Letter to Editor

Agent-Based Modeling: An Innovative Opportunity for Population-Based Oral Health Promotion

Maryam Sadeghipour Roudsari [1], Seyed Peyman Shariatpanahi [2], Arezoo Ebn Ahmady [3], Mohammad Hossein Khoshnevisan [4]✉

[1] PhD Candidate, Community Oral Health Department, School of Dentistry, Shahid Beheshti University of Medical Sciences (SBMU), Tehran, Iran; Preventive Dentistry Research Center, Dental Research Institute, Shahid Beheshti University of Medical Sciences (SBMU), Tehran, Iran
[2] Assistant Professor, Institute of Biochemistry and Biophysics, University of Tehran, Tehran, Iran
[3] Associate Professor, Community Oral Health Department, School of Dentistry, Shahid Beheshti University of Medical Sciences (SBMU), Tehran, Iran
[4] Associate Professor, Preventive Dentistry Research Center, Dental Research Institute, School of Dentistry, Shahid Beheshti University of Medical Sciences (SBMU), Tehran, Iran; Community Oral Health Department, School of Dentistry, Shahid Beheshti University of Medical Sciences (SBMU), Tehran, Iran

✉Corresponding author: MH. Khoshnevisan, Preventive Dentistry Research Center, Dental Research Institute, School of Dentistry, Shahid Beheshti University of Medical Sciences (SBMU), Tehran, Iran. mh.khoshnevisan@sbmu.ac.ir

Received: 4 August 2015
Accepted: 27 December 2015
Journal of Dentistry, Tehran University of Medical Sciences, Tehran, Iran (2016; Vol. 13, No. 2)

Dental health plays a substantial role in general health and quality of life. Tooth decay has been emphasized as the most prevalent chronic microbial condition, which is multifactorial and influenced by many lifestyle factors [1]. Although many oral diseases are preventable, it is still challenging for many individuals to maintain their oral health at optimal level.

A range of oral health promotion programs, from individual to community levels, has been designed to focus on lifestyle improvement and specifically on health behaviors. Although programs at the community level can significantly improve the public oral health status [2], it must be noted that when the size of target population increases, the cost of care increases rapidly [2]. Under these circumstances, reducing the cost and increasing the effectiveness of program are crucial for public oral health improvement.

Researchers have mostly focused on individual factors that affect dental health behaviors ranging from psychosocial to socioeconomic and environmental factors [3]. Although, these factors have considerably large effects on individuals' health behaviors, the role of other factors such as "social network" at the community level has not been taken into account for evaluation of collective behaviors in a society. It has been recognized that personal behaviors are mostly formed through social connections. These contacts are well-known to be the source of many collective behaviors at the community level [4].

The importance of this approach becomes even clearer when observing ever-growing effects of Internet-based social networks on our lives. Therefore, based on the current literature, we can extrapolate that contacts through social networks are potentially one of the most effective tools that can be applied to oral health promotion at the public level. By using interdisciplinary approaches, we can have a better impact on behavioral modification.

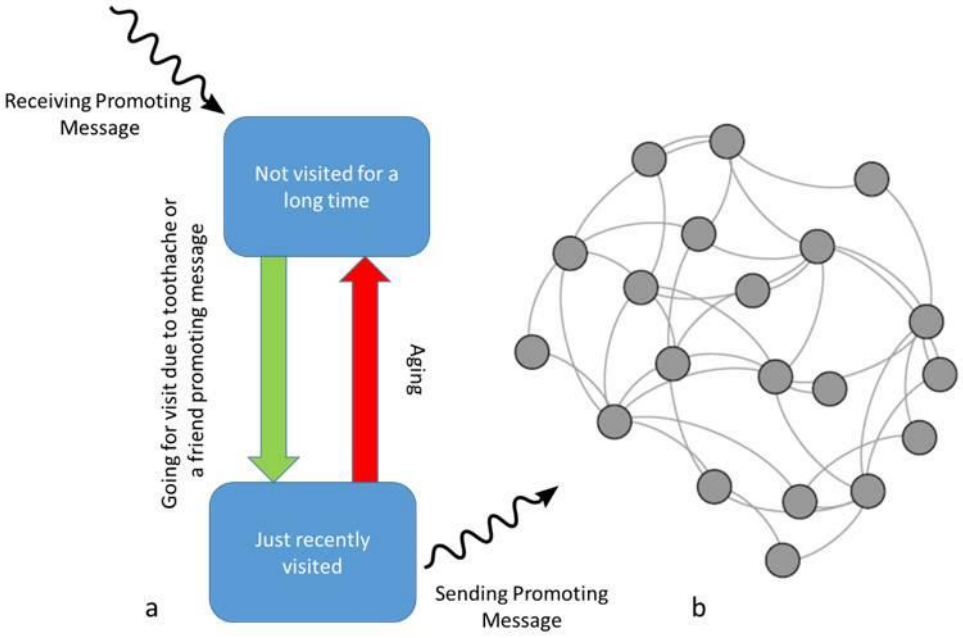

Fig. 1: Schematic view of an agent-based model. a) Simplified agent behavior exchange and (b) simulated social network structure

Modeling of complex systems has been introduced as one of the most effective tools to investigate behavioral modifications at the social level. The knowledge learned through such mathematical models can considerably reduce the overall cost and improve the effectiveness of preventive programs. In this case, a simulation model, which represents a simplified real world situation will be used to address specific questions or problems. Such models facilitate testing different proposed scenarios originated from different policies, strategies and decisions. On the other hand, mathematical and computational modeling is a set of relational methods that can identify connections between adapted policies of health system in order to predict their outcomes. For example, modeling could be built on the concept of preventive care, oral health promotion and level of effectiveness. The agent-based modeling (ABM), as one of the complex system modeling methods, is often used to assess collective behaviors within different social structures. This modeling simulates a simplified artificial society considering specific characteristics of the real world situation in a given society. The behavior of each participating individual (agent) is represented as well. Additionally, the interaction between individuals and within their social network structure is modeled. Furthermore, ABM simultaneously considers agent-environment interactions. It is able to predict different social behaviors and their emerging properties. Based on simple rules, the relationship among agents is detectable when using this method. These behavioral properties are embedded within interconnections among the model elements and cannot be predicted before simulation [5]. In contrast to other system modeling methods, ABM focuses on the agents' relationship with other agents through social networks indicating that, in many cases the network structures can significantly influence the collective behaviors [6]. In short, ABM is most useful when the dynamics of behaviors at the societal level is deeply influenced by individuals' interactions through social networks.

Apparently, ABM applications in dental public health has been poorly studied [7], while we can observe that, there is a fast growing application of this method in other public health areas such as the ABM application as a tool for better understanding of epidemiological problems [8] and its use for evaluation of the transmission of infectious diseases [9].

Likewise, ABM was used to assess health-related behaviors in different societies [10] like certain groups such as alcoholics [11] and obese individuals [12]. Other investigators focused on studying the spread of emotion in selected societies [13].

In order to show practical application of ABM in oral and dental public health, herein, we present an example of using this method to assess the dental visit demand in a selected society [14]. Figure 1a demonstrates a very simple ABM model for our evaluation. Each individual could have two visiting status: (I) Those who had no recent dental visit and (II) those who had a recent dental visit. Those in the first category may need to have an emergency visit or otherwise, one may choose to have a dental visit if somehow get encouraged by close friends such as those in the second category, who had a recent dental visit. Figure 1b shows the simulation of friendship network among individuals.

This simplified model, when simulated, is able to answer the following questions:

1- What are the collective behaviors of the group (system)? Will agents go for visit individually or collectively all together or they react uniformly over time?

2- Which parameters determine the collective behaviors?

3- Are there any emerging properties in the collective behaviors? For example any oscillation for the number of visits per month?

4- What message does the model behavior suggest for resource management (dentist)?

5- What is the role of network structure in the model behavior? Is outcome behavior sensitive to the network structure?

6- What happens to the model behavior if the network structure changes?

7- As a hypothetical promotion program, which agents (key agent) would better be promoted to most effectively influence group behavior?

8- What is the best network type for the most effective oral health promotion program? Can we plan to create and use such networks in the society?

The present overview serves as a synopsis for the ABM with emphasis on how this innovative method could be applied to improve oral health promotion and preventive care programs at the community level. Likewise, using social network opportunity seems to be a feasible and promising approach for oral health promotion at the society level.

REFERENCES

1- Petersen PE. Challenges to improvement of oral health in the 21st century—the approach of the WHO Global Oral Health Programme. Int Dent J. 2004 Dec;54(6 Suppl 1):329-43.

2- Satur JG, Gussy MG, Morgan MV, Calache H, Wright C. Review of the evidence for oral health promotion effectiveness. Health Educ J. 2010 May;69:257-66.

3- Paula JS, Leite IC, Almeida AB, Ambrosano GM, Pereira AC, Mialhe FL. The influence of oral health conditions, socioeconomic status and home environment factors on schoolchildren's self-perception of quality of life. Health Qual Life Outcomes. 2012 Jan; 10(1):1.

4- Goldstone RL, Janssen MA. Computational models of collective behavior. Trends Cogn Sci. 2005 Sep;9(9):424-30.

5- Helbing D. Social self-organization: Agent-based simulations and experiments to study emergent social behavior. 1st ed., Zurich, Springer, 2012:25-70.

6- Macal C, North M. Introductory tutorial: Agent-based modeling and simulation. 1st ed., Piscataway, NJ, IEEE Press, 2014:6-20.

7- Metcalf SS, Northridge ME, Widener MJ,

Chakraborty B, Marshall SE, Lamster IB. Modeling social dimensions of oral health among older adults in urban environments. Health Educ Behav. 2013 Oct;40(1 Suppl):63S-73S.

8- Kanagarajah AK, Lindsay P, Miller A, Parker D. An exploration into the uses of agent-based modeling to improve quality of healthcare. Unifying Themes in Complex Systems. Berlin Heidelberg, Springer, 2010:471-8.

9- Gangel M, Seiler MJ, Collins A. Exploring the foreclosure contagion effect using agent-based modeling. J Real Estate Financ 2013 Feb;46(2):339-54.

10- Christakis NA, Fowler JH. Social contagion theory: examining dynamic social networks and human behavior. Stat Med. 2013 Feb 20;32(4):556-77.

11- Mundt MP, Mercken L, Zakletskaia L. Peer selection and influence effects on adolescent alcohol use: a stochastic actor-based model. BMC Pediatr. 2012 Aug 6;12:115.

12- Christakis NA, Fowler JH. The spread of obesity in a large social network over 32 years. N Engl J Med. 2007 Jul 26;357(4):370-9.

13- Adam C, Canal R, Gaudou B, Vinh HT, Taillandier P. Simulation of the emotion dynamics in a group of agents in an evacuation situation. Principles and practice of multi-agent systems. Berlin, Heidelberg, Springer, 2010:604-19.

14- Sadeghipour M, Shariatpanahi P, Jafari A, Khosnevisan MH, Ahmady AE. Oscillatory patterns in the amount of demand for dental visits: An agent based modeling approach. J. Artif. Soc. Soc. Simulat. 2016 Jun;19(3):10.