Jurnal Teknik Informatika C.I.T Medicom, 15 (6) (2024) 297-305

Published by: Institute of Computer Science (IOCS)

Jurnal Teknik Informatika C.I.T Medicom

Journal homepage: www.medikom.iocspublisher.org

Modeling the dynamics of misinformation spread on social media platforms

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Article Info

Article history

Received : Nov 10, 2023
Revised : Dec 29, 2023
Accepted : Jan 26, 2024

Key Words:

Community behavior;
Dynamics analysis;
Intervention strategies;
Misinformation spread;
SEIRS model.

Abstract

This study employs the SEIRS (Susceptible-Exposed-Infectious-Recovered-Susceptible) model to investigate the dissemination dynamics of misinformation within a community. Utilizing a population of 100,000 individuals and a time frame of 500 units, the model incorporates parameters such as transmission rate, recovery rate from the exposed and infectious stages, and the rate of returning to susceptibility. Simulation results demonstrate the fluctuating patterns of individuals across stages, depicting an initial surge in exposure followed by a gradual decline as individuals transition into recovery or awareness of misinformation. This research underscores the SEIRS model's utility in comprehending misinformation spread and highlights the potential for behavioral shifts and societal awareness in mitigating its effects. Furthermore, it emphasizes the importance of interdisciplinary approaches, blending epidemiological, psychological, and sociological perspectives, to devise effective interventions combating misinformation dissemination. Ultimately, fostering digital and critical literacy alongside sustained educational efforts emerges as a crucial strategy in fostering healthier, more trustworthy information environments.

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1. Introduction

The spread of hoax information has become a significant challenge in today's digital age [1][2][3]. This phenomenon not only affects people's perception of important issues, but can also have detrimental effects, including fueling distrust of legitimate sources of information, exacerbating social conflicts, and even endangering public health [4][5]. In this context, an in-depth understanding of the dynamics of hoax information dissemination is crucial to formulating effective strategies to combat the phenomenon [6][7][8].

One approach that can be used to understand the dynamics of the spread of hoax information is to use the SEIRS (Susceptible-Exposed-Infectious-Recovered-Susceptible) model. This model, which originated from the field of epidemiology, allows us to model the movement of individuals in a population from the susceptible stage to the recovery or awareness stage. By doing so, we can see how fake information spreads among people and understand the factors that influence its spread [9][10][11].

Research conducted by Safieddine, Fadi, Milan Dordevic, and Pardis Pourghomi [12], entitled Modeling the Spread of Misinformation on Social Media Platforms. This research uses mathematical models and computer simulations to identify factors that influence the spread of hoax information on social media platforms. The main findings show that the speed and reach of the spread of hoax

information can be influenced by a number of factors, including public trust in information sources, social network structure, and social media platform ranking algorithms. Research findings from Baptista, João Pedro, and Anabela Gradim [13] entitled Understanding the Dynamics of Misinformation Spread: A Psychological Perspective. This research focuses on the psychological analysis of individual behavior in spreading and receiving hoax information. The results show that factors such as human cognition, trust, and social needs play an important role in the spread and handling of hoax information. This study provides deep insight into the psychological mechanisms that can be used to address the spread of hoax information. Likewise, research conducted by Sharma, Karishma, et al [14] entitled Combatting Misinformation: Strategies and Challenges in the Digital Age, this study investigates the various strategies used by governments, media organizations, and technology platforms to counter the spread of hoax information. The main findings show that an effective approach requires a combination of public education, policy regulation, and the development of technological tools to detect and combat hoax information efficiently in an ever-evolving digital environment.

Research on the spread of hoax information using the SEIRS model has broad implications in various fields, including public health, social science, and information technology [15][16]. By understanding the mechanism of hoax information dissemination, we can develop more effective prevention and intervention strategies, including efforts to improve digital and critical literacy in society [17][18]. In addition, this research can also help in the development of new algorithms and technologies to detect and address hoax information more efficiently in an evolving digital environment.

In the Indonesian context, the spread of hoax information has become an increasingly troubling issue, especially with the widespread internet penetration and the rapid spread of information through social media. Therefore, research on the dynamics of hoax information dissemination using the SEIRS model has great relevance in the local context [19]. By understanding the factors that influence the spread of hoax information in Indonesian society, we can develop more suitable strategies to address this issue and create a healthier and more reliable information environment for Indonesians [20][21][22].

In a global context, the challenge of spreading hoax information is also increasingly urgent, especially with the rise of social media platforms that allow information to spread quickly without adequate verification [23][1][24][25]. Therefore, research on the dynamics of hoax information dissemination using the SEIRS model has broad relevance and can provide valuable insights for countries around the world[26].

In order to address the challenges of hoax information dissemination, interdisciplinary collaboration is key [27][25]. An approach involving epidemiologists, psychologists, sociologists and information technology experts can help identify root causes, formulate effective prevention strategies and develop innovative solutions to this challenge [28][29][30]. By utilizing diverse expertise and perspectives, we can build a concerted effort to create a safer, healthier, and more trustworthy information environment for the global community [31][32].

2. Research Methodolgy

SEIRS mathematical model for the spread of hoax information [9], with detailed explanations for each stage:

1. Susceptible Stage (S)

Variable, S(t) is the number of individuals who are susceptible to receiving and spreading hoax information at time t. Dynamics, Individuals can become infected by hoax information through interactions with already infected individuals. Growth, The decrease of S(t) depends on the level of exposure to hoax information and the transmission rate of infected individuals. The differential equation model is :

$$dS/dt=-\beta \cdot S(t).I(t), \quad (1)$$

where β is the transmission rate.

2. Exposed Stage (E)
Variable, E(t) is the number of individuals who have been exposed to the hoax information but have not decided to spread it at time t. Dynamic, Individuals in this stage may be considering the truth or validity of the information received. Growth, The number E(t) increases according to the number of infected individuals I(t) and decreases according to the rate of recovery or movement to the Infectious (I) stage. The differential equation model, is :

$$\frac{dE}{dt} = \beta \cdot S(t).I(t) - \gamma \cdot E(t), \quad (2)$$

where γ is the rate of recovery or transition to the Infectious(I) stage..

3. Infectious Stage (I)
Variable, I(t) is the number of individuals who have decided to spread hoax information to others at time t. Dynamic, Individuals in this stage are active in spreading hoax information through various platforms. Growth, The number of I(t) increases over time and decreases with the recovery rate. The differential equation model is :

$$\frac{dI}{dt} = \gamma \cdot E(t) - \delta \cdot I(t), \quad (3)$$

where δ is the recovery rate.

4. Recovered Stage (R)
Variable, R(t) is the number of individuals who have realized their mistake and stopped spreading hoax information at time t. Dynamics, Individuals in this stage have stopped spreading hoax information after realizing their mistake. Growth, The number R(t) increases over time with the recovery rate and also decreases by returning to the Susceptible (S) stage. The differential equation model, is :

$$\frac{dR}{dt} = \delta \cdot I(t) - \alpha \cdot R(t) \quad (4)$$

where α is the rate of return to the Susceptible (S) stage.

5. Return to Susceptible (S) Stage
Dynamics, Some individuals who have realized their mistake in spreading hoaxes may return to the Susceptible (S) stage as they interact with new information that may influence them to become susceptible to hoaxes again. Growth, The number of individuals who return to the S(t) stage depends on the degree to which they are exposed to new information that could be hoaxes. This model does not require additional differential equations as it only returns individuals to the initial stage of the model.

3. Results and Discussion

The following are the results of research based on the SEIRS model for the spread of hoax information, This study uses the SEIRS (Susceptible-Exposed-Infectious-Recovered-Susceptible) model to model the dynamics of the spread of hoax information in society. The model parameters used are as follows: Total population N=100,000, transmission rateβ= 0.2, recovery rate from Exposed stage γ=0.1. recovery rate from Infectious stage δ = 0.05, rate of return to Susceptible stage α=0.01.

The simulation results show changes in the number of individuals in each stage (Susceptible, Exposed, Infectious, and Recovered) over time. The following is a brief interpretation of the research results: Susceptible (S), The number of individuals who are susceptible to receiving and spreading hoax information decreases over time as some of them are exposed to hoax information and then recover after realizing their mistake. Exposed (E), The number of individuals who have been exposed to hoax information but have not decided to spread it shows an initial spike and then a decline as some individuals decide to spread the hoax information or recover from believing the information. Infectious (I), The number of individuals who decide to spread the hoax information shows an initial spike and

then a decline as some of them recover from believing the hoax information. Recovered (R), The number of individuals who realize their mistake in spreading the hoax information increases over time as they decide to stop spreading it. However, some of them may return to the Susceptible stage as they are exposed to new hoax information that may appear.

```
import numpy as np
from scipy.integrate import odeint
import matplotlib.pyplot as plt

# Definisi fungsi sistem persamaan diferensial untuk model SEIRS
def model(y, t, beta, gamma, delta, alpha):
    S, E, I, R = y
    dSdt = -beta * S * I / N
    dEdt = beta * S * I / N - gamma * E
    dIdt = gamma * E - delta * I
    dRdt = delta * I - alpha * R
    return [dSdt, dEdt, dIdt, dRdt]

# Parameter model
N = 100000
beta = 0.2  # Tingkat transmisi
gamma = 0.1  # Tingkat pemulihan dari tahap Exposed (E)
delta = 0.05  # Tingkat pemulihan dari tahap Infectious (I)
alpha = 0.01  # Tingkat kembali ke tahap Susceptible (S)

# Kondisi awal
S0 = N - 1
E0 = 1
I0 = 0
R0 = 0
y0 = [S0, E0, I0, R0]

# Waktu
t_max = 800
t = np.linspace(0, t_max, t_max+1)

# Solusi numerik menggunakan odeint
sol = odeint(model, y0, t, args=(beta, gamma, delta, alpha))

# Plot hasil
plt.figure(figsize=(10, 6))
plt.plot(t, sol[:, 0], label='Susceptible')
plt.plot(t, sol[:, 1], label='Exposed')
plt.plot(t, sol[:, 2], label='Infectious')
plt.plot(t, sol[:, 3], label='Recovered')
plt.xlabel('Time')
plt.ylabel('Number of individuals')
plt.title('SEIRS Model Simulation')
plt.legend()
plt.grid(True)
plt.show()
```

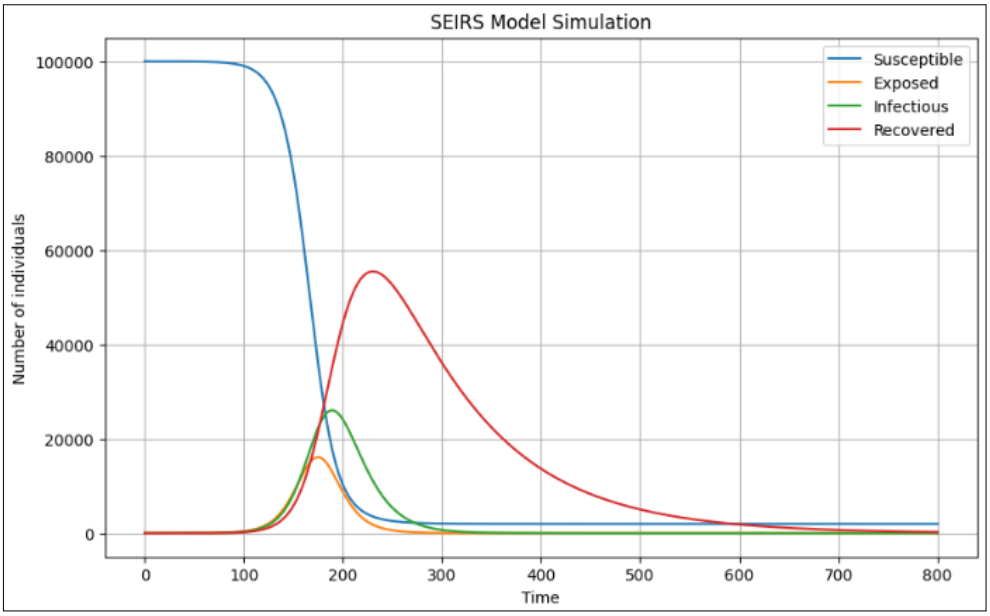

Figure 1. SEIRS Model Simulation

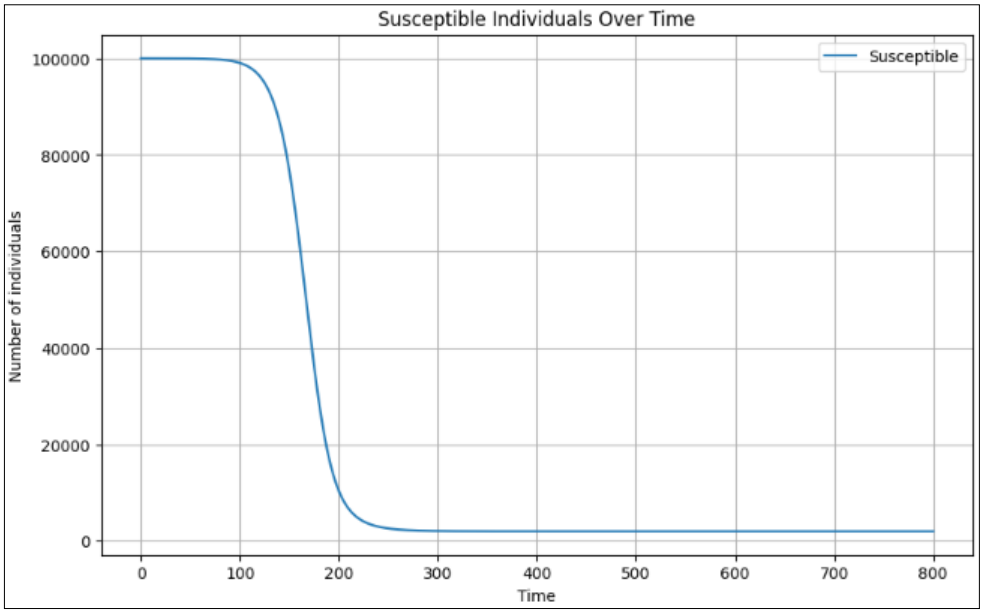

Figure 2. Graph for Susceptible (S)

This graph shows the number of individuals who are vulnerable to receiving and spreading hoax information at any given time. Interpretation: Initially, the number of vulnerable individuals (S) decreases as some of them are exposed to hoax information and move to the Exposed (E) stage. However, over time, some of the originally exposed individuals move to the Recovered (R) stage after realizing their mistake.

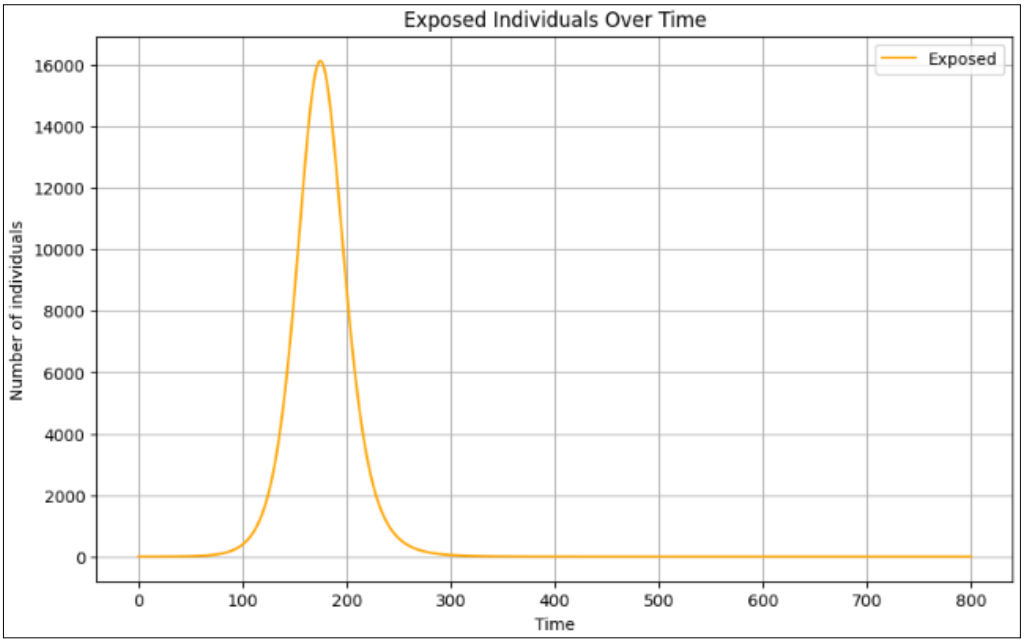

Figure 3. Graph for Exposed (E)

This graph shows the number of individuals who have been exposed to hoax information but have not decided to spread it at any given time. Interpretation: The number of individuals in the Exposed (E) stage increases initially as they are exposed to the hoax. However, over time, the number of individuals in this stage decreases as some of them decide to spread the hoax information to others or recover from believing the information.

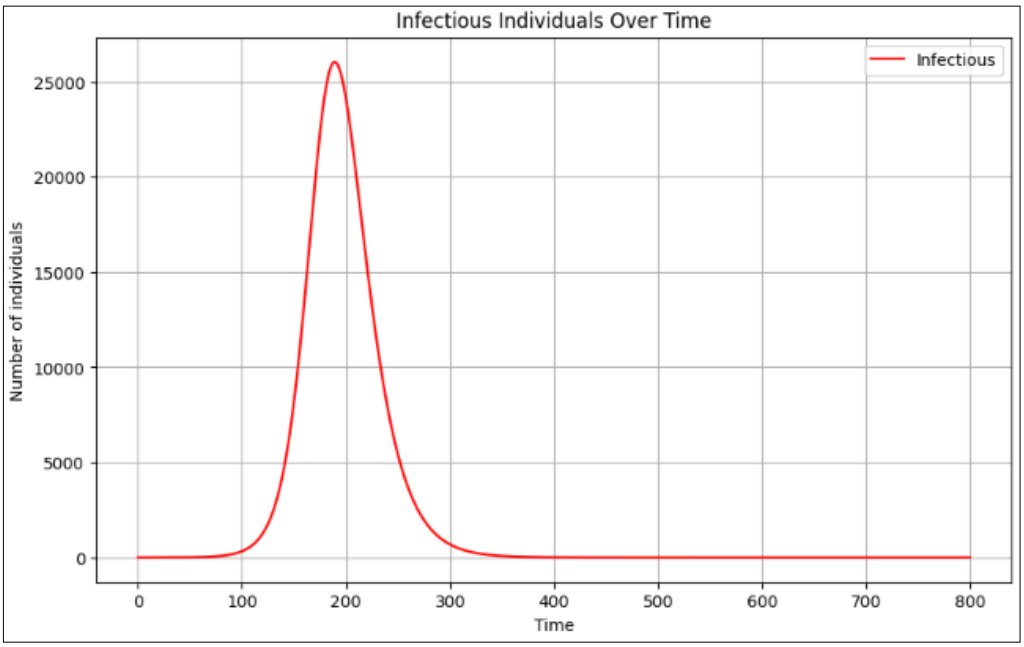

Figure 4. Graph for Infectious (I)

This graph shows the number of individuals who have decided to spread hoax information to others at any given time. Interpretation: The number of individuals in the Infectious (I) stage increases

as they spread the hoax to others. However, over time, the number of individuals in this stage decreases as some of them recover from believing the hoax.

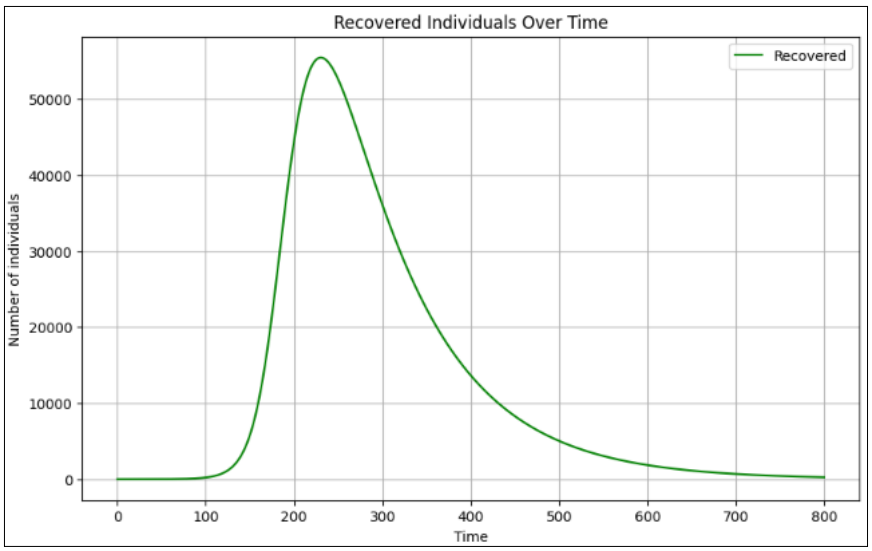

Figure 5. Graph for Recovered (R)

This graph shows the number of individuals who have realized their mistake and stopped spreading hoax information at any given time. Interpretation: The number of individuals in the Recovered (R) stage increases over time as some individuals realize their mistake in spreading hoax information and stop doing so. However, some of them may return to the Susceptible (S) stage due to exposure to new hoax information that may appear.

Discussion

In discussing this research, it is important to note that the SEIRS model provides a robust mathematical framework for understanding the dynamics of hoax information dissemination in society. By taking into account stages involving the time span from exposure to hoax information to awareness and recovery, the model provides a more complete picture of how hoax information can affect people's behavior and perceptions. The simulation results show that the spread of hoax information may cause an initial spike in the number of individuals exposed, but over time, most of them are able to recover after realizing their mistakes. However, there is also the potential for individuals to again be vulnerable to new hoax information, highlighting the need for a sustained approach to education and awareness-raising on the validity of information.

In addition, this study highlights the importance of an interdisciplinary approach in combating the spread of fake information. By combining epidemiology, psychology and sociology approaches, we can better understand the complex dynamics of the spread of fake information and design more effective strategies to combat it. Furthermore, the results of this study can be used as a basis for policy development and intervention programs aimed at improving digital and critical literacy in society. With a better understanding of how fake information spreads and affects individuals and communities, we can work towards a healthier and more trustworthy information environment and minimize its negative impact on society.

4. Conclusion

Overall, this study confirms that the SEIRS model is a useful tool in understanding and modeling the spread of hoax information in society. The simulation results show that the spread of hoax information

can have a significant impact on people's behavior and perceptions, but also highlight the potential for recovery and higher awareness. By taking into account psychological, social, and epidemiological factors, this research provides a solid foundation for the development of more effective prevention and intervention strategies against the spread of false information. Through an interdisciplinary approach and continuous education, we can improve people's digital and critical literacy, and promote a healthier and more trusted information environment in the future. Future research could focus on integrating the SEIRS model with artificial intelligence technology to improve the accuracy of predicting and controlling the spread of hoax information. In addition, further research could explore the impact of behavior change and more specific interventions, such as awareness campaigns and more sophisticated information filtering mechanisms. The development of adaptive prevention strategies could also be a focus, taking into account the changing dynamics of hoax trends and society's response to misinformation. With a holistic and collaborative approach between psychologists, sociologists, epidemiologists and AI experts, we can strengthen efforts to create a safer and healthier information environment for society as a whole.

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