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ISSN: 0193-4120 Page No. 782 - 799

Learning in Prevention of Unsafe Behavior Propagation between Production Employees

Juan Shi[1], Dingyi Chang[1*], Peng Zheng[1]
[1]School of Management, Tianjin University of Technology, Tianjin 300384, China
E-mail:changdingyi022@163. com

Article Info
Volume 83
Page Number: 574 - 585
Publication Issue:
July-August 2020

Abstract

The unsafe behavior of production staff has the characteristics of strong replication and fast propagation. It is of great significance to establish a model for the spread of unsafe behaviors under the intervention of training and education, and to study its inherent rules of propagation, so as to control the spread of unsafe behaviors among employees during the pandemic such as covid-19. The improved SEIRS infectious disease model was constructed, and the concepts of improvement rate, learning rate and direct immunity rate were added to explore the mechanism of out-of-system training and education intervention on the spread of unsafe behaviors within the system. Using the function ODE45 in MATLAB to solve the value of the differential equation and effectively simulate the movement trajectory of each particle in the system, so as to analyze the dynamic transformation relationship between employees in different states and the influence of the conversion rate on the propagation process of employees' unsafe behaviors. The results showed that the spread of unsafe behaviors could be suppressed by increasing the rate of improvement, cure and direct immunity, and decreasing the rate of infection, learning and forgetting by training the safety awareness and skills of the future personnel. Conduct pre-employment safety training and work safety supervision for future personnel, and cut off the source of infection. As a result, changes in six conversion rates to different degrees will affect the process of behavior propagation.

Article History
Article Received: *06 June 2020*
Revised: *29 June 2020*
Accepted: *14 July 2020*
Publication: *25 July 2020*

Keywords: *Unsafe Behavior of Employees, Modeling and Simulation, Infectious Disease Model, Government Intervention, Propagation Dynamics, Education, Training*

1. Introduction

Production safety in enterprises is an important problem that restricts China's social and economic development. Premier Keqiang Li pointed out in the national production safety teleconference held by the State Council on January 9th, 2019 that production safety is a major event to ensure the sustainable and healthy development of the economy and the people's peace and contentment [1]. To do a good job in production safety, we must do a good job in safety protection, so as to build a safe and stable social environment. In recent years, although the safety management has been strengthened, safety accidents still occur from time to time, and a variety of statistical data show that unsafe behavior of production employees is the most important cause of accidents. Moreover, unsafe behaviors of production employees have the characteristics of transmission, accumulation and repeatability [2]. Therefore, it is of great significance to study the spread of unsafe behaviors of production employees by starting from

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the source of safety accidents -- unsafe behaviors of production employees in enterprises and influencing the possibility of unsafe behaviors of employees by conducting safety training [3] or taking rewards and punishments [4,5,6] according to the theory of behavior correction.

Unsafe behavior of production employees refers to the behaviors of employees that endanger the lives and health of themselves and others or bring safety risks due to illegal operation, illegal behavior and not participating in safety education and training and other promotion activities in the production process. The spread of unsafe behaviors refers to that people actively learn [7], copy or imitate others' unsafe behaviors under the stimulation of the interests of unsafe behaviors. Individuals infected by the bad atmosphere of the group may learn unsafe behaviors or evolve and spread new unsafe behaviors. The spread of unsafe behaviors is a complex and uncertain process [8].

There are few studies on the spread of unsafe behaviors of production employees at home and abroad, and most of them are based on static analysis of internal and external factors [9]. Internal factors mainly refer to individual factors. Most scholars point out that safety cognition and safety attitude [10], safety psychology and behavior habits [11], and safety knowledge and skills [12] all have certain influence on the spread of unsafe behaviors. External factors mainly refer to the working environment and organizational environment. Most scholars believe that the work environment influences the safe operation of employees by affecting their health [13] and the changes of some physiological indicators [14], so as to explore the regular mechanism that causes the spread of unsafe behaviors [15]. Studies have shown that organizational factors such as risk perception, work pressure, rules and regulations arrangement, safety culture atmosphere and safety supervision and management are closely related to the spread of unsafe behaviors of employees [16,17,18].

In terms of communication model, the research objects mainly focus on the transmission of diseases [19,20,21], public opinion information [22,23,24], behavior [25,26,27], etc. Initially, the models related to disease transmission included SI model, SIS model and SIR model. Later, scholars gradually applied the infectious disease model to the spread of public opinion information and behavior prediction, and derived SIRS model and SEIQR model. In this paper, learning from the research of Chen Bo et al. [28], the incubation period was increased, and the infectious disease model was put in the open environment of enterprise production, so as to explore the spread rule of unsafe behaviors closer to the reality. Based on the transmission characteristics of unsafe behaviors of production employees, this research model introduces six conversion rate factors -- infection rate, learning rate, cure rate, forgetting rate, improvement rate and direct immunity rate -- to construct a Susceptible Exposed Infected Removed transmission model under government supervision [29,30]. MATLAB 2016a was used for simulation analysis of SEIRS model to explore the dynamic evolution law of the spread of unsafe behaviors of production employees.

2. The SEIRS model under governmental supervision

2.1. The SEIRS model hypothesis

Hypothesis 1: based on relevant research [31,32], system conservation: assume that the number of employees in an enterprise remains constant in a certain period, regardless of input and output. In reality, employees work in the form of groups, teachers and apprentices [33], and the number of employees remains unchanged in a short time. That is, $S(t)+E(t)+I(t)+R(t)=N$. According to the characteristics and infection degree of production employees, production employees are divided into four states: Susceptible S who do not occur but may be exposed to unsafe behavior; Lurker E. , who has been exposed to unsafe behavior but does not necessarily learn to imitate it and spread it to others; Spreader I with unsafe behavior and transmissibility; Immunizer R who has been infected with unsafe

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behaviors but refuses to produce unsafe behaviors and spread them due to safety awareness, organizational environmental constraints and other factors. S(t), E(t), I(t) and R(t) respectively represent the proportion of the four categories of members in the construction site at the moment t, and all of them are continuous and differentiable functions about time t, which satisfy S(t)+E(t)+ I(t)+R(t)=1. Hypothesis 2: It is assumed that employees are economic agents, with low safety quality, poor corporate safety atmosphere, more work tasks and higher labor intensity. Employees are in a chaotic working environment where unsafe behaviors are carried out and spread for the purpose of economic interests. In order to reflect this hypothesis, a higher initial value of infection rate and unsafe behavior learning rate can be set with reference to relevant studies [30,34], which makes the influence of government and other safety supervision departments on the transmission effect after the intervention of conversion rate more obvious.

Hypothesis 3: Based on the study of Han Yu et al. [35,36], a learning mechanism is introduced into communication. It is assumed that the production staff of the enterprise will model and imitate key figures such as the team leader. Individuals' imitation of unsafe behaviors will turn into group unsafe behaviors, thus creating a bad security atmosphere. Bad security atmosphere and group unsafe behaviors will also increase the learning rate of individuals for unsafe behaviors and thus accelerate the spread of unsafe behaviors. New individuals become infected by herd behavior and then develop unsafe behaviors, which eventually forms a vicious circle of transmission.

Hypothesis 4: In the whole system area, the number of disseminators, the number of immunizers, and the spread speed of unsafe behaviors in the system will have a major impact on the safety of production of enterprises. The spread degree of unsafe behaviors is positively correlated with the number of disseminators and the spread speed of unsafe behaviors, while negatively correlated with the number of immunizers.

2.2. SEIRS model construction

This model incorporated government regulation, an external environmental factor that affects communication, into the SEIR model, and established a new SEIRS model, which consists of two parts: the outer layer of the system and the inner layer of the system. The former mainly involves government intervention, while the latter mainly reflects the communication process of employees' unsafe behaviors. At the same time, six conversion rate factors including infection rate, learning rate, cure rate, forgetting rate, improvement rate and direct immunization rate were introduced to systematically analyze the spread of unsafe behaviors among production employees, so as to simulate the spread process more scientifically. Based on the above four assumptions, SEIRS model of unsafe behavior propagation of enterprise production employees under government intervention is constructed according to the actual characteristics of unsafe behavior propagation, the transition and change relationship among state members and the characteristics of state transition probability, combined with the government control outside the system, as shown in Figure 1.

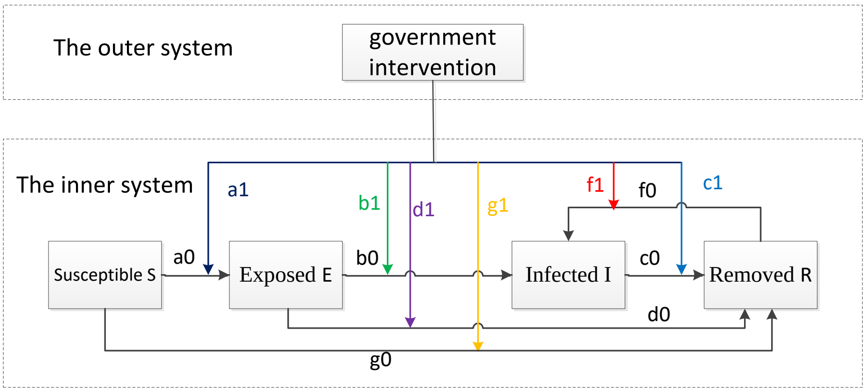

Fig. 1. SEIRS model

In Figure 1, *a0(S→E)* represents the probability that susceptible *S* will be transformed into latent person *E* by observing and contacting unsafe behaviors, which is called infection rate. *b0(E→I)* represents the probability that employees consciously or unconsciously learn, imitate and copy unsafe behaviors, transforming from lurk *E* to communicator *I*, known as learning rate. *c0(I→R)* represents the probability of communicator *I* being transformed into immune *R* due to the awakening of safety awareness or the influence of external factors such as safety education, training, rewards and punishment measures, which is called cure rate. *d0(E→R)* represents the probability that lurk *E* transforms into immune *R* due to higher safety quality or fear of punishment and other organizational factors, which is called improvement rate. *f0(R→I)* represents the probability that immune *R* is affected by unsafe behaviors again due to its own negligence, safety awareness weakened over time, forgetting rules and regulations, relaxing vigilance, or weak supervision by enterprises and governments, which is called the forgetting rate. *g0(S→R)* represents the probability of susceptible *S* being directly transformed into immune *R* due to its high safety literacy or being controlled by isolation, which is called direct immunity rate. *a1, b1, c1, d1, f1* and *g1* respectively represent the intervention coefficients of the government on the spread of unsafe behaviors, namely, the coefficients acting on *a0, b0, c0, d0, f0* and *g0*, respectively.

According to the practical significance of conversion rate and relevant studies [31], the above parameters meet: $a0$、$b0$、$c0$、$d0$、$f0$、$g0 \in [0, 1]$; $a1$、$b1$、$c1$、$d1$、$f1$、$g1 \in [-1, 1]$; $0 \leqslant a0-a1 \leqslant 1$; $0 \leqslant b0-b1 \leqslant 1$; $0 \leqslant c0-c1 \leqslant 1$; $0 \leqslant d0-d1 \leqslant 1$; $0 \leqslant f0-f1 \leqslant 1$; $0 \leqslant g0-g1 \leqslant 1$. When *a1, b1, c1, d1, f1* and *g1* are all equal to 0, it represents the infectious disease model transmitted by unsafe behaviors of anarchy intervention. According to the principle of propagation dynamics, the differential dynamics equation is established:

$$\begin{cases} \dfrac{dS(t)}{dt} = -(a0-a1)S(t)I(t) - (g0-g1)S(t)I(t) \\ \dfrac{dE(t)}{dt} = -(b0-b1)E(t) - (d0-d1)E(t) + (a0-a1)S(t)I(t) \\ \dfrac{dI(t)}{dt} = -(c0-c1)I(t) + (b0-b1)E(t) + (f0-f1)R(t) \\ \dfrac{dR(t)}{dt} = -(f0-f1)I(t) + (g0-g1)S(t)I(t) + (c0-c1)I(t) + (d0-d1)E(t) \end{cases} \tag{1}$$

Make a=a0-a1;b=b0-b1;c=c0-c1;d=d0-d1;f=f0-f1;g=g0-g1 , formula (1) is equivalent to:

$$\begin{cases} \dfrac{dS(t)}{dt} = -aS(t)I(t) - gS(t)I(t) \\ \dfrac{dE(t)}{dt} = -bE(t) - dE(t) + aS(t)I(t) \\ \dfrac{dI(t)}{dt} = -cI(t) + bE(t) + fR(t) \\ \dfrac{dR(t)}{dt} = -fI(t) + gS(t)I(t) + cI(t) + dE(t) \end{cases} \quad (2)$$

In actual production, the spread of unsafe behaviors in enterprises will be affected by government intervention and other factors. Under certain assumptions, through changing the value of different conversion rate parameters, this paper explores the rule that the change of conversion rate affects the spread of unsafe behaviors. In the SEIR transmission model, this paper explores the influence of the transmission process on the infection rate, learning rate, cure rate, improvement rate, forgetting rate and direct immunization rate under government intervention. By adjusting these parameters, the influencing factors of unsafe behavior propagation are analyzed, so as to obtain the rules of unsafe behavior propagation under different conditions.

3. Parameter setting and simulation experiment

This paper USES the function ODE45 in MATLAB to solve the numerical value of the differential equation [37,38]. According to relevant studies [39,40,41,42], The initial value of the proportion of production personnel in different states is set as: *S(t)*=0. 8，*E(t)*=0，*I(t)*=0. 2，*R(t)*=0, In the case of anarchy intervention, the conversion rate parameters are: *a*=0. 8，*b*=0. 7，*c*=0. 2，*d*=0. 1，*f*=0. 6，*g*=0. 2. Simulation time *t* is set as 15 and 25, respectively, for comparison in the following paragraphs. According to the above Settings, a change diagram of employee proportion in various states during the propagation and evolution of unsafe behaviors of enterprises can be obtained. The result in the basic case is shown in Figure 2.

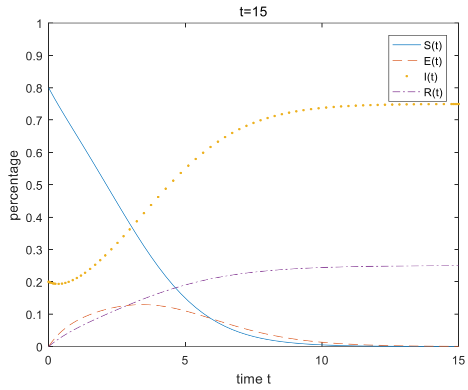

Fig. 2a

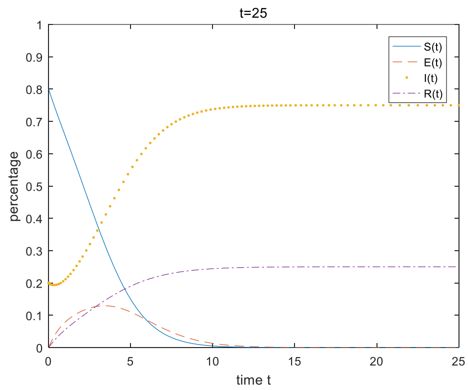

Fig. 2b

Fig. 2 Diagram of staff scale change of each state (Fig. 2a:t=15, Fig. 2b:t=25)

As can be seen from Figure 2, in the process of spreading unsafe behaviors of production employees, the proportion of susceptible people shows a decreasing trend with the passage of time, and tends to 0 when *t*=10. The lurk rose to a peak value of about 0. 13 in a short time, and then slowly decreased to 0. In the absence of supervision, communicators generally show an upward trend, with the upward speed first fast, then slow, and finally reaching a stable value, with a stable value ratio of about 0. 75. The proportion of immunized people also increased slowly, from zero to about 0. 25. When the system reaches a steady state, the proportion of people in each state is basically constant, and the curve is in a horizontal state.

When *a1,b1,c1,d1,f1* and *g1* are all equal to 0, that is, when there is no supervision, the condition is set as the control group, which is called the basic condition. Due to the different intensity and direction of

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government intervention in unsafe behaviors, new situations were set for the intervention of six conversion rates according to the control variable method, which was called the experimental group. The change gradient of intervention coefficient is 0.2, which means that the intervention degree of all conversion rates is the same. When the government promotes or restrains all conversion rates and its effect on conversion rate changes gradually, the state proportion distribution of employees and its influence on their safety behavior are investigated by simulation. The details are shown in table 1 to Table 6.

3. 1. The impact of government intervention on the transmission process of infection rate *a*

Situation 1: when the government intervenes in the infection rate, the greater the government supervision, the larger the intervention coefficient *a1*, and the smaller the infection rate *a*. When other parameters remain unchanged, parameter Settings are shown in Table 1.

Table 1. Situation 1 Parameter Setting

Situation1	*a0*	*a1*	*a=a0-a1*	*b*	*c*	*d*	*f*	*g*	*t*
Basic Situation	0.8	0	0.8	0.7	0.2	0.1	0.6	0.2	25
Situation 1.1	0.8	0.2	0.6	0.7	0.2	0.1	0.6	0.2	25
Situation 1.2	0.8	0.4	0.4	0.7	0.2	0.1	0.6	0.2	25
Situation 1.3	0.8	0.6	0.2	0.7	0.2	0.1	0.6	0.2	25

By substituting the parameters in Table 1 into formula (2) and carrying out simulation analysis on the SEIRS model under government supervision, the variation of the proportion of susceptible *S*, latent *E*, transmitter *I* and immune *R* and the variation of transmission speed in each situation can be simulated, as shown in Figure 3.

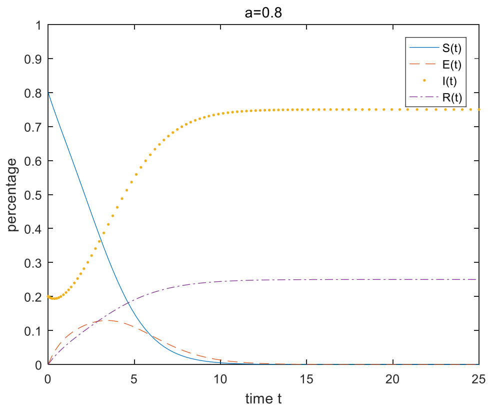

Fig. 3a

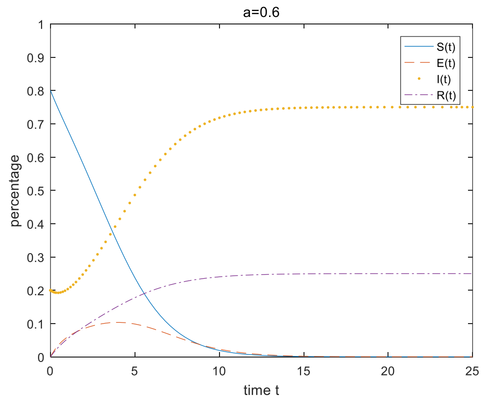

Fig. 3b

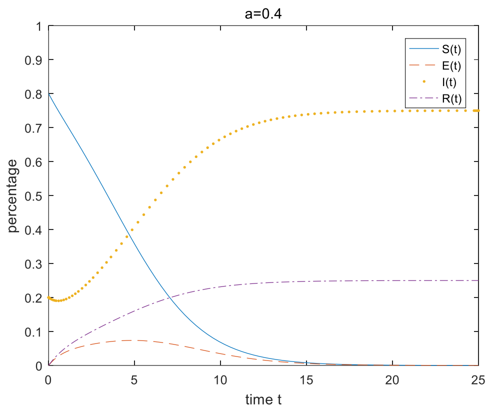

Fig. 3c

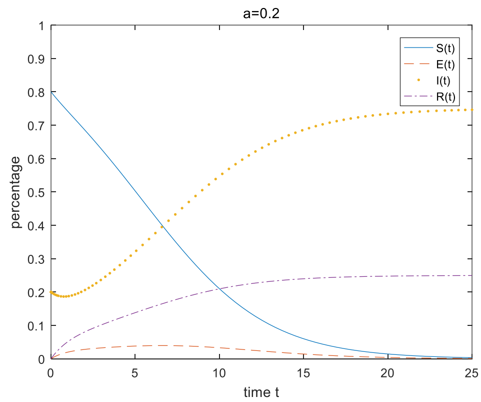

Fig. 3d

Fig. 3 Simulation Diagram of The Change of Infection Rate a (Fig. 3a:a=0. 8, Fig. 3b:a=0. 6, Fig. 3c:a=0. 4, Fig. 3d:a=0. 2)

As can be seen from Figure 3, with the strengthening of government supervision, the infection rate decreased from 0. 8 to 0. 2. The final proportion of people in the four states barely changed, but the fluctuation of each state curve became slow, and the time required for each state change extended from *t*=10 in Figure 3a to *t*=20 in Figure 3d. When the final curve remains level, the system is in a stable state. The slow change speed of communication is conducive to controlling the spread of unsafe behaviors of employees in enterprise production.

3.2. Influence of learning rate *b* on communication process under government intervention

Situation 2: when the government intervenes in the learning rate, the greater the government supervision, the larger the intervention coefficient *b1*, and the smaller the learning rate *b*. When other parameters remain unchanged, parameter Settings are shown in Table 2.

Table 2. Situation 2 parameter setting

Situation 2	*b0*	*b1*	*b=b0-b1*	*a*	*c*	*d*	*f*	*g*	*t*
Basic Situation	0.7	0	0.7	0.8	0.2	0.1	0.6	0.2	25
Situation 2.1	0.7	0.2	0.5	0.8	0.2	0.1	0.6	0.2	25

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Situation 2.2	0.7	0.4	0.3	0.8	0.2	0.1	0.6	0.2	25
Situation 2.3	0.7	0.6	0.1	0.8	0.2	0.1	0.6	0.2	25

The parameters in Table 2 are substituted into formula (2), and the simulation analysis is shown in Figure 4.

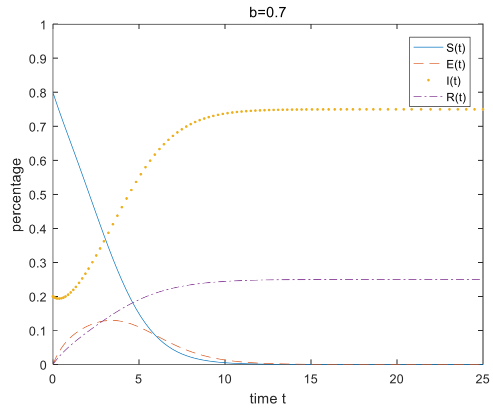

Fig. 4a

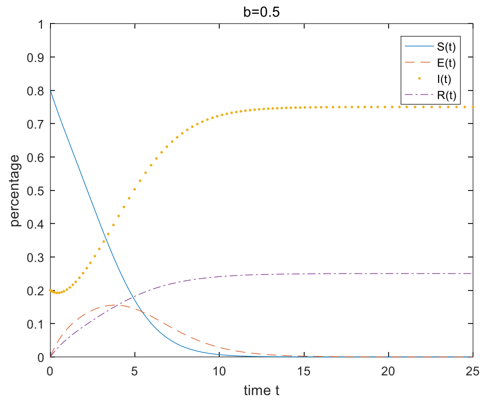

Fig. 4b

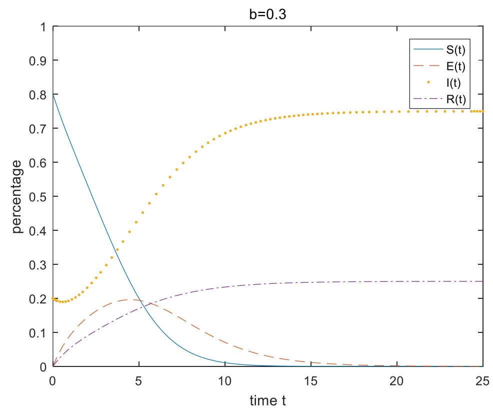

Fig. 4c

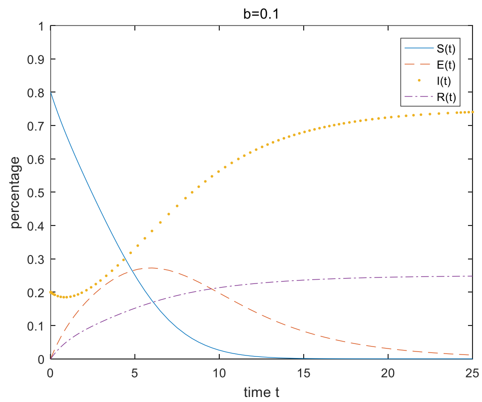

Fig. 4d

Fig. 4. Simulation Diagram of Change in Learning Rate b (Fig. 4a:b=0. 7, Fig. 4b:b=0. 5, Fig. 4c:b=0. 3, Fig. 4d:b=0. 1)

As can be seen from Figure 4, during the whole process of change from Figure 4a to Figure 4d, when government control reduces the learning rate from 0. 7 to 0. 1, the proportion of members in each state finally reaches a stable value is basically unchanged, but the change speed of all curves is slowed down, and the time required for reaching a stable value is prolonged. The time required for the proportion of susceptible people to decrease to 0 increased roughly from t=10 to t=13. The peak value of the latent person increased from about 0. 13 to about 0. 27, and the time required for the curve to first rise and then fall increased from t=10 to t=25. The number of disseminators also changed from a rapid increase in the short term to a slow rise. Over time, the immune system changes less significantly. Based on the above analysis, it can be seen that reducing the learning rate can reduce the spreading speed of unsafe behaviors. Therefore, the learning imitation of key figures and the behavior replication of surrounding employees can be reasonably used to control the unsafe behaviors of production employees.

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3.3. Effect of cure rate *c* on transmission process under government intervention

Situation 3: when the government intervenes in the cure rate, the greater the government's active guidance, the greater the absolute value of the intervention coefficient *c1*, and the greater the cure rate *c*. When other parameters remain unchanged, parameter settings are shown in Table 3.

Table 3. Situation 3 Parameter Setting

Situation 3	***c0***	***c1***	***c=c0-c1***	***a***	***b***	***d***	***f***	***g***	***t***
Basic Situation	0.2	0	0.2	0.8	0.7	0.1	0.6	0.2	25
Situation 3.1	0.2	-0.2	0.4	0.8	0.7	0.1	0.6	0.2	25
Situation 3.2	0.2	-0.4	0.6	0.8	0.7	0.1	0.6	0.2	25
Situation 3.3	0.2	-0.6	0.8	0.8	0.7	0.1	0.6	0.2	25

The parameters in Table 3 are substituted into formula (2), and the simulation analysis is shown in Figure 5.

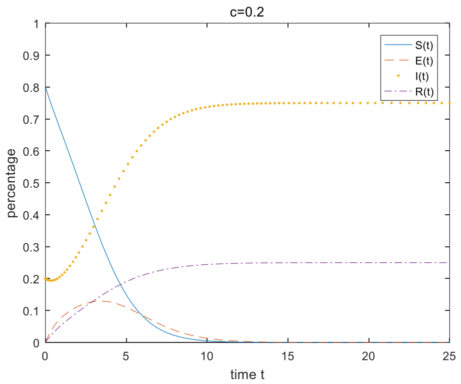

Fig. 5a

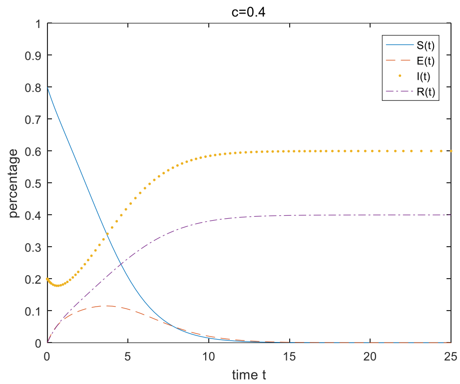

Fig. 5b

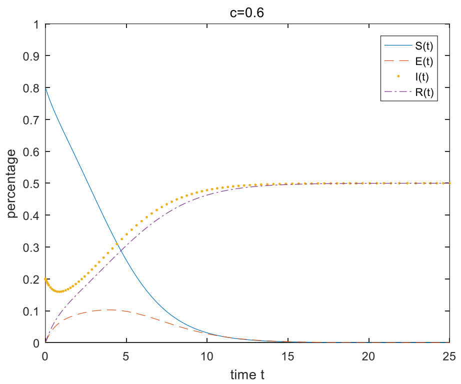

Fig. 5c

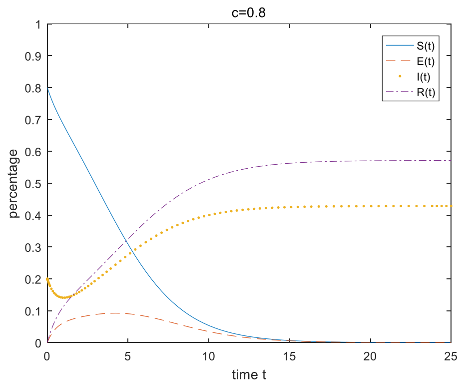

Fig. 5d

Fig. 5. Simulation Figure of Cure Rate c Change (Fig. 5a:c=0. 2, Fig. 5b:c=0. 4, Fig. 5c:c=0. 6, Fig. 5d:c=0. 8)

As can be seen from Figure 5, when the government adopts a positive guidance strategy, the increase of

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cure rate has a great influence on the changes in the number and speed of members in the system. The time required for susceptible people to fall to the final stable value of 0 increases from *t*=10 to *t*=15. The peak value of the latent person decreased from about 0. 13 to about 0. 08, and the fluctuation of the curve rose first and then decreased gradually, and the time required also increased from *t*=10 to *t*=15. The disseminator decreased slightly in a short time, and then increased with the passage of time. The final stable value of proportion decreased from about 0. 75 to about 0. 43, with a significant decrease. The number of immunized people also increased gradually over time, and the final stable value increased from about 0. 25 to about 0. 57, with a significant increase. Communicators are harmful to the safety system, while immunizers are beneficial to safety production. According to the simulation analysis, the cure rate can be improved to effectively reduce the number of disseminators of unsafe behaviors, increase the number of immunizers and slow down the propagation speed of unsafe behaviors, so as to prevent the occurrence of safety accidents to a certain extent.

3.4. Influence of improvement rate *d* on transmission process under government intervention

Situation 4: when the government intervenes in the improvement rate, the greater the government's active prevention and control, the greater the absolute value of intervention factor *d1*, and the greater the improvement rate *d*. When other parameters remain unchanged, parameter settings are shown in Table 4. In order to facilitate the analysis of graph changes, *t* is set at 15.

Table 4. Situation 4 Parameter Setting

Situation 4	***d0***	***d1***	***d=d0-d1***	***a***	***b***	***c***	***f***	***g***	***t***
Basic Situation	0. 1	0	0. 1	0. 8	0. 7	0. 2	0. 6	0. 2	15
Situation 4. 1	0. 1	-0. 2	0. 3	0. 8	0. 7	0. 2	0. 6	0. 2	15
Situation 4. 2	0. 1	-0. 4	0. 5	0. 8	0. 7	0. 2	0. 6	0. 2	15
Situation 4. 3	0. 1	-0. 6	0. 7	0. 8	0. 7	0. 2	0. 6	0. 2	15

The parameters in Table 4 are substituted into formula (2), and the simulation analysis is shown in Figure 6.

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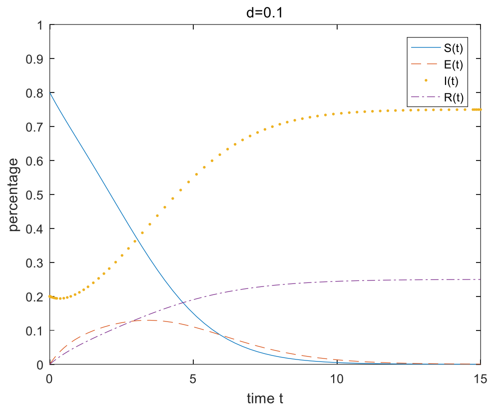

Fig. 6a

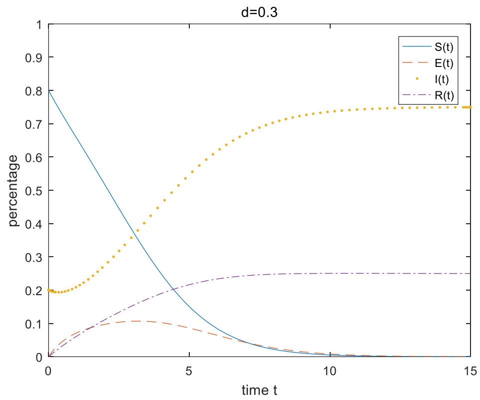

Fig. 6b

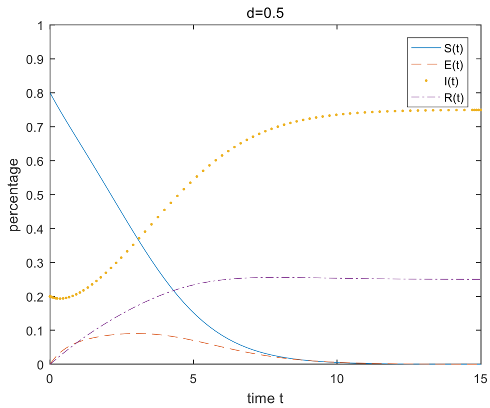

Fig. 6c

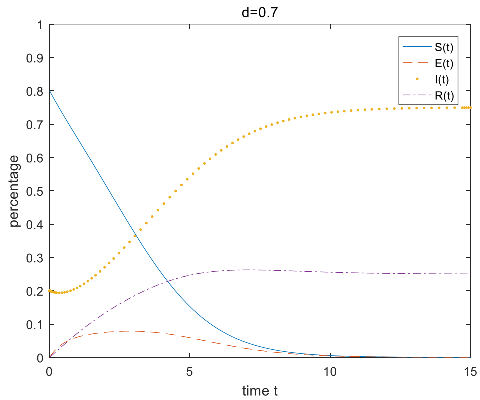

Fig. 6d

Fig. 6. Simulation Diagram of Change in Improvement Rate d (Fig. 6a:d=0. 1, Fig. 6b:d=0. 3, Fig. 6c:d=0. 5, Fig. 6d:d=0. 7)

As can be seen from figure 6, when the government's active prevention and control makes the improvement rate increase, it has little impact on the final number of members in each state, but it can slightly slow down the spread speed of unsafe behaviors in the system. The peak of the lurkers decreased from about 0. 13 to about 0. 07. According to the above simulation analysis, the government can control the spread of unsafe behaviors in enterprises to a certain extent by transforming employees from latent ones to immune ones through rewards, punishments, training and education.

3.5 The influence of forgetting rate *f* on transmission process under government intervention

Situation 5: when the government intervenes in the forgetting rate, the stronger the government regulation, the larger the intervention factor *f1*, and the smaller the forgetting rate *f*. When other parameters remain unchanged, parameter Settings are shown in Table 5.

Table 5. Situation 5 Parameter Setting

Situation 5	*f0*	*f1*	*f=f0-f1*	*a*	*b*	*c*	*d*	*g*	*t*
Basic Situation	0. 6	0	0. 6	0. 8	0. 7	0. 2	0. 1	0. 2	25

Situation 5. 1	0. 6	0. 2	0. 4	0. 8	0. 7	0. 2	0. 1	0. 2	25
Situation 5. 2	0. 6	0. 4	0. 2	0. 8	0. 7	0. 2	0. 1	0. 2	25
Situation 5. 3	0. 6	0. 6	0	0. 8	0. 7	0. 2	0. 1	0. 2	25

The parameters in Table 5 are substituted into Formula (2), and the simulation analysis is shown in Figure 7.

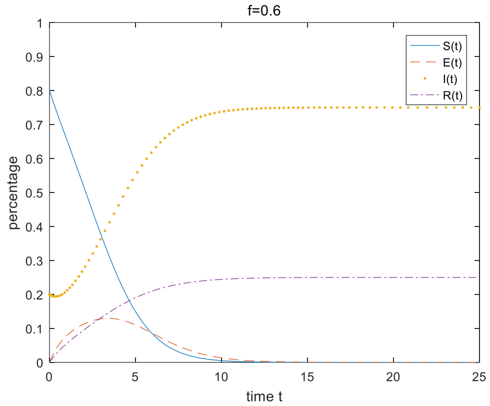

Fig. 7a

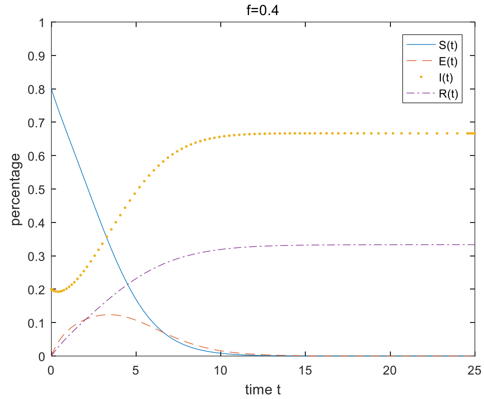

Fig. 7b

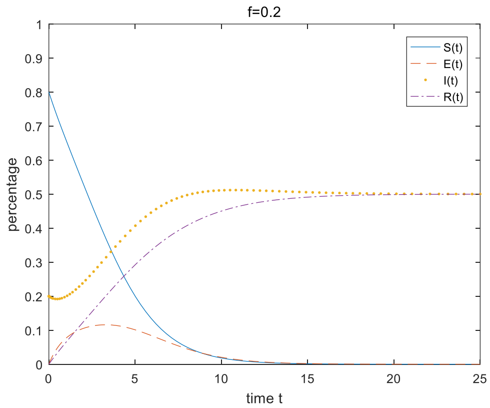

Fig. 7c

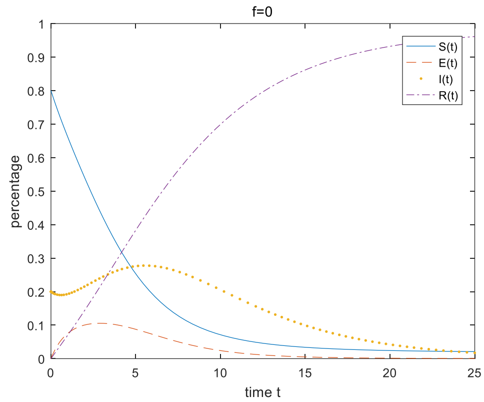

Fig. 7d

Fig. 7. Simulation Figure of Change in Forgetting Rate f (Fig. 7a:f=0. 6, Fig. 7b:f=0. 4, Fig. 7c:f=0. 2, Fig. 7d:f=0)

As can be seen from Figure 7, due to the active prevention and control by the government, safety education and training for employees and corresponding rewards and punishments, the rate of forgetting the safety constraints and spreading unsafe behaviors again by immunized people is reduced, which leads to the large fluctuation of the final stable value of members in various states and the slow spread of unsafe behaviors. At this point, the time required for susceptible people to decrease to 0 increases from t=10 to t=25. The peak value of the latent person also decreased, from about 0. 13 in Figure 7a to about 0. 1 in Figure 7d. The change time of the curve first rose and then decreased increased from t=10 to t=25. The communicator changed from an upward trend to a downward trend, and the final stable value decreased from about 0. 75 to 0, with obvious changes. The increase in

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immunized subjects increased, from about 0. 25 to about 0. 95. According to the above simulation results, the change of forgetting rate has a great influence on the change of the proportion of communicators and the proportion of immunizers. Simulation shows that forget rate and disseminator number were positively correlated relationship, negatively related with immune number, at the same time also shows that in the process of unsafe behavior spread, forget rate play a key role, production staff and enterprise itself should not be "pain is forgotten where gain follows," to keep safety awareness, has no relaxation degree of attention to the safety problems. Therefore, unsafe behaviors can be prevented and controlled by adjusting the forgetting rate.

3.6. Influence of direct immunization rate g on transmission process under government intervention

Situation 6: when the government intervenes in the direct immunization rate *g*, the greater the government supervision, the greater the absolute value of intervention coefficient *g1*, and the greater the direct immunization rate *g*. When other parameters remain unchanged, parameter Settings are shown in Table 6. In order to facilitate the analysis of graph changes, *t* is set at 15.

Table 6. Situation 6 parameter setting

Situation 6	***g0***	***g1***	***g=g0-g1***	***a***	***b***	***c***	***d***	***f***	***t***
Basic Situation	0. 2	0	0. 2	0. 8	0. 7	0. 2	0. 1	0. 6	15
Situation 6. 1	0. 2	-0. 2	0. 4	0. 8	0. 7	0. 2	0. 1	0. 6	15
Situation 6. 2	0. 2	-0. 4	0. 6	0. 8	0. 7	0. 2	0. 1	0. 6	15
Situation 6. 3	0. 2	-0. 6	0. 8	0. 8	0. 7	0. 2	0. 1	0. 6	15

The parameters in Table 6 are substituted into formula (2), and the simulation analysis is shown in Figure 8.

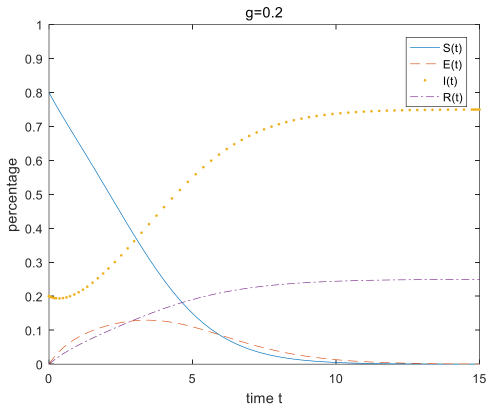

Fig. 8a

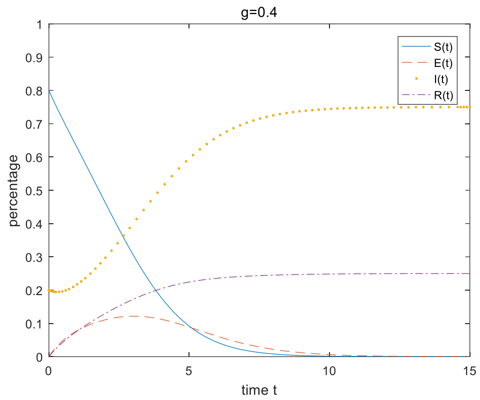

Fig. 8b

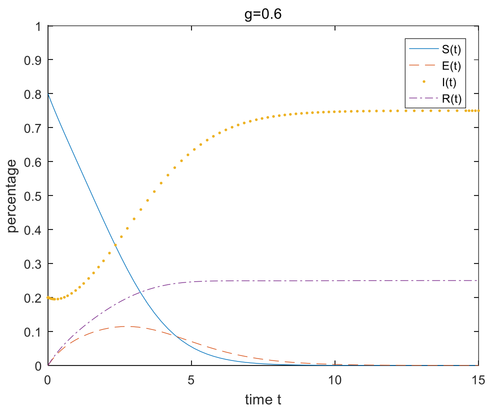

Fig. 8c

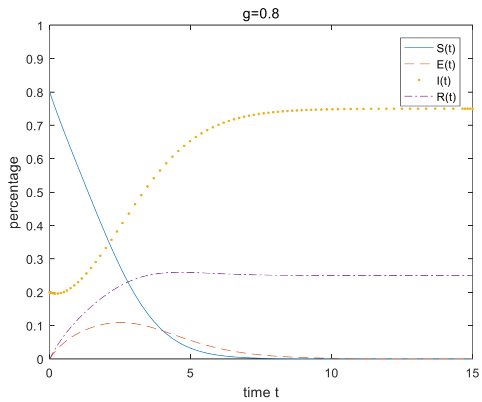

Fig. 8d

Fig. 8. Simulation Figure of g Change of Direct Immunity Rate (Fig. 8a:g=0. 2, Fig. 8b:g=0. 4, Fig. 8c:g=0. 6, Fig. 8d:g=0. 8)

As can be seen from Figure 8, with the regulatory constraints actively guided by the government, the direct immunization rate increased. In the process of transmission, although the final ratio of members in various states did not change significantly, the peak value of latent person E decreased somewhat, from 0.13 to 0.1. The time required for the change process of first increasing and then decreasing to the stable value of 0 was shortened. The time required for susceptible S to decrease to 0 also decreased from t=10 to t of about 6.5. The time required for R to increase to a stable value was also shortened, that is, t decreased from approximately 10 to 4. According to the above simulation, increasing the direct immunization rate can indirectly reduce the hidden danger of unsafe behaviors to some extent.

4. Conclusion

4.1. Experiment Conclusion

According to the spreading characteristics of unsafe behaviors of production staff, SEIRS propagation model under government supervision is constructed, and the influence of six conversion rate parameters on the propagation process is analyzed. The experimental results show that: government intervention can increase cure rate c, improvement rate d, direct immunity rate g, reduce infection rate a, learning rate b, and forgetting rate f, so that the system can maintain a high number of immunizers and a low number of transmitters, and reduce the transmission speed of unsafe behaviors. If the government does not control the infection rate a and the learning rate b, the group will be passively infected by unsafe behaviors and join the crowd, or learn to imitate unsafe behaviors for the purpose of saving time and effort, so as to accelerate the spread of unsafe behaviors and cause huge security risks. Therefore, the government should take corresponding measures to improve cure rate *c*, improvement rate *d*, direct immunity rate *g*, and reduce infection rate *a*, learning rate *b*, and forgetting rate *f* to promote enterprise safety in production.

4.2. Innovative Point

The innovation of this paper is mainly reflected in two aspects: first, it combines the theory and thought of behavior communication with the practice of enterprise safety production management, not limited to the normal research paradigm of safety behavior in terms of individual behavior characteristics. By incorporating employees into the structure of the infectious disease model and government control, an improved SEIRS model was constructed, the concepts of improvement rate, learning rate and direct immunization rate were introduced, and corresponding numerical simulation was conducted. The model includes the spread of unsafe behaviors in the system and the government regulation outside the system, and studies the spread of unsafe behaviors among employees dynamically. Secondly, based on the theory of communication dynamics, a controlled experiment was set to explore the change of conversion rate, the speed of spread of unsafe behaviors and the change of the proportion of members in each state when the government's intervention on the six conversion rates was different in intensity and direction. In order to put forward the countermeasures and suggestions on the control of each node and conversion rate, it is an in-depth analysis of the unsafe behavior of production staff.

4.3. Practical Implications

The model of unsafe behavior propagation, SEIRS, is helpful for safety managers to study the prevention of unsafe behavior propagation. In terms of education, the government should strengthen the safety education for enterprises and individuals, and formulate targeted measures of rewards and punishments, improve the system of rewards and punishments, and correctly guide the public opinion of the concept of safety. In terms of learning, employees should take the initiative to learn safe operation and develop good safety habits, safety awareness and sense of responsibility. In terms of training, enterprises should regularly carry out safety training courses combining online and offline, and use the influence of key figures such as technical backbone and safety model to control the key influencing factors in the communication process: learning rate, cure rate and forgetting rate, so as to carry out active prevention and control to promote safe production.

4.4. Shortcomings and research prospects

When selecting the initial value and parameters of simulation, this paper draws on the research basis of most scholars, consults 1 doctor majoring in computer and 2 doctor majoring in safety engineering, and obtains the set value of this paper after comprehensive analysis. In order to facilitate analysis and make the change of conversion rate after government intervention more obvious, the initial values of higher infection rate and learning rate were set in this paper. Assumptions that enterprise employees are homo-economicus, employee is in a chaotic, for the purpose of economic interests and the implementation and dissemination of unsafe behavior of work environment, this assumption has a certain deviation with the reality, in the future study, can be combined with the actual case analysis, makes the model more relevant reality, and by using a numerical simulation of the actual data simulation of a real effect.

In the next step, the author or other relevant researchers can focus on a specific type of unsafe behavior of enterprise employees and deeply explore its transmission mechanism, so as to propose specific intervention measures and better guide the production practice of enterprises. At the same time, it can be considered to combine the chain structure of infectious disease model with the topological structure of complex network. The former tends to affect the depth of behavioral transmission, while the latter tends to affect the breadth of behavioral transmission. In order to further and systematically analyze the related factors that affect the spread of unsafe behavior and the linkage among these factors. It is beneficial to improve the management level of production safety and prevent the occurrence of safety accidents.

At the same time, the results of this study also have important implications during pandemics such as covid-19. First, when an employee is in the incubation period, take precautions. Employees in the system should take the initiative to learn safety rules and regulations and safety operation skills. The government outside the system should provide safety education, training and guidance, and severely punish unsafe behaviors. Secondly, this model shows that the transmission speed is fast in the early stage, so we should grasp the golden period, early detection, early treatment. Finally, target the source of transmission. Infectious disease models eventually reach a plateau. One is the zero equilibrium point, where there are no communicators; The other is a non-zero equilibrium point where the number of members in each state remains constant. When the source of infection is eliminated, unsafe transmission can be completely eliminated; When the source of infection is kept under control, it is guaranteed that no new spreaders will be added.

Acknowledgement

This work was support by National Natural Science Foundation of China (Grant No. 71603181); Tianjin Science and Technology Program (Grant No. 701180912)

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