

Improving Healthcare Services Using Clinical Decision Support Systems: A Systematic Review

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Abstract

Patient safety and recovery is the main objective in healthcare. The knowledge and experiences of medical experts and patient big data can be transformed into a Clinical Decision Support System that will deliver benefits to healthcare, especially for the patients. This research is a literacy review that aims to create a framework for reviewing articles on DSS which highly related to patients, which were published by Elsevier from 2017 to October 2022. There were 29 articles found from search results on Elsevier, of which 13 were research articles. After conducting analysis and filtering, we found 6 articles that met the criteria for research objects that examined several DSS topics, namely Pre-hospital Decision Support Tools, Patient Referral, Antimicrobials, Patient Nutrition, and Blood Transfusion. The results of this study showed that DSS implementations in healthcare give a huge impact on medical experts, namely by providing important information for decision-making when treating patients. This enables the hospitals and medical team to provide appropriate therapy from the beginning of the treatment and it increased the success of patient therapy possibility. Another benefit is the medical cost saving since the therapies are only given when it is needed by the patient.

Keywords: Clinical Decision Support System, DSS, Elsevier, healthcare, patient.

Abstrak

Keselamatan dan pemulihan pasien merupakan tujuan utama dalam pelayanan kesehatan. Pengetahuan dan pengalaman para ahli medis dan data besar pasien dapat diubah menjadi Sistem Pendukung Keputusan Klinis yang akan memberikan manfaat bagi perawatan kesehatan, terutama bagi pasien. Penelitian ini merupakan tinjauan literasi yang bertujuan untuk membuat kerangka kerja untuk meninjau artikel tentang DSS yang sangat terkait dengan pasien, yang diterbitkan oleh Elsevier dari tahun 2017 hingga Oktober 2022. Ditemukan 29 artikel dari hasil pencarian di Elsevier, 13 di antaranya adalah penelitian artikel. Setelah dilakukan analisis dan penyaringan, ditemukan 6 artikel yang memenuhi kriteria objek penelitian yang mengkaji beberapa topik DSS yaitu Alat Pendukung Keputusan Prehospital, Rujukan Pasien, Antimikroba, Nutrisi Pasien, dan Transfusi Darah. Hasil penelitian ini menunjukkan bahwa penerapan DSS di bidang kesehatan memberikan dampak yang sangat besar bagi para ahli medis, yaitu dengan memberikan informasi penting untuk pengambilan keputusan saat merawat pasien. Hal ini memungkinkan rumah sakit dan tim medis untuk memberikan terapi yang tepat sejak awal pengobatan dan meningkatkan kemungkinan keberhasilan terapi pasien. Manfaat lainnya adalah penghematan biaya pengobatan karena terapi hanya diberikan saat dibutuhkan oleh pasien.

Kata Kunci: Sistem Pendukung Keputusan Klinis, DSS, Elsevier, kesehatan, pasien.

INTRODUCTION

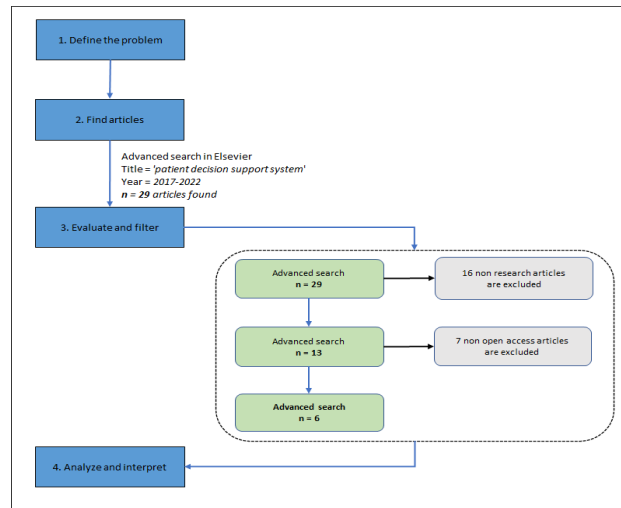
Good health services are increasingly needed by the community. One reason is increasing public awareness of the importance of health. Good service quality determines patient preferences for choosing healthcare facilities [6]. Now health service providers and medical personnel are required to be able to provide fast service at a reasonable cost. Speed in carrying out appropriate treatment of patients is a very important factor because it will affect the patient's condition during the treatment period, and can even affect the success of the therapy given. The cost factor must also be considered by service providers because it is undeniable that this factor also influences patient considerations and preferences.

Doctors and medical personnel need the support of an information system that can provide input in the form of fast information to be able to decide on the right course of action or therapy to be given to patients immediately. During a pandemic and events related to public health, decision-makers must be quick in making decisions to save human lives [12]. Information technology can also support speed and improve the quality of patient care, one of which is by implementing a Decision Support System (DSS) or Decision Support System (SPK). The development of information, telecommunication, and network technology has brought about major changes in health services [11]. We encounter DSS applications in all fields of industry because DSS provides good information and advice quickly when system users have to make a decision.

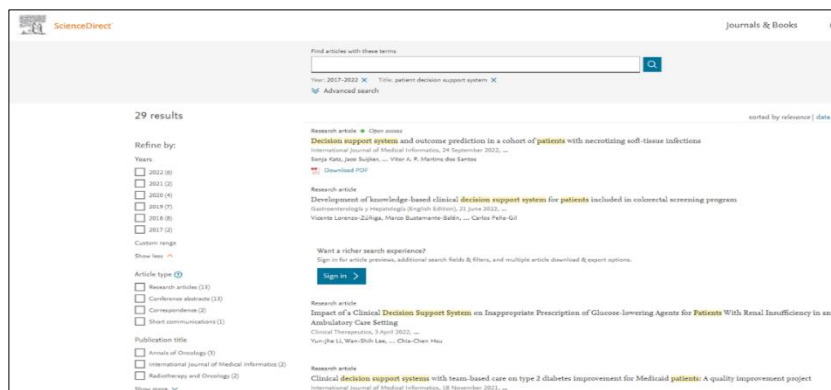
Patient service is one of the public services that require DSS because it involves patient safety. The information generated by the DSS is very helpful for medical personnel in making decisions. Many previous studies examined the application of DSS in the world of health. This literature study aims to review DSS research articles in the health sector that are directly related to patients, produce a literacy review framework, compare the methods used, and find out the benefits that patients get from each DSS that has been implemented.

METHOD

In this study we carried out four stages of literacy review research, namely, first, we formulated the problem, then second was searching for literature that was appropriate to the topic discussed, then we evaluated and filtered the articles we got, and last stage, we analyzed and interpreted the articles. who has been selected? At the literature search stage, we chose Elsevier as a source for searching published international articles. At the stage of evaluation and screening of the literature, we apply several criteria. The first criterion is that we chose articles published from 2017 to October 2022 because we wanted to focus on articles from the last five years. The next criterion is that we are looking for articles about DSS that are directly related to patients, therefore we use advanced search in the Title column with the keyword 'patient decision support system', and we managed to find 29 articles whose titles contain these keywords. consisting of 13 research articles, 13 conference abstracts, 2 correspondence articles, and 1 short communication article. The third criterion is that we choose research article type articles and we get 13 articles. As the final criterion, we take articles that are not paid or open access and we get six articles for this research. The stages of searching and filtering articles are depicted in Figure 1. Search results on Elsevier are shown in Figure 2.



Gambar 1. Kerangka kerja penelitian



Gambar 2. Hasil pencarian di Elsevier dengan *advanced search* 'patient decision support system', dalam periode 2017-2022.

DISCUSSION

In the analysis and interpretation stage, we analyze our six research articles by dividing them into five sections, namely the DSS discussed, the method applied, the data used, information systems related to DSS implementation, and finally, the benefits of DSS for patients. The titles and researchers of the six articles that we obtained after going through a search and screening process are shown in Table 1.

Tabel 1. Daftar artikel penelitian DSS

Ref.	Researcher	year	title	DSS
[1]	Duarte G, et. al	2022	Implementation of a Patient Blood Management Program Based on a Low-income Country-adapted Clinical Decision Support System	Clinical Decision Support System (CDSS)
[3]	Johansson N, et. al	2018	Developing a Decision Support System For Patient With Severe Infection Conditions in Pre-hospital Care	Pre-hospital Decision Support Tool (DST)
[4]	Katz S, et. al	2022	Decision Support System and Outcome Prediction in a Cohort of Patients With Necrotizing Soft-tissue Infections	CDSS

[7]	Paulsen M, et. al	2020	Effects of Using The MyFood Decision Support System on Hospitalized Patients' Nutritional Status and Treatment: A Randomized Controlled Trial	MyFord
[8]	Sanjaya G, et. al	2019	Using Hospital Claim Data to Develop Referral Decision Support Systems: Improving Patient Flow From The Primary Care	Patient Referral DSS
[9]	Segura B, et. al	2019	Impact of Expert Knowledge on The Detection of Patients at Risk of Antimicrobial Therapy Failure by Clinical Decision Support Systems	CDSS

Clinical Decision Support System.

The six articles we found cover different DSS topics. Duarte et. al [1] researched a Clinical Decision Support System (CDSS) that aims to provide information and advice to doctors when they want to decide whether a patient needs a blood transfusion. The DSS will provide advice on whether the patient should be given a blood transfusion or not so that the doctor can make a better decision. Johansson et. al [3] researched a Pre-hospital Decision Support Tool (DST), which is a decision support system that can provide advice to nurses in identifying patients based on three dangerous infectious diseases. DST will advise nurses in determining the right treatment options for each patient with an infectious disease so that the patient gets the care he needs and does not transmit his disease to medical personnel or other patients.

Katz et. al [4] raised a CDSS that helps medical personnel provide good predictions so they can provide the best treatment for *Necrotizing Soft Tissue Infections* (NSTI) patients. NSTI is an acute infection with a fairly high mortality rate. Doctors need predictions about the patient's condition and the best therapeutic advice for these patients so that doctors can decide on the right therapy for NSTI patients. Paulsen et. al [7] researched a DSS called MyFood, a DSS that helps medical personnel treat patients who are indicated to be malnourished or at risk of malnutrition. MyFord provides advice on proper nutritional intake for patients so that they get nutrition according to their needs at the right time.

Sanjaya et. al [8] researched Patient Referral DSS, a support system that helps hospitals find referral hospitals when the patient being treated must get special care that is not available at that hospital. The DSS will provide information on referral hospitals that can treat these patients by considering room availability, availability of specialist doctors, and the distance to the referral hospital. Segura et. al [9] conducted a study on a CDSS to help doctors detect the Antimicrobial Susceptibility Test (AST), namely an antimicrobial susceptibility test. This DSS assists doctors in prescribing the right antimicrobial for any infection that occurs.

Methods in CDSS.

Each article has different stages of the research method, however, we see one thing in common, namely that medical experts are always needed and involved in every DSS research, both in the design, analysis, evaluation, and implementation stages. Duarte et. al [1] conducted research in four stages, namely: entering blood transfusion guidelines into a system called Blood Bank Software or a blood bank application, then collecting historical data on blood transfusion requests from February 2019 to May 2020. The historical data was then analyzed and checked. repeated by qualified medical personnel, and the verified results are entered into the system. Thus the DSS is based on the correct

guidelines and provisions for blood transfusions and will provide transfusion recommendations to patients who need transfusions based on verified historical data.

Johansson et. al [3] carried out at least four steps, namely collecting data from the Electronic Patient Care Record System (ePCR), then selecting and gathering a team consisting of medical experts to conduct interviews to ask for their suggestions and opinions in developing DSS. The third step is to evaluate and the last is the validation stage. Katz et. al [3] carried out six steps in their research, namely identifying clinical needs, then conducting interviews with medical experts, and conducting data preparation followed by determining the variables to be used. The fifth stage is to classify using the Random Forest Classifier (RFC) algorithm and continue developing applications using the Python library. Paulsen et. al [7] carried out six stages in the MyFord DSS study, namely conducting a study design, then determining which patients would be included where this determination was carried out randomly. The next step is implementing the MyFood system accompanied by an explanation of procedures, training for nurses and finally carrying out a pilot project. Sanjaya et. al [8] carried out four stages, namely collecting user requirements followed by making a DSS prototype. The next step is to modify the prototype and finally to test the DSS. Segura et. al [9] carried out five stages in their research, namely conducting modeling assisted by experts and doctors, then making preparations to start the experiment. After preparation, three experiments were carried out, namely quantitative experiments, clinical relevance experiments, and signal experiments.

Data used by CDSS.

DSS implementation requires data as input to be processed to produce output in the form of information and suggestions as a reference for users in making decisions. Duarte et. al [1] used patient blood transfusion data from February 2019 to May 2020. The data was then verified by a team of experts. The verified data is then entered into the system. Johansson et. al [3] used data from 72 patients in the developed DSS. Katz et. al [4] used 409 INFECT data in which there were around 2,400 variables which included patient demographic data, clinical data such as blood samples and clinical findings, daily ICU data including administration of fluids and drugs, procedure data performed including treatment data and findings - Microbiological findings. Paulsen et. al [7] used data on 100 patients from one hospital who were treated in the period from August 2018 to May 2019. Sanjaya et. al [8] used data collected from 54 hospital networks, whereas Segura et. al [9] used 148 data in their research.

Information system integrated with CDSS.

Health is a favorite topic of research on Big Data and the world of health is believed to get increasingly significant benefits by optimizing the management and analysis of Big Data [2]. DSS can be integrated with other Big Data-based information systems that can act as a source of data to be processed. In this section, we analyze the information system or technology related to the DSS under study. Duarte et. al [1] explained that the CDSS which is the object of his research is related to Blood Bank Software, which is a system that records the availability of blood donors, and the need and use of donors. Johansson et. al [3] stated that the Pre-hospital DTS obtained data from the ePCR system. Sanjaya et. al [8] describe several related systems, namely the P-Care System, Google Maps, the Hospital Information System, and the Health BPJS System. Segura et. al [9] describe the CDSS related to the Wise Antimicrobial Stewardship Program Support System. Katz [4] and Paulsen [7] did not explain the information system related to the object of their research DSS.

Benefits of CDSS for patients.

Many of the benefits that patients get from DSS implemented by health care providers include patient safety [10] and cost efficiency of care [5,10]. In the article [1] which discusses CDSS for patient blood transfusions, at least the patient gets four benefits, namely blood transfusions are only done when needed, fewer supplies and blood donors are needed, and lower treatment costs. Whereas in Pre-hospital DST [3] patients get benefits, namely getting the right treatment at the first treatment so that the possibility of recovery is higher, then the use of drugs is less, and the cost of treatment is smaller. From CDSS [4] patients get the benefit that they can be handled more quickly. From DSS MyFord [7] patients benefit, namely receiving nutrition as needed and on time and lower treatment costs because nutrition is given as needed (not excessive). From Patient Referral DSS [8], patients get the benefit of being able to be immediately referred to a hospital that is capable of handling their complaints. Whereas from CDSS [9] patients get benefits, namely doctors will provide appropriate therapy.

CONCLUSION

The role of DSS is needed by medical personnel in serving patients because many medical decisions must be taken to determine the best therapy to be given to patients. Designed and built based on input from medical experts combined with historical treatment data, in the current Big Data era, DSS can be enriched by various types or forms of data originating from many data sources and can be refined with machine learning and artificial algorithms. intelligent.

The procedures or rules applied in the DSS must refer to valid and up-to-date health guidelines and standards. This is to ensure that the suggestions produced by the DSS are under the correct procedures. Periodically, a review must be carried out of the procedures used in the DSS, and when there are changes or new regulations, the procedures in the DSS must be immediately updated or adjusted.

The data used by the DSS must go through re-verification by experts because the data is processed to produce advice and information that is given to medical personnel who use the system when making critical decisions concerning patient safety. As operations continue and transactions increase, the amount of data will increase, this can be used as additional data that enriches and improves the accuracy of results from the DSS system.

Proper administration of therapy helps the patient's recovery process, or at least it can increase the likelihood of the success of the therapy being carried out. DSS in the world of health provides four major benefits for patients. The first is a higher success rate of therapy because medical decisions are based on solid data and analysis. The second is the speed of help or treatment by medical personnel. The third benefit is that treatment costs are more efficient because the therapy given is the only therapy that is needed. And lastly is the reduced risk due to therapeutic errors such as wrong medication or wrong action, side effects from therapy, or taking too much medicine in the long term.

Suggestions for research on DSS are to also explain information systems related to research objects, adherence to procedures, data that has been re-verified by medical personnel and carry out testing stages under the strict supervision of medical experts.

DAFTAR PUSTAKA

- Duarte G, Neto F, Junior J, Langhi D. Implementation of a Patient Blood Management Program Based on a Low-income Country-adapted Clinical Decision Support System. *Hematol Cell Ther Transfusion*. 2022; 44(3):374-378.
- Iskandar D, Mahdiana D. Systematic Literature Review: Implementation and Benefits of Big Data. *SmartComp journal* . 2022; Vol. 11, no. 3.
- Johansson N, Spindler C, Valik J, Vicente V. Developing a Decision Support System for Patients with Severe Infection Conditions in Pre-hospital Care. *International Journal of Infectious Diseases* 72. 2018; 40-48.
- Katz S, Suijker J, Hardt C, Madsen M et. al. Decision Support System and Outcome Prediction in a Cohort of Patients With Necrotizing Soft-tissue Infections. *International Journal of Medical Informatics* 167. 2022; 104878.
- Lengkong G, Langi F, Posangi J. Factors Associated with Infant Mortality in Indonesia. *Journal of HEALTH* . 2020; Vol. 9, No. 4.
- Nisrina, Aulia D, Andayani L. The Relationship between Marketing Strategy and Patient Preferences in the Pediatric Polyclinic at X Medan Hospital. *Jambi Public Health Journal*. 2020; Vol. 4, No. 1.
- Paulsen M, Paur I, Gjestland J, Henriksen C, et. al. Effects of Using The MyFood Decision Support System on Hospitalized Patients' Nutritional Status and Treatment: A Randomized Controlled Trial. *Clinical Nutrition* 39. 2020; 3607-3617.
- Sanjaya G, Lazuardi L, Hasanbasri M, Kusnanto H. Using Hospital Claim Data to Develop Referral Decision Support Systems: Improving Patient Flow From The Primary Care. *Procedia Computer Science* 161. 2019; 441-448.
- Segura B, Morales A, Juarez J, Campos M, Palacios F. Impact of Expert Knowledge on The Detection of Patients at Risk of Antimicrobial Therapy Failure by Clinical Decision Support Systems. *Journal of Biomedical Informatics* 94. 2019; 103200.
- Sutton R, Pincock D, Baumgart D, Sadowski D et. al. An Overview of Clinical Decision Support System: Benefits, Risks, and Strategies For Success. *NPJ Digital Medicine*. 2020, 3:17.
- Triyono G, Hartati S, Pulungan R, Lazuardi L. E-Referral System Modeling Using Fuzzy Multiple-Criteria Decision Making. *Indonesian Journal of Electrical Engineering and Computer Science*. 2018; Vol. 11, No. 2, pp. 475-486.
- World Health Organization. Epidemic Analysis For Response Decision-Making. *Systematic Organization of Multi-Source Information To Inform Response Decision*. World Health Organization Western Pacific Region. 2020; ISBN 9789290619161.