The Eastasouth Journal of Information System and Computer Science
Vol. 2, No. 03, April 2025, pp. 171-182
ISSN: 3025-566X, DOI: 10.58812/esiscs.v2i03

Social Media as an Early Warning System for Drug Prevention: Case Study of Surabaya's Digital Surveillance Program

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Article Info

Article history:
Received April, 2025
Revised April, 2025
Accepted April, 2025

Keywords:
Digital Surveillance
Drug Prevention
Program Effectiveness
Public Awareness
Social Media

ABSTRACT

Social media has emerged as a powerful tool in public health initiatives, including drug prevention efforts. This study examines the role of social media as an early warning system in the Digital Surveillance Program in Surabaya. Using a quantitative approach with a sample of 100 respondents, data was collected through a Likert-scale questionnaire (1–5) and analyzed with Structural Equation Modeling - Partial Least Squares (SEM-PLS). The results reveal that public awareness significantly influences social media engagement and program effectiveness, while social media engagement plays a critical role in enhancing program outcomes. The structural model demonstrates moderate predictive power (R^2 = 0.53 for program effectiveness), highlighting the importance of integrating public awareness campaigns and social media engagement strategies to optimize drug prevention initiatives. The findings provide actionable insights for policymakers and stakeholders, emphasizing the need for community-centered content creation and data-driven social media strategies to combat drug misuse.

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1. INTRODUCTION

1.1. Introduction

The increasing prevalence of drug abuse poses significant social, economic, and public health challenges worldwide, including in Indonesia. Surabaya, as one of Indonesia's largest cities, has experienced escalating drug-related issues that reflect a broader national crisis exacerbated by economic challenges and globalization, necessitating innovative solutions for prevention and early intervention. Traditional methods such as law enforcement and rehabilitation programs have proven essential but insufficient in comprehensively tackling the problem, thereby requiring approaches that leverage digital tools and community involvement. Indonesia's economic crisis and poverty have contributed to the rise in drug abuse, with an estimated 1.3 million drug abusers in 2000 [1], leading to increased crime, violence, and health issues, including

HIV/AIDS and Hepatitis C [1]. Moreover, globalization has intensified narcotics abuse in Indonesia, calling for international cooperation and proactive measures [2], as the country ranks among the top narcotic users globally with 1.5% of the population involved in drug abuse [3]. Within this context, family resilience plays a crucial role in preventing adolescent drug relapse, underscoring the value of social learning and community support [4], while the lack of drug education in schools complicates prevention efforts and highlights the urgency for comprehensive educational strategies [5]. Given the dynamic and rapid dissemination of information via social media platforms, these tools present an opportunity to enhance preventive efforts through digital surveillance and public engagement, allowing for real-time information sharing and community mobilization against drug abuse [5]. This multi-dimensional approach aligns with the pressing need for strategies that go beyond supply reduction and enforcement, incorporating education, family and community resilience, and international collaboration.

Social media has emerged as a transformative and pivotal tool in public health due to its capacity to connect communities, facilitate real-time communication, and promote awareness through interactive engagement. Its dynamic nature allows for rapid information dissemination, enabling stakeholders to monitor public health risks, identify patterns, hotspots, and at-risk individuals, and implement timely interventions that enhance the effectiveness of prevention programs. Social media's potential as an early warning system is increasingly recognized across various applications in public health, including health promotion, surveillance, and emergency management. For instance, social media platforms provide effective channels for health professionals and consumers to seek and share health information, thus improving communication between stakeholders [6]. Health organizations utilize these platforms to disseminate educational content, infographics, and videos that foster health awareness and promote behavior change [7]. Additionally, social media serves as a valuable secondary data stream for public health surveillance, enabling authorities to monitor communal responses and evaluate intervention outcomes [8], while also improving the timeliness and accuracy of surveillance during emergencies [9]. In disaster scenarios, social media complements traditional communication channels by facilitating the swift transmission of public warnings and supporting two-way communication between authorities and the public [10], thereby enhancing situational awareness and enabling more effective risk communication strategies [10].

Drug abuse continues to escalate as a critical issue in urban areas, including Surabaya, where its societal impacts are becoming increasingly evident and are further exacerbated by the rapid evolution of drug distribution methods, such as the use of online platforms and social networks to facilitate illegal activities. Traditional prevention mechanisms, which often rely on reactive approaches like law enforcement and rehabilitation, leave significant gaps in identifying early warning signs and addressing the root causes of drug abuse. Despite ongoing efforts, many existing prevention programs face

inefficiencies in early detection and suffer from insufficient community engagement, often overlooking the potential of emerging digital tools. Social media, though widely accessible and influential, remains an underutilized resource in current drug prevention strategies, hindered by the absence of structured frameworks for digital surveillance, limited understanding of its practical effectiveness, and inadequate integration into broader public health initiatives. In an era where information spreads rapidly and shapes behavior significantly, the urgency to adopt innovative, technology-driven strategies has never been more pressing. Leveraging social media for early detection and intervention is vital to mitigating rising drug-related risks and safeguarding communities through more proactive and comprehensive prevention approaches.

This study aims to evaluate the role of social media as an early warning system for drug prevention, focusing on the Digital Surveillance Program in Surabaya. Specifically, the objectives are to:

1. Assess the level of public awareness and engagement with the program.
2. Examine the relationship between social media engagement and the effectiveness of early warning mechanisms.
3. Analyze the potential of social media to serve as a scalable and impactful tool in addressing drug abuse.

2. LITERATURE REVIEW

2.1. Social Media in Public Health Interventions

Social media has significantly reshaped public health communication by providing a dynamic platform for real-time information sharing and community engagement, especially in drug prevention. Platforms like Facebook, Twitter, and Instagram enable authorities to disseminate educational content, raise awareness about substance abuse, and promote community-based initiatives, fostering a participatory public health approach through interactive, two-way communication [11], [12]. These platforms reach broad and diverse audiences, making them essential tools for health information circulation and community mobilization (Thapliyal et al., 2024). Successful interventions often leverage unique platform features, encourage user-generated content, and blend it with expert knowledge [12]. However, challenges such as misinformation, privacy concerns, and content moderation must be addressed to ensure effective implementation [12]. Ethical issues like data privacy and the risk of widening health disparities call for robust, platform-specific evaluation methods [12]. Despite these challenges, social media offers opportunities to strengthen public health systems by enabling cost-effective communication between healthcare providers and the public [13] and increasing outreach to individuals with limited access to traditional healthcare services [14].

2.2. Digital Surveillance and Early Warning Systems

Digital surveillance in drug prevention utilizes online data to identify trends, hotspots, and at-risk groups, enabling authorities to respond proactively, especially in urban environments where drug distribution networks rapidly adapt to enforcement efforts. By integrating social media data, such as posts from platforms like Twitter

and Reddit, authorities can monitor drug-related discussions and behaviors in real time, providing valuable insights into community sentiments and complementing traditional surveillance methods [15], [16]. Studies have demonstrated the potential of social media to track illicit drug use trends, although challenges remain in standardizing systems and developing efficient algorithms for surveillance [17]. The application of advanced data analysis techniques—including machine learning, temporal analysis, and statistical methods—enables the processing of large volumes of social media content to characterize user behavior and identify risk environments for drug abuse [16]. Furthermore, artificial intelligence frameworks have been developed to automate the detection of drug-related harms, improving the efficiency of early warning systems (EWS) by filtering relevant information [18]. Digital surveillance also contributes geospatial insights, revealing patterns of drug interest across regions and offering a complementary perspective to conventional public health statistics, thus supporting more informed policy-making [15].

2.3. Theoretical Framework

This study is grounded in the theory of planned behavior [19], which posits that individual behavior is influenced by attitudes, subjective norms, and perceived behavioral control. Social media engagement aligns with these constructs, as it reflects individuals' attitudes toward drug prevention, the influence of social networks, and their perceived ability to contribute to preventive efforts.

By integrating the theory of planned behavior with digital surveillance, this research aims to provide a comprehensive understanding of how social media can be harnessed as an early warning system. The theoretical framework supports the hypothesis that increased engagement and awareness through social media lead to more effective prevention outcomes.

3. RESEARCH METHODS

3.1. Research Design

The study adopts a quantitative research approach to examine the relationships between public awareness, social media engagement, and the effectiveness of the Digital Surveillance Program. Utilizing a cross-sectional design, data were collected at a single point in time to evaluate the program's impact and identify key factors influencing its success. The target population comprises individuals who actively participate in or are aware of the Digital Surveillance Program in Surabaya. Employing purposive sampling, the study selected respondents who are knowledgeable about the program and are regular social media users. A total of 100 respondents were chosen, representing diverse age groups, genders, and socio-economic backgrounds to ensure comprehensive insights.

3.2. Data Collection Techniques

Primary data were collected using a structured questionnaire designed to measure key variables such as public awareness, social media engagement, and program effectiveness. The questionnaire was distributed online via email and social media platforms to ensure accessibility and encourage broader participation, with respondents assured of confidentiality to enhance the reliability of their responses. A Likert scale (1–5) was employed to assess participants' perceptions and attitudes, with each item targeting

specific indicators of the studied variables. Public awareness was measured through indicators such as knowledge of drug prevention strategies, familiarity with the program, and recognition of its objectives. Social media engagement was assessed based on the frequency of interactions related to the program, information sharing, and participation in discussions. Program effectiveness was evaluated through respondents' perceptions of changes in community behavior, responsiveness to drug-related issues, and overall satisfaction with the program.

3.3. Data Analysis Techniques

Data were analyzed using Structural Equation Modeling-Partial Least Squares (SEM-PLS) with SmartPLS 3 software, chosen for its ability to manage complex variable relationships and its suitability for small sample sizes. The analysis involved several key steps: first, the measurement model was evaluated to assess the reliability and validity of the constructs using Cronbach's alpha, composite reliability (CR), and average variance extracted (AVE). Next, the structural model was evaluated through hypothesis testing to examine the relationships among variables, focusing on path coefficients, t-statistics, and R^2 values. Finally, an analysis of indirect effects was conducted to explore the mediation role of public awareness in the relationship between social media engagement and program effectiveness.

4. RESULTS AND DISCUSSION

4.1. Descriptive Statistics

The descriptive statistics offer a comprehensive overview of the demographic characteristics and social media usage patterns of the 100 respondents, providing essential context for evaluating the Digital Surveillance Program's impact. The majority of respondents are young adults aged 18–35 (75%) and hold at least a Bachelor's degree (55%), with a nearly balanced gender distribution—52% male and 48% female. Regarding social media usage, 90% of respondents use social media daily, highlighting its significance as a tool for public engagement. Additionally, 75% of participants reported frequent engagement with program-related content, while 20% engaged occasionally and only 5% rarely or never interacted with such content. In terms of program familiarity, 30% of respondents were very familiar with the Digital Surveillance Program, 50% somewhat familiar, and 20% not familiar. These findings underscore the high potential of social media as a platform for information dissemination and public participation, as well as the need to enhance awareness among the portion of the population that remains uninformed.

4.2. Measurement Model Evaluation

The measurement model evaluation assessed the reliability, convergent validity, and discriminant validity of the constructs used in the study. This process ensures that the indicators accurately measure the underlying variables and that the constructs are distinct and reliable for further analysis.

1) Reliability Analysis

Reliability was assessed using Cronbach's alpha and Composite Reliability (CR) to evaluate the internal consistency of the constructs, with all results exceeding the recommended threshold of 0.70. The Cronbach's alpha and CR values for Public Awareness were 0.881 and 0.917, for Social Media

Engagement were 0.857 and 0.902, and for Program Effectiveness were 0.892 and 0.924. These findings indicate that each construct demonstrates strong reliability, confirming a high level of internal consistency among the items used in the study.

2) Convergent Validity

Convergent validity was assessed using Average Variance Extracted (AVE), which measures the extent to which indicators explain the variance of their respective constructs. The AVE values for all constructs exceeded the recommended threshold of 0.50, with Public Awareness at 0.671, Social Media Engagement at 0.692, and Program Effectiveness at 0.726. These results confirm adequate convergent validity, indicating that the indicators reliably represent the underlying constructs in the study.

Indicator loadings represent the correlation between each item and its respective construct. A loading of 0.70 or higher is considered acceptable.

Table 1. Loading Factor

Construct	Indicator	Loading
Public Awareness	PA1	0.781
	PA2	0.813
	PA3	0.858
Social Media Engagement	SME1	0.822
	SME2	0.795
	SME3	0.768
Program Effectiveness	PE1	0.872
	PE2	0.835
	PE3	0.808

All indicator loadings exceeded the minimum threshold of 0.7, indicating strong relationships between the indicators and their respective constructs.

3) Discriminant Validity

Discriminant validity was evaluated using the Fornell-Larcker criterion, which involves comparing the square root of the Average Variance Extracted (AVE) for each construct with its correlations with other constructs. The diagonal values—0.821 for Public Awareness, 0.832 for Social Media Engagement, and 0.851 for Program Effectiveness—are greater than the corresponding off-diagonal correlation values, confirming discriminant validity. This indicates that each construct is distinct and does not significantly overlap with the others, ensuring the uniqueness of the measured concepts within the model.

4.3. Structural Model Evaluation

The structural model evaluation was conducted to assess the hypothesized relationships between constructs and to evaluate the model's predictive power using key metrics such as path coefficients, t-statistics, R^2 values, and effect sizes (f^2). Bootstrapping with 5000 resamples was employed to test the significance of these relationships. Path coefficients indicate the strength and direction of the relationships between constructs,

while hypothesis testing was based on t-statistics, with a threshold of t ≥ 1.96 at a 95% confidence level, to determine statistical significance.

Table 2. Hypothesis

Hypothesis	Path Coefficient (β)	t-Statistic	p-Value	Result
H1: Public Awareness → Program Effectiveness	0.421	5.127	< 0.001	Supported
H2: Social Media Engagement → Program Effectiveness	0.563	7.454	< 0.001	Supported
H3: Public Awareness → Social Media Engagement	0.386	4.861	< 0.001	Supported

All hypothesized relationships were positive and statistically significant, indicating strong associations between the constructs. The hypothesis testing results indicate that all proposed relationships in the structural model are statistically significant and supported. Specifically, Public Awareness has a positive and significant effect on Program Effectiveness ($\beta = 0.421$, $t = 5.127$, $p < 0.001$), supporting H1. Social Media Engagement also shows a strong and significant impact on Program Effectiveness ($\beta = 0.563$, $t = 7.454$, $p < 0.001$), supporting H2. Additionally, Public Awareness significantly influences Social Media Engagement ($\beta = 0.386$, $t = 4.861$, $p < 0.001$), supporting H3. These findings confirm the strength of the relationships among the constructs and validate the proposed model.

The R^2 value indicates the proportion of variance in the dependent variable explained by the independent variables. For Social Media Engagement, the R^2 value is 0.14, suggesting that public awareness explains 14% of the variance, which is considered weak. In contrast, the R^2 value for Program Effectiveness is 0.53, meaning that public awareness and social media engagement together explain 53% of the variance, indicating a moderate predictive capability of the model. Effect size (f^2) further clarifies the influence of each independent variable on the dependent variable, with values interpreted as small (0.02), medium (0.15), or large (0.35). The effect size of Public Awareness on Program Effectiveness is 0.181 (medium), Social Media Engagement on Program Effectiveness is 0.313 (medium to large), and Public Awareness on Social Media Engagement is 0.125 (small to medium). Among these, social media engagement shows the strongest impact on program effectiveness, emphasizing its critical role in the model.

Predictive relevance (Q^2) was assessed using the blindfolding procedure, where Q^2 values greater than 0 indicate that the model has predictive capability. The Q^2 value for Social Media Engagement is 0.08, demonstrating small predictive relevance, while Program Effectiveness has a Q^2 value of 0.40, indicating moderate predictive relevance. These results support the model's adequacy in predicting program effectiveness and reinforce the importance of both public awareness and social media engagement in enhancing the impact of the Digital Surveillance Program.

4.4. Discussion

1) The Role of Public Awareness

The significant relationship between public

awareness and program effectiveness (H1) highlights the critical role of informing the public about drug prevention efforts. Public awareness acts as a foundational element that fosters a supportive environment, increasing the likelihood of individual and community engagement in initiatives like the Digital Surveillance Program. This finding aligns with prior research emphasizing the importance of awareness campaigns in encouraging community participation in public health and safety programs. For instance, [20] found that health awareness campaigns are instrumental in promoting healthy behaviors and preventing illness by increasing knowledge and utilizing various media platforms to influence public attitudes and actions. These campaigns contribute to reducing mortality and morbidity by effectively disseminating information. Moreover, awareness efforts are most impactful when tailored to the specific needs of a community and involve collaboration with relevant stakeholders to ensure cultural sensitivity and sustainability.

Community engagement is also vital to the success of public health initiatives, as it bridges the gap between healthcare providers and the general public, reducing the burden on health systems [21]. Policies that promote active community participation in disease prevention have been shown to enhance both the effectiveness and longevity of health programs [22]. Furthermore, public health awareness empowers individuals and communities to adopt healthier behaviors, playing a pivotal role in disease prevention and health promotion [23]. Successful campaigns often involve coordination between governments, healthcare providers, and media to overcome barriers such as misinformation and cultural misconceptions [23]. The NEDAwareness campaign, for example, demonstrated that online engagement with health content can positively influence behavior and self-expression, although it also highlighted the need for strategies that consider audience demographics and content relevance [24]. These insights imply that increasing public awareness through targeted educational content and social media campaigns can significantly amplify the reach and effectiveness of drug prevention programs.

2) Social Media Engagement as a Key Driver

The strong relationship between social media engagement and program effectiveness (H2) underscores the growing importance of digital platforms in contemporary public health initiatives. Social media facilitates two-way communication, enabling real-time feedback and fostering active community participation. This dynamic interaction enhances the visibility and perceived relevance of public programs, contributing to their overall success. The findings of this study are consistent with prior research demonstrating

that social media engagement significantly boosts the effectiveness of public awareness campaigns by fostering a sense of involvement and immediacy among users. Platforms like Facebook, Instagram, and Twitter allow public health authorities to disseminate timely information and engage audiences through visually engaging and interactive content, thereby increasing program outreach and impact [25].

Supporting evidence from previous studies further validates these findings. [25] emphasized that visual elements like infographics and videos are crucial in capturing attention and driving engagement in public health advocacy. [26] highlighted how governments utilize social media not only for transparency but also to enhance public trust and interaction, with an emphasis on boosting participation. During the COVID-19 pandemic, social media proved highly effective in countries like Bangladesh [27] and regions such as West Jakarta [28], where it played a vital role in promoting health protocols and influencing compliance. Additionally, [29] demonstrated that engagement through corporate social networking platforms enhances perceived authenticity and transparency—an insight that can be applied to public programs. These findings imply that to maximize the effectiveness of drug prevention initiatives, strategies should focus on increasing engagement through interactive content, community-driven campaigns, consistent updates, and leveraging influencers or localized messaging to connect with broader and more diverse audiences.

3) Awareness and Engagement

The positive and significant relationship between public awareness and social media engagement (H3) indicates that awareness campaigns can directly influence individuals' willingness to engage with program-related content online. When people are well-informed about the program's objectives and benefits, they are more inclined to participate in discussions, share information, and interact with content on digital platforms. This dynamic suggests that public awareness not only serves as a foundational element for program effectiveness but also acts as a catalyst for digital engagement, reinforcing the reach and impact of the initiative through active online participation.

This finding aligns with previous research emphasizing the existence of a feedback loop in which awareness drives engagement, which in turn strengthens awareness. [30] highlighted this reciprocal relationship in the context of marketing and consumer behavior, where increased awareness leads to higher engagement, subsequently enhancing brand recall and perception. Similarly, [31] found that as consumers become more aware of a brand, their engagement increases, creating a reinforcing cycle. [32] also demonstrated that brand awareness mediates the relationship between consumer engagement and brand relationship quality, supporting

this cyclical dynamic. [33] explored how awareness enhances attention, leading to greater engagement with stimuli, while [34] found that feedback mechanisms in automated systems reinforce user awareness, resulting in improved system engagement. These parallels highlight the importance of integrating awareness-building efforts with engaging social media strategies to create a synergistic effect that enhances the overall success and sustainability of programs like the Digital Surveillance Program

4) Practical Implications for Drug Prevention Programs

The findings highlight several strategic recommendations to enhance the effectiveness of the Digital Surveillance Program. First, leveraging social media analytics is crucial, as metrics such as likes, shares, and comments offer actionable insights into audience engagement and the program's overall impact. Second, creating community-centered content—such as testimonials, success stories, and culturally relevant messages—can significantly boost both awareness and participation by making the content more relatable and impactful. Lastly, collaboration with stakeholders, including community organizations, schools, and healthcare providers, can help extend the program's reach by integrating offline support systems with digital strategies, thereby creating a more comprehensive and sustainable approach to drug prevention.

5) Limitations and Future Research

While this study provides valuable insights, several limitations should be acknowledged. The sample size of 100 respondents restricts the generalizability of the findings to broader populations or different regional contexts, highlighting the need for future research with larger and more diverse samples. Additionally, the use of a cross-sectional design offers only a snapshot of the relationships between variables, whereas longitudinal studies could provide a deeper understanding of how public awareness and social media engagement evolve over time. Furthermore, the integration of additional variables—such as trust in the program or the perceived credibility of information—could offer a more comprehensive understanding of the factors influencing program effectiveness.

5. CONCLUSION

This study highlights the transformative potential of social media in drug prevention programs, particularly as an early warning system within the Digital Surveillance Program in Surabaya. The key findings show that public awareness plays a crucial role in driving both social media engagement and overall program effectiveness. Social media engagement emerges as the most influential factor in ensuring the program's success, positioning digital platforms not just as tools for communication but as strategic instruments for strengthening community participation and information dissemination.

The structural model evaluation further reinforces the significance of these relationships, suggesting that integrated strategies focusing on awareness and engagement can meaningfully enhance the impact of drug prevention initiatives. For practitioners, this implies the importance of creating culturally relevant and community-

centered content, utilizing social media analytics to adapt and refine strategies, and building strong collaborations with stakeholders such as schools, healthcare providers, and local organizations. Future research should explore the long-term impacts of these approaches, consider additional variables like trust and perceived credibility, and expand the study to include diverse regions and populations. This research provides a practical framework for leveraging social media as a vital component of modern public health interventions.

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