Attitude towards dengue control efforts with the potential of digital technology during COVID-19: partial least squares-structural equation modeling [version 1; peer review: 1 approved with reservations]

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Abstract

Background: Dengue fever is still a public health issue in Indonesia, and during the coronavirus disease 2019 (COVID-19) pandemic, integrated digital technology will be required for its control. This study aimed to identify the factors that influence attitudes toward dengue control concerning the potential application of digital technology.

Methods: This was a cross-sectional survey, with 515 people willing to fill out an online questionnaire. The analysis was conducted using Partial Least Square-Structural Equation Modelling (PLS-SEM). There were 46 indicators used to assess attitudes toward dengue control, which are organized into six variables: the need for digital information systems, perceptions of being threatened with dengue, the benefits of dengue control programs, program constraints, environmental factors and attitudes in dengue control.

Results: The source of information needed for dengue control was mainly through social media. There was a positive relationship between perception of environmental factors to perception of dengue threat, perception of program constraints, perception of program benefits, and perception of digital technology needs. Perception of program benefits and threatened perception of dengue have a positive relationship with perception of digital technology needs.

Conclusions: This model showed the variables perception of digital technology and perception of benefits had a positive association with attitude towards dengue control.
Introduction

Dengue hemorrhagic fever (DHF) is still a global public health problem in tropical and subtropical climates. This mosquito-borne disease has spread rapidly in the last 50 years, and WHO estimates that the annual cases reach 50–100 million DHF infections. Furthermore, the cases have tripled to 390 million, with more than 70% of the world’s population at risk. 

The global spread of dengue fever is influenced by urbanization, globalization, and less effective vector control. The level of dense human population in an area is also followed by the density level of the Aedes aegypti mosquito. The hemorrhagic fever can be transmitted through mosquito bites from one human to another. In addition, the development of the aviation industry in various countries increases the mobility of humans and vectors from one country to another. The lack of practical control efforts has led to dengue disease outbreaks in various regions.

More than 70% of the population at risk of DHF live in the Southeast Asia and West Pacific region, with a global disease burden of 75%. Therefore, WHO promotes making strategic plans to quickly detect and control disease outbreaks and stop their spread to new areas. Sustainable vector control methods, public health policymakers, and vaccine development should receive serious attention in controlling the current and future global distribution of DHF.

Indonesia is one of the countries endemic to dengue fever. The first DHF case was reported in 1968 in Surabaya, and since then, the incidence rate has increased from 0.05 to 35-40 per 100,000 population and peaked in 2010 (IR 85). Based on the Ministry of Health report, until July 2020, there were 73,329 cases and 467 deaths. The regencies with the highest incidence rates in 2020 are Buleleng, Bali (2677 cases), Badung, Bali (2,138 cases), Bandung City (1,748 cases), East Jakarta (1,765 cases), and Sikka (1,715).

During the current coronavirus disease 2019 (COVID-19) pandemic, efforts to control DHF cannot be carried out optimally because of health protocols. These include social distancing, wearing masks, and being careful about receiving foreign guests. This makes it challenging to collect data door to door, and the condition requires a digital technology approach to conduct surveillance and health education in the community. An integrated dengue surveillance and control system is needed in the endemic areas. Data collection should be quick and easy, as well as educate the public on vector control. Therefore, it is necessary to study the potential development of digital technology in dengue control during the COVID-19 pandemic.

Methods

Conceptual model

The theoretical model adopts a health belief model between perceptions and dengue control behaviour. The health belief theory is then modified by adding environmental variables and the need for digital technology. The hypotheses were compared with six latent constructs related to dengue control attitudes, influenced by perceptions of the threat of dengue, program benefits, environmental factors, program constraints, and technology needs (Figure 1). The direction of the path shows the (+) and (-) effects of the relationship, and this study assessed the accuracy of the model and hypothesis with PLS-SEM.

Regarding potential bias in this study, online data collection means that respondents can answer questions repeatedly. Thus, to reduce bias, data validation was carried out based on names and addresses. Incomplete answers, this is done with a re-checking system and requires answering. Respondents also only represented the Denpasar City area, not representing Indonesia.

Study design and data collection

This cross-sectional study is conducted using an online survey with 6 variables. These include perceptions of the need for digital information systems, dangers of DHF, benefits of DHF control programs, program constraints, and environmental factors related to attitudes toward controlling DHF. Respondents answered with a Likert scale of 1-5, where 1, 2, 3, 4, and 5 represent strongly disagree, disagree, neutral, agree, and strongly agree. The questionnaire was made by discussing with experts and testing about 30 respondents to measure the validity and reliability. Respondents were selected based on inclusion criteria, aged more than 17 years, having an address in Denpasar City for more than one year, and willing to answer questions. The results of the validity and reliability tests found that 46 of the indicators were declared valid. Invalid indicators are excluded and not used. The final questionnaire can be found as Extended data.

It was then distributed online using a google form, and data collection was carried out in the Denpasar City area, which is endemic to DHF. Table 1 shows a description of the data from the composites and indicators, as well as the definitions of attitudes towards dengue control efforts with the other five composites.
Figure 1. The structural hypothesis of the relationship between perception and attitude in dengue.  

Table 1. Descriptive data.

| Composite                                | Indicator | Definition                                                                 |
|------------------------------------------|-----------|-----------------------------------------------------------------------------|
| Perception of program benefits           | Var1a     | Jumantik volunteers always visit my house every month                      |
|                                          | Var1b     | Jumantik volunteers always provide information                            |
|                                          | Var1c     | Jumantik volunteers give larvicide                                          |
|                                          | Var1d     | Jumantik program is useful for preventing dengue                           |
|                                          | Var1e     | Students can play the role of being a larva care student                    |
|                                          | Var1f     | I support the dengue control program                                       |
|                                          | Var1g     | I am willing to follow Jumantik's advice                                   |
| Perception of being threatened with dengue| Var2a     | I am at risk of being infected with dengue                                 |
|                                          | Var2b     | My family is at risk for dengue infection                                 |
|                                          | Var2c     | Dengue Haemorrhagic Fever (DHF) is a deadly disease                       |
|                                          | Var2d     | Dengue is a highly contagious disease                                       |
|                                          | Var2e     | Dengue Haemorrhagic Fever (DHF) is a dangerous disease                    |
|                                          | Var2f     | We are afraid of being infected with dengue                                |
| Perception of program constraints        | Var3a     | Program funding is still lacking                                            |
|                                          | Var3b     | A limited number of health workers                                         |
|                                          | Var3c     | Home visits are limited due to social distancing and COVID-19             |
|                                          | Var3d     | Visiting hours during business hours from 8 to 10 AM                      |
|                                          | Var3e     | Limited information                                                       |
|                                          | Var3f     | Limited larvicides                                                        |
|                                          | Var3g     | Brochure distribution is rarely done                                       |
|                                          | Var3h     | Limited smartphone facilities                                              |
Table 1. Continued

| Composite                              | Indicator | Definition                                                                                           |
|----------------------------------------|-----------|------------------------------------------------------------------------------------------------------|
| Perception of digital technology needs | Var4a     | I am willing to use my cell phone for the dengue control program                                      |
|                                        | Var4b     | I am willing to fill in the data on the website                                                      |
|                                        | Var4c     | I am willing to watch digital educational videos                                                   |
|                                        | Var4d     | I am willing to share information with my family                                                    |
|                                        | Var4e     | Support dengue control digital information system                                                    |
|                                        | Var4f     | I have an android phone that supports the program                                                    |
|                                        | Var4g     | I have social media applications such as WhatsApp, Facebook, Instagram, and others                  |
|                                        | Var4h     | Usually, use WhatsApp to communicate                                                                |
| Perception of environmental factors    | Var5a     | The rainy season affects the incidence of dengue                                                    |
|                                        | Var5b     | The number of water containers affects mosquito density                                               |
|                                        | Var5c     | Aedes mosquitoes like to lay their eggs in clean water                                               |
|                                        | Var5d     | A bucket filled with water has the potential to become mosquito breeding place                      |
|                                        | Var5e     | Bath containers have the potential to become mosquito breeding places                                |
|                                        | Var5f     | Used bottles, used tires can become mosquito breeding places                                         |
|                                        | Var5g     | Empty land has the potential to become mosquito breeding places                                      |
|                                        | Var5h     | Environmental conditions affect dengue cases                                                         |
| Attitude towards dengue control        | Var6a     | I am willing to eradicate mosquito breeding places once a week                                       |
|                                        | Var6b     | I am willing to close the water container                                                            |
|                                        | Var6c     | Carry out environmental cleaning activities once a week                                              |
|                                        | Var6d     | Fill in larva density data every week                                                                |
|                                        | Var6e     | Support the program to eradicate mosquito breeding places                                            |
|                                        | Var6f     | Support the activities of students caring for dengue every week                                     |
|                                        | Var6g     | I am willing to be penalized if larvae are found                                                     |
|                                        | Var6h     | I am willing to pay a fine if a larva is found                                                       |
|                                        | Var6i     | Willing to make efforts to eradicate mosquito breeding places following the advice of the officer  |

*These indicators were not included in latent variables due to the multicollinearity criteria of PLS-SEM.

*Jumantik* is a volunteer recruited from each village area to inspect, monitor, and control dengue vectors. They were given the task of conducting daily inspections to visit homes. The results of their activities are reported as vector entomological surveillance. This is part of community empowerment to carry out dengue control in their area actively.

**Sample**
The inclusion criteria were respondents who were over 17 years old and had resided in Denpasar City for more than six months. They are given a research approval form and receive mobile phone credit from the internet provider for two. Even though 596 respondents filled in the data, only 515 fulfilled the requirements and were complete. Sampling was carried out with non-random sampling conducted online in a limited population with the consideration that
respondents could not be visited directly due to the COVID-19 pandemic in the Denpasar City area, which had previously been permitted by the Licensing Service, Health Service, Head of Public Health Center, and Village Head.

**Variables**

This study consists of six variables with 46 indicators using a Likert scale of 1-5, where 1, 2, 3, 4, and 5 representing strongly disagree, disagree, neutral, agree, and strongly agree. Attitudes toward prevention strategies are a dependent variable that tends to act to regulate dengue in the surrounding environment through the use of vector control activities at breeding sites for mosquitoes. Therefore, nine indicators are measured, namely willingness to carry out a weekly movement to eradicate mosquito breeding areas, close water reservoirs, clean the environment regularly, filling in data on larval density weekly independently, providing assistance to dengue control programs, supporting students’ weekly larvae care activities, willing to be sanctioned when larvae are discovered, willing to pay a fine, and making efforts to eradicate mosquito breeding areas following the officer’s advice.

Perceptions of the benefits are related to the assessment of dengue control programs beneficial to the community. These consist of 7 indicators: *jumantik* volunteers always visit every month, the officers always provide information, the volunteers provide larvicide, the program is useful for preventing dengue cases, and students play a role for larvae, the dengue control program was supported, and the officer’s advice was followed.

The perception of being threatened with dengue is a condition that causes feelings of fear and vulnerability to outbreaks which consist of 6 variables. These include the risk of being infected with dengue fever and several families at risk of being infected. Dengue fever is a deadly, easily contagious, and dangerous disease that people are afraid of being infected.

Perceptions of program constraints are obstacles in carrying out activities related to facilities and pandemic conditions in dengue control. These consist of 8 variables of limited program funding, *jumantik* personnel, home visit activities due to social distancing and COVID-19, visiting time, which is during working hours from 8 to 10, the information provided, the larvicides, and smartphone facilities.

The need for digital technology is a public perception of the support for implementing the systems in dengue control. These consist of 8 variables, namely being willing to use mobile phones for dengue control programs, filling in data on websites, watching digital educational videos, sharing information with family, supporting digital information system programs, having Android phones that support the program, having social media applications such as WhatsApp, Facebook, Instagram, and others, but accustomed to using WhatsApp to communicate.

Perception of environmental factors is the surrounding conditions that affect the density of larvae and dengue cases, both natural and artificial. These consist of 8 variables, namely the rainy season affects the incidence of dengue, the number of water reservoirs affects the density of mosquitoes, the Aedes mosquitoes lay eggs in clean water, the bucket filled with water in bathroom containers, used bottles, tires, and vacant places have the potential to become a breeding place.

**Data analysis**

This study was analyzed using PLS-SEM with SmartPLS 3.0 software. It analyzed five variables related to attitudes towards dengue control. The PLS-SEM analysis uses two stages, and the first describes the measurement model connecting the constructs and indicators to the theory. In the second stage, the structural model determines the determinants of the relationship between the construction and the hypothetical model.

**Ethical approval**

This study is part of a research carried out for the development of an integrated dengue control system. This study has been approved by the ethics committee of the Faculty of Public Health, University of Indonesia (Ket-416/UN2.F10.D11/PPM.00.02/2021). Before data collection, informants had received information about their goals, risks, and rights. In addition, a written consent form was given before the interview, and all information from participants is confidential and for this study only.

**Results**

Table 2 shows the socio-demographics of respondents who filled in the data for this study. There were 515 respondents, with 41.4% and 58.6% being men and women, respectively, with the highest education level being high school level with 62.3%. The respondents' age distribution was mainly 40-44 years old (19.4%) and 17-24 years (18.6%). The type of occupation was primarily private workers (29.3%) and housewives (17.9%).

Most sources of information used for dengue control are through social media such as WhatsApp, Facebook, Instagram, Tiktok, and others (37%). Most respondents find it easier to get information through social media. However, there has
been a change in the sources due to the development of information technology. Another highest source of knowledge is television (23%), followed by digital educational videos (14.3%) and websites (10.6%) (Figure 2).

The types of information needed are the methods of controlling dengue, the dangers, symptoms of infection, characteristics of dengue-transmitting mosquitoes, the risk, the role of jumantik cadres, methods of eradicating mosquito breeding sites, and environmental factors. This information is needed to develop digital educational media for dengue control (Figure 3).

The percentage of the community’s efforts to seek health services in handling dengue symptoms is through hospitals (44.5%) and primary health centers (40.5%). Public awareness to conduct health checks while experiencing symptoms of DHF is high in the urban setting in which the number and proximity of health-care services are relatively close and easily accessible (Figure 4).

This section details the results obtained for the proposed study model.

### Table 2. Socio-demographic of respondents.

| Respondent characteristics | Frequency | Percent |
|----------------------------|-----------|---------|
| Gender                     |           |         |
| Male                       | 213       | 41.4    |
| Female                     | 302       | 58.6    |
| Education                  |           |         |
| Primary School             | 2         | 0.4     |
| Junior High School         | 27        | 5.2     |
| Senior High School         | 321       | 62.3    |
| Diploma                    | 59        | 11.5    |
| Bachelor                   | 106       | 20.6    |
| Age (years)                |           |         |
| 17-24                      | 96        | 18.6    |
| 25-29                      | 28        | 5.4     |
| 30-34                      | 56        | 10.9    |
| 35-39                      | 64        | 12.4    |
| 40-44                      | 100       | 19.4    |
| 45-49                      | 79        | 15.3    |
| 50-54                      | 44        | 8.5     |
| 55-59                      | 28        | 5.4     |
| 60                         | 20        | 3.9     |
| Occupation                 |           |         |
| Unemployment               | 31        | 6       |
| Civil servant              | 27        | 5.2     |
| Health worker              | 58        | 11.3    |
| Housewife                  | 92        | 17.9    |
| College student            | 86        | 16.7    |
| Village head               | 15        | 2.9     |
| Entrepreneur               | 48        | 9.3     |
| Private sector employee    | 151       | 29.3    |
| Teacher                    | 7         | 1.4     |
The composite measurement model in mode A (attitude) was assessed in individual item reliability, construct reliability, convergent validity, and discriminant validity. First, the reliability of each item is analyzed through a loading factor, as seen in Figure 5.

Table 3 shows the value of the measurement of validity and reliability. Cronbach’s Alpha value and composite were used to evaluate construct reliability. The values show that the construct exceeds the recommended cut-off of 0.7. Convergent validity was also proved because the construct’s extracted mean-variance (AVE) was higher than 0.500. Table 3 shows that the measurement model meets the criteria.

Table 4 presents discriminant validity results through the heterotrait-monotrait (HTMT) correlation ratio. All constructs reach discriminant validity because the confidence interval does not contain a zero value. This situation means that each

Figure 2. Percentage of sources of information technology needed regarding dengue control.14

Figure 3. Types of information needed in dengue control.14

Measurement model
Composite mode A

The composite measurement model in mode A (attitude) was assessed in individual item reliability, construct reliability, convergent validity, and discriminant validity. First, the reliability of each item is analyzed through a loading factor, as seen in Figure 5.

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Figure 4. Percentage of seeking health services if infected with dengue.14

Figure 5. Study model.14

Table 3. Validity and reliability measurement.

| Composite                             | Cronbach's Alpha | Composite Reliability (CR) | Average Variance Extracted (AVE) |
|---------------------------------------|-------------------|-----------------------------|----------------------------------|
| Attitude Toward Dengue Control        | 0.901             | 0.921                       | 0.627                            |
variable is different from one another. The data examined in the measurement model show that the attitude construct measure is reliable and valid.

**Composite mode B**

The composite measurement model in mode B was assessed in collinearity between the outer weights’ indicators, significance, and relevance. First, removing the indicator is carried out when the value exceeds the variance impact factor (VIF = 3). As a result of this process, only the indicators shown in Table 1 are without collinearity. Second, the relevance of the weights is analyzed, and Figure 6 shows the indicators in construction for latent variables. Finally, it is possible to start a bootstrap with 10,000 sub-samples to assess significance. Indicators with insignificant weights but significant loadings of 0.50 or higher were considered relevant (Table 5).

### Table 4. Heterotrait-monotrait (HTMT) inference.

| HTMT inference* | Original sample | Sample mean | 5%   | 95%   |
|-----------------|-----------------|-------------|------|-------|
| Perception Of Digital Technology Needs -> Attitude Towards Dengue Control | 0.733 | 0.735 | 0.657 | 0.804 |
| Perception Of Environmental Factors -> Attitude Towards Dengue Control | 0.596 | 0.595 | 0.476 | 0.708 |
| Perception Of Program Benefits -> Attitude Towards Dengue Control | 0.714 | 0.717 | 0.637 | 0.793 |
| Perception Of Program Constraints -> Attitude Towards Dengue Control | 0.456 | 0.450 | 0.320 | 0.564 |
| Threatened Perception Of Dengue -> Attitude Towards Dengue Control | 0.486 | 0.484 | 0.358 | 0.611 |

*Significance, the confidence interval 95% bias was corrected and performed using bootstrap procedure with 10,000 replications.

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**Figure 6. Model results SEM-PLS.**

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Table 5. Significance of weights.

| Perception of program benefits | Original sample (O)* | t     | Loading | Lo95   | Hi95   |
|--------------------------------|----------------------|-------|---------|--------|--------|
| Var1a                          | 0.124                | 14.562| 0.702   | 0.106  | 0.141  |
| Var1b                          | 0.142                | 17.507| 0.786   | 0.125  | 0.156  |
| Var1c                          | 0.139                | 12.786| 0.742   | 0.117  | 0.159  |
| Var1d                          | 0.181                | 22.076| 0.855   | 0.166  | 0.199  |
| Var1e                          | 0.218                | 16.247| 0.832   | 0.193  | 0.247  |
| Var1f                          | 0.217                | 16.050| 0.772   | 0.193  | 0.244  |
| Var1g                          | 0.232                | 20.284| 0.837   | 0.211  | 0.255  |
| Threatened perception of dengue|                      |       |         |        |        |
| Var2c                          | 0.364                | 16.095| 0.831   | 0.319  | 0.407  |
| Var2e                          | 0.438                | 19.056| 0.910   | 0.400  | 0.490  |
| Var2f                          | 0.364                | 13.604| 0.820   | 0.306  | 0.412  |
| Perception of program constraints|                    |       |         |        |        |
| Var3a                          | 0.326                | 6.585 | 0.670   | 0.239  | 0.429  |
| Var3b                          | 0.265                | 6.616 | 0.666   | 0.188  | 0.339  |
| Var3c                          | 0.391                | 8.735 | 0.682   | 0.297  | 0.472  |
| Var3d                          | 0.479                | 8.557 | 0.706   | 0.382  | 0.600  |
| Perception of digital technology needs|               |       |         |        |        |
| Var4a                          | 0.154                | 18.282| 0.780   | 0.138  | 0.171  |
| Var4b                          | 0.132                | 17.528| 0.752   | 0.118  | 0.146  |
| Var4c                          | 0.142                | 16.837| 0.784   | 0.125  | 0.158  |
| Var4d                          | 0.182                | 20.493| 0.774   | 0.165  | 0.201  |
| Var4e                          | 0.164                | 23.472| 0.841   | 0.150  | 0.177  |
| Var4f                          | 0.158                | 17.940| 0.828   | 0.141  | 0.175  |
| Var4g                          | 0.163                | 19.850| 0.830   | 0.149  | 0.181  |
| Perception of environmental factors|                |       |         |        |        |
| Var5a                          | 0.201                | 19.233| 0.827   | 0.183  | 0.222  |
| Var5b                          | 0.167                | 17.922| 0.820   | 0.150  | 0.187  |
| Var5d                          | 0.163                | 17.488| 0.831   | 0.146  | 0.181  |
| Var5e                          | 0.158                | 17.032| 0.804   | 0.139  | 0.176  |
| Var5f                          | 0.188                | 20.754| 0.887   | 0.172  | 0.207  |
| Var5g                          | 0.160                | 17.451| 0.745   | 0.145  | 0.181  |
| Var5h                          | 0.181                | 20.064| 0.823   | 0.165  | 0.201  |
| Attitude towards dengue control|                     |       |         |        |        |
| Var6a                          | 0.163                | 21.560| 0.753   | 0.149  | 0.179  |
| Var6b                          | 0.169                | 18.937| 0.779   | 0.151  | 0.186  |
| Var6c                          | 0.171                | 19.730| 0.815   | 0.157  | 0.189  |
| Var6d                          | 0.166                | 20.917| 0.778   | 0.151  | 0.182  |
| Var6e                          | 0.202                | 23.747| 0.835   | 0.188  | 0.220  |
| Var6f                          | 0.197                | 21.106| 0.823   | 0.179  | 0.216  |
| Var6i                          | 0.194                | 18.306| 0.754   | 0.175  | 0.215  |

*t statistic, and 95% bias-corrected confidence interval performed by a bootstrapping procedure with 10,000 replications.
Table 6. Whole sample results.

| Direct effect                                      | Path   | t     | p   | Lo95  | Hi95  | $R^2$ | VIF |
|---------------------------------------------------|--------|-------|-----|-------|-------|-------|-----|
| Perception of Environmental Factors -> Threatened Perception of Dengue | 0.478  | 9.259 | 0.000 | 0.378 | 0.583 | 0.296 | 1,000 |
| $R^2$=0.227                                       |        |       |     |       |       |       |     |
| Perception of Environmental Factors -> Perception of Program Constraints | 0.471  | 11.190| 0.000 | 0.392 | 0.553 | 0.285 | 1,000 |
| $R^2$=0.220                                       |        |       |     |       |       |       |     |
| Perception of Environmental Factors -> Perception of Program Benefit | 0.606  | 14.978| 0.000 | 0.532 | 0.689 | 0.580 | 1,000 |
| $R^2$=0.366                                       |        |       |     |       |       |       |     |
| Perception of Environmental Factors -> Perception of Digital Technology Needs | 0.322  | 5.776 | 0.000 | 0.206 | 0.422 | 0.100 | 1,993 |
| Perception of Program Benefits -> Perception of Digital Technology Needs | 0.293  | 6.312 | 0.000 | 0.198 | 0.380 | 0.087 | 1,862 |
| Perception of Program Constraints -> Perception of Digital Technology Needs | 0.062  | 1.520 | 0.129 | -0.020 | 0.138 | 0.005 | 1,328 |
| Threatened Perception of Dengue -> Perception of Digital Technology Needs | 0.120  | 2.654 | 0.008 | 0.035 | 0.214 | 0.018 | 1,395 |
| $R^2$=0.427                                       |        |       |     |       |       |       |     |
| Perception of Digital Technology Needs -> Attitude Towards Dengue Control | 0.405  | 10.218| 0.000 | 0.333 | 0.479 | 0.219 | 1,765 |
| Perception of Environmental Factors -> Attitude Towards Dengue Control | 0.062  | 0.966 | -0.058 | 0.187 | 0.005 | 1,993 |
| Perception of Program Benefits -> Attitude Towards Dengue Control | 0.371  | 6.552 | 0.000 | 0.271 | 0.488 | 0.172 | 1,862 |
| Perception of Program Constraints -> Attitude Towards Dengue Control | 0.003  | 0.087 | -0.057 | 0.064 | 0.000 | 1,328 |
| Threatened Perception of Dengue -> Attitude Towards Dengue Control | 0.050  | 1.193 | -0.042 | 0.127 | 0.004 | 1,430 |
| $R^2$=0.571, $Q^2$=0.569                         |        |       |     |       |       |       |     |

| Indirect Effect                                    | Path   | t     | p   | Lo95  | Hi95  | VAF  | VIF |
|---------------------------------------------------|--------|-------|-----|-------|-------|------|-----|
| Perception of Environmental Factors -> Perception of Digital Technology Needs-> Attitude Towards Dengue Control | 0.487  | 10.269| 0.000 | 0.398 | 0.587 | 0.511 | na  |
| Perception of Environmental Factors -> Threatened Perception of Dengue-> Attitude Towards Dengue Control | 0.487  | 10.269| 0.000 | 0.398 | 0.587 | 0.752 | na  |
| Perception of Environmental Factors -> Perception of Program Benefits-> Attitude Towards Dengue Control | 0.487  | 10.269| 0.000 | 0.398 | 0.587 | 0.469 | na  |
| Perception of Environmental Factors -> Perception of Program Benefits-> Perception of Digital Technology Needs | 0.264  | 6.938 | 0.000 | 0.198 | 0.350 | 0.300 | na  |
| Perception of Program Benefits -> Perception of Digital Technology Needs-> Attitude Towards Dengue Control | 0.119  | 5.267 | 0.000 | 0.074 | 0.165 | 0.152 | na  |
| Perception of Program Constraints -> Perception of Digital Technology Needs-> Attitude Towards Dengue Control | 0.025  | 1.455 | 0.146 | -0.008 | 0.060 | 0.058 | na  |
| Threatened Perception of Dengue -> Perception of Digital Technology Needs-> Attitude Towards Dengue Control | 0.049  | 2.626 | 0.009 | 0.015 | 0.085 | 0.097 | na  |

Note: ns = not significant. t statistic, and confidence 95% bias was corrected. The interval was performed using a bootstrap procedure with 10,000 replication. VIF: Inflation of model variance in factors; VAF: variance recorded.
**Structural model**

The structural model is evaluated after verifying the correctness of the construction measurements. The path coefficients and their 10,000 resampling bootstrap significance levels are reported in Table 6 and Figure 6. Additionally, Table 6 shows that the VIF constructs range from 1,000 to 1,700, indicating no collinearity between variables. This study also assesses the quality by examining the overall predictive relevance of the model with a Q2 value above zero which indicates a fit in the prediction model. The magnitude of Q2 has a value of $0 < Q2 < 1$, where the closer to 1, the better the model. The coefficient of determination ($R^2$) also exceeds 0.1 for endogenous latent variables since the construct has an acceptable predictive power quality.

From Table 6, there is a direct influence of Perception of Environmental Factors on the Threatened Perception of Dengue, Program Constraints, Program Benefits, and Digital Technology Needs. Perception of Program Benefits and Threatened Perception of Dengue directly influences Digital Technology Needs. In general, Perception of Digital Technology Needs and Program Benefits directly influence Attitude Towards Dengue Control. Variables Perception of Digital Technology Needs and Perception of Program Benefits positively correlate to Attitude Towards Dengue Control.

VAF values above 80% indicate that the variable serves as a full mediator. The variable can be categorized as a partial mediator when the VAF value ranges from 20% to 80%. However, when the value is less than 20%, it can be concluded that there is almost no mediating effect. The value of VAF indicates that the proportion of Perception Of Digital Technology Needs from the pathway has no mediating effect (VAF<0.2 or 20%). Perception of Digital Technology Needs, Threatened Perception of Dengue, and Program Benefits can be categorized as partial mediators between Environmental Factors and Attitudes Towards Dengue Control (see the indirect effect in Table 6).

**Discussion**

The use of digital technology in dengue surveillance is currently needed, specifically during the COVID-19 pandemic. Health protocols such as social and physical distancing make direct door-to-door observation activities difficult. Therefore, there is an increase in smartphones and digital applications in conducting disease surveillance.

This study is a novelty in developing a new model that adopts the health belief model and then collaborates between digital information systems with perceptions of environmental factors, disease threats, and the obstacles related to dengue control attitudes. This study begins with a qualitative study of the potential development of digital surveillance for dengue control, which requires a digitally integrated system for reporting in real-time.16

This study aims to determine the variables that influence attitudes in dengue control related to the potential application of digital technology. It indicates a direct influence of Perception of Environmental Factors on Threatened Perception of Dengue, Program Constraints, Program Benefits, and Digital Technology needs. Perception of Program Benefits and Threatened Perception of Dengue directly Influences Digital Technology Need. Perception of Digital Technology Needs and Program Benefits directly influence Attitude Towards Dengue Control.

Most sources of information needed for dengue control are through social media such as WhatsApp, Facebook, Instagram, Tiktok, and others (37%). Due to the availability of internet access and public WIFI, people have switched their sources of information, which were previously direct from health workers, television, and then using social media. In addition, teenagers use internet media for learning, specifically in urban areas, and access to information is high.17–20

Attitudes in dengue control are directly influenced by the variable perception of the need for digital technology and program benefits. This is related to the source of information obtained through digital media. Perception of environmental factors is influenced by Threatened Perception of Dengue, Program Constraints, Program benefits, and Digital Technology Need.

Other studies showed an increase in the use of digital technology during the pandemic for monitoring, surveillance, detection, and prevention of COVID-19.21,22 Studies in Saudi use various digital platforms such as mobile health applications, artificial intelligence, and machine learning in the pandemic surveillance.23 A digital dengue surveillance system has also been developed to predict, detect and control the threat of outbreaks.24–26 The incidence is often related to climate change, ecological and socio-demographic factors.24–31 Developing a system based on technology and the environment using spatial mapping makes it possible to predict the potential for outbreaks in an area.29,31

**Study strengths and limitations**

The strength is the development of a model that combines measurement of attitudes towards dengue control with environmental factors on the threatened perception of dengue, program constraints, program benefits, and digital
technology needs. The commonly used model is the health belief, but a different approach combines the perceived need for digital technology, environmental factors, and health beliefs.

This study uses PLS-SEM analysis which was selected because it is variance-based and estimates composite components and factors. The PLS analysis is a multivariate statistical technique that compares several responses and explanatory variables. Through this approach, it is possible to make appropriate structural equations toward dengue control related to the perception of environmental factors on the threatened perception of dengue, program constraints, program benefits, and digital technology needs.

The use of online surveys is limited to certain areas and does not represent the whole of Indonesia, only Denpasar City. Generally, the respondents used were those with mobile phones and internet networks, and they were not randomly assigned.

Policy implications and future studies
The results are helpful for policymakers to promote the use of digital technology in data collection of disease cases, surveillance, monitoring, and evaluation of health programs supported by socialization through social media that can influence perceptions of the benefits of the program. The community’s attitude toward controlling the disease is also related to the source of information that affects public perception. Policies to support digital facilities such as the availability of internet networks, computer facilities, mobile phones, and data packages affect the disease reporting system and its control. In the future, it is necessary to develop an integrated digital system for reporting disease cases and collecting data on the ecological environment, specifically larval density. This system should perform spatial mapping and predict the potential for a dengue outbreak to occur. Therefore, technology can be helpful in case surveillance for quick control measures.

Conclusion
Digital technology has the potential to be developed during the COVID-19 pandemic, specifically in conducting data collection, surveillance, reporting, monitoring, and evaluation. Attitudes towards dengue control directly affect the perception of digital technology needs and program benefits. Social media is a more dominant source of information about dengue disease than other forms of electronic media. The perception of environmental factors is also directly influenced by the variables of threatened perception of dengue, program constraints, program benefits, and digital technology needs.

Data availability
Underlying data
Dryad: Attitude towards dengue control efforts with the potential of digital technology during COVID-19: partial least squares-structural equation modelling, https://doi.org/10.5061/dryad.jdfn2z3f0.

Extended data
Figshare: Dengue integrated surveillance system questionnaire, https://doi.org/10.6084/m9.figshare.21300309.

Data are available under the terms of the Creative Commons Attribution 4.0 International license (CC-BY 4.0).

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I appreciate the effort that the authors did in this manuscript. However, I have some apprehensions which I have highlighted below:

Introduction
- The authors mainly explained the lack of understanding of the factors that influence attitudes toward dengue control concerning the potential application of digital technology in Indonesia. It will be more beneficial if they could provide further evidences based on previous studies from the context of Southeast Asia countries; specifically, Indonesian context.

Literature review
- I could not find any serious attempt to write a literature review related to the variables of the study. Researchers should create a new separate section that discuss the previous conducted studies in this field of research (based on the study model).

Method
- As the study is deductive in nature, the authors should clarify the rationale behind adopting the health belief theory. In its current form, there is not enough theoretical justification to propose the study hypotheses.

- The authors need to make sufficient justification on how they determined the sample size?

- A standard PLS-SEM methodology was utilized. More evidence should be provided that the statistical assumptions of PLS-SEM have been fulfilled before using it.

- In term of the study respondent characteristics, were there no respondents with master's or doctoral degrees?

- The authors must write the hypotheses of the study clearly and explicitly. For better readability, I recommend the authors create a new table that includes the hypothesis statement with its result (supported / not supported).
Discussion

- Based on the study model, I don’t see a significant attempt to discuss the study findings. Authors must provide a detailed discussion that includes sufficient linkage/justification between the study findings with previous recent studies.

Implication

- The authors have focused on the practical/managerial implications of the study. On the other hand, the authors have not given explicit discussion/examples of theoretical implications.

Is the work clearly and accurately presented and does it cite the current literature?
Partly

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
No source data required

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Technology Diffusion, Knowledge Management, Innovation Management

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.
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