Study on Incentive Strategies for Recovery of Expired Drugs in Households

Zhang Huiying

Chongqing Vocational College of Transportation, Chongqing, China

Keywords: Household expired medicines, Recovery, Incentive strategy, Feedback relationship, System dynamics

Abstract: recovery of expired drugs in households is of great significance to the ecological environment and the safety of medication for the public, Through empirical research, Using the method of system dynamics modeling and imitation, And on the basis of comprehensive analysis of the feedback relationship among the various elements of the system, The system dynamics model is constructed and applied to the study of family expired drug recycling, The results show that the incentive strategy of adding recycling points has no significant effect on the increase of the amount of expired drugs recovered by families, The economic subsidy has no obvious effect on the increase of the amount of recovered drugs when the unit cost is 0, 5 yuan, While the amount of recovered drugs will increase rapidly when the unit cost is increased to 1 yuan, The short-term impact of the investment in the propaganda cost of expired drugs recycling is low, But in the long run, This strategy has more and more obvious incentive effect

1. Introduction

Due to the unreasonable habit of purchasing medicines, too large specifications of medicines packaging, large prescriptions of doctors and other reasons, the phenomenon of overdue medicines generally exists in urban and rural households in China. Improper disposal of expired medicines in families will cause serious harm to the safety of drug use and the ecological environment of the public[1].

The recovery of expired drugs in families in China is still in its infancy and exploring stage. There are two main recovery modes: government-led recovery mode and spontaneous recovery mode in pharmaceutical enterprises. However, due to the lack of direct economic benefits, the government-led recovery mode still dominates the recovery of expired drugs.

Through empirical research, this paper obtains the key factors that affect residents participation in expired drug recycling activities. Based on the comprehensive analysis of the feedback relationship among the elements of the system, a standardized and quantitative system dynamics model is constructed by using the method of system dynamics modeling and imitation. The model is applied to practical cases to realize the dynamic simulation and policy of the operation status of the actual recovery system. By simulation, the implementation effect of different recovery incentive strategies is intuitively investigated, which provides countermeasures, suggestions and methodological support for the formulation of better recovery schemes.

2. Analysis of Factors Affecting Residents' Participation in Family Overdue Drug Recycling

Based on the empirical research results of previous scholars on the influencing factors of consumers' recycling behavior, combined with the current situation of family expired drug recycling in China, the main factors affecting residents' participation in family expired drug recycling are as follows:

1) Economic factors

Lan Ying [2] et al. found that economic motivation has a significant impact on consumer's recycling intention when conducting empirical research on the influencing factors of consumer's intention to participate in the disposal of waste household appliances.

2) Residents' awareness of environmental protection and health

  DOI: 10.25236/soshu.2020.055

Previous studies have confirmed that residents' environmental awareness has a significant impact on individual waste disposal behavior. Whether they have sufficient knowledge of recycling and recycling projects is an important determinant of family participation in recycling projects[3].

3) Recycling Convenience

Some scholars found that 66.55% of the residents listed “convenience of recycling points” as the most important factor affecting their participation in drug recycling[4].

3. Modeling Based on System Dynamics

Feedback loop is a closed loop composed of a series of causal and interaction chains. It describes the main feedback mechanism of the system, which includes positive feedback and negative feedback. The positive feedback loop makes the deviation of variables in the loop increase continuously, while the negative feedback loop has the ability of self-regulation, which can restrain the change of variables and make the system stable [5].

Based on the analysis of factors affecting residents' participation in family expired drug recycling, the main feedback loops in the causal loop diagram of government-led family expired drug recycling are as follows:

Negative feedback loop B1: “The quantity of expired drugs recovered from regular drug recycling points” + “the expenditure for destruction of drugs invested by the government annually” - “the expenditure for propaganda invested by the government annually” + “the total expenditure for propaganda invested by the government” + “the quantity of expired drugs recovered from regular drug recycling points”.

Negative feedback loop B2: “The quantity of expired drugs recovered from regular drug recycling points” “the amount of recovered subsidies invested annually by the government”-”the propaganda funds invested annually by the government” + “the total propaganda funds invested by the government” + “the amount of expired drugs recovered from regular drug recycling points”.

In addition, there are many parameters that do not participate in the feedback loop in the causal loop diagram of the government-led family expired drug recovery system. They interact with each other and form many causal chains.

L1: “The number of recycling points added annually” + “the number of regular drug recycling points” + “the number of expired drugs recovered from regular drug recycling points” is a positive causal chain, indicating that the new drug recycling points can improve the convenience of residents participating in the recycling, thereby increasing the number of expired drugs recovered from regular drug recycling points.

L2: “the government's annual investment in the supervision of each recovery point” → + “the number of expired drugs recovered from the regular drug recovery point” is a positive causal chain, indicating that increasing the supervision of the recovery point can increase the number of expired drugs recovered from the regular drug recovery point.

L3: “Subsidy for unit drug recovery from government to residents” + “Number of expired drugs recovered from regular drug recovery points” is a positive causal chain, indicating that increasing subsidies for unit drug recovery from residents can increase the number of expired drugs recovered from regular drug recovery points.

L4: “The number of additional recovery points per year” + “the funds for setting up the recovery points invested by the government annually” - “the publicity funds invested by the government annually” + “the total publicity funds invested by the government” + “the quantity of expired drugs recovered from the regular drug recovery points”;

Based on the above analysis, the causal loop diagram of the government-led family expired drug recovery system is shown in Figure 1.

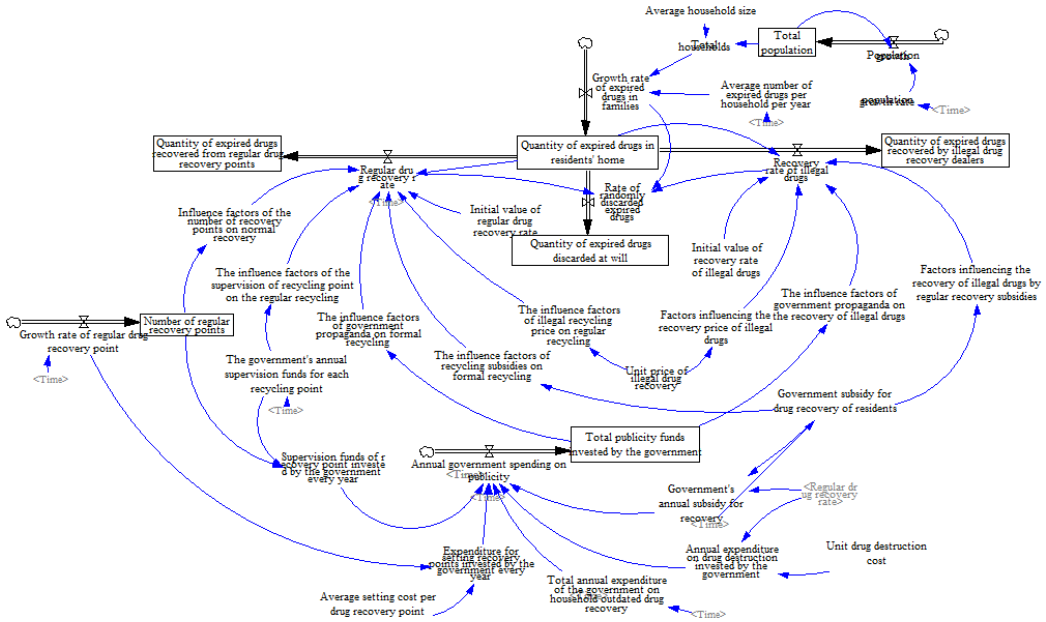

Fig.1 Causal Loop Diagrams of Expired Drug Recovery System Recycling by Government

4. Case Study on Household Outdated Drug Recycling

Ruian City is one of the earliest cities in China to carry out family expired drug recycling. The system dynamics model of family expired drug recycling was applied to Ruian family expired drug recycling system. The model parameters were set according to the actual data of drug recycling in Ruian city, and the dynamic changes of the model under different parameters input were analyzed.

4.1 Parameter Estimation

(1) Estimation of parameters in the sub-model of family expired drug production

a. Estimation of Population Growth Rate

According to the statistical yearbook of Ruian City, the total population of Ruian City has been on the rise from 2003 to 2018. By regression analysis, the exponential fitting equation between the total population (y) and the year (x) of Ruian City is as follows:

$$\begin{cases} y = 6.099\text{E-}6e^{0.00835x} \\ R^2 = 0.976 \end{cases}$$

Coefficient of determinationR^2=0.976,It can be predicted that the population growth rate of Ruian City will be about 0.84% in 2019-2028.

b. initial value of total population

In 2008, the total population of Ruian City was 117.52 million.

c. Estimation of average household size

From 2003 to 2018, the average household size in Ruian City was about 3.73 (person/household).

d. Estimation of the number of expired drugs per household per year

According to the survey of relevant scholars, at present, each family in China produces an average of 500 grams of expired drugs every year, and the average number of expired drugs produced by each family in Ruian City is about 3.33 boxes / household.

(2)Estimation of parameters in the sub-model of family expired drug recovery and disposal

a. Estimation of the Initial Value of the Quantity of Outdated Drugs in Residents' Homes

Data shows that about 89% of families have expired drugs, and each family has about 8 boxes of expired drugs on average. In 2008, there were 318900 households in Ruian City, so the initial value of overdue drugs in households was 31.89 * 89% * 8 = 227100 boxes.

b. Estimation of Initial Value of Regular Drug Recovery Rate

The initial value of the number of expired drugs in residents' homes is 227100 boxes, while in 2008, Ruian Municipal Government recovered a total of 2308 boxes of expired drugs through regular channels, so the initial value of the regular drug recovery rate is set to 0.102%.

c. Estimation of initial value of illicit drug recovery rate

Some scholars in Taizhou City, Zhejiang Province, found that about 1% of the residents sell their expired drugs to “drug dealers”, so the initial recovery rate of illegal drugs is set to 1%.

d. Initial Value of the Amount of Outdated Drugs Recycled from Regular Drug Recycling Points

Only in 2008 did Ruian municipal government officially start to carry out the recovery of expired drugs, so the initial value of the number of expired drugs recovered from the regular drug recovery point is 0.

e. Initial number of normal recovery points

In 2008, Ruian Municipal Government set up a total of 45 regular drug recycling points.

f. Growth rate of regular drug recovery point

In 2011 and 2012, the Ruian Municipal Government set up 15 and 67 new regular drug recycling points respectively. Assuming that the Ryan government will not set up new drug recycling points after that, it will be used as one of the initial state conditions of the model.

g. Estimation of unit price of expired drugs illegally recovered

According to the investigation, the price of illegal recovery of expired drugs is about 25% of the original price of drugs, and the average value of recovered expired drugs in Ruian City is about 9.09 yuan / box (bottle). Therefore, the unit price of illegal recovery of expired drugs is taken as: RANDOM NORMAL(1.5,20,9.09,5,5)*0.25.

h. Estimation of Table Function of Influencing Factors in Drug Recovery

In this paper, the table function method is used to establish the nonlinear relationship between the influencing factors and their influencing factors. According to the actual historical data of household overdue drug recycling in Ruian since 2008, the key points are selected, and the relevant research results in the field of waste electrical appliances recycling are used for reference to make the table function parameter setting more reasonable, basically in line with the actual operation of the system. Specific table function expressions are as follows:

The Influencing Factor of the Number of Recycling Points on Regular Recycling =WITH LOOKUP（Number of Recycling Points）, ([(40,0)-(250,3)], (45,1), (60,1.11), (127,1.35), (174.22,1.45), (212.11,1.51), (232.02, 1.53), (242,1.56)).

Influencing factors of government propaganda on formal recycling =WITH LOOKUP（Total publicity funds invested by government) , ([(0,0)-(600000,10)], (1.265e+004,1), (4.771e+004,1.18), (8.991e+004,1.58), (1.41e+005,2.14912), (2.34e+005,3.15), (3.45e+005,4.61), (4.07e+005,5.79), (4.59e+005,7.11)).

Influencing Factors of Regulatory Recovery Points on Regular Recovery =WITH LOOKUP（The government's annual supervision funds for each recycling point), ([(0,1)-(150,1.5)], (50,1), (68.3486, 1.04167), (76.6055, 1.075), (100, 1.24), (120.642, 1.28), (137.156, 1.29825), (145.872, 1.30702)).

Economic factors affecting formal recycling = WITH LOOKUP（The Difference between the Unit Price of Illegal Recovery and the Subsidy of Regular Recovery）, ([(0,0.6)-(2.8,2)], (1.13,1.42), (1.21,1.39), (1.30,1.33), (1.39,1.28), (1.42,1.26), (1.46,1.30), (1.63,1.14), (1.71,1.11), (1.803,1.07), (1.89,1.03), (1.93,1.01), (2.15,1.04), (2.43,0.92), (2.64,0.705), (2.67,0.631)).

4.2 Result Analysis

Using Vensim DSS software to simulate the dynamic change of “regular drug recovery rate” to investigate the implementation effect of different incentives.

(1)Add regular overdue drug recovery point

The number of recycling points can measure the convenience of residents participating in drug recycling to a certain extent. Observe the change of regular drug recovery rate after the improvement of recovery convenience, and the simulation results are shown in Figure 2.

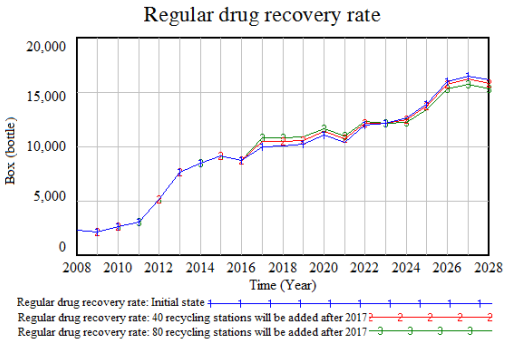

Fig.2 Simulation Results of Increasing the Number of Recovery Points

As can be seen from the figure above, the incentive strategy of adding recycling points has no significant effect on the improvement of the regular amount of expired drugs recycled by families in Ruian City every year.

(2)Recycling subsidy for residents

The Ruian Municipal Government shall compensate residents who participate in the activities of recovering expired drugs to a certain extent.,0.5 yuan and 1 yuan are taken as the unit cost of the government's drug subsidy. The change of the recovery rate of regular drugs after the government's recovery subsidy is observed. The simulation results are shown in Fig. 3.

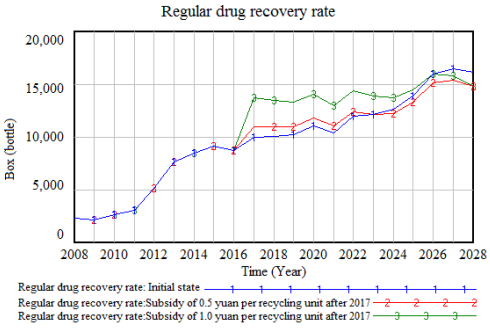

Fig.3 Simulation Results of the Implementation of Recycling Subsidies

As can be seen from the chart above, when the unit cost of the recovery subsidy for residents is 0.5 yuan, the promotion of the recovery is not obvious, but when the unit cost increases to 1 yuan, the recovery will increase rapidly.

(3)Strengthen propaganda on the recovery of expired drugs

On the basis of the original recovered funds, Ruian municipal government added funds for publicity work, and separately inspected the implementation effect of the incentive strategy of increasing the publicity of overdue drug recovery. The simulation results are shown in Figure 4.

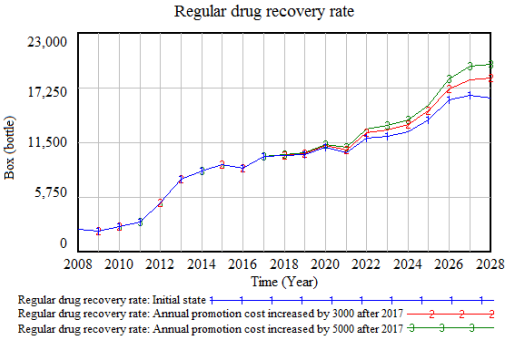

Fig.4 Simulation Results of Increasing Publicity Efforts

As can be seen from the above chart, residents are not sensitive to the government's increasing investment in propaganda funds for the recovery of expired drugs in the short term, but in the long

run, this strategy has more and more obvious incentive effect.

5. Conclusion

Based on the main factors of residents' participation in the recovery of expired drugs, a dynamic model of the recovery system of expired drugs in the family was established. The model was applied to the recovery system of expired drugs in Ruian City, and the development trend of the recovery of expired drugs in Ruian City in the future was predicted. The conclusions are as follows:

(1) In terms of the establishment of recycle bin, it is not advisable to add too many recycle bins blindly, so as to avoid idleness of recycle bin and waste of resources;

(2) In the aspect of implementing recovery subsidy: in the short term, the implementation of recovery subsidy policy can effectively promote the growth of recovery of expired drugs, but in the long term, the incentive effect of economic means is weakening.

(3) In the aspect of recycling publicity: the rate of return is low in the short term, but with the passage of time, the incentive effect of increasing recycling publicity on promoting the recovery of expired drugs in families will be more and more obvious.

References

[1] National Hazardous Waste List [S]. Decree No. 1 of the Ministry of Environmental Protection, 2008.

[2] Blue Ying, Zhu Qinghua. Empirical Study on the Influencing Factors of Consumer Participation in Waste Household Appliances Recycling Management [J]. Eco-economy, 2009, (7): 52-55.

[3] Guo Qiang. Research on influencing factors and differential incentives of consumer's recycling behavior of waste household appliances [D]. City: Hunan University of Science and Technology, 2014.

[4] Bao Hanna. Study on the influencing factors and policy intervention path of consumer green consumption behavior [D]. City: Beijing University of Technology, 2015.

[5] Xu Guangqing, Zou Ji. System Dynamics Method: Principle, Characteristics and Recent Progress [J]. Journal of Harbin University of Technology (Social Sciences Edition), 2006, 8 (4): 72-77.