**Research Paper**

**Dynamics of Tobacco Use, Scenarios, and Control Policies**

Ahmad Haghiri Dehbarez*, Ali Mohammad Ahmadvand†, Amir-Bahador Morovat‡

1. Health Policy Secretariat, Hormozgan University of Medical Sciences, Bandar Abbas, Iran.
2. Department of Future Studies, Faculty of Industrial Engineering, Eyvanekey University, Eyvanekey, Iran.

* Corresponding Author:
Ahmad Haghiri Dehbarez
Address: Health Policy Secretariat, Hormozgan University of Medical Sciences, Bandar Abbas, Iran.
Tel: +98 (917) 7697318
E-mail: Hagheri@yahoo.com

**ABSTRACT**

**Background:** A review of the tobacco control initiatives indicates that the evolution of tobacco control and public health into complex interconnected systems requires approaches and methodologies based on the dynamic nature of this environment. This study attempts to view tobacco control policies from the perspective of systemic dynamics.

**Materials and Methods:** The research methodology is based on the stages of system dynamics.

**Results:** Through the model’s analysis, two primary smoking control policies are proposed: First, a strategy focused on reducing consumption through enhanced awareness and ongoing monitoring via an active learning program, and second, enhancing the smoking cessation rate by establishing dedicated clinics and utilizing cultural approaches that condemn smoking.

**Conclusion:** Using either a system dynamics approach or qualitative and descriptive methods, tobacco studies reveal no quantitative decision support system to measure the effectiveness of the policies guiding the development of this system. This gap inhibits the identification of the root cause of the problem and improves the behavior of essential variables with dynamic hypotheses. A fundamental issue in the development of any model is access to valuable and accurate data, a resource not readily and transparently available in Iran.
Introduction

Globally and particularly in Iran, smoking continues to pose a formidable health concern, contributing to rising mortality and morbidity rates, including a variety of health problems like noncommunicable diseases [1-3]. Despite the dire predictions of an alarming increase in smoking-related deaths worldwide by 2030 [4-6] and an anticipated 450 million deaths over the next half-century based on the current smoking trends among 1.3 billion smokers [4], the situation in Iran is equally concerning. Smoking is a significant health problem that varies from country to country. However, it is a major concern of the Iranian health system, as it is in many developing countries [7]. Iran ranks 73rd among 181 nations in a 2006 survey on cigarette consumption and faces unique challenges due to a smoking-related death rate of 10%-15% from 1990 to 2019 [8].

In addition to the alarming increase in tobacco consumption up to 20% from 2015 to 2019, (Table 1) a substantial economic burden of 200 to 300 thousand billion Rials annually is attributed to both direct costs and lost productivity caused by premature death or disability due to smoking-related diseases [8, 9]. Despite these plain realities and an unmet target of a 30% reduction in smoking prevalence by 2025 by the National Committee for the Prevention and Control of Noncommunicable Diseases [9], efforts toward tobacco control in Iran have encountered challenges and limitations, highlighting a perceptible gap in both epidemiological and personal health management.

This intricate issue, which entangles multiple entities like policymakers, healthcare professionals, and various stakeholders, demands an exploration through the lens of system dynamics. As a result, the discussion moves toward examining the dynamics of tobacco consumption in Iran, intertwined with policy implementation and prospective proposals. This procedure introduces pivotal variables and explores systems psychology. Subsequent sections of this text commit to developing a systems model and present control policies that integrate a deep understanding of systemic dynamics with psychological dynamics to formulate and propose future strategies for Iranian tobacco control and public health.

Having introduced some relevant research projects and the system dynamics methodology, the research method will be discussed in this article. As a result of raising the influencing variables and investigating tobacco consumption in Iran from the perspective of systems psychology, a proper system model is developed, and control policies are also presented.

Materials and Methods

Theoretical basis and research background

System dynamics, a method pivotal for enhancing learning within complex dynamic systems, exhibits comprehensive applicability, extending from deciphering human behavior to scrutinizing physical and technical systems, thereby infiltrating diverse disciplines such as sociology and economics. From Forrester’s seminal 1961 work “Industrial Dynamics,” its methodological applications have widely pervaded various fields, including strategy planning, monetary policy design, commercial and public sector management, cognitive and medical modeling, natural and social sciences theorization, and decision-making within nonlinear systems. Subsequent sections will illuminate pertinent empirical studies, exploring methodology applications across various industries and analytically probing into the causative dynamics of smoking.

A review of studies on tobacco and risk factors

Najarian et al. explored smoking epidemiology among 1334 government office employees in Ahvaz City, Iran, and compared various smoking cessation methods, considering age, smoking duration, and sensation seeking. Their findings revealed that 23% of male and 1.2% of female employees smoke, averaging 9 cigarettes per day, with an average smoking initiation age of 20.9 [10].

<table>
<thead>
<tr>
<th>Gender</th>
<th>Other Countries (%)</th>
<th>Iran (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>23.24</td>
<td>34.01</td>
</tr>
<tr>
<td>Female</td>
<td>6.4</td>
<td>3.53</td>
</tr>
</tbody>
</table>
In a study by Ayatollahi et al. exploring the psychological predictors of smoking progression among 1132 students, illegal drug use and a positive smoking inclination were identified as strong predictors. The findings recommend early initiation of smoking prevention programs, preferably in high school or earlier [11].

By using BASNEF (beliefs, attitudes, subjective norms and enabling factors model), Sharifi Rad and Kamran identified that easy access to cigarettes (44%) and having smoking friends (52%) were vital initiating factors for smoking among 100 dormitory students at University of Isfahan. They found significant relationships between initiating factors, age of smoking initiation, and paternal smoking through the chi-square test [12]. Agha Molaei and Zare determined the smoking and hookah use prevalence among 1810 Bandar Abbas residents, Iran, aged over 15, reporting that 11.7% of them were smokers—a figure higher among men—and around 1% used hookah, with higher use among women [13]. Targhee Jah et al. analyzed predictors of smoking and hookah consumption among 7375 public university students, revealing that 30.8% smoked cigarettes and 40.3% used hookah. Regression analysis found several variables, including province of residence, marital status, and attitude toward smoking, as predictive factors for both smoking behaviors [14].

Moeini and Allah Vardipour explored smoking predictors among 900 male high school students in Malayer City, Iran, revealing a 14% smoking rate with an average starting age of 12 and identifying factors, including parental conflicts (76%), a history of running away from school (72.2%), entertainment, and having smoking friends (71.4%). Getting rid of anxiety and anger, despair, mental and emotional pressures, and an insecure family environment were also significant factors [15]. Ebadi et al. analyzed smoking behaviors among 27883 Iranians aged 18-65, reporting a 25.4% smoking rate, and identified age, education, gender, occupation, and marital status as significantly associated with smoking [16]. Sarami et al. reviewed two decades of research on drug use epidemiology among Iranian university students, noting an upward trend in usage, particularly of cigarettes (20.25%) and hookah (31.5%) [17]. Pirdelghan et al. studied factors influencing cigarette use among 450 high school students in Yazd City, Iran, reporting a 23.5% smoking rate, and identified gender, parental smoking, peer pressure, religious adherence, and home environment satisfaction as key predictors, among several other demographic, psychological, and social factors [18].

Pirdelghan et al. investigated hookah smoking among 704 pre-university students in Yazd City, Iran, revealing a 31.1% prevalence and identifying various demographic and psychosocial factors (e.g. gender, household income, social environment disturbances) significantly associated with consumption [19]. Fazeli found that 16% of 108 student smokers began before age 10 and identified attitudes as a highly correlated predictor of smoking tendencies among 361 students [20]. A 2021 study by Alborzi and Mozafari among 600 youths [18-29] in Shiraz showed that 44.2% had previously smoked hookah, linking its use to socio-cultural factors like age, gender, and education level [21]. Khayati et al. discovered that 46.47% of students at the Islamic Azad University of Kurdistan Province, Iran, had tried smoking, often associated with recreation and entertainment, with 50% of cigarette and 20.05% of hookah smokers intending to quit [22]. The 2021 national survey reported that 34.59% of men and 7.23% of women used tobacco, with specific percentages using cigarettes and hookah [9]. Various factors related to smoking across different age and educational groups have been documented (Table 2).

Also, various domestic studies reported different figures for smoking prevalence (Table 3).

System dynamics studies in different fields of health and tobacco

Initially, some COVID-19 dynamic studies are reviewed, then the issue of patient safety management in hospitals is examined, and finally, the studies on tobacco and cigarettes are discussed.

Shuwei et al. (2022) developed a model assessing COVID-19’s health and social impacts, employing several strategies like material supply and public opinion dissemination and utilizing causal chain analysis and dynamic simulations to pinpoint optimal combination modes [23]. Azizi and Seifi compiled a demographic isolation model based on COVID-19 dynamics and its spread in Iran, studying virus behavior and propagation [24]. Bastan et al. investigated clinical risk management in hospitals through a system dynamics approach, identifying, mapping, and simulating systemic problem-generating structures and enabling systematic effectiveness evaluation of management systems [25].

Ghafrakchi et al. explored addiction dynamics, particularly women’s addictions. They found that addiction acts as a dynamic system to manage tensions from life changes. They highlighted the significant role of addiction in maintaining a dynamic balance in macrosocial systems after other systems fail without determining...
causality [26]. Skinner et al. provided insights into tobacco control programs in Australia, leading to a marked decrease in smoking prevalence (from 23.1% in 2001 to 14.6% in 2016) and in highly dependent smokers (from 61.9% to 53.2%) through various interventions like tobacco tax and anti-smoking campaigns [27].

Lastly, Maciosek et al. detailed the health and economic outcomes of a smoking reduction in Minnesota from 1998 to 2017. They reported that the decrease in adult smoking prevalence (from 21.8% in 1997 to 15.2% in 2016) resulted in numerous health benefits and cost savings, including preventing 4560 cancers and 4118 smoking-related deaths and saving approximately 2.7 billion dollars on health care while gaining 2.4 billion dollars in productivity. The comprehensive tobacco control measures were deemed effective in reducing smoking prevalence, saving costs, and preventing tobacco-related illnesses in Minnesota [28].

The review in Iran did not yield significant results and reports on tobacco as a dynamic system with psychological, physical, and social dimensions and micro, mezzo, and macro levels. Moreover, the functions of this system are to ensure the equilibrium of the macro system and evaluate the compensation of inadequacies in other institutions. Therefore, the theoretical and research gap and different research assumptions are the main reasons for using other researchers’ and even hypothetical data.

Theoretical framework

The underlying causes of social problems and phenomena are diverse and cannot be studied by a single factor. To account for all aspects of smoking, various reasons have been analyzed.

In this research, we combined Merton’s anomie theory with Besta’s relative deprivation theory, Sutherland’s differential association theory, Hirschi’s social control theory, and youth subculture theory. Based on these theories, a person interacts with social institutions, such as family, friends, etc. when using tobacco products (Figure 1). Individuals’ tendency to use tobacco (as a dependent variable) is associated with the surrounding

<table>
<thead>
<tr>
<th>Component</th>
<th>Smoking Component</th>
<th>Smoking</th>
<th>Community</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unemployment</td>
<td>Low-income family emotional support</td>
<td>+</td>
<td>University students</td>
</tr>
<tr>
<td>Poor education</td>
<td>Low grade point average (GPA) in the previous academic years</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Family members</td>
<td>Being religious</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Friends with a tendency to addiction</td>
<td>Having a smoking friend</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Financial problems</td>
<td>Other age groups</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Marital conflict</td>
<td>Positive attitude towards smoking</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Lack of exercise</td>
<td>Marital status</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>Lacking the power to say no</td>
<td>Province of residence, native and non-native</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Anger and frustration, mental and emotional pressures</td>
<td>An unsafe family atmosphere</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Relieving anxiety</td>
<td>Capital and general self-efficacy</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Fun and entertainment</td>
<td>Health-related, social, and cultural capital</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>History of running away from school</td>
<td>High school students</td>
<td></td>
<td>The youth</td>
</tr>
<tr>
<td>Parental conflict and argument</td>
<td>Social belonging</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Alcohol consumption</td>
<td>Education</td>
<td>+</td>
<td></td>
</tr>
<tr>
<td>Emotional support</td>
<td>Marital status</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Gender (male)</td>
<td>+</td>
<td></td>
</tr>
</tbody>
</table>

+Positive effect, -Negative effect.

Table 2. Predictors of smoking in different age groups (source: Reviewed articles)
environment, such as creating social control, feelings of deprivation, creating suitable social and environmental conditions, social normlessness, and youth subculture as independent variables.

Our research methodology is based on the stages of the system dynamics method. By introducing the generative structure of problematic behavior based on systemic thinking [29], dynamics serves as an effective tool for analyzing and understanding the causes of dynamic behavior in complex systems.

This methodology provides the appropriate conditions for improving problematic behavior and presenting more effective solutions based on systemic thinking. It evaluates different decision policies using various scenarios and learning from the system as a result of this methodology. Through qualitative simulations of implementing a policy in a small setting, referred to as a micro-world [30, 31], we can provide more effective solutions based on systemic thinking. This figure illustrates the nonlinear modeling process proposed by Sterman (Figure 2). In this case, the modeling approach is not a linear sequence of steps but a feedback process. A repeating cycle is shown in the modeling process, which can generally change our initial understanding of the problem and resolve it through feedback. Thus, repetition may occur at various stages, and the results obtained at each stage can lead to the correction and editing of other stages due to feedback received at each stage.

Table 3. Prevalence of smoking in various domestic research studies

<table>
<thead>
<tr>
<th>Categories</th>
<th>Tobacco</th>
<th>Cigarettes</th>
<th>Hookah</th>
</tr>
</thead>
<tbody>
<tr>
<td>High school students</td>
<td>-</td>
<td>23</td>
<td>31.1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>11.4</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>6.5</td>
</tr>
<tr>
<td>University students</td>
<td>-</td>
<td>20.25</td>
<td>31.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>-0.51</td>
</tr>
<tr>
<td>Population over 15 years of age</td>
<td>-</td>
<td>11.7</td>
<td>9.1</td>
</tr>
<tr>
<td>18-29 years</td>
<td>-</td>
<td></td>
<td>44.2</td>
</tr>
<tr>
<td>18-65 years</td>
<td>-</td>
<td>25.4</td>
<td>-</td>
</tr>
<tr>
<td>Men</td>
<td>23.24</td>
<td>17.4</td>
<td>22.2</td>
</tr>
<tr>
<td>Women</td>
<td>3.54</td>
<td>0.74</td>
<td>196.2</td>
</tr>
<tr>
<td>Men</td>
<td>34.59</td>
<td>26.06</td>
<td>10.51</td>
</tr>
<tr>
<td>Women</td>
<td>7.23</td>
<td>1.21</td>
<td>6.2</td>
</tr>
</tbody>
</table>

Figure 1. Factors affecting smoking based on different theories (source: Reviewed articles)
Results

According to the system dynamics methodology, the behavior of a system is determined by its structure, encompassing feedback loops, stocks, and corresponding flows, along with nonlinear relationships between them. The stock and flow model constitutes an essential component of the system dynamics approach. This quantitative continuous mathematical simulation model can simulate various policies and decisions’ long-term effects and consequences. This model was constructed using a sample of parameters used in international research models and the data of several domestic studies on smoking prevalence (Tables 2 and 3).

Also, the systems dynamics approach has been used to analyze the variables affecting smoking. Using this approach, it is necessary to identify the factors that affect the system’s performance.

Cause and effect diagrams and models

Based on the literature review, it has been determined that a variety of factors contribute to the prevalence of smoking, some of which are illustrated in factors influencing smoking levels (Figure 3) and predictors of smoking in different age groups (Table 2).

As shown in Figure 4, tobacco use fluctuates where the population of smokers is impacted by two factors: People who become smokers every year based on prevalence rates and people who quit smoking or died from related diseases. Due to the lack of statistics pertaining to smoking Social abnormality, Social control, Environmental social conditions, Feeling deprived, Living in certain provinces, Easy Access, despair in the family, internal pressure, death of parents, Fear of the future, Family dispute, Arguments, Marital status, paying money, Low income, Religious tendencies, Satisfaction with family, Health Family, Parents education, School, Workplace, Smoking friends, Consumer attitudes, History of running away from school, alcohol consumption, alcohol consumption, work environment, smoking prevalence, smoking cessation, and related diseases.
to people who have died as a result of smoking, this variable was not included in the analysis.

Using the chart above, definitions are provided for each variable that may be subject to epidemiological and statistical errors.

Conversely, smoking increases the burden of disease, which can lead to increased disability and mortality, as well as reduced productivity. This will negatively impact the economy’s growth due to reduced productivity.

Figure 5 illustrates the formation of a positive feedback loop. Smoking increases the burden of disease and, in turn, increases the burden of disability. Disability increases mortality, which in turn has a negative and decreasing effect on an organization’s productivity, jobs, and the work environment. Obviously, the decrease in productivity caused by deaths and disabilities in the work environment contributes to a decline in the economy. The reduction in economic growth, in turn, leads to an increase in disease burden, and this increasing cycle will adversely affect the public’s health.

Figure 6 illustrates the relationship between tobacco consumption and its distribution. Tobacco use and distribution are reciprocally related. As a result, a self-reinforcing positive feedback loop is established.

Several factors influence the distribution and supply of tobacco products, including the cultivation area, legislation, taxes, and smuggling. Similarly, laws and regulations control the distribution of tobacco products, so stricter laws reduce distribution and increase smuggling, which in turn leads to enforcing stricter laws. As a result of regulations, tax rates increase, impacting the area of cultivation and distribution (Figure 7).

**Table 4. Definitions of chart variables**

<table>
<thead>
<tr>
<th>Title</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary population</td>
<td>The number of possible consumers (total population×birth rate+immigrant rate)-children under 6 years old)=70000000</td>
</tr>
<tr>
<td>Annual growth rate</td>
<td>Prevalence=20.90%</td>
</tr>
<tr>
<td>Annual cessation rate</td>
<td>The degree of willingness to quit (50% is included)</td>
</tr>
<tr>
<td>New smokers</td>
<td>Number of possible consumers×growth rate</td>
</tr>
<tr>
<td>Smoking population</td>
<td>Current user-number of people who quit+new users</td>
</tr>
</tbody>
</table>

**Figure 4. Tobacco use flowchart (source: Vensim software output)**

**Figure 5. Cause and effect cycle of the impact of disease burden caused by smoking (source: Vensim software output)**
The loops of smoking predictors are shown in Figure 8. This loop diagram is a combination and simplified version of Figures 5-7. Generally, smoking is influenced systemically by taxes, cultivation areas, distribution channels, smuggling, and laws and regulations, each supported by a network of subsystems.

### Scenarios related to the flow of the population of tobacco users

The modeling process is conducted based on the flowchart of the tobacco user population. This modeling is based on a selected period of 4 years (until 2025) (Figure 9).

Following the above model, two variables can affect fundamental changes in the next 4 years: Tobacco use and annual cessation rates. This process will result in a simultaneous decrease in both the annual growth rate and the cessation rate (scenario 1), which will reduce the population of tobacco users (Figure 10).

If we reduce the increase rate by 2.5% per year and increase the cessation rate by 4% per year, the tobacco user population will decrease significantly from the second year onwards.

### Discussion

#### Control policies

This comprehensive study has identified and explored two key control policies throughout its development: One focused on judicious reductions of tobacco consumption and another strategically oriented towards escalating effective smoking cessation rates. The first policy, which aims to reduce consumption rates, involves various interventions, including establishing an active learning plan to raise awareness. As part of this approach, not only are children and primary school students taught, but also demographic groups that exhibit the highest consumption rates are strategically targeted with tactics such as text messaging and telephone coun-

---

**Figure 6.** Chart of tobacco use (consumption) and distribution (source: Vensim software output)

**Figure 7.** Variables affecting tobacco distribution (source: Vensim software output)

**Figure 8.** The tobacco use (consumption) and distribution loops and the factors affecting them (source: Vensim software output)

**Figure 9.** Flowchart of the tobacco user population (source: Vensim software output)

**Figure 10.** Scenarios related to the flow of the population of tobacco users (source: Vensim software output)
suling. Moreover, this policy facilitates the creation of viable alternatives such as electronic cigarettes and alternative tobacco products, incorporating methods like raising tobacco taxation, organizing tobacco product supply and distribution, implementing birth certificate requirements for smokers, and monitoring tobacco product distribution. Additionally, several interventions are considered critical, including those designed for the workplace, schools, families, and communities, using mobile phones for community-based interventions, and examining various methods for enhancing the effectiveness of community-based interventions.

On the other hand, the policy focused on enhancing the effective cessation rate embarks upon a broad spectrum of strategies, such as developing smoking quitting clinics that provide pharmacological treatment and insurance coverage and utilizing cultural means to encourage smokers to quit smoking progressively. This campaign significantly highlights this detrimental habit’s negative social value, especially among the youth and adolescent demographic. Through various media and activities, efforts have fortuitously been made to deemphasize the social value of smoking, especially among younger populations. The various activities include getting fatwas, establishing anti-tobacco centers, passing laws from the Islamic Councils, practical advertising in the media, and enforcing stringent smoking prohibitions in public transportation facilities, thus making smoking an anti-value in society. The rigorous application of such measures can notably influence smoking cessation. Furthermore, the simultaneous encouragement and fortification of religious beliefs are discerned as two paramount factors in smoking cessation. Alongside the hostile combat against smoking, the promotion of religious beliefs and the motivation to quit smoking should not be marginalized, considering the profound impact religious beliefs can potentially harness in facilitating smoking cessation, thereby reflecting a holistic approach towards human progress and wellbeing.

**Conclusion**

Studies on tobacco, which were conducted either using a system dynamics approach or qualitative and descriptive methods, demonstrate that no quantitative decision support system can be used to assess whether the development policies of this system are effective. It is therefore recommended that a comprehensive research topic be chosen.
The literature review also indicates suitable international studies using the system dynamics approach; however, Iranian researchers have not researched this topic. Consequently, it is essential to investigate this topic using a systematic approach to identify the dynamic hypotheses of the cause of the problem, as well as to simulate the proposed policies to improve the behavior of the essential variables. In any model development, it is crucial to access reliable and accurate data, which cannot be collected efficiently and transparently in Iran.

To achieve the goals of reducing tobacco consumption in the health system of the Islamic Republic of Iran, it is proposed to implement the above two control scenarios.

Ethical Considerations

Compliance with ethical guidelines

There were no ethical considerations to be considered in this research.

Funding

This research received no specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Authors' contributions

Conceptualization, study design, the definition of intellectual content: Ali Mohammad Ahmadvand; Investigation, writing, reviewing and editing: Ahmad Haghiri Dehbarez; Project administration and literature search: Ahmad Haghiri Dehbarez and Amir-bahador Morovat; Statistical analysis and supervision: Amir-bahador Morovat. Statistical analysis: Ali Mohammad Ahmadvand and Amir-bahador Morovat.

Conflict of interest

The authors declared no conflict of interest.

References


