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DECIPHERING CELEBRITY WORSHIP PHENOMENON: SIMULATION AND ANALYSIS USING SFR MATHEMATICAL MODEL AMONG FANS IN SOUTH SULAWESI

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Abstrak. Studi ini menyelidiki model SFR matematis yang menangkap laju Perilaku Celebrity Worship di kalangan penggemar setia K-Pop. Data primer dikumpulkan melalui kuesioner yang bersumber langsung dari komunitas di Provinsi Sulawesi Selatan, yang memberikan wawasan tentang ritme Perilaku Celebrity Worship di kalangan pecinta K-Pop. Penelitian ini dimulai dengan membangun model SFR dan kemudian menelusuri serangkaian analisis dan simulasi yang berkaitan dengan Perilaku Celebrity Worship di bidang K-Pop. Pendekatan komprehensif ini mencakup penentuan titik keseimbangan, pemeriksaan stabilitas model, penghitungan bilangan reproduksi fundamental (R_0), penyusunan simulasi model menggunakan perangkat lunak Maple, dan penguraian implikasi hasil simulasi. Dalam artikel ini, model matematis SFR diwujudkan melalui sintesis analisis dan simulasi, mengungkap dua titik keseimbangan: keseimbangan tak terbatas dari Perilaku Pemujaan Selebriti di kalangan penggemar K-Pop, dan keseimbangan khusus untuk perilaku khas ini. Angka reproduksi dasar yang dihitung sebesar R_0=0,425 menunjukkan penurunan populasi yang melakukan Perilaku Celebrity Worship dalam komunitas K-Pop.

Kata Kunci: Celebrity Worship, Model SFR, Titik Kesetimbangan, Bilangan Reproduksi Dasar

Abstract. This study delves into the mathematical SFR model capturing the pace of Celebrity Worship Behavior among devoted K-Pop enthusiasts. Primary data is harnessed via questionnaires directly sourced from the community within South Sulawesi Province, offering insights into the rhythm of Celebrity Worship Behavior among K-Pop aficionados. The research embarks on constructing the SFR model and subsequently navigating through an array of analyses and simulations pertaining to Celebrity Worship Behavior in the K-Pop sphere. This comprehensive approach encompasses pinpointing equilibrium junctures, scrutinizing model stability, computing the fundamental reproduction number (R_0), orchestrating model simulations using Maple software, and untangling the implications of simulation outcomes. Within this article, the SFR mathematical model materializes through a synthesis of analysis and simulation, uncovering two equilibrium points: the unconstrained equilibrium of Celebrity Worship Behavior in the realm of K-Pop enthusiasts, and the equilibrium specific to this distinctive behavior. A calculated basic reproduction number of R_0=0,425 alludes to a decline in the populace engaging in Celebrity Worship Behavior within the K-Pop community.

Keywords: Celebrity Worship, SFR Model, Equilibrium Points, Basic Reproduction Number

A. Introduction

The popularity of K-Pop fans in Indonesia is increasing year by year. However, some K-Pop fans sometimes display excessive behavior in their admiration for their idols, which is known as celebrity worship. Celebrity worship is a psychological phenomenon in which someone excessively admires and idolizes celebrities.

Previous research(Zia, M. H., et al., 2018; Ziegler, F. V., et al., 2012; Zsila, Á., et al., 2021; Chen, O., et al., 2022; Zsila, Á., et al., 2020; Zhuang, L., et al., 2019; Zsila, Á., et al., 2018;

Gong and Huang, 2022). has been conducted to understand the differences in celebrity worship among K-Pop fans based on demographics such as gender, age, and education. The research results show that there are differences in the level of celebrity worship among K-Pop fans based on these demographic factors. Additionally, other research(Lu, S. et al., 2022; Hand, 2020; Hamuddin, et al., 2020). has also identified forms of celebrity worship behavior among K-Pop fans, such as dissociation, tendencies toward addiction, compulsive buying, depression, and anxiety.

Mathematical modeling can also be used to understand celebrity worship behavior among K-Pop fans. A study developed a mathematical model to simulate the fanatic behavior of K-Pop fans. This model involves interacting populations, including non-fans who are susceptible to becoming fans, fanatics, and individuals who are no longer fans.

South Sulawesi is one of the regions in Indonesia with a large number of K-Pop fans. Therefore, this article discusses the analysis and simulation of celebrity worship behavior among K-Pop fans using mathematical modeling in the South Sulawesi region. This research aims to provide a better understanding of celebrity worship behavior among K-Pop fans in that region and offer insights into how mathematical modeling can be used to comprehend psychological phenomena like celebrity worship.

Furthermore, this research can also provide practical benefits to society, especially for parents and teachers who have children or students that are K-Pop fans. By understanding celebrity worship behavior among K-Pop fans, parents and teachers can provide appropriate education to avoid excessive behavior in their admiration of idols.

In this study, a survey method will be used to gather data about celebrity worship behavior among K-Pop fans in the South Sulawesi region. Additionally, mathematical modeling will be employed to analyze and simulate celebrity worship behavior among K-Pop fans in that area. By utilizing mathematical modeling, this research aims to provide more accurate and reliable results in understanding celebrity worship behavior among K-Pop fans.

The mathematical model previously formulated is subjected to analysis to ensure its appropriateness in addressing the discussed issues (Maesaroh in Side, 2016). In this context, as students, we hold a vital role in finding solutions to real-world problems by analyzing and simulating the fundamental challenges faced by society using mathematical models. During the model's development, we draw references from various journals. These include "Analysis and simulation of a mathematical model for typhus disease in Makassar" (Anas et al., 2021), "SEIAS-SEI model on asymptomatic and superinfection malaria with imperfect vaccination" (Maryam et al., 2021), "SEIRS model analysis for online game addiction problems among mathematics students" (Anwar et al., 2021), "Analysis and Solution of The SEIRS Model for The Rubella Transmission with Vaccination Effect using Runge-Kutta Method" (Asri et al., 2021), "SEIRI Model analysis using the mathematical graph as a solution for Hepatitis B disease in Makassar" (Side et al., 2021), "Numerical Solution of SIRS model for Dengue Fever Transmission in Makassar City with the Runge-Kutta Method" (Sanusi et al., 2021), "A mathematical model for the novel coronavirus epidemic in Wuhan, China" (Yang et al., 2020), and "Review on COVID-19 disease so far" (Singhal et al., 2020). This collaborative effort aims to contribute to addressing complex societal challenges through mathematical analysis and modeling. The hope is that this article can make a significant contribution to understanding celebrity worship behavior among K-Pop fans in the South Sulawesi region. Additionally, this research can offer practical benefits to society, particularly for parents and teachers with children or students who are K-Pop fans.

B. Method

This study is an exploratory approach that combines both hypothetical and practical aspects. It aims to investigate the analysis and simulation of Celebrity Worship behavior among K-Pop fans

using Mathematical Modeling in the South Sulawesi region. The study's population data encompasses the total population of South Sulawesi Province, which amounts to 9.3 million individuals. The research process involves several key stages, beginning with the construction of an SFR model formulation to understand the spread of Celebrity Worship. This includes defining assumptions, variables, and parameters specific to the SFR model. Subsequently, the SFR model is subjected to analysis, which encompasses the identification of equilibrium points, assessment of stability types based on eigenvalues, and calculation of the basic reproduction number (R0). A higher R0 value indicates easier transmission, while a lower value implies the opposite (Side, 2020).

In the final step, the SFR model is simulated to understand the propagation of Celebrity Worship within South Sulawesi Province, utilizing the Maple software.

C. Result And Discussion

1. SFR Model Celebrity Worship

In this research, the population within the model is divided into four classes: Susceptible (S) class, comprising individuals potentially prone to experiencing celebrity worship with a population of 140 samples; Fanatic (R) class, representing individuals actively engaged in celebrity worship with a population of 100; and Recover (R) class, indicating individuals who are either free from or have recovered from celebrity worship behavior, totaling 160 samples. The schematic model depicting the SFR celebrity worship behavior can be observed in Figure 1 below.

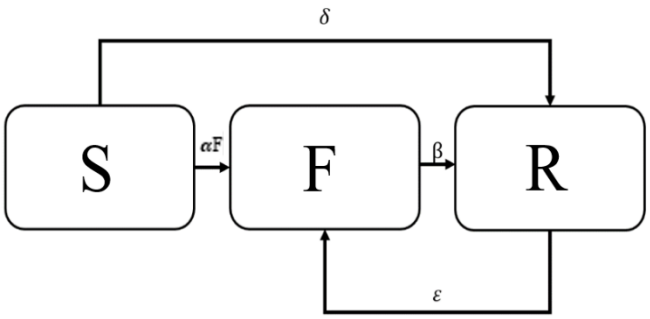

Figure 1. The SFR Model Scheme for the Rate Celebrity Workship

Figure 1 can also be translated into a mathematical model in the form of a nonlinear differential equation as follows:

$$\frac{ds}{dt} = \mu_1 N - \alpha SF - \delta S - \mu_2 S \quad (1)$$

$$\frac{df}{dt} = \alpha SF + \varepsilon R - (\beta + \mu_2)F \quad (2)$$

$$\frac{dr}{dt} = \beta F + \delta S - (\varepsilon + \mu_2)R \quad (3)$$

Table 1 Parameters in the SFR Model

No	Parameter	Description	Data
1	μ_1	Birth Rate	0,017
2	μ_2	Death Rate	0,010
3	α	Rate of Individuals Experiencing Celebrity Worship	0,250
4	β	Rate of Individuals Free from or Ceasing Celebrity Worship Behavior	0,150
5	δ	Rate of Individuals Who Have Never Experienced or Engaged in Celebrity Worship Behavior	0,300
6	ε	Rate of Individuals Freed from Celebrity Worship Behavior After Therapy	0,200

N = S + F + R" represents the total sample

2. Analysis of the Equilibrium Points of the SFR Model

The initial step in determining the equilibrium point is to simplify equations (1)-(3) by dividing them by N, where $\left(S = \frac{s}{N}, F = \frac{f}{N}, R = \frac{r}{N}\right)$, resulting in equations (4)-(6)

$$\frac{dS}{dt} = \mu_1 - \alpha sf - \delta s - \mu_2 s \quad (4)$$

$$\frac{dF}{dt} = \alpha sf + \varepsilon r - (\beta + \mu_2) f \quad (5)$$

$$\frac{dR}{dt} = \beta f + \delta s - (\varepsilon + \mu_2) r \quad (6)$$

To determine the equilibrium point, each equation in equations (4)-(6) should be set equal to zero, which means $\left(\frac{dS}{dt}, \frac{dE}{dt}, \frac{dR}{dt}\right)$ = (0,0,0), As a result, equations (7)-(9) can be obtained

$$\mu_1 - \alpha sf - \delta s - \mu_2 s = 0 \quad (7)$$

$$\alpha sf + \varepsilon r - (\beta + \mu_2) f = 0 \quad (8)$$

$$\beta f + \delta s - (\varepsilon + \mu_2) r = 0 \quad (9)$$

Next, by using a simple substitution method, we will determine the values of S, F, and R for the equilibrium point of the SFR model. The equilibrium point is a state where there is no celebrity worship in the population, which implies F=0. By performing some algebraic manipulation on equations (7)-(9), we obtain equations (10)-(12) as follows:

$$S = \mu_1 - \alpha sf - \delta s - \mu_2 s \quad (10)$$

$$F = \alpha sf + \varepsilon r - (\beta + \mu_2) f \quad (11)$$

$$R = \beta f + \delta s - (\varepsilon + \mu_2) r \quad (12)$$

By substituting F=0 into each equation in equations (10)-(12), we can determine the equilibrium point of the SFR model in South Sulawesi, which is:

$$(S, F, R) = \left(\frac{\mu_1}{\mu_2 + \delta}, 0, \frac{\mu_1 \delta}{\delta\varepsilon + \delta\mu_2 + \varepsilon\mu_2 + {\mu_2}^2}\right) \quad (13)$$

So, the equilibrium point for free celebrity worship is (S, F, R) = (0.05483870968, 0, 0.94516129032).

Continuing with the same method, which involves substituting each equation in equations (10)-(12), we can obtain the values for the equilibrium point SFR model of celebrity worship behavior in the South Sulawesi province.

$$(S, F, R) = \begin{pmatrix} \frac{\mu_1(\delta+\mu_2(-\varepsilon\beta(\delta+\mu_2)-(\varepsilon+\mu_2)(\alpha\mu_1+(\beta+\mu_2)(\delta\mu_2)))}{(\mu_2+\delta+\alpha)(\varepsilon(\delta\mu_2(\alpha\mu_1+(\beta+\mu_2)(\delta\mu_2))(\delta+\mu_2)(\alpha\mu_1-(\beta+\mu_2)(\delta\mu_2)}, \\ \frac{(\varepsilon(\delta\mu_2(\alpha\mu_1+(\beta+\mu_2)(\delta\mu_2))(\delta+\mu_2)(\alpha\mu_1-(\beta+\mu_2)(\delta\mu_2)}{\delta+\mu_2(-\varepsilon\beta(\delta+\mu_2)-(\varepsilon+\mu_2)(\alpha\mu_1+(\beta+\mu_2)(\delta\mu_2))}, \\ \frac{\delta\mu_2(\alpha\mu_1+(\beta+\mu_2)(\delta+\mu_2))}{\delta+\mu_2(-\varepsilon\beta(\delta+\mu_2)-(\varepsilon+\mu_2)(\alpha\mu_1+(\beta+\mu_2)(\delta\mu_2))} \end{pmatrix} \quad (14)$$

And then, the equilibrium point for celebrity worship is (S, F, R) = (0.3394557116, 0.6354589184, 0.02508537).

3. Basic Reproduction Number

The basic reproduction number can be determined using the next-generation matrix method. This matrix is formed by considering the positive and negative components of the transmission rate of the fanatic population. The formula for calculating the basic reproduction number can be found in equation (15).

$$\boldsymbol{R = F' \cdot (V')^{-1}} \quad \textbf{(15)}$$

Based on equation (2), then:

$$\boldsymbol{F = \alpha s f + \varepsilon r - (\beta + \mu_2) f}$$

As a result, we obtain:

$$\boldsymbol{F = [\alpha S F]},\ \boldsymbol{F' = [\alpha S]} \quad \textbf{(16)}$$

$$\boldsymbol{V = [\beta F + \mu_2 F - \alpha S F]},\ \boldsymbol{V' = [\beta + \mu_2]} \quad \textbf{(17)}$$

Therefore, the inverse of the matrix in equation (13) is:

$$\boldsymbol{(V')^{-1} = \left[\frac{1}{\beta(t-\tau)+\mu_2}\right]} \quad \textbf{(18)}$$

Next, the eigenvalues of the matrix R will be determined based on equation (15).

$$\boldsymbol{R = [\alpha S]\left[\frac{1}{\beta+\mu_2}\right]}$$

$$\boldsymbol{R = \left[\frac{\alpha S}{\beta+\mu_2}\right]} \quad \textbf{(19)}$$

After obtaining the matrix R in equation (19), the eigenvalues can be found using the equation Det $(\lambda I - R) = 0$, where F is the identity matrix. The basic reproduction number will be determined based on the largest eigenvalue (λ).

$$\boldsymbol{|\lambda I - J| = \left|\left(\lambda[1] - \left[\frac{\alpha S}{\beta+\mu_2}\right]\right)\right| = 0} \quad \textbf{(20)}$$

As a result, the eigenvalues based on equation (20) are:

$$\boldsymbol{\lambda = \frac{\alpha S}{\beta+\mu_2}}$$

Therefore, the eigenvalues are as follows: $\lambda = \frac{\alpha S}{\beta+\mu_2}$

Thus, we obtain the basic reproduction number. :

$$\boldsymbol{R_0 = \frac{\mu_1 \alpha}{(\mu_2)(\mu_2+\delta)}} \quad \textbf{(21)}$$

Based on Table 1, for the SFR model, the value of R_0 is 0.425, which indicates a decrease in celebrity worship behavior.

4. Stability of the SFR Celebrity Worship Model

Based on equations (1) - (3), the Jacobian matrix (J) can be formed as follows::

$$\boldsymbol{J = \begin{bmatrix} -\alpha f - \mu_2 - \delta & -\alpha S & 0 \\ \alpha f & -\alpha s - \beta - \mu_2 & -\varepsilon \\ \delta & -\beta & -\varepsilon - \mu_2 \end{bmatrix}} \quad \textbf{(22)}$$

Theorem

The equilibrium point in the mathematical model of celebrity worship behavior is considered stable if the basic reproduction number (R_0) is less than or equal to 1 ($R_0 \leq 1$), and it is considered unstable if R_0 is greater than 1 ($R_0 > 1$)..

Proof:

equilibrium point into the matrix J of equation (22),

$$J = \begin{bmatrix} -\alpha f - \mu_2 - \delta & -\alpha S & 0 \\ \alpha f & -\alpha s - \beta - \mu_2 & -\varepsilon \\ \delta & -\beta & -\varepsilon - \mu_2 \end{bmatrix}$$

then, the eigenvalues of the matrix in equation (22) are determined, with the description as follows:

$$\boldsymbol{|\lambda I - J| = 0}$$

- $$|\lambda I - J| = \left| \left(\lambda \begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix} - \begin{bmatrix} -\alpha f - \mu_2 - \delta & -\alpha S & 0 \\ \alpha f & -\alpha s - \beta - \mu_2 & -\varepsilon \\ \delta & -\beta & -\varepsilon - \mu_2 \end{bmatrix} \right) \right| = 0$$

$$\boldsymbol{|\lambda I - J| = \left| \begin{bmatrix} -\alpha f - \mu_2 - \delta - \lambda & -\alpha S & 0 \\ \alpha f & -\alpha s - \beta - \mu_2 - \lambda & -\varepsilon \\ \delta & -\beta & -\varepsilon - \mu_2 - \lambda \end{bmatrix} \right| = 0}$$

(24)

Next, the determinant will be calculated, resulting in

$$\boldsymbol{(\alpha f + \delta + \lambda + \mu_2)\ ((-\alpha s + \beta + \lambda + \mu_2)(\varepsilon - \mu_2 + \lambda) - \varepsilon\beta) + \alpha^2 f s(\varepsilon - \mu_2 + \lambda) + \alpha s \varepsilon \delta = (\alpha f + \delta + \lambda + \mu_2)\ (-\alpha s + \beta + \lambda + \mu_2)\ (\lambda + \alpha^2 f s)} \quad (25)$$

Based on Descartes' rule of signs, equation (25) will have roots that are all negative if all the signs in each of its terms are positive. Therefore, it can be concluded that the equilibrium point for psychological health is considered stable when $R_0 \leq 1$ and unstable when $R_0 > 1$.

1. Eigen Values

Based on equation (24), the obtained eigenvalues are $\lambda = -\alpha f - \delta - \mu_2$, $\lambda = -\alpha s + \beta - \mu_2$, and $\lambda = -\alpha^2 fs$. The values of λ obtained at equilibrium point (24) are real and negative. Referring to stability properties, the type of stability at this equilibrium point is asymptotically stable.

So, the stability of the SFR celebrity worship model for free celebrity worship is (S, F, R) = (-0.31, -0.1462903226, -0.49). And then, the stability of the SFR celebrity worship model for celebrity worship is (S, F, R) = (-0.4688647296, -0.07513607210, -0.01348188496). Therefore, the type of stability at both equilibrium points is asymptotic stability.

2. Results of the SFR Celebrity Worship Model Simulation

The simulation of the SFR model for the celebrity worship population growth can be observed in Figure 2 as follows..

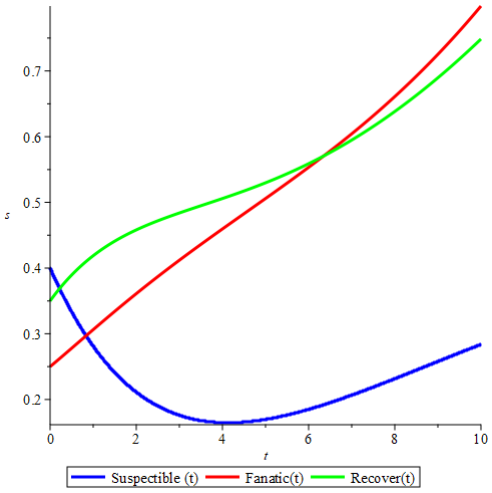

Figure 2. Plot of the SFR model depicting the rate of individuals exhibiting celebrity worship behavior in the population of South Sulawesi province.

In Figure 2, it is evident that the number of individuals potentially experiencing an increase goes from 0.35 to 0.74 over 10 months. Individuals exhibiting celebrity worship behavior also undergo a similar increase, going from 0.25 to 0.79 within the same 10-month period. Those who aspire to break free from or recover from the worship behavior experience a decline from 0.4 to 0.01 in the first 4 months, followed by an increase to 0.31 in the subsequent 6 months.

In Figure 2, it's apparent that the increases in fanaticism and recovery are nearly equal. Therefore, it can be concluded that psychological therapy plays a crucial role in helping fanatics of celebrity worship to mitigate the rising cases. However, South Sulawesi province is still far from being free of this celebrity worship behavior.

3. Discussion

In this research, the phenomenon of idolization of K-Pop celebrities among fans in South Sulawesi was examined using simulations and analysis utilizing the mathematical SFR model. Our findings indicated that the level of idolization of K-Pop celebrities in this region is quite significant, as reflected in the active participation of fans in various activities related to their favorite celebrities, such as following news, attending concerts, and engaging on social media. The mathematical modeling using the SFR model helped us gain a deeper understanding of the impact of this idolization on fan behavior and allowed for a more accurate measurement. Additionally, our research highlighted the crucial role of social media in reinforcing celebrity idolization, as well as the influence of cultural and social factors on the expression of idolization. These findings have important implications in the context of the entertainment industry, marketing, fan engagement, and pave the way for further research in understanding the evolving phenomenon of celebrity idolization.

Beyond explaining the phenomenon of celebrity idolization, this research also discusses potential solutions in the form of therapy. Psychological therapy and counseling may be effective approaches to assist individuals who may be overly attached to celebrities to the extent that it disrupts their daily lives. Through therapy, individuals can understand the root causes of excessive idolization, learn to manage their emotions and obsessions, and develop strategies to redirect their focus towards positive aspects of their lives. Furthermore, supporting K-Pop fans to engage in more balanced and healthy social activities can be a beneficial solution. Therefore, solutions such as therapy and social

support can aid individuals in maintaining a balance between their personal lives and idolization of celebrities, thereby reducing potential negative impacts.

D. Conclusion

Based on the discussion conducted, the SFR Mathematical Model among Fans in South Sulawesi with a 3-dimensional differential equation has been established. This model yields two equilibrium points: the fanatic equilibrium point and the non-fanatic equilibrium point, both of which are stable. The spread of celebrity worship behavior results in an R0 value of 0.425, indicating that the spread is unlikely to occur. Therefore, based on the equilibrium points, the spread tends to be stable, and its potential for dissemination is low.

Psychological therapy and counseling have been suggested as effective approaches to assist individuals who may be excessively attached to celebrities to the point where it disrupts their daily lives. Through therapy, individuals can gain insights into the root causes of their excessive idolization, learn techniques to manage their emotions and obsessions, and develop strategies to refocus on positive aspects of their lives.

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