

# Development of Hand Hygiene Monitoring System Based on Android Mobile Application and User Perspective

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## INDEXING

### Keywords:

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Mobile Application;  
Android;  
User's Perspective

## ABSTRACT

Hand hygiene plays a crucial role in promoting overall health and preventing the spread of diseases. The World Health Organization reported that the prevalence of healthcare-associated infections (HAIs) ranges from 3-12% in high-income countries and 5-19% in low-and middle-income countries. Improved hand hygiene compliance can substantially reduce HAI rates. In Indonesia, the Ministry of Health has designated handwashing compliance as a compulsory quality indicator for hospitals. Introducing a mobile app can improve hand hygiene practices. This study aims to develop and design an Android mobile application that serves as an easy-to-operate hand hygiene monitoring system and to understand user perspectives. The study used Agile Methods for app development and a qualitative approach to know users' perspectives. Respondents (n=10) from AMC Muhammadiyah Hospital, including the IPC team, department heads, and administrators, were interviewed. The result revealed that mobile application is easy to use and have an attractive user interface. Users expressed the application's user-friendliness and utility in conducting observations. Nonetheless, they identified some drawbacks, such as lagging issues and a complicated manual installation process due to the app's unavailability on Playstore. Users expect the app's future inclusion on Play Store for simplified installation and request its development for iOS to cater to hospital staff using iPhones.

### Kata kunci:

Pemantau  
Kebersihan Tangan;  
Aplikasi Seluler;  
Android;  
Perspektif pengguna

Kebersihan tangan memainkan peran penting dalam meningkatkan kesehatan secara keseluruhan dan mencegah penyebaran penyakit. WHO melaporkan bahwa prevalensi infeksi terkait perawatan kesehatan (HAIs) berkisar antara 3-12% di negara berpendapatan tinggi dan 5-19% di negara berpendapatan rendah dan menengah. Kepatuhan kebersihan tangan yang lebih baik dapat secara signifikan mengurangi tingkat HAI. Di Indonesia, kementerian kesehatan telah menetapkan kepatuhan mencuci tangan sebagai indikator kualitas wajib untuk rumah sakit. Pengenalan aplikasi seluler dapat meningkatkan praktik kebersihan tangan. Tujuan studi ini adalah untuk mengembangkan dan merancang aplikasi seluler Android yang berfungsi sebagai sistem pemantauan kebersihan tangan yang mudah dioperasikan dan untuk memahami perspektif pengguna. Studi ini menggunakan Metode Agile untuk pengembangan aplikasi dan pendekatan kualitatif untuk mengetahui perspektif pengguna. Responden (n=10) dari staf rumah sakit AMC Muhammadiyah, termasuk tim PPI, kepala departemen, dan administrator, diwawancarai. Hasilnya adalah aplikasi seluler yang mudah digunakan, dengan antarmuka pengguna yang menarik. Pengguna menyatakan aplikasi ini ramah pengguna dan berguna dalam melakukan pengamatan. Namun, mereka mengidentifikasi beberapa kekurangan, seperti masalah lag dan proses instalasi manual yang rumit karena ketidaktersediaan aplikasi di Playstore. Pengguna mengharapkan aplikasi ini akan dimasukkan ke Playstore untuk memudahkan instalasi dan meminta pengembangannya untuk iOS agar dapat melayani staf rumah sakit yang menggunakan iPhone.

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## INTRODUCTION

Hand hygiene is a crucial aspect of maintaining good health and preventing the spread of disease. With the ongoing threat of infectious diseases, it is more important than ever to understand the importance of hand washing and the most effective methods for cleaning



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your hands (WHO, 2022). Based on the WHO, there are two recommended techniques in hand hygiene: washing hands using soap and rubbing hands using alcohol (WHO, 2009). World Health Organization estimates that the prevalence of HAIs at any moment is between 3 and 12% in high-income countries and between 5 and 19% in low- and middle-income countries. Nevertheless, given the underreporting of HAIs from many countries, this estimation may only represent a tiny percentage of the real prevalence (Lotfinejad *et al.*, 2021).

Hand hygiene compliance among nurses in the United States is quite good (Sands and Aunger, 2020). Hand hygiene compliance is still relatively low in low-income countries such as Vietnam. Studies showed that the compliance rate of doctors is only 14.6%, while that of nurses is 38.8% (Le *et al.*, 2019). It proves significant differences between high-income and low-income countries. Several factors can affect hand hygiene compliance, including the level of knowledge, attitude, behavior, and motivation (Hastuti, Fadilla, and Apriansyah, 2021). A study conducted in a hospital in Indonesia revealed that training on the importance of hand hygiene increased the hand hygiene compliance rate among hospital staff (Santosaningsih *et al.*, 2017).

Increasing hand hygiene compliance reduces healthcare-associated infections. Research from 2013 to 2018 showed the number of hand hygiene compliance from 76.4% to 88.5% and the incidence rate of health-care-associated infections initially in 2012 to 1831 cases (Ojanperä, Kanste and Syrjala, 2020). In Indonesia, handwashing compliance is one of the mandatory quality indicators that all hospitals must meet. These indicators have been set together with 13 other quality indicators by the Ministry of Health (Kemenkes RI, 2022).

The development of a mobile application can certainly help and have a positive impact, one of which is the relationship between patients and healthcare providers (Qudah and Luetsch, 2019). Mobile applications also help healthcare providers monitor patients diagnosed with dementia and Alzheimer's (Yousaf *et al.*, 2020). So far, the hospital has been observing hand hygiene compliance using an old-fashioned method. They visually inspect and manually record the data using paper. Currently, digital monitoring of hand hygiene compliance is highly necessary because the old method is too cumbersome, and there is a risk of losing or damaging the observation forms that are on paper. In addition, convenience is a reason, as everyone has a smartphone and can bring it anywhere and anytime. Developing a mobile application to monitor hand hygiene compliance is possible, as the healthcare 4.0 era forces us to compete in information and digital technology.

This study aims to develop and design an Android mobile application as a hand hygiene monitoring system that is easy to operate and to know the user's perspective.

## RESEARCH METHOD

A hand hygiene compliance mobile application was developed using the agile method and the user perspective through a qualitative approach.

The first step in developing an Android mobile application using Agile was to define the requirements. The researchers searched for an Android application to monitor hand hygiene compliance in the Play Store and found three of the most downloaded applications. These applications include SpeedyAudit Hand Hygiene Audit, HAT Hygiene Audit Tool, and SureWash Hand Hygiene.

**Table 1. Hand hygiene application most downloaded on Play Store**

Name	Developer	Downloaded
SpeedyAudit Hand Hygiene Audit	HandyMetrics Corp	10.000++
HAT Hygiene Audit Tool	B.Braun Melsungan AG	1.000++
SureWash Hand Hygiene	SureWash Developer	1.000++

*Source:* by researcher

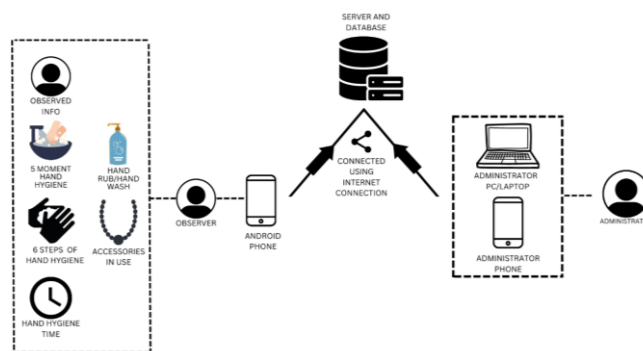
In this process, the three applications were tested for one week, and observed each application's user interface, ease of operation, and features. Based on the observation, the applications are not yet available in Indonesia. The three applications also have features that confuse and complicate users and unattractive user interfaces. So, creating a mobile application in Indonesian with an attractive and user-friendly user interface was decided.

The next step was to plan the sprints. The researchers divided the sprint into several tasks. The first task was designing the general architecture, user interface, feature menu, server, hosting, and admin login page. The user interface is a critical aspect of an Android mobile application. It is the first aspect that users will interact with, so it must be designed to be intuitive and easy to use. The researchers developed the application based on the sprints planned in the previous stage using Flutter. This process took one week until it resulted in a mobile application design. At the end of each sprint, the development team reviews the progress and identifies improvement areas. Any issues that arose during the sprint and developing a plan to address them in the next sprint would be discussed. After four weeks of development, the mobile application was internally tested and was stable. It can be a beta version and ready for trial.

From the user's perspective, the researchers used a qualitative approach while interviewing ten respondents (N=10) to test the mobile application for hand hygiene compliance and recorded it. The respondents were hospital staff, the Prevention and Infection Control team, department heads, and hospital administrators. The trial lasted for four days and took place at the AMC Muhammadiyah Hospital, one of the private hospitals that still observe hand hygiene compliance using the old method of using paper and manually recording.

## RESULTS AND DISCUSSION

### General Architecture



**Picture 1.** The general architecture of a mobile application

*Source:* by researcher

The general architecture of this mobile application is presented in Picture 1. The system is divided into two units: an observer unit and an administrator unit. The main components of the observer unit are observed info, five moments of hand hygiene, six steps of hand hygiene, hand hygiene time, hand rub/hand wash, accessories in use, and mobile phone installed in the mobile application. Observed info contains data about the user to be monitored, including name, registration number, and room. Five Moments of Hand Hygiene contains details of which moments are performed by observing every hand hygiene session. The six steps of hand hygiene contain how to do hand hygiene, whether it is following the standards set by WHO. Hand hygiene time contains data on how long hand hygiene is observed. Hand rub/hand wash provides information about what liquid is used in hand hygiene. Accessories provide information about the accessories used during the ongoing hand hygiene process. The observer will record all that data using a mobile application installed on the device.

After the data is recorded, the mobile application will send data to the web server, which will be stored in the database with an internet connection. After the data is successfully transmitted to the database server, the administrator unit can access the data using a computer or mobile device connected to the internet through the admin page. The administrator will download the data, which will be processed and analyzed for the hospital used.

### **Mobile Application**

The hand hygiene monitoring app is easy to use and operate by sending observer data from a mobile phone to the database system so that the data is stored, and at any time, the administrator unit can download and analyze the data. This mobile application is designed and developed considering several aspects, including making it easier to observe hand hygiene compliance, paperless, easy access anytime and anywhere, and a user-friendly interface. This app can only be installed on mobile devices on the Android smartphones.

#### **A. User Requirement**

This mobile application has been designed following an extensive literature review and observation from another mobile application. The researchers adapted some features and modified such as language and pictures. This app runs on all Android versions. Most importantly, this mobile app must be connected to the internet.

#### **B. Architecture**

The three-tier architecture, which organizes application components into three independent tiers, was used to create the mobile application. The data transfer between the mobile phone and the Administrator unit's database is handled through a web service. PHP code adheres to the Simple Object Access Protocol (SOAP) standard for data communication. There is no direct communication between the Administrator unit and the Observer unit. Using MySQL, data have been sent, kept in databases, and improved overall security.

#### **C. User Interface**

Users must first register using the registration menu at the beginning of the mobile application display. After being registered, the user must first log in to use the features in this mobile application.



**Picture 2.** Register page and login page

*Source:* Hand hygiene app by researcher

After logging in, a main menu containing some of the features available in this mobile application will be displayed. A "mulai" or start menu is used to start a session in observation. "Panduan cuci tangan," or washing hand guidelines, contains procedures for doing hand hygiene per applicable WHO standards. Menu "info" contains developer and affiliate information. Menu "riwayat" displays a history of observations that the observer has made.

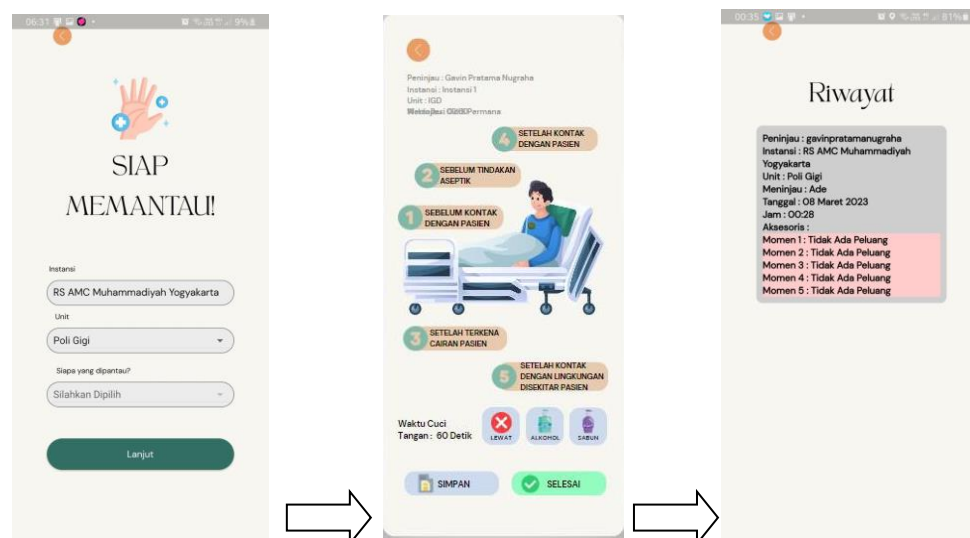


**Picture 3.** The mobile app menu

*Source:* Hand hygiene app by researcher

To start an observation, click "mulai" or start first, and then you will be taken to the next page to enter details about who you want to observe. Select the name and unit that will be observed. After that, there will be the core page of hand hygiene compliance observation. There, it contains the hand hygiene moments that will be performed, and you can select according to what you want to record and choose whether to use soap or alcohol. To end an

observation momentarily, click "simpan" or save; to end the observation session, click "selesai" or finish. After that, you will be taken to the history page, where you can see the observation process that you have done.



**Picture 4.** Start the observation

*Source:* Hand hygiene app by researcher

#### D. Mobile Application Development Tools

The development tools for this mobile application are Flutter, PHP Programming, and MySQL database, and the admin page is used as the backend uses the web hosting server.

#### User's Perspective on Hand Hygiene Compliance Mobile Application

In this study, significant codes were discovered and then categorized into four main themes: 1) user-friendly, 2) make observation easier, 3) drawbacks of the mobile application, and 4) User's expectation from the application.

##### User's Friendly

A user-friendly interface supports the ease of this mobile application. The following is a quote from the respondents:

"...its user interface is easy to understand too." (trial user)

"...It's also easy to use, very user-friendly." (trial user)

"The software is simple, not confusing, its use is also easy." (trial user)

Some people mentioned that the design of the application is very attractive. The following is an excerpt from the informants' statements:

"The design is also good, simple, attractive. Its use is also very easy." (trial user)

*"...the design is good and attractive." (trial user)*

This app is very simple and effective. The following is an excerpt from the informants' statements:

*"The advantage of this mobile application is simple and effective." (trial user)*

*"...It's also simple and easy to use." (trial user)*

### **Make Observation Easier**

This app makes observing hand hygiene compliance easier to do. The following is a quote from the respondents.

*"Previously, I was confused about how to take notes, and it was quite troublesome. But with this application, it's easy. After making an assessment, it will appear in the history." (trial user)*

*"It's helpful because we don't need to use a stopwatch anymore to conduct observations. The history is already recorded, so it's easy for us to check whom we have observed." (trial user)*

This mobile app also makes hand hygiene compliance observations up-to-date method. The following is an excerpt from the informants' statements:

*"Before, we could only see whether they had washed their hands or not, but it wasn't detailed. And now it's not complicated. We just need to take out our phones." (trial user)*

*"That's right, with this application, it's not complicated at all. We just need to open the app, and since we usually carry our phones with us wherever we go, it's easy to use anytime." (trial user)*

*"Yes, it's very different now. With this application, we can input the data directly, and the result comes out as data. It's not complicated like before, where we had to collect the data, input it, and process it again in Excel." (trial user)*

This mobile app makes hand hygiene observations paperless. The following is an excerpt from the informants' statements:

*".... and we don't need to use paper anymore, so it saves paper." (trial user)*

*"Before, it was troublesome to use paper, but now it's easier, just a few clicks. Usually, we would check off using paper or forms from infection prevention and control team." (trial user)*

*"In my opinion, it's more practical because it's paperless, not wasting paper." (trial user)*

*"Yes, it also increases the efficiency of paper usage and helps reduce paper waste in hospitals." (trial user)*

The app can also reduce the risk of data loss and damage. The following is an excerpt from the informants' statements:

*"...using paper can be messy, and there is a risk of losing the form. If we use this application, the risk of losing data is much smaller." (trial user)*

*"That's right, we won't have to worry about misplacing or losing paper records anymore." (trial user)*



*"Also, paper records can be easily lost or damaged" (trial user)*

*"Usually, when using paper, there is a high risk of losing or damaging it. Using this application is easier and safer." (trial user)*

Recording hand hygiene compliance in hospitals has become more flexible. The following is an excerpt from the informants' statements:

*"...and it can be done anytime without having to prepare paper." (trial user)*

*"...data input process is also convenient, and the timing is flexible too."*

*"...we are more likely to conduct observations, as we tend to carry our phones with us everywhere we go." (trial user)*

This app also displays details about hand hygiene compliance moments. The following is an excerpt from the informants' statements:

*"The advantage is that it already includes the hand hygiene steps, moments, and the duration of hand hygiene." (trial user)*

*"Yes, that's correct. The application is designed to include the five hand hygiene moments and provide guidance on proper hand hygiene techniques during each moment." (trial user)*

*"Yes, there are guidelines for each hand hygiene moment included in the application." (trial user)*

The hand hygiene compliance observation can be accessed directly anytime. The following is an excerpt from the informants' statements:

*"The history is already recorded, so it's easy for us to check who we have observed." (trial user)*

*"It's faster to determine the quality indicators and see the results directly." (trial user)*

*"Yes, the results are already available in the application for us to view." (trial user)*

### **Drawbacks of mobile application**

There is a slight difficulty when starting to install the mobile application. The following is a quote from the respondents:

*"The installation process of this application can be a bit difficult." (trial user)*

*"...so it's difficult to download and install. It needs to be done manually." (trial user)*

This mobile application is still not officially available on the Play Store. The following is an excerpt from the informants' statements:

*"The drawback is that the installation process can be complicated because the application is not available on the Play Store." (trial user)*

*"The application is not available on the Play Store, so it can be difficult to download and install." (trial user)*

*"The installation process of this application can be a bit difficult because it's not available on the Play Store." (trial user)*



There is a lag when running the application. The following is an excerpt from the informants' statements:

*"It may experience some lagging on my phone, but I'm not sure if it's because of the phone or the application." (trial user)*

*"Sometimes, the loading time can be quite long." (trial user)*

### User's Expectations from Mobile App

Some users suggest that this application be uploaded to the Play Store as soon as possible. The following is an excerpt from the informants' statements:

*"Uploading the application to the Play Store would make it easier to download and install." (trial user)*

*"...goes for uploading the application to the Play Store." (trial user)*

*"Uploading it to the Play Store would make it easier to access and use the application." (trial user)*

*"Please consider uploading the application to the Play Store as soon as possible to make the download process easier." (trial user)*

*"Please also consider uploading it to the Play Store as soon as possible." (trial user)*

Users also hope that this application will be available not only on Android but also on iOS. The following is an excerpt from the informants' statements:

*"If possible, please release an iOS version as well because we don't know what type of phone the users have." (trial user)*

*"It would be great if there could be an iOS version of the application." (trial user)*

**Table 2. Essential coding, category, and themes**

No.	Coding	Category	Theme
1	Simple user interface	User interface	User Friendly
2	Easy to use		
3	Attractive design		
4	Not using the old method anymore	Updated	Make observation easier
5	Not using paper		
6	No loss or damage to the form	Low risk	
7	Being able to observe anywhere and anytime	Convenience	
8	Showing hand hygiene moments in detail		
9	The observation results can be accessed immediately.		
10	The installation process is a bit complicated.	Installation	Drawbacks of mobile application
11	It is not available on the Play Store yet	Download	
12	Lagging when running the application	Running software	User's expectations from the application
13	Uploaded on Play Store	Ease of access	
14	Availability for iOS		

Table 2 shows how users have expressed that this application's interface is very simple, making it easy to use and comfortable. That aligns with the research (Portz *et al.*, 2019), showing that a simple user interface can make an application easy to use and understand. Additionally, colors and fonts can also have an impact on user experience. In this study, users expressed that this mobile application has an attractive design, making them interested in using it. An attractive design app can positively impact the user experience, making design an important factor in developing an application (Chaouali *et al.*, 2020). The user interface is typically evaluated first (Kaya, Ozturk, and Altin Gumussoy, 2019).

Users have high expectations for this app because it can revolutionize the traditional manual method of recording hand hygiene compliance observations on paper to a more innovative, paperless, and flexible approach. A study was conducted in a hospital that tested a hand hygiene monitoring system to replace the traditional manual observation method. The study revealed positive impacts on hospital staff compliance with hand hygiene after using the hand hygiene monitoring system (Iversen *et al.*, 2020). Additionally, this app offers fast, accurate, and easily accessible hand hygiene compliance observation that can be accessed anytime. This service helps conduct routine evaluations of hand hygiene compliance in hospitals. (Boyce *et al.*, 2019) mentioned that hand hygiene compliance should be evaluated regularly, as compliance with hand hygiene can impact healthcare-associated infections (HAIs).

Mobile app for hand hygiene monitoring system is relatively applicable even though some weaknesses are still found, such as challenges with data integration, accuracy, privacy and confidentiality, usability, expenses connected with them, and infrastructure upgrades (Wang *et al.*, 2021). (Knepper, Miller, and Young, 2020) stated that hand hygiene monitoring systems can increase hand hygiene compliance rates to over 70%. Apart from that, using a hand hygiene monitoring system increases the number of hand hygiene compliances in a hospital (Benudis *et al.*, 2019). Other studies also revealed that hand hygiene compliance increases drastically with a hand hygiene monitoring system, and infection due to treatment tends to decrease (Knudsen *et al.*, 2021). Although it is highly possible to implement it in AMC Muhammadiyah Hospital, other supporting factors must be prepared to increase hand hygiene compliance rates. According to (Edmisten *et al.*, 2017), several factors contribute to the success of a hand hygiene program in healthcare settings. These factors include a collaborative work environment, commitment from leadership, the use of data to guide improvement efforts, consistent and clear messaging, empowering staff to take ownership of hand hygiene practices, and involving patients in the process. When these elements are present, hand hygiene compliance rates tend to be higher, ultimately reducing healthcare-associated infections and improving patient outcomes.

This app's download and installation process is somewhat complicated. However, it is unavailable on the Play Store due to some issues related to the Google Wallet account when uploading there.

## CONCLUSION

Developing an Android mobile application for a hand hygiene monitoring system is possible. Agile methods is a flexible and collaborative process that emphasizes continuous improvement. By breaking down the development process into smaller tasks and planning

sprints, the development team can ensure that the application meets the target audience's requirements and provides a positive user experience.

The users expressed that the developed app was user-friendly and helpful in conducting observations. However, it also had its limitations, as some users still experienced lag, and the download and installation process was a little bit complicated as it must be done manually due to its unavailability in the Play Store. Users expect this app to be available on the Play Store soon, so the download and installation process could be simpler. Some users also mentioned that this app needs to be developed for the iOS platform, as hospital staff may also have iOS smartphones. Although this app is expected to assess hand hygiene compliance well and impact increasing hand hygiene compliance rates, AMC Muhammadiyah Hospital must prepare other supporting factors to achieve this goal.

Due to some issues, this study is limited to mobile apps and unavailable on the Google Play Store. Until now, the process is ongoing.

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### REFERENCES

- Benudis, A., Stone, S., Sait, A. S., Mahoney, I., Price, L. L., Moreno-Koehler, A., Anketell, E., & Doron, S. (2019). Pitfalls and Unexpected Benefits of an Electronic Hand Hygiene Monitoring System. *American Journal of Infection Control*, 47(9), 1102–1106. <https://doi.org/10.1016/j.ajic.2019.03.011>
- Boyce, J. M., Laughman, J. A., Ader, M. H., Wagner, P. T., Parker, A. E., & Arbogast, J. W. (2019). Impact of an automated hand hygiene monitoring system and additional promotional activities on hand hygiene performance rates and healthcare-associated infections. *Infection Control & Hospital Epidemiology*, 40(7), 741–747. <https://doi.org/10.1017/ice.2019.77>
- Chaouali, W., Lunardo, R., Ben Yahia, I., Cyr, D., & Triki, A. (2019). Design aesthetics as drivers of value in mobile banking: does customer happiness matter? *International Journal of Bank Marketing*, 38(1), 219–241. <https://doi.org/10.1108/ijbm-03-2019-0100>
- Edmisten, C., Hall, C., Kernizan, L., Korwek, K., Preston, A., Rhoades, E., Shah, S., Spight, L., Stradi, S., Wellman, S., & Zygadlo, S. (2017). Implementing an electronic hand hygiene monitoring system: Lessons learned from community hospitals. *American Journal of Infection Control*, 45(8), 860–865. <https://doi.org/10.1016/j.ajic.2017.03.033>
- Hastuti, S. K. W., Fadilla, A. I., & Apriansyah, S. (2021). Factors Related to Nurse Compliance in The Implementation of Universal Precaution in The Inpatient Room One of Private Hospital in Yogyakarta. *JMMR (Jurnal Medicoeticolegal Dan Manajemen Rumah Sakit)*, 10(2), 177–188. <https://doi.org/10.18196/jmmr.v10i2.10637>
- Iversen, A.-M., Kavalaris, C. P., Hansen, R., Hansen, M. B., Alexander, R., Kostadinov, K.,

- Holt, J., Kristensen, B., Knudsen, J. D., Møller, J. K., & Ellermann-Eriksen, S. (2020). Clinical experiences with a new system for automated hand hygiene monitoring: A prospective observational study. *American Journal of Infection Control*, 48(5), 527–533. <https://doi.org/10.1016/j.ajic.2019.09.003>
- Kaya, A., Ozturk, R., & Altin Gumussoy, C. (2019). Usability measurement of mobile applications with system usability scale (SUS). In *Industrial Engineering in the Big Data Era: Selected Papers from the Global Joint Conference on Industrial Engineering and Its Application Areas*, GJCIE 2018, June 21–22, 2018, Nevsehir, Turkey (pp. 389–400). Springer International Publishing. [https://doi.org/10.1007/978-3-030-03317-0\\_32](https://doi.org/10.1007/978-3-030-03317-0_32)
- Kemenkes RI (2022) *PERATURAN MENTERI KESEHATAN REPUBLIK INDONESIA NOMOR 30 TAHUN 2022*. Indonesia.
- Knepper, B. C., Miller, A. M., & Young, H. L. (2020). Impact of an automated hand hygiene monitoring system combined with a performance improvement intervention on hospital-acquired infections. *Infection Control & Hospital Epidemiology*, 41(8), 931–937. <https://doi.org/10.1017/ice.2020.182>
- Knudsen, A. R., Kolle, S., Hansen, M. B., & Møller, J. K. (2021). Effectiveness of an electronic hand hygiene monitoring system in increasing compliance and reducing healthcare-associated infections. *Journal of Hospital Infection*, 115, 71–74. <https://doi.org/10.1016/j.jhin.2021.05.011>
- Le, C., Lehman, E., Nguyen, T., & Craig, T. (2019). Hand Hygiene Compliance Study at a Large Central Hospital in Vietnam. *International Journal of Environmental Research and Public Health*, 16(4), 607. <https://doi.org/10.3390/ijerph16040607>
- Lotfinejad, N., Peters, A., Tartari, E., Fankhauser-Rodriguez, C., Pires, D., & Pittet, D. (2021). Hand hygiene in health care: 20 years of ongoing advances and perspectives. *The Lancet Infectious Diseases*, 21(8), e209–e221. [https://doi.org/10.1016/s1473-3099\(21\)00383-2](https://doi.org/10.1016/s1473-3099(21)00383-2)
- Ojanperä, H., Kanste, O. I., & Syrjala, H. (2020). Hand-hygiene compliance by hospital staff and incidence of health-care-associated infections, Finland. *Bulletin of the World Health Organization*, 98(7), 475–483. <https://doi.org/10.2471/blt.19.247494>
- Portz, J. D., Bayliss, E. A., Bull, S., Boxer, R. S., Bekelman, D. B., Gleason, K., & Czaja, S. (2019). Using the Technology Acceptance Model to Explore User Experience, Intent to Use, and Use Behavior of a Patient Portal Among Older Adults With Multiple Chronic Conditions: Descriptive Qualitative Study. *Journal of Medical Internet Research*, 21(4), e11604. <https://doi.org/10.2196/11604>
- Qudah, B., & Luetsch, K. (2019). The influence of mobile health applications on patient - healthcare provider relationships: A systematic, narrative review. *Patient Education and Counseling*, 102(6), 1080–1089. <https://doi.org/10.1016/j.pec.2019.01.021>
- Sands, M., & Aunger, R. (2020). Determinants of hand hygiene compliance among nurses in US hospitals: A formative research study. *PLOS ONE*, 15(4), e0230573. <https://doi.org/10.1371/journal.pone.0230573>
- Santosaningsih, D., Erikawati, D., Santoso, S., Noorhamdani, N., Ratridewi, I., Candradikusuma, D., Chozin, I. N., Huwae, T. E. C. J., van der Donk, G., van Boven, E., Voor in 't holt, A. F., Verbrugh, H. A., & Severin, J. A. (2017). Intervening with healthcare workers' hand hygiene compliance, knowledge, and

- perception in a limited-resource hospital in Indonesia: a randomized controlled trial study. *Antimicrobial Resistance & Infection Control*, 6(1). <https://doi.org/10.1186/s13756-017-0179-y>
- Wang, C., Jiang, W., Yang, K., Yu, D., Newn, J., Sarsenbayeva, Z., Goncalves, J., & Kostakos, V. (2021). Electronic Monitoring Systems for Hand Hygiene: Systematic Review of Technology. *Journal of Medical Internet Research*, 23(11), e27880. <https://doi.org/10.2196/27880>
- WHO (2009) CONSENSUS RECOMMENDATIONS - WHO Guidelines on Hand Hygiene in Health Care - NCBI Bookshelf. Retrieved from <https://www.ncbi.nlm.nih.gov/books/NBK144035/> (Accessed: March 6, 2023).
- WHO (2022) Infection prevention and control. Retrieved from <https://www.who.int/teams/integrated-health-services/infection-prevention-control/hand-hygiene> (Accessed: March 6, 2023).
- Yousaf, K., Mehmood, Z., Awan, I. A., Saba, T., Alharbey, R., Qadah, T., & Alrige, M. A. (2019). A comprehensive study of mobile-health based assistive technology for the healthcare of dementia and Alzheimer's disease (AD). *Health Care Management Science*, 23(2), 287–309. <https://doi.org/10.1007/s10729-019-09486-0>

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