R. Hartnoll, C. Rossi, The epidemiology of drug use at the macro level: indicators, models and policy-making, Bull. Narcot. 53 (2001), 119-133.

[11] WHO, Global status report 2018, World Health Organization, 2018.

[12] NHMRC-Australia, Australian alcohol guidelines: health risks and benefits, National Health and Medical Research Council, 2001.

[13] M. Grönbaek, The positive and negative health effects of alcohol-and the public health implications, J. Intern. Med. 265 (2009), 407–420.

[14] A.B. Tusekwa, T.C.E. Mosha, H.S. Laswai, E.E. Towo, Traditional alcoholic beverages of Tanzania: production, quality and changes in quality attributes during storage, Int. J. Food Sci. Nutrit. 51 (2000), 135–143.

[15] J.M. Francis, H.A. Weiss, G. Mshana, K. Baisley, H. Grosskurth, S.H. Kapiga, The epidemiology of alcohol use and alcohol use disorders among young people in northern Tanzania, PLoS One 10 (2015), e0140041.

[16] H.G. Koening, M. McCullough, D. Larson, Handbook of religion and health, Oxford University Press, 2001.

[17] D.B. Creel, Assessing the influence of religion on health behavior. LSU Doctoral Dissertations. (2007), 2389. https://digitalcommons.lsu.edu/gradschool_dissertations/2389

[18] W.R. Miller, C.E. Thoresen, Spirituality Religion and Health, Amer. Psychol. 58 (2003), 24–35.

[19] B. Benedict, Modeling alcoholism as a contagious disease: how infected drinking buddies spread problem drinking, SIAM News 40 (2007), 11–13.

[20] M.P. Mundt, L. Mercken, L. Zakletskaia, Peer selection and influence effects on adolescent alcohol use: a stochastic actor-based model, BMC Pediatr. 12 (2012), 115.

[21] S.D. Walsh, A. Djalovski, M. Boniel-Nissim, Y. Harel-Fisch, Parental, peer and school experiences as predictors of alcohol drinking among first and second generation immigrant adolescents in Israel, Drug Alcohol. Depend. 138 (2014), 39–47.

[22] European Commission, Attitudes Towards Alcohol, 2007.
http://ec.europa.eu/public_opinion/archives/ebs/ebs_272b_en.pdf

[23] D. Mishra, I. Akman, A. Mishra, Theory of reasoned action application for green information technology acceptance, Comput. Human Behav. 36 (2014), 29–40.

[24] H.A. Hausenblas, A.V. Carron, D.E. Mack, Application of the theories of reasoned action and planned behavior to exercise behavior: A meta-analysis. J. Sport Exercise Psychol. 19 (1997), 36–51.

[25] R. Shepherd, G. Towler, Nutrition knowledge, attitudes and fat intake: application of the theory of reasoned action, J. Human Nutr. Diet. 5 (1992), 387–397.

[26] A.D. Bright, M.J. Manfredo, M. Fishbein, A. Bath, Application of the theory of reasoned action to the National Park Service's controlled burn policy, J. Leis. Res. 25 (1993), 263–280.

[27] H. Bang, A.E. Ellinger, J. Hadjimarcou, P.A. Traichal, Consumer concern, knowledge, belief, and attitude toward renewable energy: An application of the reasoned action theory, Psychol. Market. 17 (2000), 449–468.

[28] R.P. Bagozzi, N. Wong, S. Abe, M. Bergami, Cultural and situational contingencies and the theory of reasoned action: Application to fast food restaurant consumption, J. Consumer Psychol. 9 (2000), 97–106.

[29] C. Darwin, The origin of species by means of natural selection: Or, the preservation of favoured races in the struggle for life and the descent of man and selection in relation to sex. John Murray, London, 1859.

[30] C. Darwin, The decent of man, Watt and Co. London, 1930.

[31] I. Ajzen, M. Fishbein, Understanding attitudes and predicting social behavior, Pbk. ed, Prentice-Hall, Englewood Cliffs, N.J, 1980.

[32] W.M. Cox, E. Klinger, A motivational model of alcohol use. J. Abnorm. Psychol. 97 (1988), 168–180.

[33] S. Mandal, R. R. Sarkar, S. Sinha, Mathematical models of malaria-a review, Malaria J. 10 (2011), 202.

[34] H.G. Koenig, Handbook of religion and mental health, Academic Press, San Diego, 1998.

[35] X. Wang, H. Huo, Q. Kong, W. Shi, Optimal control strategies in an alcoholism model, Abstr. Appl. Anal. 2014 (2014), 954069.

[36] S. Mushayabasa, The role of optimal intervention strategies on controlling excessive alcohol drinking and its adverse health effects, J. Appl. Math. 2015 (2015), 238784.

[37] H. Xiang, N. Song, H. Huo, Modelling Effects of Public Health Educational Campaigns on Drinking Dynamics, J. Biol. Dyn. 10 (2016), 164–178.

[38] I. Adu, M. Osman, C. Yang, Mathematical Model of Drinking Epidemic, Br. J. Math. Computer Sci. 22 (2017) BJMCS.33659.

[39] J. Mushanyu, F. Nyabadza, A Risk-Structured Model for Understanding the Spread of Drug Abuse, Int. J. Appl. Comput. Math. 4 (2018), 60.

[40] Z. Sloboda, Drug abuse epidemiology: an overview, Bull Narcot. 54 (2002), 1–13.

[41] G.E.P. Box, All models are wrong, but some are useful, Robust. Stat. (1979), 202.