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## The Agent-based Value Co-creation Behaviors in Online Health Communities and Its Influencing Factors

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# The Agent-based Value Co-creation Behaviors in Online Health Communities and Its Influencing Factors

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**Abstract.** In order to explore the mechanism of value co-creation behaviors in online health communities, a multi-agent conceptual model was constructed to simulate the dynamics of value co-creation in different online health communities. The corresponding results deny that the more trust community members have in each other, the better it is to co-create values in the community, suggesting to manage communities according to their patterns and the conditions of community members. According to our research data, to improve the mindsets and knowledge reserves of community members is the key to strengthen value co-creation in online health communities.

## 1. Introduction

With the development of science and technology and the higher levels of education, patients have changed their behaviors from passively receiving healthcare services<sup>[1]</sup> to actively using online platforms to self-manage their health<sup>[2]</sup>. The online health platforms allow patients to discuss confusions over treatments<sup>[3]</sup> with each other and integrate a variety of resources<sup>[4]</sup> that will create value for themselves. This unique pattern is called value co-creation<sup>[5]</sup> in online health communities (short for OHCs). Value co-creation by patients has become the research focus in the service science field<sup>[6]</sup>, because it provides an effective access for participants to spend less and gain more in enjoying medicine and healthcare services to strengthen physical and mental health<sup>[7]</sup>.

There have been empirical documents about the influence of social capital<sup>[8]</sup>, empathy, social identity<sup>[9]</sup>, trust, and shared vision on value co-creation behaviors in OHCs. But value co-creation behaviors are such a complex dynamic system which is subject to intricate influencing factors that the selected variables and control conditions in empirical analysis have some limitations. On this basis, the agent-based simulation model is established in this paper to simulate the value co-creation behavior mechanism in OHCs, providing reference for building up a system that is effective to support and encourage system users to share knowledge and co-create values. The following parts in this paper are: the second part, an analysis of relevant theories; the third part, constructing a value co-creation model and simulating value co-creation in online health communities; the fourth part, discussion and analysis; the fifth part, conclusions.



## 2. Agent-based modeling of OHC value co-creation

### 2.1. Model assumptions

The value co-creation behaviors in OHCs are a complex system that is subject to a wide range of factors. As all influencing factors cannot be included in the simulation model, we put forward the following assumptions:

Assumption 1: The total number of agents  $N$  in the community and the initial state of the agents  $I$  are known external conditions.

Hypothesis 2: The influence of mutual trust between and medical knowledge of community members on value co-creation behaviors in OHCs is considered.

Hypothesis 3: If information is adopted, the information provider will be more willing to offer information; if information is rejected, the information provider will be less willing to offer information; when the level of mutual trust between OHC members increases, the willingness to offer information will increase accordingly.

### 2.2. Subject attribute

The patients in the online health community are both resource demanders and providers. From the perspective of resource supply and demand, value co-creation agents can be divided into information consultants and information providers. Their attributes are shown in Table 1.

**Table 1.** Agent attribute settings

Agent type	attribute	Attribute description	Variable setting
Information consultant	state $I_c(a, b)$	$a$ is the mental state of patients faced with diseases; $b$ is the experimental knowledge of the patient	$a \in [-1, 1]$ , $b \in [-1, 1]$ . Negative $a$ and negative $b$ refer to pessimism and wrong knowledge, respectively; positive $a$ and positive $b$ refer to optimistic attitude and correct knowledge. The closer $a$ and $b$ are to, the higher degree it is.
	Consulting willingness $Q$	The willingness to consult others in the OHC	$Q \in [0, 1]$ , which is positively proportional to the patient's trust in the OHC $T$ and state of mind $a$ , and negatively proportional to the patient's knowledge level. Only when the value of $Q$ exceeds a threshold will the patient ask questions.
	Accepting probability $P$	The probability of an information consultant to accept the support of other members in the OHC	$P \in [0, 1]$ . The higher value $P$ is, the more supports the patient accepts from other patients.
Information provider	state $I_p(a, b)$	$a$ is the mental state of patients faced with diseases; $b$ is the experimental knowledge of the patient	$a \in [-1, 1]$ , $b \in [-1, 1]$ . Negative $a$ and negative $b$ refer to pessimism and wrong knowledge, respectively; positive $a$ and positive $b$ refer to optimistic attitude and correct knowledge. The closer $a$ and $b$ are to $\pm 1$ , the higher degree it is.
	Supplying willingness $W$	The willingness to provide supports for information consultants	$W \in [0, 1]$ , which is positively correlated with the patient's state and trust in the OHC $T$ .

### 2.3. Interaction Rules

#### (1) the value contribution behavior of OHC members

At a moment  $t$ , the information demander  $i$  whose  $Q$  value is larger than 0.5 requests information from other members in the OHC, and the information provider  $j$  ( $J = 1, 2, 3, \dots i-1, i+1, \dots N$ ) decides to provide information to  $i$  according to his willingness of information provision  $W_j$  and state  $I_j$ . When receiving the information from patient  $j$ , patient  $i$  decides whether or not to adopt the information according to his degree of trust in  $j$ , discernment of knowledge, and information from  $j$ . In the case of low knowledge, the level of trust is the major factor influencing the patient's choice; in the case of high knowledge, the patient's choice is heavily dependent on his/her own knowledge and their agreement on the issue.

#### (2) OHC member information adopting behavior

In light of the different states  $I$  and degrees of trust in the OHC, there are different quantities of knowledge  $S$  from patient  $j$  to be adopted and transformed. Highly discerning patients are able to acquire useful or positive information, while poorly discriminative patients are likely to absorb wrong or negative information. In this case, the level of trust is the major factor influencing the patient's choice.

#### (3) OHC member state update

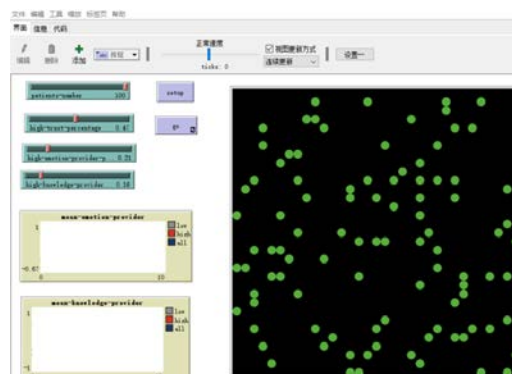
With continuous changes in the interaction process, according to the model hypothesis, if information is adopted, the information provider will be more willing to offer information; if information is rejected, the information provider will be less willing to offer information; when the level of mutual trust between OHC members increases, the willingness to offer information  $W$  will increase accordingly.

## 3. Organization of the Text Simulation and Analysis of OHC value co-creation model

### 3.1. Simulation platform introduction

The Netlogo simulation platform is a multi-agent modeling and simulation integration environment developed by Northwestern's Center for Connected Learning and Computer-Based Modeling. It is the right one for the modeling and simulation of time-varying complex systems.

In the initial condition  $N = 100$ , we analyze how the willingness of information demand and supply varies with the change of the initial member state  $I$  ( $a, b$ ) and the mutual trust  $T$ , and how the co-created value (the mental state and knowledge state of all OHC members) alters accordingly. The simulation experiment is shown in Figure 1, in which the green dots represent the 100 patients in the OHC. Adjustable parameters include the proportion of community members with high level of trust, the proportion of positive and optimistic members, and the proportion of patients with correct medical knowledge.

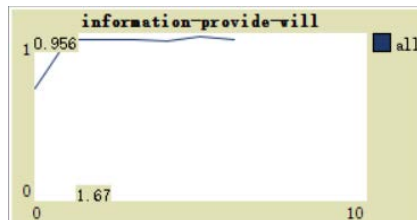


**Figure 1.** Online health community value co-creation behavior simulation experiment

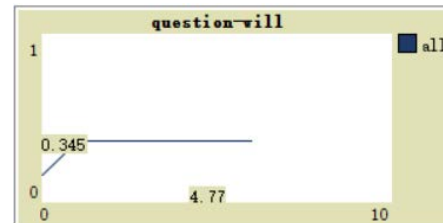
### 3.2. Online health community value co-creation behavior simulation in different situations

(1) The situation is when the levels of trust between OHC members are all higher than  $Q$ , but the proportion of positive and optimistic members with correct medical knowledge is as low as  $Q$ . In this

situation, the willingness of information demand and supply increases with the higher level of interaction, as shown in Figure 2-3. The x-coordinate is time, and the y-coordinate is the willingness of information demand/supply whose value ranges between 0 and 1. The more closer to 1 the ordinate value is, the higher the willingness is. According to the figures, despite the huge growth of information providing willingness which levels off at a high level, the rise in information consulting willingness is relatively small.

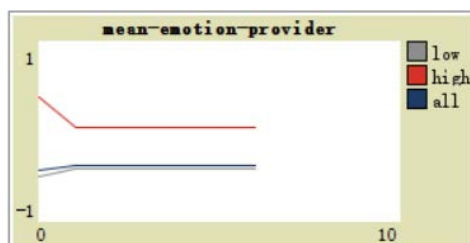


**Figure 2.** providing willingness change 1

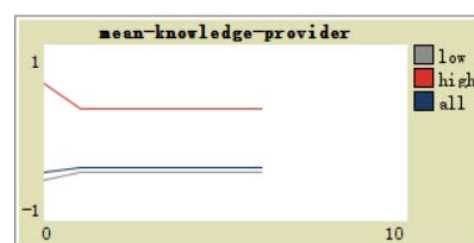


**Figure 3.** consulting willingness change 1

The value co-creation results of all OHC members are shown in Figure 4 and Figure 5. Figure 4 is the change of mental state of all members, whose x-coordinate and y-coordinate represent the interaction time and the mental state (ranging from -1 to 1), respectively. The mental state of patients are positive and optimistic when the ordinate value is more than 0; the more closer it is to 1, the higher level of positive and optimistic mind the patient has. The mental state of patients are negative and pessimistic when the ordinate value is less than 0; the more closer it is to -1, the higher level of negative and pessimistic mind the patient has. In the figure, the red line represents the average mental change of the community members whose initial state is positive and optimistic, the grey line represents the average mental change of the community members whose initial state is negative and pessimistic, and the blue line is the mental change of all the community members. According to the figure, as the interaction continues, the mental state of negative and pessimistic members is slightly improved, leveling off at a lower level Q; while the mental state of positive and optimistic members is greatly worsened, levelling off at Q. The mental state of all community members is improved to Q, which is relatively pessimistic and negative. Figure 5 shows the change in the overall knowledge level of the community members. The horizontal and vertical axes represents the interaction time and the knowledge level of community members, respectively. The ordinate value ranges from -1 to 1. The patients have correct medical knowledge when the ordinate value is more than 0; the more closer it is to 1, the higher amount of correct knowledge the patients have. The patients have wrong medical knowledge when the ordinate value is less than 0; the more closer it is to -1, the higher amount of wrong knowledge the patients have. It can be seen from Figure 5 that the knowledge level of low-knowledge community members changes, the knowledge level of high-knowledge community members decreases, and the overall knowledge level increases slightly.



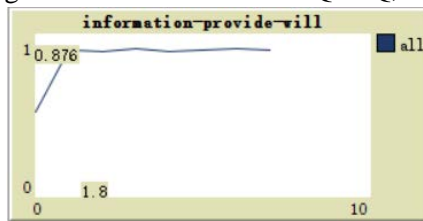
**Figure 4.** Mental changes 1



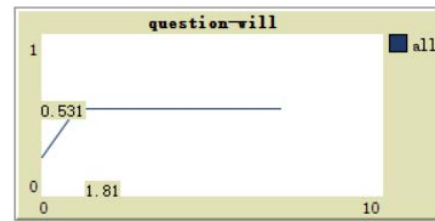
**Figure 5.** Knowledge change 1

The situation is when the levels of trust between OHC members are low, Q of which has higher level of trust than Q, but the proportion of positive and optimistic members with correct medical knowledge is as high as Q. In this situation, the willingness of information demand and supply increases with the higher level of interaction, as shown in Figure 6-7. The information providing

willingness increases from Q to Q and maintains steady at a high level; the information consulting willingness also increases from Q to Q, exceeding the one in the first situation.

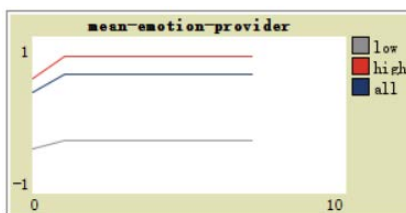


**Figure 6.** Willingness change 2

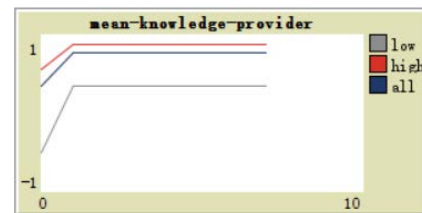


**Figure 7.** Consulting willingness change 2

The value co-creation results of all OHC members are shown in Figure 8 and Figure 9. Figure 8 shows that the proportion of members with poor initial mental states rises from Q to Q, and their negative and pessimistic mind is weakened; the proportion of members with good initial mental states rises from Q to Q; the overall mental state of community members increases from Q to Q. Figure 9 shows that the knowledge level of low-knowledge community members rises from Q to Q; the knowledge level of high-knowledge community members rises from Q to Q; and the overall knowledge level in the community rises from Q to Q. In spite of the low initial trust level between members, the mindsets and quality of medical knowledge are improved continuously as a result of online communication.

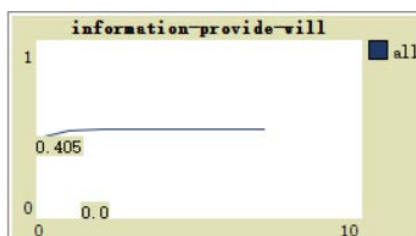


**Figure 8.** Mental changes 2

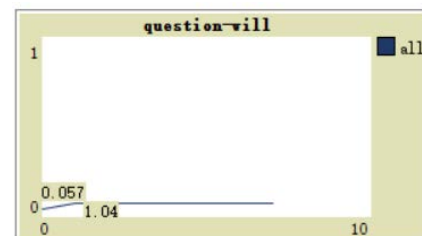


**Figure 9.** Knowledge change 2

The situation is when the level of trust between OHC members is relatively low, Q of which exceeds 0.5; the proportion of positive and optimistic members with correct medical knowledge is as low as Q. In this situation, the willingness of information demand and supply increases with the higher level of interaction, as shown in Figure 10-11. The information providing willingness increases; the information consulting willingness increases from Q to Q, albeit with the lowest growth rate in all situations.

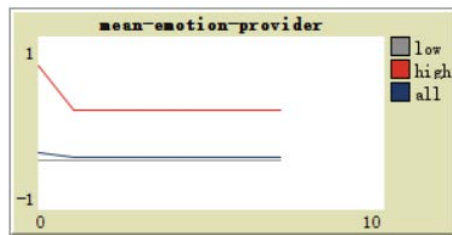


**Figure 10.** Providing willingness change 3

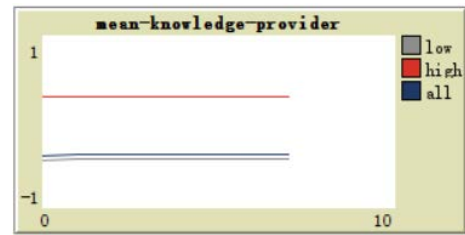


**Figure 11.** Willingness change 3

The value co-creation results of all OHC members are shown in Figure 12 and Figure 13. Figure 12 shows that the mental state of initially negative and pessimistic members is barely changed; the proportion of members with good initial mental states declines sharply from Q to Q; and the overall mental state of community members is worsened from Q to Q. Figure 13 shows that the overall knowledge level in the community basically remains unchanged.



**Figure 12.** Mental changes 3



**Figure 13.** Knowledge change 3

#### 4. Conclusion

Based on the above analysis, it can be found that OHC members with different initial states will conduct different value co-creation behaviors as the interaction between each other is deepened. The research data deny that higher level of mutual trust is more conducive to value co-creation behaviors in the community. The community management strategies should be targeted at community types and community member states. The high level of trust between members with poor initial states (with negative and pessimistic minds and wrong medical knowledge) is detrimental to value co-creation. OHCs with this problem should take measures to improve the mental state and knowledge quality of their members. When community members have good states (with positive and optimistic minds and correct medical knowledge), the value co-creation ability will be strengthened as the interaction between members is deepened, even if the initial level of mutual trust is low. Therefore, OHC management should give priority to improving the mindsets and knowledge quality of OHC members.

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