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Predictive Model of the Impact of Digital Health Infrastructure on Health Equity in Developing Regions

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Abstract. Health equity in developing regions is constrained by limited access and unequal distribution. Digital health infrastructure offers a strategic opportunity to reduce these disparitas. This study aimed to develop and test a predictive model examining the impact of digital health infrastructure on health equity mediated by service accessibility and service qualty. A quantitative study involving 300 healthcare stakeholders from twelve developing regions in Indonesia was conducted. Data collected by validated questionnaires were analyzed using multiple linear regression. Results showed digital health infrastructure significantly predicts improved service accessibility and quality, which in turn significantly predict higher health equity. The overall model demonstrated strong predictive power with an R squared value of 0.59, indicating that fifty-nine percent of the variance in health equity was explained by the predictor variables. These findings confirm that digital health infrastructure enhances health equity primarily through improvements in accessibility and service quality. This study contributes theoretically by offering a regression-based predictive model and practically by providing guidance for policymakers and healthcare managers to align technological investments with strategies for equitable service distribution.
Keywords: Digital Health Infrastructure, Health Equity, Primary Healthcare, Developing Regions, Predictive Model

1 Introduction

The advancement of digital technology has brought significant changes across various sectors, including healthcare [1,2]. Digital health infrastructure, such as electronic medical record systems [3], telemedicine [4], digitalized hospital management platforms [5], and community-based health applications [6], constitutes a crucial foundation for enhancing the efficiency and effectiveness of healthcare services. Amid challenges related to limited healthcare service capacity, particularly in developing regions, According to Elendu, C., et al, the adoption of digital infrastructure presents opportunities to accelerate diagnostic processes, facilitate coordination among healthcare facilities, and support data-driven decision-making [7]. These phenomena underscore the importance of strategic investment in digital health infrastructure as an effort to improve the quality and equitable access of healthcare services.

Health service equity also constitutes a critical issue in many developing countries, including Indonesia [8]. Disparities in access to and quality of healthcare services exist between urban and rural areas, as well as between high- and low-income populations. These phenomena indicate that achieving equitable healthcare remains a significant challenge. Health service equity not only reflects the distribution of facilities and medical personnel but also encompasses aspects of accessibility, affordability, and the quality of care received by all segments of society. Research by Hoagland and Kipping Jhon [9], Yao, R. et al. [10] suggests that without an integrated strategy,

advancements in health technology may inadvertently exacerbate service disparities among different population groups.

The relationship between digital health infrastructure and health service equity is an increasingly relevant area of research [11]. Well-designed and properly implemented digital infrastructure has the potential to enhance service accessibility, accelerate the provision of health information, and improve the quality of care, thereby supporting the achievement of equitable healthcare [12]. In the context of developing regions in Indonesia, such as the eastern provinces and remote areas, challenges related to physical infrastructure and human resources remain significant. These regions often face limited healthcare facilities, uneven distribution of medical personnel, and low access to technology. The implementation of digital health infrastructure offers strategic opportunities to bridge these gaps through telemedicine, integrated health information systems, and data-driven health monitoring. However, its utilization must be accompanied by local policies and strategies that are sensitive to the socio-economic conditions of the population to ensure a meaningful impact on service equity.

Research by Ng'andu and Haabazoka explored the impact of digital health infrastructure on operational efficiency [13]. Le, et al. examined its influence on service quality [14], while Fennessy, et al. investigated its effect on patient satisfaction [15]. Demirci and Yardan focused on its role in health data management [16]. However, empirical studies specifically linking the digitalization of health infrastructure to health service equity remain limited. This gap highlights the need for quantitative research capable of developing predictive models and exploring the mechanisms through which digital infrastructure affects the equitable distribution of healthcare services, particularly in regions facing significant resource challenges.

The aim of this study is to predict the impact of digital health infrastructure on health service equity in developing regions. This research is expected to contribute by providing a regression-based predictive model that enriches the quantitative literature while offering practical recommendations for policymakers and healthcare managers to balance technological investments with strategies for equitable service distribution.

2 Methods

This study employed a non-experimental quantitative approach with a predictive multiple linear regression design to analyze the impact of digital health infrastructure on health service equity through the mediating variables of service accessibility and service quality. This approach allows for the development of a predictive model that can serve as a basis for evidence-based intervention strategies aimed at improving equitable healthcare distribution in developing regions.

The study population consisted of healthcare personnel, administrative staff, and facility managers across 12 developing regions in Indonesia. A purposive sampling technique was used to select 300 respondents with direct experience in the use of digital technology and healthcare facility operations. Inclusion criteria included a minimum of one year of experience in facility management or healthcare service provision and involvement in the use of digital systems within their respective facilities.

The study involved four variables: 1) Digital Health Infrastructure (DHI) as the independent variable, measuring the availability, integration, and effectiveness of digital technologies within healthcare facilities [17,18]. 2) Service Accessibility (SA) as a mediating variable, assessing patient ease of access, waiting times, and service distance [19,20]. 3) Service Quality (SQ) as a mediating variable, measuring speed, accuracy, patient satisfaction, and healthcare professional competence [21,22]. 4) Health Service Equity (HSE) as the dependent variable, evaluating equitable access, fairness of services, and resource availability across different population groups [11,23].

A standardized online questionnaire using a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree) was developed based on theoretical indicators and previous studies. Each variable included several indicator items as summarized in Table 1.

Table 1. Variable Indicators and Questionnaire Items

Variable	Indicators	Questionnaire Items
Digital Health Infrastructure (DHI)	Availability of digital systems; Data integration; Technolxogy usability	1. Healthcare facilities have an integrated electronic medical record system. 2. Digital information systems are consistently used in operations. 3. Access to and use of digital technologies are adequate to support service delivery.
Service Accessibility (SA)	Ease of obtaining services; Waiting time; Service distance	1. Patients can easily access healthcare services through digital technologies. 2. Digital services reduce patient waiting times. 3. Digital services reach patients in remote areas.
Service Quality (SQ)	Service speed; Accuracy; Patient satisfaction; Professionalism	1. Digital services provided meet professional standards. 2. Health information delivered via digital systems is accurate and reliable. 3. Digital services enhance patient satisfaction.
Health Service Equity (HSE)	Equitable access; Service fairness; Resource distribution	1. All patients receive equal services regardless of location or socio-economic status. 2. Digital infrastructure helps reduce service disparities across regions. 3. Resources and services are distributed evenly among all patients.

The questionnaire of Table 1 underwent validity testing using item-total correlation analysis, with significant correlation at $p < 0.05$. Results showed that all indicators were significantly correlated with the total variable scores ($p < 0.05$). Reliability testing using Cronbach's alpha yielded the following values: Digital Health Infrastructure ($\alpha = 0.87$), Service Accessibility ($\alpha = 0.84$), Service Quality ($\alpha = 0.86$), and Health Service Equity ($\alpha = 0.89$), indicating that all variables were reliable and internally consistent. These validity and reliability results confirm that the instrument can be used for empirical measurement of the study variables.

The research hypotheses were formulated as follows: (H1) Digital health infrastructure predicts service accessibility. (H2) Digital health infrastructure predicts service quality. (H3) Service accessibility predicts health service equity. (H4) Service quality predicts health service equity. (H5) Digital health infrastructure indirectly predicts health service equity through service accessibility and service quality.

Data analysis was conducted using predictive multiple linear regression to develop a model capable of predicting health service equity based on the independent variable (DHI) and mediating variables (SA and SQ). The analytical procedure included: 1) Classical Assumption Testing: testing residual normality, linearity, homoscedasticity, and multicollinearity to ensure compliance with linear regression assumptions. 2) Partial Predictive Regression Analysis: testing the influence of digital health infrastructure on service accessibility (H1) and service quality (H2). 3) Predictive Mediation Regression Analysis: examining the effects of service accessibility and service quality on health service equity (H3 and H4), as well as testing the indirect effect of digital infrastructure on equity through mediation (H5). 4) Predictive Model Evaluation: using the coefficient of determination (R^2) to assess the proportion of variance in health service equity explained by the model and standardized beta (β) to evaluate the relative contribution of each predictor. 5) Model Validation: comparing predicted values from the model with actual data to ensure reliable predictive capability.

3 Results And Discussion

3.1 Respondent Characteristics

This study involved 300 respondents, including healthcare personnel, administrative staff, and facility managers across 12 developing regions in Indonesia. The distribution of respondents by occupational category was 45% healthcare personnel, 35% administrative staff, and 20% facility

managers. The majority of respondents had more than three years of experience in using digital technology within their respective facilities. The distribution of respondents by occupational category is presented in Table 2.

Table 2. Respondent Distribution by Occupational Category

Occupational Category	Number of Respondents	Percentage (%)
Healthcare Personnel	135	45
Administrative Staff	105	35
Facility Managers	60	20
Total	300	100

3.2 Descriptive Analysis of Variables

Table 3 presents the descriptive analysis of the study variables. The mean scores indicate that respondents' perceptions of digital health infrastructure, service accessibility, service quality, and health service equity fall within the high category. This suggests that healthcare facilities in the developing regions have made substantial use of digital technology.

Table 3. Descriptive Statistics of Study Variables

Variable	Mean	Std. Dev	Minimum	Maximum
Digital Health Infrastructure (DHI)	4.1	0.55	2.5	5
Service Accessibility (SA)	3.9	0.60	2	5
Service Quality (SQ)	4.0	0.57	2.5	5
Health Service Equity (HSE)	3.8	0.62	2	5

3.3 Classical Assumption Test Results

Prior to conducting multiple linear regression analysis, this study performed classical assumption tests to ensure the validity of the predictive model. These tests are essential to guarantee that the regression results can be interpreted accurately and that the model predictions are reliable. Table 4 summarizes the results of the classical assumption tests.

Table 4. Classical Assumption Test Results

Assumption	Method / Statistic	Result	Conclusion
Residual Normality	Shapiro-Wilk	$p = 0.162$	Normal
Linearity	Residual scatter plot	Linear	Linearity satisfied
Homoscedasticity	Breusch-Pagan	$p = 0.278$	Homoscedasticity satisfied
Multicollinearity	VIF & Tolerance	VIF < 5, Tol > 0.2	No multicollinearity

Table 4 shows that residual normality was tested using the Shapiro-Wilk test. The analysis yielded $p > 0.05$, indicating that the residual distribution approximates normality. This was further confirmed visually through a residual histogram, which exhibited a bell-shaped distribution. Residual normality implies that prediction errors are symmetrically distributed around the regression line, ensuring unbiased regression coefficient estimates and valid statistical inference.

Linearity between predictor and dependent variables was assessed using residual plots against predictors. The results showed a clear linear pattern between digital health infrastructure (DHI) and the mediating variables of service accessibility (SA) and service quality (SQ), as well as between the mediators and health service equity (HSE). This linearity confirms that the relationships modeled in multiple linear regression satisfy the basic assumptions, allowing β coefficients to reflect the proportional influence of each predictor accurately.

Homoscedasticity was tested using the Breusch-Pagan test to examine whether residual variance was constant across predictor levels. The results ($p > 0.05$) indicated uniform residual variance, meaning no heteroscedasticity was present. This condition is essential for stable model predictions and unbiased standard error estimates, ensuring that the statistical significance of regression coefficients is reliable.

Multicollinearity among predictors was examined using the Variance Inflation Factor (VIF) and tolerance. All predictors had VIF < 5 and tolerance > 0.2, indicating no significant multicollinearity. This ensures that each independent variable contributes uniquely to explaining the variability in the dependent variable, allowing regression coefficients to be interpreted accurately without distortion due to redundancy among variables.

Overall, the classical assumption tests indicate that the study data meet all requirements for multiple linear regression. Consequently, the predictive model developed can be reliably used to examine the effect of digital health infrastructure on health service equity through the mediating variables of service accessibility and service quality.

3.4 Predictive Regression Analysis

Predictive regression analysis was conducted to examine the predictive strength of digital health infrastructure on the mediating variables, namely service accessibility and service quality, as well as the influence of these mediators on health service equity.

Table 5. Predictive Multiple Linear Regression Results

Predictor → Mediator/Dependent Variable	β	p-value	Significance
Digital Infrastructure → Service Accessibility	0.51	0.000<0.001	Significant
Digital Infrastructure → Service Quality	0.44	0.000<0.001	Significant
Service Accessibility → Health Service Equity	0.40	0.003<0.01	Significant
Service Quality → Health Service Equity	0.35	0.002<0.01	Significant

Table 5 indicates that digital health infrastructure has a significant effect on both mediating variables. The standardized regression coefficients (β) show that an increase in digital infrastructure scores is positively associated with improvements in service accessibility and service quality, suggesting that facilities with better digital technology are capable of providing more accessible and higher-quality services.

Furthermore, the mediating variables, service accessibility and service quality, significantly predict health service equity. This indicates that the effect of digital infrastructure on service equity is not direct but operates through the mediating pathways of accessibility and service quality. In other words, enhancements in digital infrastructure effectively improve equity when they translate into easier access and better quality of care for patients.

These regression results are supported by p-values below the significance threshold ($p < 0.05$) for all pathways, confirming that the relationships among variables are statistically robust and not due to chance. The predictive regression model enables the identification of key variables that contribute most to improving service equity, providing a foundation for strategic planning by policymakers and healthcare facility managers.

Overall, this predictive regression analysis demonstrates that digital health infrastructure serves as a primary predictor of health service equity improvement, with its effect mediated through service accessibility and service quality. The model not only quantifies the relationships among variables but also offers predictions that can be used to design evidence-based interventions in developing regions.

3.5 Predictive Model Analysis Results

Following the examination of the partial effects of variables through multiple linear regression, the next step was to evaluate the overall predictive capability of the model in explaining health service equity. This predictive model integrates the independent variable, Digital Health Infrastructure (DHI), and the mediating variables, Service Accessibility (SA) and Service Quality (SQ), to predict the variability of Health Service Equity (HSE). Table 6 shows that the model has an overall coefficient of determination R^2 of 0.59, indicating that 59% of the variation in health service equity can be explained by the combination of DHI, SA, and SQ. This value reflects a substantial predictive

contribution, suggesting that the model can serve as a basis for strategic planning to improve services in developing regions.

Based on Table 6, standardized beta (β) analysis reveals the relative contribution of each predictor to the dependent variable. Digital infrastructure has the largest influence on service accessibility (β = 0.51) and service quality (β = 0.44), which in turn affect health service equity through the mediating effects of accessibility (β = 0.40) and service quality (β = 0.35). Thus, strengthening digital infrastructure indirectly enhances health service equity via a clear mediation mechanism.

To illustrate model predictions, a simulation was conducted with a scenario in which the digital infrastructure score increased by 1 unit. The simulation results showed that this increase would raise the service accessibility score by 0.51 units and service quality by 0.44 units. Collectively, these improvements would subsequently increase health service equity by 0.40 units through the accessibility pathway and 0.35 units through the service quality pathway. This simulation confirms that investment in digital infrastructure can predictively enhance service equity, both directly by strengthening accessibility and quality, and indirectly via the mediation pathways.

Table 6. Predictive Model Statistics for Health Service Equity

Model Statistics	Value
R^2	0.59
Adjusted R^2	0.58
F-statistic	134.57 ($p < 0.001$)
Standardized β (DHI → SA)	0.51
Standardized β (DHI → SQ)	0.44
Standardized β (SA → HSE)	0.40
Standardized β (SQ → HSE)	0.35

This predictive model analysis underscores the role of digital health infrastructure as a primary predictor of health service equity, with its effects occurring through improvements in service accessibility and quality. The model not only provides theoretical insights into the relationships among variables but also produces quantitative predictions that can guide policy planning and strategic digital investment in developing regions.

3.6 The Role of Digital Health Infrastructure in Enhancing Service Accessibility

The results indicate that digital health infrastructure has a significant impact on healthcare service accessibility, with a coefficient of β = 0.51 ($p < 0.001$). These findings confirm that healthcare facilities implementing adequate digital systems including electronic medical records, online registration applications, and patient management information systems—can facilitate patient access to services. In other words, digitalization not only streamlines administrative processes but also reduces waiting times and enables patients in remote areas to receive services more quickly and efficiently.

This aligns with the Technology Acceptance Model, which posits that technology adoption is influenced by perceived ease of use and perceived benefits [24,25]. In the healthcare context, patients and healthcare providers are more likely to embrace digital systems that tangibly simplify access and enhance service efficiency. This supports previous study by Zaman, et al. indicating that information and communication technology (ICT) can improve healthcare accessibility, especially in developing regions with geographic and resource constraints [26].

According to Digital Health Equity theory, digital technology can serve as a tool to reduce service disparities if implemented inclusively and equitably [11]. The current study demonstrates that strengthening digital infrastructure is not merely a technological investment but also a strategic approach to enhancing equitable access to services. By providing easier and faster access, potential disparities across regions or social groups can be minimized, thereby promoting greater health service equity.

Therefore, these findings underscore the critical role of digital health infrastructure in improving service accessibility in developing regions. Strategic digital implementation not only enhances

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operational efficiency of healthcare facilities but also contributes to the goal of equitable healthcare delivery, aligning with global agendas to expand universal health access through digital technology.

3.7 The Impact of Digital Infrastructure on Service Quality

Regression analysis results indicate that digital health infrastructure has a significant effect on service quality, with a coefficient of $\beta = 0.44$ ($p < 0.001$). This demonstrates that enhancing the capacity and integration of digital systems within healthcare facilities such as electronic medical records, telemedicine, and patient information platforms can improve the quality of care received by patients. Service quality in this context includes service speed, information accuracy, patient satisfaction, and healthcare professional competence. In other words, facilities with adequate digital infrastructure not only expand access but also enhance the effectiveness and precision of services provided.

This aligns with the Information Systems Success Model (ISSM), which posits that the quality of information systems, including digital health systems, directly affects output quality and user satisfaction [27,28]. In healthcare, reliable and integrated systems support more accurate clinical decision-making, reduce medical errors, and improve coordination across service units [29]. This reinforces prior literature by Maki with highlighting that healthcare digitalization plays a crucial role in improving service quality in regions with limited human resources and facility capacity [30].

According to the Service Quality (SERVQUAL) theory, dimensions such as reliability, timeliness, and responsiveness can be enhanced through digital technology [31]. The current findings demonstrate that digital infrastructure facilitates consistent and measurable service standards, enabling patients to receive care that is not only prompt but also accurate and satisfying. Thus, healthcare digitalization functions not merely as an operational tool but as a key strategy for systematically improving service quality.

Digital health infrastructure plays a strategic role in enhancing service quality. Improvements in service quality through digitalization support the achievement of health service equity, as equitable access combined with high-quality services ensures that patients from diverse social groups and geographic locations receive comparable care.

3.8 Service Accessibility and Quality as Mediators of Health Service Equity

The results indicate that service accessibility and service quality serve as significant mediators in the relationship between digital health infrastructure and health service equity. Regression analysis shows that accessibility ($\beta = 0.40$; $p < 0.01$) and service quality ($\beta = 0.35$; $p < 0.01$) jointly predict health service equity. In other words, digital infrastructure does not influence equity directly alone, but rather through improvements in access and service quality, ensuring that patients from diverse social groups and geographic locations receive more equitable services.

These findings are consistent with the Digital Health Equity theory, which posits that digital technology can serve as a tool to reduce healthcare disparities when implemented inclusively and effectively [32]. Increased accessibility through digital systems, such as online registration platforms and telemedicine, enables patients in remote areas or vulnerable populations to obtain services comparable to those available in urban areas. Meanwhile, enhanced service quality through digital systems ensures that equity in service delivery is not only quantitative but also meets expected quality standards.

According to the Mediation in Health Services Research theory, mediating variables are crucial in projecting healthcare outcomes [33]. In the context of this study, accessibility and service quality function as key mechanisms bridging the effect of digital infrastructure on service equity. In other words, healthcare digitalization can only contribute to equitable service delivery when it positively impacts ease of access and the quality of care received by patients.

Strategies to improve health service equity should combine the strengthening of digital infrastructure with efforts to simultaneously enhance accessibility and service quality. This approach ensures that investment in digital technology not only increases operational efficiency but also results in tangible equitable service delivery for all patients, particularly in developing regions facing geographic and socio-economic challenges.

3.9 Contribution of the Predictive Model to Improving Health Service Equity

The results indicate that the developed predictive regression model makes a significant contribution to understanding and enhancing health service equity, with a coefficient of determination $R^2 = 0.59$. This means that 59% of the variation in health service equity can be explained by the variables of digital health infrastructure, service accessibility, and service quality. These findings suggest that the predictive model not only explains the relationships among variables but can also serve as a tool to project the impact of digital infrastructure improvements on equitable healthcare delivery in developing regions.

The predictive model demonstrates that digital infrastructure functions as a key factor which, through the mediating pathways of accessibility and service quality, effectively enhances health service equity. This contribution is highly relevant for policymakers and healthcare facility managers, as it allows the identification of priority interventions—for example, emphasizing the strengthening of digital technology in facilities with limited access or service quality. Consequently, the predictive model can serve as an evidence-based guide for designing digital investment strategies aligned with the goal of equitable healthcare provision.

Furthermore, the predictive approach enables scenario simulations of digital infrastructure improvements and their impact on accessibility, quality, and equity. For instance, an increase of one unit in the digital infrastructure score is predicted to raise the accessibility score by 0.51 and the service quality score by 0.44, which subsequently leads to increases in service equity of 0.40 and 0.35, respectively. This simulation confirms the model's capability to provide quantitative projections applicable to strategic planning and data-driven decision-making.

Overall, the contribution of the predictive model is dual both theoretical and practical. Theoretically, it strengthens the literature on digital health and service equity by providing quantitative evidence mapping the mechanisms through which digitalization influences equitable service delivery. Practically, the model offers an evaluation and prediction tool for policymakers, facility managers, and health stakeholders to design measurable and effective interventions to enhance service equity, particularly in developing regions facing geographic and resource constraints.

3.10 Implications for Developing Regions in Indonesia

The findings of this study have important implications for developing regions in Indonesia, where limited healthcare infrastructure, difficult geographic access, and service disparities remain major challenges. The results indicate that strengthening digital health infrastructure can serve as an effective strategy to enhance equitable healthcare delivery, operating through mechanisms that improve service accessibility and quality. In other words, investment in digital technology not only expands service coverage but also enhances service quality, ensuring that patients from diverse locations and socio-economic groups receive comparable care.

The implementation of digital systems should be accompanied by healthcare personnel training, strengthened communication networks, and provision of adequate hardware to ensure optimal utilization of technology. This strategy ensures that healthcare facilities in remote or underdeveloped regions are not left behind and can provide services comparable to those in urban centers.

The predictive model developed in this study can serve as an evidence-based planning tool. Government authorities and facility managers can project the impact of digital investments on accessibility, quality, and service equity prior to implementation, enabling more efficient and targeted resource allocation. For example, regions with limited access or suboptimal service quality can be prioritized for digital infrastructure development.

Digital health implementation in developing regions of Indonesia can support the achievement of Universal Health Coverage (UHC) by ensuring that healthcare services are not only widely available but also high-quality and equitable. This study provides empirical evidence that digitalization of healthcare is not merely a technical modernization but also a critical policy instrument to reduce service disparities and enhance health equity across regions.

4 Conclusion

The findings of this study indicate that digital health infrastructure serves as a primary predictor of health service equity in developing regions, operating through mechanisms that enhance service accessibility and quality. Multiple regression analysis revealed that digital infrastructure significantly affects accessibility ($\beta = 0.51$; $p < 0.001$) and service quality ($\beta = 0.44$; $p < 0.001$), while accessibility and service quality jointly predict health service equity ($\beta = 0.40$ and $\beta = 0.35$; $p < 0.01$). The developed predictive model explains 59% of the variation in health service equity ($R^2 = 0.59$), providing a robust empirical basis for planning digitalization strategies aimed at improving equitable service delivery in developing regions. These findings confirm that healthcare digitalization not only enhances operational efficiency but also contributes tangibly to equitable access and service quality.

This study has several limitations, including the use of a quantitative survey design, which does not capture causal dynamics in depth, and the focus on a limited set of predictor variables: digital infrastructure, accessibility, and service quality. Future research could consider longitudinal or experimental designs to strengthen causal evidence, as well as incorporate additional variables such as regional policies, human resource capacity, and socio-economic factors to expand understanding of service equity. The contributions of this study are twofold: theoretically, it enriches the digital health and service equity literature with a quantitative predictive model; practically, it provides actionable recommendations for policymakers and healthcare facility managers to balance technology investments with strategies to achieve equitable healthcare delivery in developing regions.

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