

Technology for Patient's Fall Detection System in Hospital Settings: A Systematic Literature Review

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Abstract:

The prevalence of falls among patients in hospitals around the world is still relatively high. Technology is needed to detect the incidence of patients falling in hospitals. The aim of this study is to analyze technology to detect patient fall in hospital settings. A systematic literature review was chosen as the research design. The databases used to search for literature include Google Scholar, Science Direct, PubMed, and Springer using keywords combined with Boolean operators. The selection of articles is based on several criteria including the publication year 2017-2021, full-text articles, the research setting in a hospital, articles in English, and articles that used research design qualitative, quantitative, and mix-method. The Articles found according to the criteria were 13 articles. The findings showed that there are two types of technology found in this review which are wearable devices and ambient sensor devices. Most of the technical procedure is by connecting the technologies with a wireless network and uploading the data to the server and only a few technologies measure directly. This review also found the advantages and disadvantages of these two types of technology. The health service provider can choose technology by considering the results of the analysis that has been carried out by considering the type of technologies, working procedures, advantages, and disadvantages of the technology so the health service provider can choose the appropriate technology in the hospital.

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INTRODUCTION

Patient safety is a system that makes patient care safer, including risk assessment, patient risk identification and management, incident reporting and analysis, the ability to learn from incidents and their follow-up, as well as implementing solutions to minimize risks and prevent injury caused by an error due to carrying out an action or not taking the action that should have been taken (Permenkes, 2017). Patient safety is a fundamental principle in the implementation of health care (Salawati, 2020). A few countries have published studies showing that the number of patients who are harmed during the treatment process has an impact on the longer the patient will be hospitalized. In addition to causing harm to the patient himself, the impact of not enforcing patient safety in the hospital will also have an impact on the hospital as a provider of health care services (Morse, 2008). This is because the value of patient satisfaction with health services is the main component of a quality hospital (Rahmawati, Ardiana, & Kurniawan, 2020).

Many factors are at risk of endangering patient safety in hospitals. One of the things included in patient safety that needs to be considered is the incidence of patient falls. According to the World Health Organization (WHO) (2007) found unwanted events where one of them is the

incidence of patients falling with an incidence range of 3.2-16.6% of the total patients in hospitals in hospitals in various countries, namely America, England, Denmark, and Australia (Susanti, 2016). In addition to experiencing physical losses, the incident of a patient falling will also increase hospital costs. While in Indonesia itself, in 2012, it was reported that the incidence of patient falls was included in the top three hospital incidents and was in the second level after medicine errors. This still needs to be added to the Joint Commission International (JCI) standard, which states that patient falls are not expected to occur in the hospital (Nur, Dharmana, & Santoso, 2017).

The incidence of patient falls was an important issue to be discussed in more depth. Because the incidence of patients falling in the hospital resulted in a lot of losses. For patients themselves, falling incidents can result in injury or injury to the patient's body, especially if the patient experiences a fatal fall, it will be dangerous to the patient's health (Dewi et al., 2018). One of the impacts of falls for patients is physical injury consisting of abrasions, lacerations, and bruises; even in some severe cases, falls experienced by patients can cause fractures, bleeding, and head injuries. In addition to having an impact on patients, the incidence of falling patients also has an impact on hospitals, where the occurrence of falling patients gives the hospital will get a bad image by the community or patients and will have an impact on the sustainability of the health service process itself (Marpaung, 2019).

Previous studies related to technology to detect falling patients have been carried out and have even been applied in several hospitals in various parts of the world. The types of technology that have been applied include sensor- and camera-based technology that can detect patients experiencing falling incidents (Marpaung, 2019). There need to be studies that specifically discuss the types of technology, technology work procedures, and advantages and disadvantages of fall detection technology in detail. This signifies a research gap that the researchers aim to address by conducting a literature review to identify fall patient detection technology in hospitals, including types of technology, technology work procedures, and advantages and disadvantages of fall detection technology in the hospital.

METHOD

This study used the systematic literature review method. The articles that have been collected are read carefully then summarize, draw conclusions, and find gaps in the manuscript that are adapted to the topic and research question (Ulhaq & Rahmayanti, 2019). The databases used in this literature review include PubMed, Science Direct, Google Scholar, and Springer. All databases were accessed by the researchers on April 4, 2022. In the literature search, the keywords used were combined with Boolean Operators, which aims to expand or make the literature search more specific. The keywords were (detection OR observation) AND (technology OR tools) AND (patient OR client) AND (fall OR accident). From the results of article research through four databases with the aid of Boolean Operators, the researchers found 2.322.567 articles that matched these keywords, consisting of 2.171 articles in PubMed, 139.574 articles in Science Direct, 822 articles in Springer, and 2.180.000 articles in Google Scholar. After being excluded based on the inclusion and exclusion criteria, 13 articles were included in the analysis.

This systematic literature review used the following inclusion criteria: 1) the article was published in 2017-2021; 2) the study was conducted in a hospital setting; 3) articles were written in English; 4) the research was available in the full-text article; 5) research design is quantitative, qualitative, or mixed methods. Types of research include cross-sectional studies, diagnostic test accuracy studies, cohorts, quasi-experimental, case-control, or randomized control trials. The exclusion criteria were: 1) the article was published before 2017; 2) the article is not full text.; 3) the

articles were written in languages other than English; 4) the article is the result of a proceeding or conference; 5) an article from the results of a literature review; and 6) articles published in two or more journals.

RESULT

The results of initial analysis, review, and further identification finally included only 13 articles. The following table describes the details of each article.

Table 1. Literature Analysis Results

ID	Author and Journal Identity	Journal Title	Objective	Population and Sample	Method	Summary of Results
A1	Author: Mara Nikolaidou, et al Journal Identity: Health Informatics Journal/2021/ Vol.27(1): 1-15.	Incorporating patient concerns into design requirements for IoT-based systems: The fall detection case study	Demonstrate the effectiveness of using IoT or the Internet of Medical Things for remotely monitored elderly patients.	1 patient with postoperative heart problems.	Qualitative descriptive. Data collection by Using a case study model involving 1 postoperative elderly patient with heart problems.	Although the use of IoT technology has proven to be effective in detecting falls for patients, there are still many shortcomings of this technology, such as network delays that do not make observations in real time.
A2	Author: Chou, Hsi Chiang Han, Kai Yu Journal Identity: Journal of Intelligent & Fuzzy Systems/2021 / Vol.40 (2021): 8073–8086.	Developing a smart walking cane with remote electrocardiogram and fall detection	This research developed a smart stick with a remote electrocardiogram (ECG) and fall detection.	16 volunteers	Diagnostic Test Accuracy Studies. Data collection by Invited 16 volunteers to participate in the trial of making the tool.	This study succeeded in developing a walking cane that can detect the user experiencing a fall, besides that this walking cane is equipped with an ECG tool that can take measurements in real time.
A3	Author: Marge Cochran, et al Journal Identity: Canadian Journal on Aging/La Revue canadienne du vieillissement/ 2018/Vol.37(3) : 245-260.	Automated Fall Detection Technology in Inpatient Geriatric Psychiatry: Nurses' Perceptions and Lessons Learned	Describe the performance of the HELPER system being piloted in a geriatric mental health hospital.	55 patients	Diagnostic Test Accuracy Studies. Data collection by Installing HELPER tools in some patient rooms and for some other rooms not installing HELPER for 12 weeks.	There were 28 recorded falls during the research where 1 undocumented fall occurred from a room with a HELPER installed, while 27 falls came from a room without a HELPER installed.

ID	Author and Journal Identity	Journal Title	Objective	Population and Sample	Method	Summary of Results
A4	Author: Shu, Francy and Shu, Jeff Journal Identity: Collegian/2019/Vol.26(1):86-94	An eight-camera fall detection system using human fall pattern recognition via machine learning by a low-cost android box	Designing a fall detection system that is able to detect falls due to falls, slips, faints that can penetrate through transparent glass, screens and rain by analyzing fall patterns using machine learning methods.	50,000 human image datasets	Diagnostic Test Accuracy Studies. Data collection was carried out using a dataset of 50,000 images of humans doing daily activities.	The advantages of using a camera-based fall detection system include falling events that are not blocked by furniture because they are installed at a height, because they are installed at a height, they are relatively undamaged, widely available and durable.
A5	Author: Eleonore Bayen, et al Journal Identity: Journal of medical internet research/2017 /Vol.19(10):80-95.	Reduction in Fall Rate in Dementia Managed Care Through Video Incident Review: Pilot Study	Analyze how continuous video monitoring and review of falls of individuals with dementia can support better quality of care.	38 patients	Quasi-Experimental Studies. A Pilot Observational Study was conducted from July to September 2016 using 43 wall-mounted cameras in both common areas and bedrooms.	A total of 16 falls can be recorded on video. The decrease in fall rates observed in the final month of the study results from video reviews can be used to screen for the severity of falls and injuries from falls, in addition to the identification of video recordings can be used for secondary prevention for individuals with a high level of fall risk.
A6	Author: Daniel H Strauss, dkk Journal Identity: JMIR research protocols/2021 /Vol.10(4):e24-455.	The Geriatric Acute and Post-Acute Fall Prevention Intervention (GAPcare) II to Assess the Use of the Apple Watch in Older Emergency Department Patients With Falls: Protocol for a Mixed Methods Study	Researching Apple Watch Series 4 suitability, acceptance, and usability paired with iPhone and apps in Rhode Island FitTest (RIFitTest) in patients at risk for falls.	30 patients	Mixed-Method Study. Collecting data with Conducted a field trial of 25 ED patients who experienced a fall and their 5 caregivers for determine if they can use Apple Watch, iPhone well.	Fall detection devices and medical warning devices can collect and transmit health information about patients in timely mode directly to the researcher or doctor. this data can be used to help researchers and clinicians prevent future falls. However, currently the study aims to assess the feasibility, and usefulness of the Apple Watch in the population most at risk of falling is still less.

ID	Author and Journal Identity	Journal Title	Objective	Population and Sample	Method	Summary of Results
A7	Author: Nico Jähne-Raden, et al Journal Identity: Sensors/2019/ Vol.19(5):1017	INBED: A Highly Specialized System for Bed-Exit-Detection and Fall Prevention on a Geriatric Ward	Developed Inexpensive Node for bed-exit Detection (INBED) technology as a smart solution to prevent falls in the clinic environment and in everyday life.	1 patient in geriatric ward	Diagnostic Test Accuracy Studies. By using the scenario of a patient in the geriatric ward who is at high risk of falling, experiencing a functional motor deficit and being applied to the INBED technology.	The test of Inexpensive Node for bed-exit Detection (INBED) technology shows that the system can be used to detect several events such as movement up the mattress, down the mattress or falling events.
A8	Author: Luca Palmerini, et al Journal Identity: Sensors/2020/ Vol.20(22):6479	Accelerometer-Based Fall Detection Using Machine Learning: Training and Testing on Real-World Falls	Analyzed the acceleration signal recorded by the inertial sensor attached to the back during 143 falls from 55 subjects.	55 patients and residents	Diagnostic Test Accuracy Studies. By analyzing the database in the form of records of 143 falls from 40 subjects and also analyzing the daily activities of 15 subjects.	The implemented algorithm of features based on multiphase model outperforms the algorithm on conventional features and the researcher suggests useful metrics to characterize the fall detection system to be implemented in the real world.
A9	Author: Venous Roshidibenam, et al Journal Identity: Sensors/2021/ Vol.21(10):3481	Machine Learning Prediction of Fall Risk in Older Adults Using Timed Up and Go Test Kinematics	Develop a non-intrusive sensor system that can measure intrinsic risk factors when the patient interacts with environment.	100 patients	Diagnostic Test Accuracy Studies. Probability sampling. Measured the gait kinematics of the subject during the Time Up and Go (TUG) test using 3 non-intrusive wearable sensors.	The use of machine learning applied to sensor data obtained from the TUG test can be matched with the ability of experienced geritarians to predict falls.
A10	Author: Serpen, Gursel and Khan, Rakibul Hasan Journal Identity: Procedia Computer Science/2018/ Vol.140:238-247.	Real-time Detection of Human Falls in Progress: Machine Learning Approach	Investigating the use of machine learning algorithms that receive real time sensors from a 3-axis accelerometer and gyroscope placed on the human body	42 volunteers	Diagnostic Test Accuracy Studies Data were obtained from two types of sensors, namely a three-axis accelerometer and a three-axis gyroscope mounted on the chest and thighs of volunteers.	The performance of matrix in assessing missed alarms and false alarms is well monitored. The simulation results on the conceptual prototype show that the design is promising to be implemented in the real world.

ID	Author and Journal Identity	Journal Title	Objective	Population and Sample	Method	Summary of Results
A11	Author: Fangmin Sun, et al Journal Identity: Information fusion/2020/Vol.53:134-144.	Gait-based identification for elderly users in wearable healthcare systems	Introducing gait-based identity recognition used to access control of wearable health devices by the elderly.	64 volunteers	Diagnostic Test Accuracy Studies The data is obtained from the public dataset which contains acceleration signals from three IMUs used by 64 elderly people with an age range of 50-79 years.	The results of the study prove that the average level of gait-based identity recognition used is quite beneficial for the identification process for the elderly who use medical devices.
A12	Author: Issam Boukhenoufa, et al Journal Identity: Journal of Biomedical Informatics/2020/Vol.109:10352.	A novel gateway-based solution for remote elderly monitoring	Develop a secure and energy-efficient real time platform to provide solutions to reduce computing load in the cloud delays in uploading elderly monitoring data.	7 volunteers	Qualitative study collected data using a case study model involving 7 volunteers with an age range of 21-22 years.	The results show that the proposed solution reduces as much as 15.4% of the energy consumption in the sensor which makes this prototype a good candidate for the use of the Internet of Things in healthcare.
A13	Author: Elisa Dolci, et al Journal Identity: Journal of medical Internet research/2020 /Vol.22(9):e19516.	Automated Fall Detection Algorithm With Global Trigger Tool, Incident Reports, Manual Chart Review, and Patient-Reported Falls: Algorithm Development and Validation With a Retrospective Diagnostic Accuracy Study	Develop fall detection algorithms for use with electronic health records then evaluate them with global trigger tools, incident reports, manual review charts and patient fall reports.	538 patients	Diagnostic Test Accuracy Studies. Collected the first data from 240 patients to develop the algorithm and collected data from 298 patients for validation.	Twenty hospital falls were found in the study. Of these, the algorithm detected 19 (sensitivity 95%), Global Triggers detected 18 (90%), and incident reports detected 14 (67%). Of the 15 falls found in validation sample, the algorithm identified all 15 (100%), manual chart review identified 14 (93%), and patient reports of falls

The results of the literature analysis found related to the types of technology to detect patient falls in the hospital, the working procedures of the technology, the advantages and disadvantages of the technology.

DISCUSSION

Further explanation regarding the indicators that have been mentioned as follows:

1. Types of Technology for Fall Detection in Hospitals

The types of technology to detect patients falling in hospitals are divided into two, namely the type of technology that can be worn by the patient or commonly called wearable devices and the type of technology that is not worn directly by the patient or ambient sensors devices (Rajagopalan, Litvan, & Jung, 2017). The following types of technology are used:

a. Wearable devices

The type of patient fall detection technology based on wearable technology or wearable devices consists of two tools, namely an accelerometer which is useful for measuring the acceleration or acceleration of an object (Hardjianto, Rony, & Trengginas, 2016). And a gyroscope that is useful for tracking the rotation or rotation of an object based on motion. The gyroscope is able to read the direction of a movement when experiencing an acceleration (Arifien, Bachtiar, & Yudistira, 2021). The tools found in this research process that combine the two technological components above include the smart walking cane, INBED, and Apple watch.

b. Ambient sensor devices

The types of technology used in the ambient sensor-based fall detection system include camera-based and proximity sensors. camera-based sensor, which is a type of camera-based fall detection technology that is supported by other supporting sensors such as infrared sensors, night vision sensors, and sensors that can penetrate glass usually this technology is connected directly to a computer that can directly send the captured images to the server (Melita, Bhaskoro, & Subekti, 2018). The analysis of the article found tools that use camera-based technology, including HELPER and camera-based technology that can penetrate glass, rain and transparent screens. The second is Proximity Sensors which is a tool that can detect the distance of an object to the sensor. Proximity sensors can detect motion information and the presence of an object or object and turn it into an electrical signal (Koyama, Shimojo, Senoo, & Ishikawa, 2018). But in the process of analyzing the article no tools were found that use this technology in its operation.

2. Technology Working Procedures Used to Detect Falling Patients in Hospitals

The application of the technology in a fall patient detection system, usually the accelerometer and gyroscope used will be integrated with a data transmitter connected to the internet so that data from falls detected by the accelerometer will be directly sent via the internet to the health service provider so that the health service provider can monitor patients remotely (Faluzi, Machmud, & Arif, 2018). In the article that has been analyzed, it is found that the working principle of the accelerometer is more or less the same as the explanation described above, but differences are found in the technology that uses ordinary accelerometers and three-axis accelerometers where ordinary accelerometers can only recognize changes in acceleration in certain directions while three-axis accelerometers can recognize changes in acceleration. change in the acceleration of an object in three different directions.

The camera-based patient fall detection system works like a camera in general, but the camera to detect falling patients is equipped with a sensor that can detect the movement of the subject being observed so that due to the sensor, the system will detect that the subject has fallen, not only that the system The camera-based fall patient detection will be equipped with a computer to process the images from the camera (Jian et al., 2017). This system is usually also connected to

the internet so that data from direct camera observations can be sent directly to the health service provider so that the patient's fall can be taken immediately.

3. Advantages and Disadvantages of Technology to Detect Falling Patients in Hospitals

The accelerometer has advantages in its use, such as the price of this tool is affordable so that this tool is widely used in patient fall detection systems. In addition, the advantage of this tool is that the measurement results are considered accurate, especially when the system is at rest or static (Anggunadi & Sutarina, 2017). The gyroscope also has several advantages, the advantages of the gyroscope itself include the measurements made by this gyroscope are not affected by gravity, besides that the gyroscope can also detect movement from all directions and the images and movements produced from this gyroscope are also smoother than the motion images produced by the gyroscope. generated by the accelerometer (Nurhafizah, Fajrin, & Kartika, 2022). Although it has several advantages that have been mentioned above, the accelerator also has several disadvantages, including the response of this tool tends to be slow; high-power consumption makes this tool tend to waste battery. Similar to accelerators, although they have many advantages, gyroscopes also have several disadvantages, they are relatively expensive, and the gyroscope will function optimally when combined with an accelerometer so that this tool will not produce maximum results when used without being combined with an accelerometer (Sun, Zang, Gravina, Fortino, & Li, 2020). In addition, the drawback of a wearable fall patient detection system is that the device is generally less comfortable to use because it interferes with the mobility of the patient, besides using the device for a long time will result in injuries and bruises to the patient (Rajagopalan et al., 2017).

The camera-based fall detection system has several advantages; among others, this system can detect objects that are observed at all times as long as the object is still within reach of the camera. tools contained in the body (Coahran et al., 2018). The camera-based patient fall detection system can also reveal the cause of the patient's fall. In addition to having some of the advantages already mentioned, the camera-based fall detection system also has several weaknesses, including the lack of patient privacy, because the patient will be monitored and observed all the time so that the patient will feel that his privacy is disturbed. In its application, this system usually uses a camera with the latest technology, and this tool is also classified as consuming large amounts of power because this tool continuously monitors patients without stopping (Arifien et al., 2021).

The analysis of the selected articles resulted in some of the points discussed above, although this research has several limitations, including incomplete database features, no articles sourced from the Springer database because they need to meet the requirements, and less specific keywords resulting in searches being wide. The results of this literature review are expected to be used as guidelines for the use of patient fall detection tools in hospitals so that nurses can detect falls experienced by patients without having to monitor patients continuously and nurses only need to monitor at the nurse station. In addition, with the technology described in this literature review, it is hoped that the handling of falls in patients can be faster and more precise.

CONCLUSION

This systematic literature review concludes that the types of technology used to detect falls in hospitals are divided into two parts, namely wearable devices, and ambient-based sensors. The working procedure from devices that are worn directly by the patient or devices that are not worn directly by the patient that is, the device is equipped with data transmission technology via an

internet-based network that is directly connected to the health service provider's device or by sending a warning signal to the server regarding the incident falls experienced by the patient. This type of wearable device-based technology has advantages, in general, is patient privacy is maintained and has disadvantages patients feel uncomfortable when wearing it for a long time, while ambient-based sensor technology has the advantage that patients feel comfortable because they do not use technology directly and the disadvantage patient privacy will be disturbed because patient feels watched all the time.

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CONFLICT OF INTEREST

There is no conflict of interest in this article.

REFERENCES

- Anggunadi, A., & Sutarina, N. (2017). Manfaat Accelerometer Dalam Pengukuran Aktivitas Fisik. *Jorpres (Jurnal Olahraga Prestasi)*, 13(1), 10–33. <https://doi.org/10.21831/jorpres.v13i1.12881>
- Arifien, Z., Bachtiar, F. A., & Yudistira, N. (2021). Pengenalan Aktivitas Manusia Menggunakan Sensor Akselerometer Dan Girooskop Pada Smartphone Dengan Metode K-Nearest Neighbor. *Sentrin*, 9(1). <https://doi.org/10.25126/jtiik.202295593>
- Coahran, M., Hillier, L. M., Van Bussel, L., Black, E., Churchyard, R., Gutmanis, I., ... Mihailidis, A. (2018). Automated Fall Detection Technology in Inpatient Geriatric Psychiatry: Nurses' Perceptions and Lessons Learned. *Canadian Journal on Aging*, 37(3), 245–260. <https://doi.org/10.1017/S0714980818000181>
- Dewi, T., Noprianty, R., Rumah, P., Ibu, S., Anak Bandung, D., Dharma, S., & Bandung, H. (2018). Phenomenologi study: risk factors related to faal incidence in hospitaliced pediatric patient with theory faye g. abdellah. *NurseLine Journal*, 3(2). Retrieved from <https://jurnal.unej.ac.id/index.php/NLJ/article/view/8249>
- Faluzi, A., Machmud, R., & Arif, Y. (2018). Analisis Penerapan Upaya Pencapaian Standar Sasaran Keselamatan Pasien Bagi Profesional Pemberi Asuhan Dalam Peningkatan Mutu Pelayanan di Rawat Inap RSUP Dr. M. Djamil Padang Tahun 2017. *Jurnal Kesehatan Andalas*, 7(0), 34. <https://doi.org/10.25077/jka.v7i0.919>
- Hardjianto, M., Rony, M. A., & Trengginas, G. S. (2016). Deteksi jatuh pada lansia dengan menggunakan akselerometer pada smartphone. *Prosiding SENTIA - Politeknik Negeri Malang*, 8, 284–288.
- Jian, Z., Guo, X., Liu, S., Ma, H., Zhang, S., Zhang, R., & Lei, J. (2017). A cascaded approach for Chinese clinical text de-identification with less annotation effort. *Journal of Biomedical Informatics*, 73, 76–83. <https://doi.org/https://doi.org/10.1016/j.jbi.2017.07.017>
- Koyama, K., Shimojo, M., Senoo, T., & Ishikawa, M. (2018). High-Speed High-Precision Proximity Sensor for Detection of Tilt, Distance, and Contact. *IEEE Robotics and Automation Letters*, 3(4), 3224–3231. <https://doi.org/10.1109/LRA.2018.2850975>
- Marpaung, S. H. S. (2019). *Pelaksanaan Peningkatan Keselamatan Pasien Dengan Sasaran Pengurangan Resiko Pasien Jatuh Di Rumah Sakit*. Available at <https://doi.org/10.31227/osf.io/usb4j>

- Melita, R. A., Bhaskoro, S. B., & Subekti, R. (2018). Pengendalian Kamera berdasarkan Deteksi Posisi Manusia Bergerak Jatuh berbasis Multi Sensor Accelerometer dan Gyroscope. *Elkomika: Jurnal Teknik Energi Elektrik, Teknik Telekomunikasi, & Teknik Elektronika*, 6(2), 259. <https://doi.org/10.26760/elkomika.v6i2.259>
- Morse, J. (2008). *Preventing patient falls (2nd ed.)*. Springer Publishing Company.
- Nur, H. A., Dharmana, E., & Santoso, A. (2017). Pelaksanaan asesmen risiko jatuh di rumah sakit. *Jurnal Ners Dan Kebidanan Indonesia*, 5(2).123-133. <https://doi.org/10.21927/jnki.2017>.
- Nurhafizah, A., Fajrin, H. R., & Kartika, W. (2022). Gelang Giroskop dengan Parameter Sumbu X dan Y sebagai Alat Pemandu Salat bagi Tunarungu. *SEMESTA TEKNIKA*, 25(1), 47–59.
- Permenkes. (2017). Peraturan menteri kesehatan republik Indonesia nomor 11 Tahun 2017 tentang keselamatan pasien. *Progress in Physical Geography*, 14(7), 450.
- Rahmawati, K., Ardiana, A., & Kurniawan, D. E. (2020). Gambaran Kepuasan Pasien yang Menggunakan Jaminan Kesehatan (BPJS) terhadap Mutu Pelayanan Keperawatan di Rumah Sakit Kabupaten Jember. *Pustaka Kesehatan*, 8(2), 112. <https://doi.org/10.19184/pk.v8i2.16422>
- Rajagopalan, R., Litvan, I., & Jung, T.-P. (2017). Fall Prediction and Prevention Systems: Recent Trends, Challenges, and Future Research Directions. *Sensors*. <https://doi.org/10.3390/s17112509>
- Salawati, L. (2020). Penerapan keselamatan pasien rumah sakit. *Jurnal Averrous*, 6(1), 98–107. <https://doi.org/10.29103/AVERROUS.V6I1.2665>
- Sun, F., Zang, W., Gravina, R., Fortino, G., & Li, Y. (2020). Gait-based identification for elderly users in wearable healthcare systems. *Information Fusion*, 53, 134–144. <https://doi.org/https://doi.org/10.1016/j.inffus.2019.06.023>
- Susanti, R. (2016). Hubungan pengetahuan dengan kepatuhan perawat melaksanakan standar prosedur operasional : menurunkan risiko cedera akibat jatuh di ruang perawatan dewasa RSUD dr.Moewardi. (*Undergraduate Thesis*). Stikes Kusuma Husada, Solo, Indonesia.
- Ulhaq, Z. S., & Rahmayanti, M. (2019). *Panduan Literature review*. Fakultas Kesehatan Masyarakat Universitas Jember.