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Development and validation of digital health literacy competencies for citizens (DHLC), an instrument for measuring digital health literacy in the community

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A R T I C L E   I N F O

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A B S T R A C T

COVID-19 is a new disease in human life and has become pandemic. Pandemic Coronavirus Disease (COVID-19) has been speeding up digital transformation in every sector. Implementation of digital technology in health should be supported by the community’s readiness, such as digital health literacy to achieve the goals, optimize health service performance, and blockage infodemics and miss information. Implementation of digital technology in health should be supported by the community’s readiness, such as digital health literacy to achieve the goals, optimize health service performance, and blockage infodemics and miss information. This study aims to develop a tool to measure digital health literacy in the community through three stages such as expert review, pre-test and field test. DHLC adopted the five competencies areas into 18 questions and put eight questions related to health literacy; the total items question of DHLC are 26 items questions. This study reveals that all of the score digital competencies areas below 4. Score 4 in DHLC indicates that the community still need guidance to doing activity in the digital environment. Elevating digital health literacy in the citizens is urgent to control the spreading misinformation and disinformation that could worsen pandemics. Future studies need to conduct to test the validity and reliability of DHLC in various settings.

1. Introduction

The pandemic Coronavirus Disease (COVID-19) has been speeding up digital transformation in every sector because Prevention and Controlling of Program Covid-19 require physical distancing and restricted traveling for people to reduce the transmission of Covid-19. [1] During the COVID-19 crisis, digital technologies have become a problem-solving and significant route for accessing remote services. Technologies routinely change human beings differently, including the health sector. Recently, technology has changed people’s approach to health, such as how to access and receive health services at different levels of healthcare furthermore how people communicate with health professionals.

The transformation of digital slowly changes human behavior; the development of the technology system has already reached Digital Industry 4.0 and is moving forward to Society 5.0. [2, 3] Digital Industry 4.0 is about automation, while Society 5.0 will combine humans and autonomous machines to utilize human brainpower and creativity further to increase process efficiency by combining workflows with intelligent systems. [4]

Furthermore, developing wireless technology wireless technologies creates opportunities to revolutionize the health sector. Wireless technology could solve geographic access problems, facilitate appropriate interventions, reduce intervention costs, and even help raise public awareness of approaching health problems and promoting healthy lifestyles contributing to patient empowerment. [5] However, digitalization in human life, especially the internet, could make human life more manageable and have negative impacts. It is because of inaccurate and misleading information on Internet-based that consists of incomplete or based on insufficient scientific evidence. [6]

COVID-19 is a new disease in human life and has become a pandemic. Globally, there have been 200,840,180 confirmed cases of Covid-19, including 4265,903 deaths. [7] The exploding facts and fiction of COVID-19 as an infodemic result from anxiety, fear, depression,
and irrational thinking because the scientific knowledge on COVID-19 takes time to grow and prove. [8, 9] Furthermore, the massively sharing of information through social media and the internet also develops infodemics and often creates misinformation about Covid-19. [10, 11] Infodemic defines as "an overabundance of information – some accurate and some not – that makes it hard for people to find trustworthy sources and reliable guidance when they need it". Misinformation is "false or inaccurate information deliberately intended to deceive". [12]

The infodemic makes it difficult for the public to understand what public health experts and politicians say to control Covid-19. [13] The influential role of digital media, especially online social networks, facilitates and fosters misinformation about health and science, making individuals overwhelmed, especially because social media often blur the line between the good and bad, the scientific and unscientific, and the true and false. [14] Infodemic could worsen the pandemic because it is hard for people to find trustworthy sources to decide on health, negatively impacting their health status. Infodemics should be filtered through health literacy, especially Digital Health literacy (DHL). [11, 15-17]

Digital health literacy could reflect the community’s readiness to digitalize the health system. DHL is a required competency when implementing digital technology in human life, especially in health, because this competency could support achieving the health program goals, optimizing health service performance, and blocking infodemics and misinformation-related health. [18]

Indonesia has faced misinformation and disinformation since 2014 with various topics; political topics and, recently, health topics such as vaccine hesitancy during COVID-19 pandemic. The misinformation and disinformation are massively widespread using social media and have become worse because of the reflection of the low digital literacy in Indonesia. [19–22]

Recent studies still explored the tool related to health literacy [22], but limited studies explore tools for measuring digital health literacy in the community. [23, 24] This study aims to develop a tool to measure digital health literacy in the community through three stages: expert review, pre-test, and field test.

2. Theory/calculation

COVID-19 pandemic accelerates the usage of digital devices and the internet in the community. The exploding of health information on the
internet requires specific skills of citizens to adapt to the situation. Those skills are known as digital health literacy (DHL). The concept of DHL emerges from a convergence of Digital Literacy (DL) and Health Literacy (HL).

Digital Literacy (DL) is individuals’ awareness, attitude, and ability to use digital tools and facilities to identify appropriately, access, manage, integrate, evaluate, analyze, and synthesize digital resources. This ability constructs new knowledge, creates media expressions, communicates with others in specific life situations to enable constructive social action, and reflects upon this process. Competencies digital health literacy has three stages: digital health literacy competencies, digital usage, and digital transformation. [25]

Health literacy (HL) is linked to literacy. It entails people’s knowledge, motivation, and competencies to access, understand, appraise, and apply health information to make judgments and make decisions concerning healthcare, disease prevention, and health promotion to maintain or improve quality of life during the life course. [26]

The concept of digital health literacy is defined as the ability of individuals to search for, find, understand and evaluate health information obtained from electronic sources and to apply the knowledge acquired to address or solve a health problem. [27] These competencies are crucial because the internet has democratized access to health information. It is essential to empower individuals to understand and use this information practically so that the internet can be a support resource in health issues and not a source of inequalities in access to information. In this sense, the development of tools that help measure and develop these skills in citizens and even help prevent the emergence of some health conditions is still necessary.

3. Material and methods

This study was conducted in three stages: expert review, pre-test, and field test using online and offline questionnaires (Fig. 1). Stage 1; this study distributed an online questionnaire (DHLC ver.0) to experts from academe and practitioners in the health area and ICT area. In this stage, this study gets ten responses from the experts. The result of the expert review generated DHLC ver.1, and this version would test in the next stage. Stage 2 operated two pilot studies, both of them using an online questionnaire. The first pilot study distributed DHLC ver.1 to random online groups, resulting in DHLC ver.2 that this version had been tested in Pilot Study 2. The second pilot study distributed DHLC ver.2 to health college students through an online survey and generated DHLC ver.3 to be distributed in the next stage. The third stage was conducted in the community at Tanjung Mas Sub-District.

4. Result

4.1. Literature review

This study developed a tool to measure citizens’ digital health literacy competence based on the Digital Competence Framework for Citizens (DigComp 2.1) [28] and digital health literacy. [29] Fig. 2 shows that the initial DHLC (DHLC ver.0) has two main indicators: digital competencies and health information literacy. Each main indicator has sub-main indicators and indicators to measure digital health literacy competencies. Health information literacy has four sub-main indicators, while digital competency has five sub-main indicators and 17 indicators.
This literature review stage generated DHLC ver.0 consists of 21 indicators with 29 questions that experts will check in the following steps. The final DHLC questionnaire has 18 indicators with 26 questions. The reduction sub-indicators manage data, information, and digital content, collaborate through digital technologies and integrate and re-elaborate digital content (Table 1).

4.2. Expert review

The first stage consists of literature and an expert review. This study engaged ten experts to review the initial DHLC questionnaire. The experts consist of three males and seven females. Two of them have Doctoral Education backgrounds, and the rest experts are Master Education backgrounds with Informatics and Health Majors. The experts are...

| No | Literature review | Expert (DHLC ver.1) | Pilot study 1 (DHLC ver.2) | Pilot study 2 (DHLC ver.3) | Field Test (DHLC) |
|----|-------------------|---------------------|---------------------------|---------------------------|-------------------|
| A  | DIGITAL COMPETENCIES |                     |                           |                           |                   |
| 1  | Information and data literacy |                     |                           |                           |                   |
| 1.1| Browsing, searching and filtering data, information and digital content | Valid | Valid | Valid | Valid |
| 1.2| Managing data, information and digital content | Valid | Not valid | Delete | Delete |
| 2  | Communication and collaboration |                     |                           |                           |                   |
| 2.1| Interacting through digital technologies | Valid | Valid | Valid | Valid |
| 2.2| Sharing through digital technologies | Valid | Valid | Valid | Valid |
| 2.3| Engaging in citizenship through digital technologies | Valid | Valid | Valid | Valid |
| 2.4| Collaborating through digital technologies | Valid | Not valid | Delete | Delete |
| 2.5| Netiquette | Valid | Valid | Valid | Valid |
| 2.6| Managing digital identity | Valid | Valid | Valid | Valid |
| 3  | Digital content creation |                     |                           |                           |                   |
| 3.1| Developing digital content | Valid | Valid | Valid | Valid |
| 3.2| Integrating and re-elaborating digital content | Not valid | Delete | Delete | Delete |
| 4  | Safety |                     |                           |                           |                   |
| 4.1| Protecting devices | Valid | Valid | Valid | Valid |
| 4.2| Protecting personal data and privacy | Valid | Valid | Valid | Valid |
| 4.3| Protecting health and well-being | Valid | Valid | Valid | Valid |
| 5  | Problem solving |                     |                           |                           |                   |
| 5.1| Solving technical problems | Valid | Valid | Valid | Valid |
| 5.2| Identifying needs and technological responses | Valid | Valid | Valid | Valid |
| 5.3| Creatively using digital technologies | Valid | Valid | Valid | Valid |
| 5.4| Identifying digital competence gaps | Valid | Valid | Valid | Valid |
| B  | HEALTH INFORMATION LITERACY |                     |                           |                           |                   |
| 6  | Health Information Access | Valid | Valid | Valid | Valid |
| 7  | Health Information Management | Valid | Valid | Valid | Valid |
| 8  | Health Information Integration | Valid | Valid | Valid | Valid |
| 9  | Health Information Evaluation | Valid | Valid | Valid | Valid |

| Table 2 |
|---|

| Reduction of the questionnaire by expert panel. |
|---|

| NO | Statements DHLC ver.0 | Mean | Valid |
|----|-----------------------|------|-------|
| 1  | I can identify list of generic keywords and tags available those which would be useful for finding information related topic | 4.5 | Valid |
| 2  | I can identify how and where to organize and keep track of website or information in my smartphone in order to retrieve them when I need them in daily use. | 3.3 | Valid |
| 3  | I can use a commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) to talk to my friends in daily use | 4.3 | Valid |
| 4  | I can manage a group commonly used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) such as create group, add or delete members | 4.4 | Valid |
| 5  | I can use a commonly-used chat on my smartphone and a cloud-based storage system (e.g. Dropbox, Google Drive) to share material (message, file, picture, link) with other members of my group | 3.9 | Valid |
| 6  | I can propose and use different media strategies (e.g. Survey on Facebook, Hastags on Instagram and Twitter) to empower the citizens of my city to participate in defining the main topics of an event | 4.5 | Valid |
| 7  | I can choose and use the most appropriate digital tools in my smartphone or computer (e.g. Dropbox, Google Drive, wiki) to create content with my friends such as a leaflet, a picture, and a blog on the event. | 4.5 | Valid |
| 8  | I can manage and solve problems that arise while writing and communicating in digital environments, (e.g. inappropriate comments or Hoax in my social network) | 4.5 | Valid |
| 9  | I can manage a new social media that avoids actions which could harm my digital data reputation (e.g. spam) when using social media in internet | 4.5 | Valid |
| 10 | I can make a video from a tutorial video on YouTube or Instagram, how to create a brief video on my tablet/mobile phone to present content video such as video related health. | 4.6 | Valid |
| 11 | I know how to add new dialogues and images onto a brief support video already created on the internet to illustrate the new video. | 2.9 | Not Valid (Delete) |
| 12 | I can protect my social media (e.g. Twitter, Facebook, Instagram) account such as using different methods (e.g. a strong password, control the recent login) | 4.8 | Valid |
| 13 | I can detect risks like receiving tweets and messages from others with false profiles or phishing attempts. | 4.5 | Valid |
| 14 | I can select the most appropriate way to protect my personal data and others (e.g. address, phone number) when sharing digital content (e.g. a picture) on the social media. | 4.6 | Valid |
| 15 | I can distinguish between appropriate and inappropriate digital content to share it on my social media, so that my privacy and that of my friends are not damaged. | 4.7 | Valid |
| 16 | I can create a digital health campaign using social media (e.g. Twitter, FB) which can that others shared share by use smartphones or tablets. | 3.8 | Valid |
| 17 | I can identify a simple technical problem from a list of those that can arise while using a digital device, and | 4.1 | Valid |
| 18 | I can identify what type of IT support would solve it. I can adjust my computer/smartphone/tablet, such as can make the font larger to help the readability while reading on the screen of my tablets/computer/smartphone | 4.0 | Valid |
| 19 | I can select digital tools and technologies that can create well-defined knowledge and well-defined innovative processes and products related to health. | 4.2 | Valid |
| 20 | I can collaborate with my friend in some cognitive processing to understand and resolve well-defined and routine conceptual problems and problem situations in digital environments | 4.0 | Valid |
| 21 | (continued on next page) |      |       |
Table 2 (continued)

| NO | Statements DHLC ver.0 | Mean | Valid |
|----|------------------------|------|-------|
| 22 | I can evaluate whether new digital environments that I find while surfing are appropriate | 4.2 | Valid |
| 23 | Know what kind of health information can be found on the internet | 4.7 | Valid |
| 24 | I know where can find useful health information on the internet | 4.3 | Valid |
| 25 | I know how to find useful health information on the internet | 4.6 | Valid |
| 26 | I know how to use the internet to answer questions about health | 4.1 | Valid |
| 27 | I know how to use health information that had been found to help my daily task | 4.2 | Valid |
| 28 | I can evaluate health information found on the internet | 4.6 | Valid |
| 29 | I can differentiate between correct and incorrect health information found via the internet | 4.8 | Valid |

The experts reviewed the DHLC ver.0 and judged the importance of each question’s competencies through Linkert Scale responses ranging from strongly unimportant (score one) to strongly important (score 5). The cut of point that items questions could be accepted in the items of the questionnaire is using a mean cut of value 3.

Table 2 shows that question number 11: “I know how to add new dialogues and images onto a brief support video already created on the internet to illustrate the new video,” had a score mean 2.9, so this question was categorized as Not Valid and deleted in the following form questionnaire. The invalid question lies in the sub-main indicator of a digital content creator. This expert’s stage judgment generated DHLC ver.1 with 28 questions.

4.3. Pilot test

The pilot test stage has two steps; this study randomly distributed an online questionnaire to the community and got 30 responses in the first step; later, the questionnaire was distributed to 220 health information management vocational school students.

The DHLC ver.0 has 28 questions related to the activity in the digital environment with a range of response competencies: unable to do (0), very difficult to do and need guidance (1), difficult to do and need guidance (2), easy to do but still need guidance (3), easy without guidance (4), easy could help others (5), very easy if do not have guidance (2), easy to do but still need guidance (3), easy without mean of 20.27 problems (6), very easy can solve the problems (7).

The first pilot test involved 13.3% males and 86.7% females, with a mean of 20.27 ± 2.95. The second pilot test consists of 20.5% males and 79.5% females. The minimal age is 17 years old, maximal age is 42 years old (19.46 ± 2.58).

The validity and reliability testing results in the first pilot test resulted in the Cronbach Alpha being 0.926. Table 3 shows that two of 28 questions should be excluded because they are invalid (Item total correlation < 0.36). The questions are number 2: “I can identify how and where to organize and keep track of websites or information in my smartphone in order to retrieve them when I need them in daily use” and number 7: “I can choose and use the most appropriate digital tools in my smartphone or computer (e.g. Dropbox, Google Drive) to create a content with my friends such as a leaflet, a picture, and a blog on the event.”

In the second pilot test, all of the item’s questions were accepted in the form of the questionnaire; the Cronbach alpha is 0.94. In this stage, the activity resulted in DHLC ver.3.

4.4. Field test

In this field stage, DHLC v.3 was validated to 383 respondents by doing an offline survey in one urban village in Semarang City.

Table 3

| NO | Statements DHLC ver.1 | Pilot 1 | Pilot 2 |
|----|------------------------|--------|--------|
| 1  | I can identify list of generic keywords and tags available which would be useful for finding information related topic | 0.377 (valid) | 0.449 (valid) |
| 2  | I can identify how and where to organize and keep track of website or information in my smartphone in order to retrieve them when I need them in daily use | 0.34 (not valid) | Delete |
| 3  | I can use a commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) to talk to my friends in daily use | 0.428 (valid) | 0.483 (valid) |
| 4  | I can manage a group commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) such as create group, add or delete members | 0.600 (valid) | 0.549 (valid) |
| 5  | I can use a commonly-used chat on my smartphone and a cloud-based storage system (e.g. Dropbox, Google Drive) to share material (message, file, picture, link) with other members of my group | 0.435 (valid) | 0.571 (valid) |
| 6  | I can propose and use different media strategies (e.g. Survey on Facebook, Hashtags on Instagram and Twitter) to empower the citizens of my city to participate in defining the main topics of an event | 0.548 (valid) | 0.538 (valid) |
| 7  | I can choose and use the most appropriate digital tools in my smartphone or computer (e.g. Dropbox, Google Drive, wiki) to create content with my friends such as a leaflet, a picture, and a blog on the event | 0.273 (not valid) | Delete |
| 8  | I can manage and solve problems that arise while writing and communicating in digital environments, (e.g. inappropriate comments or Hoax in my social network). | 0.722 (valid) | 0.654 (valid) |
| 9  | I can manage a new social media that avoid actions that could harm my digital data reputation (e.g. spam) when using social media in internet | 0.614 (valid) | 0.612 (valid) |
| 10 | I can make video from a tutorial video on YouTube or Instagram, how to create a brief video on my tablet/mobile phone to present content such as video related health information or Hoax in my social network. | 0.420 (valid) | 0.647 (valid) |
| 11 | I can protect my social media (e.g. Twitter, Facebook, Instagram) account such as using different methods (e.g. a strong password, control the recent logins) | 0.677 (valid) | 0.564 (valid) |
| 12 | I can detect risks like receiving tweets and messages from others with false profiles or phishing attempts. | 0.609 (valid) | 0.554 (valid) |
| 13 | I can select the most appropriate way to protect my personal data and others (e.g. address, phone number) when sharing digital content (e.g. a picture) on the social media. | 0.641 (valid) | 0.632 (valid) |
| 14 | I can distinguish between appropriate and inappropriate digital content to share it on my social media, so that my privacy and that of my friends are not damaged. | 0.545 (valid) | 0.581 (valid) |
| 15 | I can create a digital health campaign using social media (e.g. Twitter, FB) which can that others shared share by use smartphones or tablets. | 0.593 (valid) | 0.598 (valid) |
| 16 | I can identify a simple technical problem from a list of those that can arise while using a digital device, and | 0.551 (valid) | 0.673 (valid) |
| 17 | I can make adjustment on my computer/smartphone/tablet such as can make the font larger to help the readability while | 0.557 (valid) | 0.617 (valid) |

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years old, Mean education. The ranged age of respondents (Min = 13 years old, Max = 68 years old, Mean = 37.59 ± 12.69)

Table 4
The final DHLC questionnaire consists of indicators and item questions.

| No | Indicators                                                                 | Mean | SD  | r    | Cronbach alpha if items deleted |
|----|---------------------------------------------------------------------------|------|-----|------|---------------------------------|
| A  | DIGITAL COMPETENCIES                                                      |      |     |      |                                 |
| 1. | Information and data literacy                                            |      |     |      |                                 |
| 1.1| Browsing, searching and filtering data, information and digital content   |      |     |      |                                 |
| 2   | I can identify list of generic keywords and tags available that would be useful for finding information related topic | 3.30 | 2.093 | 0.705 | 0.970                          |
| 2.  | Communication and collaboration                                          |      |     |      |                                 |
| 2.1 | Interacting through digital technologies                                 |      |     |      |                                 |
| 2   | I can use a commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) to talk to my friends in daily use | 4.27 | 1.864 | 0.745 | 0.970                          |
| 2.2 | Sharing through digital technologies                                     |      |     |      |                                 |
| 4   | I can use a commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) such as create group, add or delete members | 4.14 | 1.861 | 0.803 | 0.970                          |
| 2.3 | Engaging in citizenship through digital technologies                      |      |     |      |                                 |
| 5   | I can propose and use different media strategies (e.g. Survey on FaceBook, Hashtags on Instagram and Twitter) to empower the citizens of my city to participate in defining the main topics of an event | 3.46 | 2.007 | 0.794 | 0.970                          |
| 2.5 | Netiquette                                                                |      |     |      |                                 |
| 6   | I can manage and solve problems that arise while writing and communicating in digital environments, (e.g. inappropriate comments or hoax in my social network) | 3.53 | 2.013 | 0.832 | 0.970                          |
| 2.6 | Managing digital identity                                                |      |     |      |                                 |
| 7   | I can manage a new social media that avoids actions which could harm my digital data reputation (e.g. spam) when using social media in internet | 3.48 | 1.941 | 0.820 | 0.970                          |
| 3   | Digital content creation                                                 |      |     |      |                                 |
| 3.2 | Integrating and re-elaborating digital content                            |      |     |      |                                 |
| 8   | I can make video from a tutorial video on YouTube or Instagram, how to create a brief video on my tablet/mobile phone to present content video such as video related health. | 2.99 | 1.994 | 0.771 | 0.970                          |
| 4   | Safety                                                                    |      |     |      |                                 |
| 4.1 | Protecting devices                                                       |      |     |      |                                 |
| 9   | I can protect my social media (e.g. Twitter, Facebook, Instagram) account such as | 3.13 | 2.093 | 0.815 | 0.970                          |

Table 3 (continued)

| NO | Statements DHLC v.1 | Pilot 1 | Pilot 2 | Pilot 2 v.3 |
|----|---------------------|---------|---------|-------------|
| 18 | I can select digital tools and technologies that can create well-defined knowledge and well-defined innovative processes and products related to health. | 0.524 | 0.662 | 0.662 |
| 19 | I can collaborate with my friend in some cognitive processing to understand and resolve well-defined and routine conceptual problems and problem situations in digital environments. | 0.572 | 0.621 | 0.621 |
| 20 | I can evaluate whether new digital environments that I find while surfing are appropriate | 0.553 | 0.66 | 0.66 |
| 21 | I know what kind of health information can be found on the internet. | 0.597 | 0.449 | 0.449 |
| 22 | I know where can find useful health information on the internet. | 0.634 | 0.65 | 0.65 |
| 23 | I know that the internet can be used as a health information resources. | 0.613 | 0.483 | 0.483 |
| 24 | I know how to find useful health information on the internet. | 0.767 | 0.679 | 0.679 |
| 25 | I know how to use the internet to answer questions about health. | 0.796 | 0.549 | 0.549 |
| 26 | I know how to use health information that had been found to help my daily task. | 0.678 | 0.738 | 0.738 |
| 27 | I can evaluate health information found on the internet. | 0.502 | 0.571 | 0.571 |
| 28 | I can differentiate between correct and incorrect health information found via the internet. | 0.551 | 0.67 | 0.67 |

Table 5
The final DHLC questionnaire consists of indicators and item questions.

| No | Indicators                                                                 | Mean | SD  | r    | Cronbach alpha if items deleted |
|----|---------------------------------------------------------------------------|------|-----|------|---------------------------------|
| A  | DIGITAL COMPETENCIES                                                      |      |     |      |                                 |
| 1. | Information and data literacy                                            |      |     |      |                                 |
| 1.1| Browsing, searching and filtering data, information and digital content   |      |     |      |                                 |
| 1   | I can identify list of generic keywords and tags available that would be useful for finding information related topic | 3.30 | 2.093 | 0.705 | 0.970                          |
| 2.  | Communication and collaboration                                          |      |     |      |                                 |
| 2.1 | Interacting through digital technologies                                 |      |     |      |                                 |
| 2   | I can use a commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) to talk to my friends in daily use | 4.27 | 1.864 | 0.745 | 0.970                          |
| 2.2 | Sharing through digital technologies                                     |      |     |      |                                 |
| 4   | I can use a commonly-used chat on my smartphone (e.g. Facebook messenger or WhatsApp, Line, Telegram) such as create group, add or delete members | 4.14 | 1.861 | 0.803 | 0.970                          |
| 2.3 | Engaging in citizenship through digital technologies                      |      |     |      |                                 |
| 5   | I can propose and use different media strategies (e.g. Survey on FaceBook, Hashtags on Instagram and Twitter) to empower the citizens of my city to participate in defining the main topics of an event | 3.46 | 2.007 | 0.794 | 0.970                          |
| 2.5 | Netiquette                                                                |      |     |      |                                 |
| 6   | I can manage and solve problems that arise while writing and communicating in digital environments, (e.g. inappropriate comments or hoax in my social network). | 3.53 | 2.013 | 0.832 | 0.970                          |
| 2.6 | Managing digital identity                                                |      |     |      |                                 |
| 7   | I can manage a new social media that avoids actions which could harm my digital data reputation (e.g. spam) when using social media in internet | 3.48 | 1.941 | 0.820 | 0.970                          |
| 3.  | Digital content creation                                                 |      |     |      |                                 |
| 3.2 | Integrating and re-elaborating digital content                            |      |     |      |                                 |
| 8   | I can make video from a tutorial video on YouTube or Instagram, how to create a brief video on my tablet/mobile phone to present content video such as video related health. | 2.99 | 1.994 | 0.771 | 0.970                          |
| 4.  | Safety                                                                    |      |     |      |                                 |
| 4.1 | Protecting devices                                                       |      |     |      |                                 |
| 9   | I can protect my social media (e.g. Twitter, Facebook, Instagram) account such as | 3.13 | 2.093 | 0.815 | 0.970                          |

respondents were distributed in 16 hamlets (Rukun Warga).

Table 4 shows that most respondents (57.2%) are female and graduated from Senior High School (62.9%), and only 13.4% ever get higher education. The ranged age of respondents (Min = 13 years old, Max = 68 years old, Mean = 37.59 ± 12.69)

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Table 5 (continued)

| No | Indicators                                                                 | Mean | SD    | r     | Cronbach alpha if items deleted |
|----|-----------------------------------------------------------------------------|------|-------|-------|---------------------------------|
| 10 | I can detect risks like receiving tweets and messages from others with false profiles or phishing attempts | 2.65 | 2.054 | 0.748 | 0.970                           |
| 11 | I can select the most appropriate way to protect my personal data and others (e.g. address, phone number) when sharing digital content (e.g. a picture) on the social media. | 3.25 | 2.018 | 0.822 | 0.970                           |
| 12 | I can distinguish between appropriate and inappropriate digital content to share it on my social media, so that my privacy and that of my friends are not damaged. | 3.69 | 1.997 | 0.822 | 0.970                           |
| 13 | I can create a digital health campaign using social media (e.g. Twitter, FB) which can be shared and used by others on their smartphones or tablets. | 2.92 | 1.942 | 0.765 | 0.970                           |

Table 6

| No | Indicators                                                                 | Mean | SD    | r     | Cronbach alpha if items deleted |
|----|-----------------------------------------------------------------------------|------|-------|-------|---------------------------------|
| 21 | I know that the internet can be used as a health information resource        | 4.04 | 1.902 | 0.793 | 0.970                           |
| 22 | I know how to find useful health information on the internet                | 3.93 | 1.869 | 0.813 | 0.970                           |
| 23 | I know how to use the internet to answer questions about health             | 3.72 | 1.926 | 0.826 | 0.970                           |
| 24 | I know how to use health information that had been found to help my daily task | 3.70 | 1.925 | 0.827 | 0.970                           |
| 25 | I can evaluate health information found on the internet                      | 3.60 | 1.888 | 0.808 | 0.970                           |
| 26 | I can differentiate between correct and incorrect health information        | 3.52 | 1.878 | 0.797 | 0.970                           |

Table 4 shows that almost the respondents (96.6%) have mobile phones, most of which are Android phones (88.8%), even though 27.2% still do not use the internet on mobile phones.

In the field test, the validity and reliability testing results indicated that all questions were valid and had a Cronbach’s alpha coefficient of 0.970. DHLC ver.3 has range response competencies to do the activity in the digital environment starting from being unable to do (0) until very easy to do the activity and can solve the problems (7).

Table 5 shows that most activities have a score mean < 4 (easy doing the activity without guidance). The score indicates that most of the respondents are unable to do activities in the digital environment independently. The lowest score is the competence-related safety-protecting device (“I can detect risks like receiving tweets and messages from others using different methods (e.g. a strong password, control the recent logins) and try to create secure passwords.”) with a mean of 2.65 and Cronbach’s alpha of 0.970.
with false profiles or phishing attempts”). In contrast, the highest score (4.27) was competence-related communication and collaboration-interacting through digital technologies.

Table 6 shows that the final DHLC questionnaire has 9 main indicators and 18 indicators with 26 questions. The competencies that are lower than score point 3 (easy doing the activity but still need guidance): solving technical problems, protecting health and well-being, identifying digital competencies gap, and integrating and re-creating digital content. The field test stage reveals the competencies with a score > 4 (easy doing the activity without guidance): health information management, interacting through digital technologies, and sharing through digital technologies.

5. Discussion

Indonesia has poor digital literacy skills (52 of 62 countries globally) despite the penetration rate of 71.1% for internet users. It appears that Indonesia has a clear disadvantage in using digital technology, and it is easy to impact digital technology through misinformation and Hoax negatively. Recently, Indonesia has experienced facing infodemic during the election and COVID-19 diseases. [19, 21, 30]

Lifestyle has been changed. Recently, social media and influencers have made a great impact on people’s decisions in health. Unfortunately, the information spread through them is sometimes inaccurate. Bias information makes the pandemic change to infodemic. [31] The effect of the Covid-19 infodemic in Indonesia is sometimes worse than the disease itself. [32] Collaboration between the community, social media platforms, and the government is required to improve digital literacy. [33]

In Indonesia, there are over 1800 types of misinformation and disinformation, including conspiracy theories, vaccines, et.al. [34] The previous study found that 30–60% of people had even been exposed to hoaxes. [30] Social media makes a massive spread of online health information, and inadequate digital health literacy among citizens is the perfect combinations to accelerate the infodemic of Covid-19.

This study developed a tool to measure digital health literacy competencies. The competencies in the digital environment allow people to use digital technologies to access, manage, understand, integrate, communicate, evaluate, and create health information through digital technologies. The recent digital health literacy: eHeals (eHealth literacy scale) measures digital health literacy skills but does not measure interactive skills on the internet. In contrast, DHLI (digital health literacy instrument) did not measure mobile health literacy skills. [24] This DHLC (Digital health Literacy Competencies for Citizens) measures digital competencies, including mobile devices and health information literacy.

DHLC was developed based on DigComp 2.1, the digital framework competencies for European citizens, and health information literacy. The DigComp 2.1 framework has eight proficiency levels and five competencies areas. [28] DHLC adopted the five competencies areas into 18 questions and put eight questions related to health literacy; the total number of items for DHLC is 26. The DHLC can be accessed at https://sicerdk.dinus.ac.id/kategori-dhlc/. [35]

This study reveals that all digital competency scores are below 4. Consistently, the Indonesian digital literacy index was only 3.47 of 5. Low digital literacy reinforces the infodemic. [19, 20] Score of 4 in DHLC indicates that the community still needs guidance to engage in digital activities. The lowest competency area is digital content creation, in this case, health-related content, followed by the safety competency area.

6. Conclusion

This study developed DHLC to measure digital health literacy for the citizen, filling the gap of the previous tool in digital health literacy. DHLC has been proven valid and reliable in measuring digital health literacy. This study reveals that digital health literacy in citizens needs to be improved. Elevating digital health literacy among citizens is urgent to control the spreading misinformation and disinformation that could worsen the pandemic. Future studies need to conduct to test the validity and reliability of DHLC in various setting.

Ethics approval and consent to participate

“This study have been reviewed and approved by Review Committee of Commission on Health Research Ethics, Semarang State University by Chairman Committee Prof. Dr. dr. Oktia Woro K.H. M.Kes with Certificate Number No. 172/KEPK/EC/2020”.

Availability of data and material

The data will be provided in the Health Data Respiratory of Faculty of Health Science Universitas Dian Nuswantoro (https://sehariku.dinus.ac.id).

Authors’ contribution

ER and H have been responsible for the manuscript; ER, ETR, H have been responsible for observing, analyzing the data.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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References

[1] I. Ayouni, et al., Effective public health measures to mitigate the spread of COVID-19: a systematic review, BMC Public Health 21 (1) (2021) 1–14.
[2] M.E. Gladdien, Who will be the members of Society 5.0? Towards an anthropology of technologically posthumanized future societies, Soc. Sci. 8 (5) (2019) 148.
[3] Rabeuh Morrar, a.Husam Arman, S. Mousa, The fourth industrial revolution (Industry 4.0): a social innovation perspective, Technol. Innovation Manag. Rev. 7 (11) (2017).
[4] V.V. Martynov, D.N. Shavaleeva, A.A. Zaytseva, Information technology as the basis for transformation into a digital society and industry 5.0, in: 2019 International Conference ‘Quality Management, Transport and Information Security, Information Technologies’(IT&QM&IS), IEEE, 2019.
[5] D. Novillo-Ortiz, H. De Fatima Marín, F. Saigi-Rubio, The role of digital health in supporting the achievement of the sustainable development goals (SDGs), Int. J. Med. Inform. 114 (2018) 106–107.
[6] M. Benigeri, P. Playa, Shortcomings of health information information on the Internet, Health Promot. Int. 18 (4) (2003) 381–386.
[7] WHO. WHO coronavirus (Covid-19) dashboard. 2021 [cited 2021 August, 6]; Global Situation. Available from: https://covid19.who.int/.
[8] Nicosmedes, C.J.C. and R.M.A.J.l.o.a.d. Avila, An analysis on the panic during COVID-19 pandemic through an online form. 2020. 276: p. 14–22.
[9] Sakib, N., et al., Fear of COVID-19 and depression: a comparative study among the general population and healthcare professionals during COVID-19 pandemic crisis in Bangladesh. 2021: p. 1–17.
[10] L. Bode, E.K. Vrags, See something, say something: correction of global health misinformation on social media, Health Commun. 33 (9) (2018) 1131–1140.
[11] G. Eysenbach, How to fight an infodemic: the four pillars of infodemic management, J. Med. Internet Res. 22 (6) (2020) e21820.
[12] W.H. Organization, Understanding the Infodemic And Disinformation In The Fight Against Covid-19 Department Of Evidence And Intelligence for Action In Health, WHO; Geneva, 2020, p. 5.
[13] T. Abel, D. McQueen, Critical health literacy and the COVID-19 crisis, Health Promot. Int. (2020).
[14] Nguyen, A., D.J.M. Catalan, and communication, Digital mis/disinformation and public engagement with health and science controversies: fresh perspectives from Covid-19. 2020. 8(2): p. 323–328.
[15] H. Kim, B. Xie, Health literacy in the eHealth era: a systematic review of the literature, Patient Educ. Couns. 100 (6) (2017) 1073–1082.

[16] A.M. Huhta, N. Hirvonen, M.L. Huotari, Health literacy in web-based health information environments: systematic review of concepts, definitions, and operationalization for measurement, J. Med. Internet Res. 20 (12) (2018) e10273.

[17] X. Chen, et al., Health literacy and use and trust in health information, J. Health Commun. 23 (8) (2018) 724–734.

[18] P. Dunn, E. Hazzard, Technology approaches to digital health literacy, Int. J. Cardiol. 293 (2019) 294–296.

[19] I. Nadzir, S. Setiawan, Y.S. Permana, Hoax and misinformation in Indonesia: insights from a nationwide survey, Perspective 92 (2019) 1–12.

[20] M.E. Sunilo, S. Afifi, S. Yustitia, Hoax as a reflection on the low digital literacy in Indonesia, Revolution 4 (2020) 165–174.

[21] M. Angeline, Y. Safitri, A. Luthfiya, Can the damage be undone? Analyzing misinformation during COVID-19 outbreak in Indonesia, in: 2020 International Conference on Information Management and Technology (ICIMTech), IEEE, 2020.

[22] S. Yustitia, P.D. Asharianto, Misinformation and disinformation of COVID-19 on social media in Indonesia, in: Proceeding of LPIM UPN ‘VETERAN’ Yogyakarta conference series 2020-political and social science series, 2020.

[23] E. Rachmani, et al., Development and validation of an instrument for measuring competencies on public health informatics of primary health care worker (PHICAPHC) in Indonesia, Prim. Health Care Res. Dev. 21 (2020) e22.

[24] R. van der Vaart, C. Drossaert, Development of the digital health literacy instrument: measuring a broad spectrum of health 1.0 and health 2.0 skills, J. Med. Internet Res. 19 (1) (2017) e27.

[25] A. Martin, J. Grudziecki, DigEuLit: concepts and tools for digital literacy development, Innovation in Teaching and Learn. Inf. Comput. Sci. 5 (4) (2015) 249–267.

[26] K. Sorensen, et al., Health Literacy and Public health: a Systematic Review and Integration of Definitions and Models, 12, BMC Public Health, 2012, p. 80.

[27] C.D. Norman, H.A. Skinner, eHealth Literacy, Essential skills for consumer health in a networked world, J. Med. Internet Res. 8 (2) (2006) e9.

[28] S. Carretero, R. Vuroikari, DigComp 2.1. The Digital Competence Framework For Citizens. With eight Proficiency Levels Examples of Use, Publications Office of the European Union, 2017.

[29] C.D. Norman, H.A. Skinner, eHEALS: the eHealth literacy scale, J. Med. Internet Res. 8 (4) (2006) e27.

[30] Indonesia, M.o.C.a.L.o., Indonesia Digital Literacy Status. 2020: Jakarta.

[31] R.P. Prabawangi, M.N. Faranti, From pandemic to infodemic: bias information of covid-19 and ethic al consideration among Indonesian you tuber, in: Development, Social Change and Environmental Sustainability: Proceedings of the International Conference on Contemporary Sociology and Educational Transformation (ICCSSET 2020), Malang, Indonesia, Routledge, 2020, 23 September 2021.

[32] H.I Wahyuni, K. Ambardi, Problem Infodemic Dalam Merespon Pandemi Covid-19, Universitas Gadjah Mada, 2020.

[33] Sari, K.A.K., COVID-19 Infodemic: underlining the importance of digital literacy skills. 2021.

[34] Rizkinaswara, L. Kominfo Turunkan 1.897 Konten Hoaks Seputar Vaksin Covid-19. 2021 [cited 2021 August, 4]; Available from: https://aptika.kominfo.go.id/2021/08/kominfo-turunkan-1-897-konten-hoaks-seputar-vaksin-covid-19/.

[35] Rachmani, E., et al. Si Cerdik (Information system how to evaluate the digital range of health information literacy). 2022 [cited 2022; Available from: https://sicerdik.dinus.ac.id/kategori-dhlc/.