Health Care System Based on the Theory of Dynamic Systems

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Abstract

The adverse effects of cigarette usage not only affect the smoker, but also are extended to both the family and society. Governments have therefore always tried to reduce, control and prevent the possible damages caused by smoking, and have adopted various policies for this purpose. The Iranian government is one of such governments, and the most important law that it has legislated in this regard is the "Monopoly of Tobacco Law". However, many questions exist about the consequences of this legislation because the adoption or abolition of such a law can have widespread and multi-faceted effects on individuals, families, the society and the government. In this research, we attempted to use the "dynamic system" method to study the cycle related to the use of cigarettes and its effects on various sectors of society in the two instances of "the implementation of the monopoly of tobacco law" and "the abolishment of the monopoly of tobacco law". This was done in order to determine the impact of the implementation or abolishment of the monopoly of tobacco law on the factors involved in this cycle. Given the present conditions in Iran, the implementation of this law would have adverse effects on public health, including an increase in the incidence of lung cancer. As a solution, the related model shows that if part of the income from tobacco sales is spent on effective public education programs, there would be a reduced prevalence of smoking, and the related health issues would become less prominent.

Keywords: Dynamic systems, monopoly of tobacco, tobacco cycle, abolition of tobacco monopoly

1 Introduction

Tobacco use remains a serious threat to global health and has killed almost 100 million individuals during the 20th century, and if current trends continue, approximately 1 billion people will die from tobacco use during the 21st century1. The rates of smoking prevalence are still increasing in many low- and middle-income countries, although decreasing in most high-income countries, thus, the number of tobacco-related deaths will continue to increase in the future years. Smoking is the cause of the incidence of many fatal and non-fatal diseases faced by mankind. In this research, it should be noted that not only the consumer is at risk of developing these problems, but also those who are exposed to cigarette smoke are faced with similar threats. According to the data provided by the American Center for Disease Control and Prevention (CDC), people

who do not smoke themselves but inhale second hand smoke at home or in the workplace are also exposed to the dangers of smoking, such that the incidence of lung cancer in such people increases by 20-30 %. Governmental revenue is generated from cigarette production, distribution, and taxes on imported cigarettes. In this research, twice the revenue is spent by governments for treating diseases caused by smoking. According to statistics in developed countries, these costs account for 6 to 15 % of all healthcare costs. Governments have always been trying to control smoking via legislation. In the case study of Iran, such legislation is in the form of the "Monopoly of Tobacco" law, which was first approved in 1915.

The last law in this field was proposed on March 17, 1932, and some of its clauses were legislated in November 1932. In this research, certain commercial policies on cigarette trade have been instated and sometimes changed, with the law regarding taxes on imported cigarettes being one example. Over time and due to population growth, cigarette consumption increased in Iran in such a way that domestic production could not meet the increased demand. Furthermore, due to the type of tobacco grown in Iran, the produced cigarettes lacked a desirable and stable quality. Farmers did not try to improve their tobacco quality due to the exclusive purchasing of tobacco and its mandatory sale price. Given these factors, and considering the rising production costs, the market steadily moved towards the smuggling of cigarettes. For further clarification, the statistics published in 2002 predicted that the country's demand for those years (according to a population of about 60 million Iranians) was estimated at about 53 billion cigarettes per year. This is while the annual domestic production capacity was 12 billion cigarettes and 7 billion cigarettes were officially imported. This means that about 32 billion cigarettes were smuggled into the country per year, which is 2.66 times the domestic production of those years. The reasons behind such a high rate of cigarette smuggling may be its high demand and high price difference. As a result of the instability caused by the monopoly of tobacco, Iranian lawmakers decided to abolish this law in the Third Development Plan.

Hence, Article 31 of the Third Development Plan Act was submitted to the parliament for this purpose. From this bill, it can be inferred that competition in the production and distribution of tobacco is benefits only the government, while neglecting societal health and the negative effects of increased smoking on the various classes of society, especially on the youth. The effects of the liberalization of tobacco trade in various countries are further evidence to this claim in 2000 [1], India generated 70 billion rupees in revenue from the liberalization of the tobacco trade, but its direct and indirect costs for the treatment of tobacco-related illnesses were approximately 270 billion rupees. One year after the arrival of American companies, smoking in South Korean youth increased by 12 % in boys and by 9 % in girls. As mentioned in the previous section, smoking has widespread effects on the health and well-being of the individual, family and governments. Meanwhile, governments impose laws such as monopolies for various economic, health and cultural purposes. A literature review showed that there is a paucity of studies that comprehensively investigate the effects of the implementation or abolition of tobacco monopolies over time, which requires a systematic look at the cycle of cigarette usage and the role of a tobacco monopoly on this cycle. This is because a one-dimensional view of the effects of cigarette smoking and the impact of monopoly results in the elimination of important facets from this issue. In order to achieve this comprehensiveness and to examine all the

aforementioned effects, it is necessary to consider cigarette usage and the role of the implementation or abolition of the monopoly legislation as a system in which the existing variables, while also directly affecting each other, indirectly interact with one another. The "dynamic systems" approach was used for this goal, in which the cause and effect cycle of cigarette usage was drawn and analyzed in the two cases of the implementation and abolition of the tobacco monopoly legislation. In this research we attempted to use the "dynamic systems" method to investigate cycles related to the use of cigarettes in Iran in terms of implementing or abolishing the "monopoly of tobacco" law. In this research, we were expected to include information on the progressive effects of the implementation or abolition of the tobacco monopoly on health, cigarette usage and smuggling, the age of becoming addicted to smoking, life expectancy of smokers, the quality of cigarettes, as well as the expenditure and revenues for the Government, all of which can be useful for policy-making.

2 Literature Review

The background of this research is first presented in terms of the factors associated with lung cancer and smoking, the brand and quality of cigarettes available in Iran, and the effect of monopoly and the prevention of cigarette imports. The factors influencing the incidence of lung cancer are mentioned initially, followed by an explanation of the detailed relationship between each of such factors. Finally, a summary of the research background is presented along with the potential fields for future research. Over the past three decades, lung cancer has become one of the leading causes of global deaths [2]. Sun et al. noted in their research that the main causes of lung cancer are, in order of significance, smoking, environment tobacco smoke, local radioactive substances, cooking oil vapors, charcoal and wood burning in closed environments, genetic factors, and viral factors. In 2002[3], it was estimated that 1.18 million people died from lung cancer [4]. Of these, about 85 % were men and 47 % were women who were addicted to one type of tobacco [5]. A large amount of research has been conducted on the association of tobacco use (especially cigarette smoking) with lung cancer [6]. Ozlu and Bulbul reported that about one-third of the adult population is addicted to one of the types of tobacco products, and in the year 2025, 10 million people are expected to die due to smoking, which would comprise one third of total adult mortalities. They have mentioned that smoking is the main reason for the occurrence of lung cancer in 90 % of men and in 79 % of women, and 90 % of the mortalities from lung cancer are due to tobacco use. It should be noted that statistics on the incidence of lung cancer and the role of smoking on the development of this type of cancer varies in different research. The reason for this is the difference in the statistical society and the time of sampling by various scientists. In this research, what is certain is that the risk and likelihood of developing lung cancer in life-time smokers is 20 to 40 times relative to non-smokers. The incidence of lung cancer among women in developed countries has been rising since the 1950s [7]. A study on a group of women in France showed that the risk of lung cancer and other cancers of the respiratory system in smokers depends on the length of their smoking, the severity of their addiction and the number of packets consumed per year. Studies have shown that the risk of lung cancer increases linearly with an increase in the years of smoking, and decreases linearly immediately after cessation of smoking. Inhaling cigarette smoke, using non-filtered cigarettes, using

heavier tobacco, and an onset of addiction at an earlier age, increase the risk of cancer [8]. The results of a survey among French women showed that more than 55 % of people with lung cancer are smokers, and the main cause of the increase in lung cancer in the preceding years was the increase in cigarette usage [9]. Another issue commonly raised is whether the relationship between smoking and the risk of lung cancer is the same for men and women [10]. The results of the research indicate that, despite the notion in many societies that smoking causes greater harm to women, the risk of lung cancer due to smoking remains higher in men. However, the incidence of lung cancer in both men and women is dependent on the amount of cigarette smoking, the years of addiction, and/or the amount of time since cessation [12]. In general, it can be said that controlling the amount of tobacco used by both men and women is critical [13]. Although it is well proven that cigarette smoking increases the risk of lung cancer, the effect of smoking on the risk of metastasis and probability of survival of patients with cancer is unknown [14]. Studies have shown that smoking rates are higher in older patients, and cancer is more likely to progress and/or cause death in cancer patients who use more than 61 cigarette packs per year. However, age, sex, and cancer type are not statistically significant for predicting lung cancer [15]. On the other hand, the progression of cancer is significantly related with its stage, the age of the patient and their smoking pattern [16]. In general, it can be said that the intensity of smoking can be an independent diagnostic agent for large cancer cells, which can lead to cancer progression and metastases [17]. Tobacco refers to a variety of products. Cigarettes, cigars, cigarillos or little cigars, and pipes are among the variety of these products. The World Health Organization (WHO) reported in its 2016 Global Tobacco Epidemic Report that globally, more than 5 million people die annually due to tobacco use. They predict that if this trend continues, this figure will increase to over 8 million by 2030 [18]. In general, smokers (cigarette addicts) are referred to people who regularly use at least one cigarette per day for at least one year [19]. In this research, the relationship between smoking and mortality over the course of 50 years was investigated among 34,439 English male doctors. They concluded that among this population, 1052 died due to lung cancer, among which 80 % were cigarette addicts.

3   Problem modeling and analysis

As mentioned in the literature review, there are many factors involved in the incidence of lung cancer. Each of these factors, in turn, has a special relationship with other social and economic factors that cannot be easily analyzed together to achieve optimal outcomes when it comes to making decisions and macro-policies. Hence, using the dynamic systems theory, which includes a set of perceptual tools, allows decision makers to understand the structure and dynamics of complex systems.

3.1 Causal Diagram

The causal diagram is one of the most widely used methods for presenting causing relationships. With its help, one can put together all the factors influencing the problem and observe how they affect one another. Fig. 1, presents the causal diagram for the problem. Vectors drawn between different causes indicate the effect of different causes on each other, and the positive and negative signs at the end of each vector indicate that if a certain cause becomes prominent, the effect pointed to at the end of the vector increases (positive sign) or decreases (negative sign).
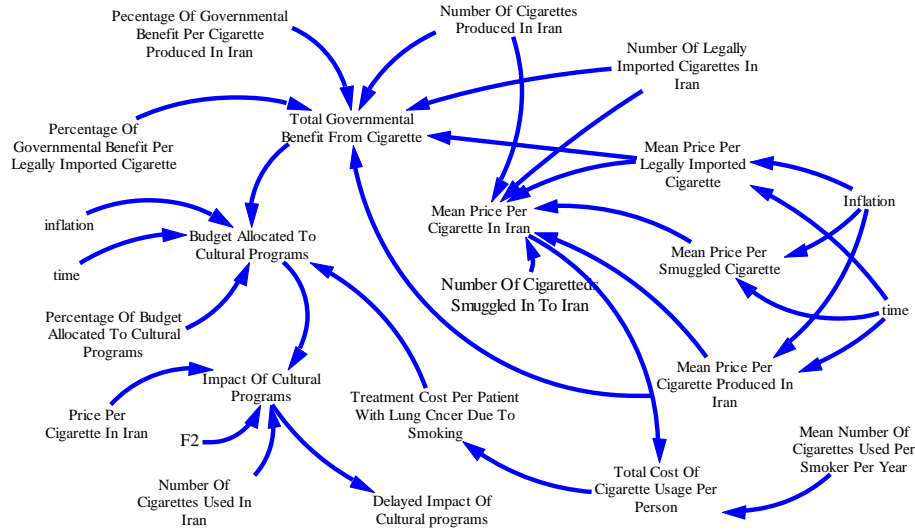
Fig.1. Causal diagram for the relationship between monopoly and lung cancer

3.2 Key variables

As shown in Fig 1., there are various factors that affect the relationship between the monopoly of tobacco law and lung cancer in Iran, and the type of relationship between these factors can be observed in the causal diagram. Some key variables presented in the chart can be defined as follows:

- ➢ **The prevalence of lung cancer in smokers**: This variable represents the number of people who have acquired lung cancer due to smoking.
- ➢ **Cigarette smuggling**: This variable indicates the rate of cigarette smuggling in Iran.
- ➢ **Cigarette cost**: This variable represents the average price of cigarettes in Iran.

The number of cigarettes per day: This variable represents the average number of cigarettes consumed per person per day.

3.3 Flowchart

To simulate the issue, the Vensim Software was used to present the flowchart (illustrated in Figures 2-3) based on the causal diagram and the key variables:

Fig. 2. Relationship between the monopoly of smoking and lung cancer
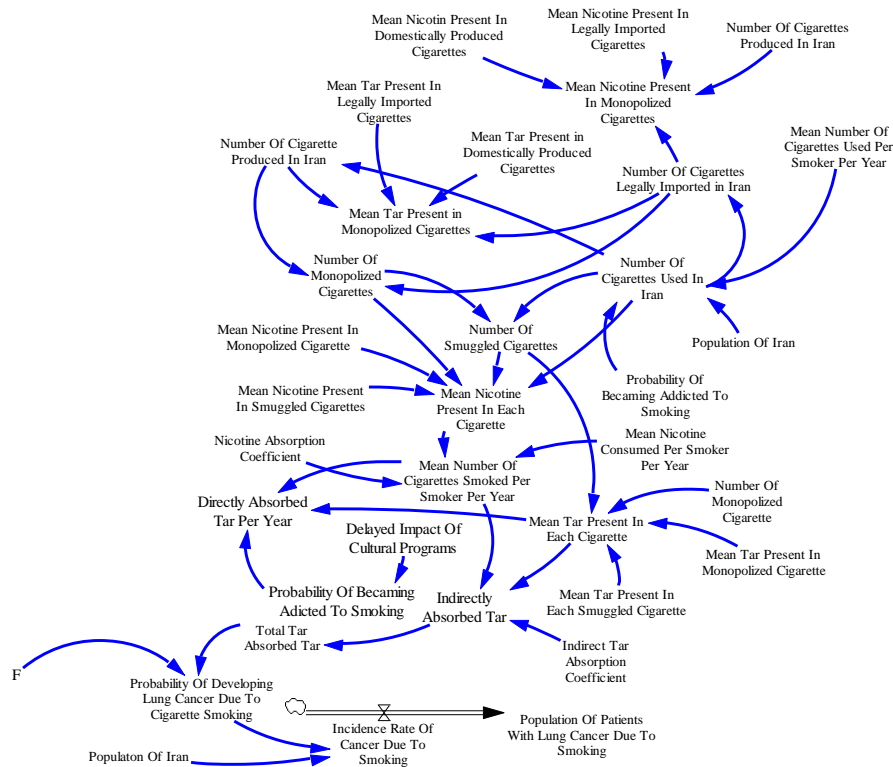

Fig. 3 (Fig. 2 continued): Relationship between the monopoly of smoking and lung cancer

3.4 Model Functions

Given the flowchart presented in the previous section, the key relationships between key variables are as follows:

Mean level of nicotine present in monopolized cigarettes =

(Number of legally imported cigarettes in Iran * Mean level of nicotine present in imported cigarettes) + (Number of cigarettes produced in Iran * Mean level of nicotine present in cigarettes produced in Iran)

(Number of legally imported cigarettes in Iran + Number of cigarettes produced in Iran)

Indirectly absorbed tar =

Mean number of cigarettes smoked by a smoker in one year * Mean amount of tar in one cigarette * Indirect tar absorption coefficient

Directly absorbed tar per year =

Probability of becoming a smoker * Mean number of cigarettes smoked by a smoker in one year * Mean amount of tar in one cigarette

Probability of becoming a smoker = (15/82) * Effect of cultural programs

The reason for using the coefficient 15/82 is that in the present conditions, 15 out of the 82 million Iranian population smoke.

Mean number of cigarettes smoked by a smoker =

(Mean nicotine consumed by a smoker per year) / (Mean level of nicotine present in one cigarette * nicotine absorption coefficient)

Total tar absorbed by an individual = directly absorbed tar per year + indirectly absorbed tar per year

Population of patients with lung cancer due to smoking = $\int (\text{Rate of lung cancer due to smoking}) dt$

Incidence of lung cancer due to smoking = Iranian Population * Probability of incidence of lung cancer due to smoking

Total cost of smoking to an individual = Mean number of cigarettes used per person per year * Mean cost per cigarette in Iran.

3.5 Execution of the model in the present situation

Given the current state and the existence of a monopoly law in Iran, the model has been simulated for the next twenty years, and the results are presented in the following graphs:
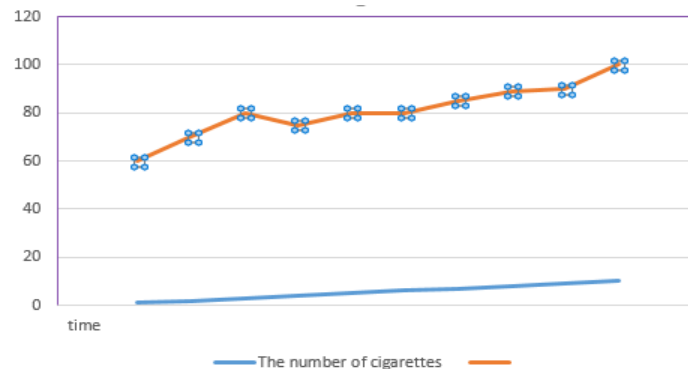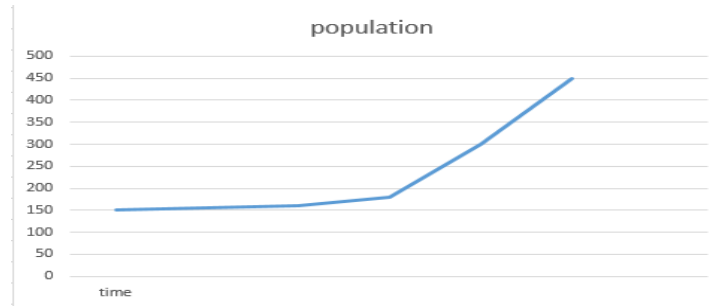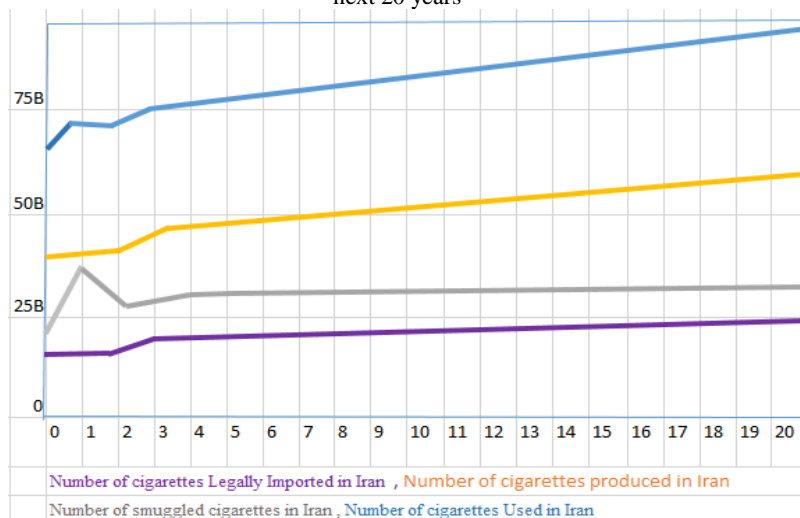

Fig.3. The number of cigarettes that are expected to be used in Iran over the next 20 years

Fig. 4. Projected population of patients with lung cancer due to smoking in Iran over the next 20 years

Number of cigarettes Legally Imported in Iran , Number of cigarettes produced in Iran
Number of smuggled cigarettes in Iran , Number of cigarettes Used in Iran

Fig.5. The number of cigarettes that are expected to be used in Iran over the next 20 years in different scenarios
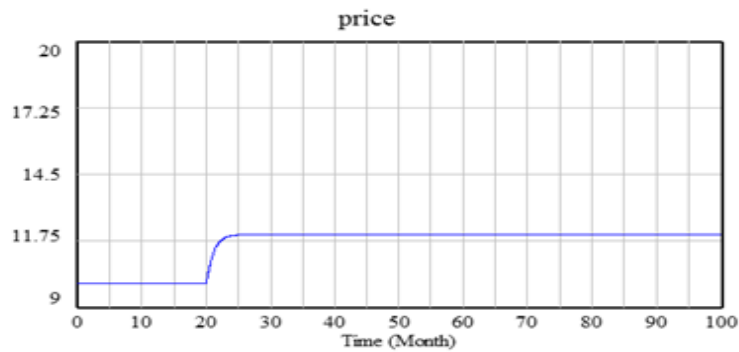
4   Sensitivity analysis

Five different scenarios were considered for the model as follows:

1. The monopoly law for tobacco imports changes, and fifty percent of the currently smuggled tobacco is allowed to be imported legally.
2. The monopoly law for tobacco imports changes, and all currently smuggled tobacco is allowed to be imported legally.
3. The monopoly law for tobacco imports changes, and the budget allocated to cultural programs (related to the prevention of cigarette smoking) increases from one to five percent.
4. The monopoly law for tobacco imports changes, and fifty percent of the currently smuggled tobacco is allowed to be imported legally. In addition, the budget allocated to cultural programs (related to the prevention of cigarette smoking) increases from one to five percent.
5. Tobacco pricing could be more effectively monitored with the development of a national research network. Surveillance of the tobacco industry's methods to push tobacco and pull consumers can help the public health community
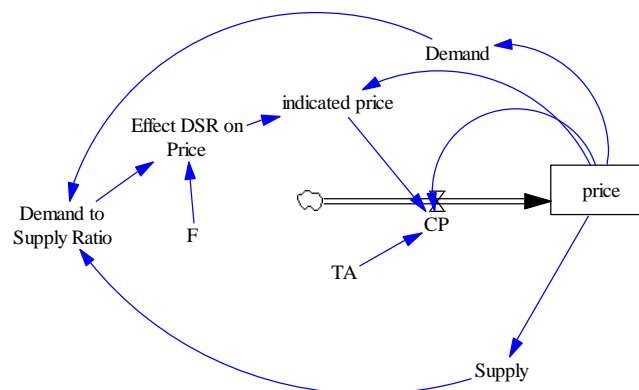
identify new markets and campaigns, justify and tailor effective tobacco control strategies, and evaluate existing counter-pricing efforts.

Fig.6. Impact of price on cigarettes in Iran

The monopoly law for tobacco imports changes, and all currently smuggled tobacco is allowed to be imported legally. In addition, the budget allocated to cultural programs (related to the prevention of cigarette smoking) increases from one to five percent. In addition, we have examined the effects of prices on cigarettes and, with increasing demand and reduced purchasing power, this reduces cancer.

Fig.7. Impact of price on cigarettes

5 Conclusion and future works

The Iranian law for the monopoly of cigarette imports has been legislated to reduce smoking. Through modeling and the use of the theory of system dynamics, we have shown that this law not only will not reduce cigarette consumption over time, but also will increase it. which results in an increased prevalence of lung cancer. By simulating different scenarios, we concluded that if this law is changed and high quality cigarettes are allowed to be imported into Iran, cigarette usage and the rate of lung cancer due to cigarettes would both decrease. Also, if the government passes a law to allow part of the governmental profit from the sale and import of cigarettes to be spent on cultural programs to inform the general public about the dangers of smoking, the rate of

cigarette usage would decrease after a few years (assumed as one year in the present study).

Based on the results and review of previous research, the following suggestions can be made for future research:

- ➤ Considering the various factors that follow the statistical functions, followed by the development of the model by addressing the costs and paying more attention to dynamic systems.
- ➤ In recent years, there has been a rapid trend in the field of dynamic systems problems for the use of hybrid and integrated models. For example, combining health policy with smoking cessation and lung cancer, dynamic scheduling systems are among the issues that have attracted a lot of attention. We recommend that the possibility of combining the proposed model in this paper with the cases mentioned as a future topic should be considered.
- ➤ To cope with uncertain parameters, we suggest fuzzy concepts and dynamics systems for improving the model.

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