The Spread of TikTok's Influence Worldwide from the View of the SIRO Model

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Abstract. TikTok is the most downloaded short video platform in the world which brings a significant negative impact on adolescents. Furthermore, there is a substantial similarity between the spread of TikTok's influence and the spread of the epidemic. Based on this fact, we can model the spread of the TikTok's influence by introducing the Ignorant-Recommender-Indifference-Opposer (SIRO) model. We derive the differential equation and obtain the disease-free equilibrium. Then we calculate the generation matrix and basic reproduction number (R0) and discuss the method to control the spread of TikTok's influence. The study suggests that in order to decrease the population of TikTok users, the rate of ignorant people and indifferent people turning to recommenders should decrease, and the rate of recommenders turning to indifferent people should increase by improving education and the government's propaganda to the harm of TikTok.

Keywords: SIRO model · TikTok · spreading · negative influence · differential equation · basic reproduction number

1 Introduction

TikTok, the most famous and influential short video platform worldwide, has gained billions of active users since it was launched in China by the company Byte-Dance in 2016. People can play or record 15 s videos and leave comments, give a thumb up and forward the videos to others [1]. In this way, it attracts many users and spreads its influence rapidly and drastically in the world among young people because of its addictive music and straightforward content. However, it has a significant and adverse impact on many people, especially adolescents, because they are too naive and cannot distinguish right from wrong. TikTok can not only cost their time and shape their opinion but also can cause intense mental and physical problems to them [2].

Firstly, improper content on TikTok will distort young children's values. For example, there are so many beautiful girls making videos showing their bodies and makeup, which will cause young girls to pay too much attention to their body and appearance, which leads to their body shame and appearance anxiety [2]. They might compare themselves to the celebrities and models on TikTok and become unconfident and self-abasement [3]. Another example is pornography, which might de-sensitize teenagers to dangerous people, and might consider pornography on TikTok is common, and imitate in real life,

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which some people might take advantage of [4]. Likewise, some people may post many dangerous videos on TikTok to get people's attention to make money, and some children may imitate them and get hurt. For example, some people might do parkour on the roof of tall buildings. If some people try to imitate these behaviors, they might get hurt from it. Besides, there are some celebrities advertising demerit goods on TikTok, including e-cigarettes, which can contribute to their health problems, such as lung cancer and bring negative externality to society, for passive smoking might do harm to other people and cost the government money to subsidize hospital [5, 6]. Additionally, loss of privacy is also a problem for TikTok. Some hackers might detect and steal users' information and data, which is an invasion of privacy [7]. Moreover, TikTok might cause intense cyberbullying, for malicious people might criticize others' outfits and make-up, which might lead to disorders, loneliness, and anxiety, and some of them might want to do plastic surgery or try to lose weight in an unhealthy way [8–10]. Additionally, too much exposure to TikTok videos might shorten the time that people spend in their daily life, such as studying, outdoor activity, and socializing, which is harmful to their mental health and cause their grades to go down. By contrast, spending too much steering on the screen will do harm to their eyesight and spine. Because of its significant negative effect, it is meaningful to use the SIR model to simulate the spread of TikTok's influence. Therefore, it is important to use the dynamic equation to model the spread of TikTok's influence.

The paper is organized as follows: Session 2 introduces the preliminaries of the SIR model and its variants; in Session 3, we propose a SIRO model to stimulate the spread of TikTok influence, derive the differential equation of our model, and calculate the basic reproduction number. In Session 4, we discuss the factor that can determine the R_0 and discuss how to decrease the recommender of TikTok in reality. In Session 5, we draw a conclusion on the spread of TikTok influence and give some suggestions on the way to decrease R_0 and control the spread of TikTok.

2 Application of SIR and Its Variants to the Spread of TikTok

2.1 SIR

The SIR model is the most fundamental compartment model to model the spread of the epidemic, from which many other models are derived. It consists of three parts: susceptible, infectious and recovered. Susceptible (S) are the people who have the potential to be infected by infected individuals. Infected people are those who have been infected and can infect susceptible individuals. Recovered are the people who have been infected and become healthy again (Fig. 1).

In this model, susceptible individuals can turn into infectious individuals, and infectious individuals can turn into recovered individuals, while recovered individuals cannot

Fig. 1. The structure of SIR model

turn into infectious or susceptible individuals, for there is an antibody in their body, which can prevent them from being infected again. This model can predict the number of susceptible individuals, infectious individuals, and recovered individuals in a period [11]. In such a case, the spread of influence of TikTok is similar to the propagation of an epidemic, because when some people are interested in TikTok, they might recommend TikTok to their family and friends, who might also recommend TikTok to other people, which is similar to infected people spreading the virus to other people. Also, if they get broad with TikTok, they might not use it anymore. Susceptible represent ignorant people, who haven't heard about TikTok, and Infectious represent recommender who get interested in TikTok and keep recommending it to others, Recovered represent indifferent people who lose interest in TikTok. Ignorant individuals turn to recommender at a rate of, and recommenders turn to indifferent individuals at a rate of Assuming the recommender is the negative state, and the differential equation can be written as:

$$\frac{dI}{dt} = \beta SI - \gamma I \tag{1}$$

$$\frac{dS}{dt} = -\beta SI \tag{2}$$

$$\frac{dR}{dt} = \gamma I \tag{3}$$

2.2 SICR

The SICR model is a compartment model that builds on the basics of the SIR model. C represents a carrier who can carry and spread the virus without suffering from the disease, while S, I and R represent the same meaning as the SIR model. In the spreading of TikTok influence, C represents the people who don't use TikTok but keep recommending it to others. The letter ω represents the rate of infectious individuals turning to carriers, while the letter ζ represents the rate of carriers turning to infectious individuals (Fig. 2).

Assuming infectious is the negative state, we can derive the differential equation:

$$\frac{dI}{dt} = \beta SI - \omega I + \zeta C \tag{4}$$

$$\frac{dS}{dt} = -\beta SI \tag{5}$$

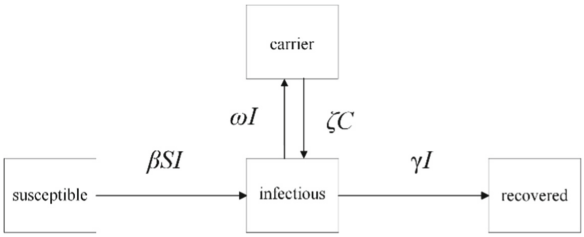

Fig. 2. The structure of SICR model

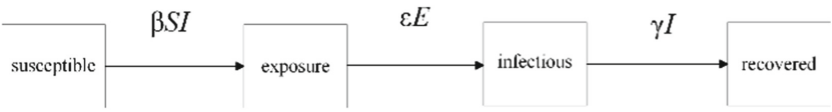

Fig. 3. The structure of SEIR model

$$\frac{dR}{dt} = \gamma I \tag{6}$$

$$\frac{dC}{dt} = \omega I - \zeta C \tag{7}$$

2.3 SEIR

The SEIR model is also a case built on the basic SIR model. In this case, E represents exposure, who is exposed individuals who have been infected but are not yet infectious. In the spreading of TikTok influence, E represents the people who have been recommended TikTok and use TikTok but do not recommend it to others (Fig. 3).

Assuming infectious is the negative state, the differential equation can be written as:

$$\frac{dI}{dt} = \epsilon \mathrm{E} - \gamma I \tag{8}$$

$$\frac{dS}{dt} = -\beta SI \tag{9}$$

$$\frac{dR}{dt} = \gamma I \tag{10}$$

$$\frac{dE}{dt} = \beta SI - \epsilon \mathrm{E} \tag{11}$$

2.4 SIS

Similarly, the SIS model is when there is no immunity to the disease. Such as the common cold virus, people might have a cold again and again without getting recovered. This model cannot represent the spread of TikTok influence, because the recommender cannot turn to ignorant people anymore (Fig. 4).

Assuming infectious is the negative state, the differential equation of it is:

$$\frac{dI}{dt} = \beta SI - \gamma I \tag{12}$$

$$\frac{dS}{dt} = -\beta SI + \gamma I \tag{13}$$

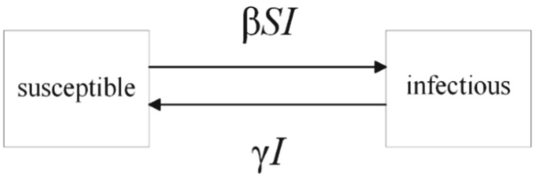

Fig. 4. The structure of SIS model

3 The SIRO Model

This chapter can be a generalized case of the previous chapter. In such a case, some people try to convince other people to give up using TikTok who are like doctors treating patients in the epidemic. The entire population can be divided into four types: *S* stands for people who don't know what is TikTok (ignorant, similar to Susceptible), *I* stands for the people who use TikTok and keep recommending it to others (recommenders, similar to infected), and *R* stands for whom indifference to TikTok and do not recommend it to other or persuade others to not to use TikTok(Indifference, similar to recover), and *O* stands for opposer, who have heard about TikTok but keep persuading others to not to use TikTok [12] (Fig. 5).

In reality, ignorant people might be affected by TikTok recommenders or opposers and join them, while indifferent people may not affect ignorant people, for they are not interested in TikTok and persuading others. Also, indifferent people can turn to recommender or opposer, and recommenders and opposers might turn to indifferent people, for people's minds might change at a probability. In this case, I assume the recommender is the negative state, for the spread of TikTok has many negative effects. The product of S and I is the random mixing of ignorant people and recommender, and the product of S and O is the random mixing of ignorant people and opposer [13]. When ignorant people contact recommenders, the ignorant people will become recommenders with probability β_I. Similarly, when ignorant people contact opposers, they become opposers with probability β_O. The rate of recommenders turning to indifferent people to TikTok is defined as γ_1, The rate of indifferent people turning into recommenders is defined as γ_2, The rate of indifferent people turn into opposers is defined as γ_3, The rate of opposers turn to indifferent people is defined as γ_4. As a result, the differential equation can be written as:

$$\frac{dI}{dt} = \beta_S SI - \gamma_1 I + \gamma_2 R \tag{14}$$

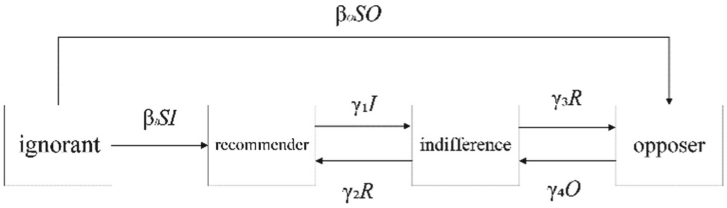

Fig. 5. Structure of SIRO TikTok influence spreading model

$$\frac{dS}{dt} = -\beta_I SI + \beta_O SI \tag{15}$$

$$\frac{dR}{dt} = \gamma_1 I - (\gamma_2 + \gamma_3)R + \gamma_4 O \tag{16}$$

$$\frac{dO}{dt} = \beta_O SO + \gamma_3 R \tag{17}$$

4 Theoretical Analysis

4.1 The Basic Reproduction Number

In many epidemiological models, there is a disease-free equilibrium where the population remains in the absence of disease [14]. In this case, the disease-free equilibrium is where the population remains in absence of the recommender, by setting R to zero, we can calculate the Disease-Free equilibrium:

$$\mathrm{E}_0 = (\mathrm{S}_0, 0, 0, 0), \text{so } \mathrm{E}_0 = 1.$$

Let

$$\mathcal{F} = \begin{pmatrix} \beta_S SI + \gamma_2 R \\ 0 \\ 0 \\ 0 \end{pmatrix} \tag{18}$$

$$\mathcal{V} = \begin{pmatrix} \gamma_1 I \\ \beta_S SI + \beta_0 SO \\ -\gamma_1 I + (\gamma_2 + \gamma_3)R + \gamma_4 O \\ -\beta_0 SO - \gamma_3 R \end{pmatrix} \tag{19}$$

In order to get F and V, we should do the partial derivative of $\mathcal{F}$ and $\mathcal{V}$, and $\mathrm{F} = \frac{d\mathcal{F}}{dI}$, $\mathrm{V} = \frac{d\mathcal{V}}{dI}$, so $\mathrm{F} = \beta_S S$, V=γ_1 [15].

Evaluating the derivatives of F and V at the disease-free equilibrium point, FV^{-1} which is the generation matrix, and $\rho(\mathrm{FV}^{-1})$ is the spectral radius of the matrix, which is the maximum of the absolute values of its eigenvalues. For epidemiological models, R_0 denotes the basic reproduction number, which is the average number of susceptible people that acquire the disease from one infected person. The greater the value of R_0, the easier an epidemic to outbreak, so the transmissibility of infection can be quantified by its basic reproduction number. In the spread of TikTok influence, R_0 is the number of ignorant people and indifferent people who turn to recommenders under the influence of one recommender. R_0 is a threshold to determine the popularity of TikTok, for $\mathrm{R}_0 > 1$, a recommender will turn more than one ignorant people or indifferent people into the recommender, so the number of recommenders is likely to increase. By contrast, when $\mathrm{R}_0 < 1$, the transmission from ignorant and indifferent to recommender is likely

to disappear [16, 17]. The R_0 is given by the dominant eigenvalue of FV^{-1}, so $R_0 = \rho(FV^{-1})$. Then the product of F and V^{-1} is $\frac{\beta_S S}{\gamma_1}$, so the spectral radius is:

$$\rho(FV - 1) = \frac{\beta_S S}{\gamma_1} = R0 < 1 \tag{20}$$

As a result, the disease-free equilibrium is stable if $R_0 < 1$, and unstable if $R_0 > 1$ [15].

4.2 Discussion

Because TikTok will lead to some negative impacts on adolescent, such as anxiety and some health problems, the recommender of TikTok can be considered as a negative state in the SIRO model. If R_0 is greater than 0, everyone in the society will eventually be the recommender of TikTok, and if R_0 is less than 0, the recommender will be absent in society. From (20), we can notice that β_S and R_0 have a linear relationship, while γ_1 and R_0 also have a linear relationship. When β_S decrease, the rate that ignorant people turn to recommender will decrease, R_0 will decrease, and when γ_1, the rate of recommender turning to indifferent people increase, R_0 will decrease. In order to decrease β_S, education should be improved to enhance their judgment skill. Besides, the government should let people know the harm of TikTok through propaganda to prevent information failure. In this case, people might not download and use TikTok even though the recommenders recommend TikTok to them. In order to decrease γ_1, the aesthetic education should also be improved, so people might get broad with TikTok faster, and be interested in other things which is more meaningful.

5 Conclusion

This paper first does a background survey about TikTok and gives some of the drawbacks of using TikTok. Then it reviews and discusses some applications of the SIR model and its variants on the spread of TikTok's influence. Next, it proposes a new model, named the Ignorant-Recommender-Indifference-Opposer (SIRO) model, to investigate the spread of TikTok influence, derive the differential equation, and calculate the explicit solution of R_0. Indeed, TikTok is the most famous software around the globe which have gained two billion downloads so far. However, its negative impact is nonnegligible, for it can cause many problems to users, especially to adolescents. It costs people time, shapes their opinions, and impairs their mental and physical health. In order to control the spread of the influence of TikTok, people should decrease the rate of ignorant people, indifference people turning to recommenders by improving education and ideology, and the rate of recommenders turning to indifferent people should be also increased by improving education on aesthetics. Also, the government should let all people know the harm of TikTok to prevent information failure by propaganda.

References

1. C. Montag, H. Yang, and J. D. Elhai, 'On the psychology of TikTok use: A first glimpse from empirical findings', *Front. Public Health*, vol. 9, p. 641673, 2021.
2. Jiayan Liu, 'The Influence of the Body Image Presented Through TikTok Trend-Videos and Its Possible Reasons', in *Proceedings of the 2nd International Conference on Language, Art and Cultural Exchange (ICLACE 2021)*, Jun. 2021, pp. 359–363. https://doi.org/10.2991/assehr.k.210609.072.
3. G. M. Hülsing, '#Triggerwarning: Body Image: A qualitative study on the influences of TikTok consumption on the Body Image of adolescents', Jun. 2021, [Online]. Available: http://essay.utwente.nl/86504/
4. B. A. Jaffar, S. Riaz, and A. Mushtaq, 'Living in a moment: Impact of TicTok on influencing younger generation into micro-fame'.
5. C. Abidin, 'Mapping Internet Celebrity on TikTok: Exploring Attention Economies and Visibility Labours', *Cult. Sci. J.*, vol. 12, no. 1, pp. 77–103, 2020, https://doi.org/10.5334/csci.140.
6. A. S. L. Tan and E. Weinreich, '#PuffBar: how do top videos on TikTok portray Puff Bars?', *Tob. Control*, vol. 30, no. 6, p. 712, Nov. 2021, https://doi.org/10.1136/tobaccocontrol-2020-055970.
7. A. Neyaz, A. Kumar, S. Krishnan, J. Placker, and Q. Liu, 'Security, privacy and steganographic analysis of FaceApp and TikTok', *Int. J. Comput. Sci. Secur.*, vol. 14, no. 2, pp. 38–59, 2020.
8. N. P. U. Oktarini, N. P. K. Dewi, M. R. A. K. Putra, J. H. A. Ataupah, and N. L. D. D. Oktarini, 'Analysis of the Positive and Negative Impacts of Using Tiktok For Generation Z During Pandemic', *J. Digit. Law Policy*, vol. 1, no. 2, pp. 53–58, 2022.
9. C. L. Nixon, 'Current perspectives: the impact of cyberbullying on adolescent health.', *Adolesc. Health Med. Ther.*, vol. 5, pp. 143–158, 2014, https://doi.org/10.2147/AHMT.S36456.
10. K. E. Anderson, 'Getting acquainted with social networks and apps: it is time to talk about TikTok',*Libr. Hi Tech News*, vol. 37, no. 4, pp. 7–12, Jan. 2020, https://doi.org/10.1108/LHTN-01-2020-0001.
11. J. Tolles and T. Luong, 'Modeling Epidemics With Compartmental Models',*JAMA*, vol. 323, no. 24, pp. 2515–2516, Jun. 2020, https://doi.org/10.1001/jama.2020.8420.
12. L. Zhao, J. Wang, Y. Chen, Q. Wang, J. Cheng, and H. Cui, 'SIHR rumor spreading model in social networks', *Phys. Stat. Mech. Its Appl.*, vol. 391, no. 7, pp. 2444–2453, 2012, https://doi.org/10.1016/j.physa.2011.12.008.
13. L. Fu, W. Song, W. Lv, and S. Lo, 'Simulation of emotional contagion using modified SIR model: A cellular automaton approach', *Phys. Stat. Mech. Its Appl.*, vol. 405, pp. 380–391, 2014.
14. P. Van den Driessche and J. Watmough, 'Reproduction numbers and sub-threshold endemic equilibria for compartmental models of disease transmission', *Math. Biosci.*, vol. 180, no. 1–2, pp. 29–48, 2002.
15. L. Zou, S. Ruan, and W. Zhang, 'On the sexual transmission dynamics of hepatitis B virus in China',*J. Theor. Biol.*, vol. 369, pp. 1–12, Mar. 2015, https://doi.org/10.1016/j.jtbi.2015.01.005.
16. Y. Liu, A. A. Gayle, A. Wilder-Smith, and J. Rocklöv, 'The reproductive number of COVID-19 is higher compared to SARS coronavirus', *J. Travel Med.*, 2020.
17. A. Cintrón-Arias, C. Castillo-Chávez, L. Betencourt, A. L. Lloyd, and H. T. Banks, 'The estimation of the effective reproductive number from disease outbreak data', North Carolina State University. Center for Research in Scientific Computation, 2008.