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Article

Designing of Decision Support System for Determining the Underlying Cause of Death in Mortality Codification

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Abstract: *Inaccuracies are often encountered in determining the Underlying Cause of Death (UCoD), which can impact the quality of reported mortality data. In this case, a system is needed to assist coders in determining the UCoD. Clinical Decision Support System (CDSS) is a system designed to assist decision-making in patient clinical management, including in determining UCOD.* The purpose of this study was *to design a CDSS in determining UCOD mortality codification.* The research method used is *descriptive research with an Action Research design consisting of four stages: Diagnosing, Planning, Taking, and Evaluating Action. The objects of this study were SIMRS, medical record documents, and death certificates. Data were collected through interviews and documentation studies. The research results obtained were user requirements consisting of features, databases, and system displays. The design was carried out using UML modeling such as Flowcharts, Use Case Diagrams, Activity Diagrams, Class Diagrams, Data Flow Diagrams, and Prototypes. The evaluation results showed that the designed CDSS was acceptable to users as a tool in determining UCOD, with a value above the global average score (77). The conclusion of this study obtained that the CDSS design is considered effective in helping coders to determine UCoD.*

Keywords: Clinical Decision Support System; Cause of Death; Designing; Mortality Codification Rule.

1. Introduction

The health sector plays a vital role in improving public welfare. One crucial component is accurate medical data management, particularly cause-of-death data. Mortality data is highly valuable for health planning, policymaking, and epidemiological research. Therefore, accurate death coding, including the Underlying Cause of Death (UCoD), is crucial because it provides a clear picture of the underlying cause of death. Death coding in Indonesia still refers to the International Statistical Classification of Diseases and Related Health Problems (ICD-10) for recording, analyzing, and comparing morbidity and mortality data (Prihantoro et al., 2023). With ICD-10, all terms and categories for diseases, injuries, signs, symptoms, and factors affecting health can be standardized (Pramono et al., 2021). However, the process of determining the UCoD is still largely done manually by coders. This requires high skill and risks inaccuracy in coding (Sulrieni et al., 2023).

Clinical Decision Support Systems (CDSS) are implemented in clinical settings to assist physicians in decision-making, with the goal of improving the quality of clinical performance and patient care. The implementation of CDSS has been shown to reduce diagnostic errors, increase efficiency, and decrease the risk of medication errors (Muhiyaddin et al., 2020). However, its implementation is still limited due to limited resources and healthcare workforce readiness, requiring attention to the work environment, workflow, and skills of healthcare workers (Horwood et al., 2023). Based on previous research conducted by (Zahra et al., 2022), it was shown that the inaccuracy of the cause of death code was 22.8%, while (Wittri et al., 2024) reported that the inaccuracy of the cause of death was 56.5%, with the causal factors coming from internal and external sources such as incomplete writing of the main diagnosis, doctors' writing that was difficult to read, the use of abbreviations, and new terms that were not standardized.

The results of a preliminary survey at a hospital in Batam in January 2025 showed that although the hospital had used death certificates, it had not yet implemented mortality codification rules as a basis for determining the cause of death codification. The MMDS Table had also not been used as a tool for determining UCoD, and there was no system available to support the implementation of mortality codification. Based on this, this study aims to design a Clinical Decision Support System (CDSS) to assist in determining the Underlying Cause of Death (UCoD) in mortality codification.

2. Materials and Methods

This method of this study is quantitative descriptive with Action Research design, which is a research design approach that emphasizes active collaboration between researchers and related parties to identify and solve problems (Utarini, 2020). This research was conducted in one of the hospitals in Batam in January 2025.

2.1. Subjects and Objects of The Study

The subjects of this study were selected using purposive sampling technique, namely taking subjects intentionally and randomly (Lenaini, 2021), as many as 5 people consisting of 1 head of the medical records unit room, 2 medical records unit reporting officers, 1 head of IT and 1 IT officer. While the object of study is the main focus observed and analyzed in this study, namely certain characteristics or conditions relevant to the research objectives (Subhaktiyasa, 2024) which include SIMRS, medical record documents and death certificates.

2.2. Data Collection Tools

The instruments in this study used interview guidelines equipped with writing tools, questionnaires in the form of sheets of paper containing questions for respondents, documentation study guidelines in the form of written documents relevant to this study and observation guidelines by observing in detail.

2.3. Data Collection Technique

Data collection techniques included interviews, questionnaires, documentation studies, and observations.

2.4. Data Processing Techniques

This data processing technique is carried out in 4 stages: diagnosing action, planning action, taking action and evaluating action. Action evaluation is carried out to measure how efficiently the system is used, the analysis of the results uses a Likert scale and the SUS method to produce a usability score for the system. Classification of interpretation of SUS scores as a reference in assessing the level of system usability (Damayanti et al., 2024).

Table 1. This is a table of *System Usability Scale* (SUS) Interpretation

SUS Score	Rank	Adjective Rank
84,10 – 100	A	Best Imaginable
72,60 – 84,00	B	Exellent
62,7 – 72,50	C	Good
51,7 – 62,60	D	OK
25,10 – 51,60	E	Poor
0 – 25,00	F	Worst Imaginable

2.5. Data Analysis

The data obtained were then processed and analyzed descriptively and quantitatively through four stages of action research: diagnosing action, planning action, taking action, and evaluating action. System feasibility was assessed through an evaluation using the System Usability Scale (SUS) method. System development was conducted using a prototype model, a design approach used to ensure the software developed meets requirements (Supiyandi et al., 2022) and aligns with the action research stages. The tools and materials used included a laptop and tools to support prototype design. The research results are presented in tables and narrative descriptions.

3. Results and Discussion

3.1. Result

3.1.1. Hospital Information System Review

This Hospital Information System is equipped with various additional features, such as direct bridging with BPJS (Social Security Agency) and polyclinics, as well as integration with the Satu Sehat platform. These features simplify the recording, documentation, and reporting of healthcare service data in a more integrated and efficient manner. One use of this Hospital Information System, is for processing and reporting mortality data. This process is carried out by two reporting officers assigned to manage patient mortality data. The integrated Hospital Information System significantly facilitates data access for officers.

The Hospital Information System features an electronic medical resume, which serves as a critical source of information for reporting mortality data. This medical resume summarizes the final diagnosis made by the doctor, making it easier for reporting staff to review and verify the information before reporting the cause of death.

3.1.2. Respondent Characteristic

The respondent in this study consisted of healthcare providers, including the head of the medical records unit, the reporting officer, the head of IT, and the IT officer. To determine the informants in this study, the researcher used purposive sampling, selecting five hospital staff members according to the research criteria. The table presents the characteristics of the informants who were successfully interviewed in this study.

Table 2. This is a table of Respondent Characteristic

Inisial	Usia	Jenis Kelamin	Jabatan	Lama Bekerja
R1	36	Laki-laki	Kepala Unit Rekam Medis	11 Tahun

R2	31	Laki-laki	Petugas Pelaporan	8 Tahun
R3	24	Laki-laki	Petugas Pelaporan	1 Tahun
R4	36	Laki-laki	Kepala IT	13 Tahun
R5	35	Laki-laki	Petugas IT	6 Tahun

3.1.3. CDSS design

This study is divided into several steps according to the action research method. The following are the stages in designing a Clinical Decision Support System for determining the UCOD mortality code.

Diagnosing Action

In the diagnosing action, problems were identified in determining the UCOD for mortality coding, based on four management aspects: people, materials, machines, and methods. Challenges in the human aspect included the lack of implementation of mortality codification rules, coders' lack of understanding of mortality codification, and the lack of specific mortality codification training. Challenges in the materials aspect included incomplete medical resumes and the unavailability of medical certificates for the cause of death. The machines aspect stated that the provided facilities supported UCOD determination. Challenges in the methods aspect included the lack of implementation of mortality codification rules. The user needs analysis for the Head of the Medical Records Unit, Reporting Officer, Head of IT, and IT Officer indicated that users needed an automated feature that displays recommendations for mortality codification rules, a feature for reporting officers to determine the final results, and a simple and uncomplicated printing and design feature.

Planning Action

The next stage is planning action, which involves the initial design, which includes the creation of flowcharts, use case diagrams, activity diagrams, class diagrams, data flow diagrams, and prototypes. The following is the flowchart designed for this research:

a. Flowchart

The flowchart in the CDSS design is divided into 2, the left image is the flowchart before the CDSS was designed, the right image is the flowchart after the CDSS design was carried out. On the left flowchart starts from the start then opens the medical resume page after that inputs the death data code, the input is complete. The right flowchart starts from the start then opens the patient diagnosis menu then selects the death status menu, inputs the patient's treatment number then inputs the cause of death code then can be saved immediately then a notification appears in the form of a mortality codification rule, there is a confirmation from the reporting officer if the officer does not want to use the recommendation results then the officer will re-input the cause of death code but if the officer uses the recommendation then the officer prints the medical certificate form for the cause of death, finished.

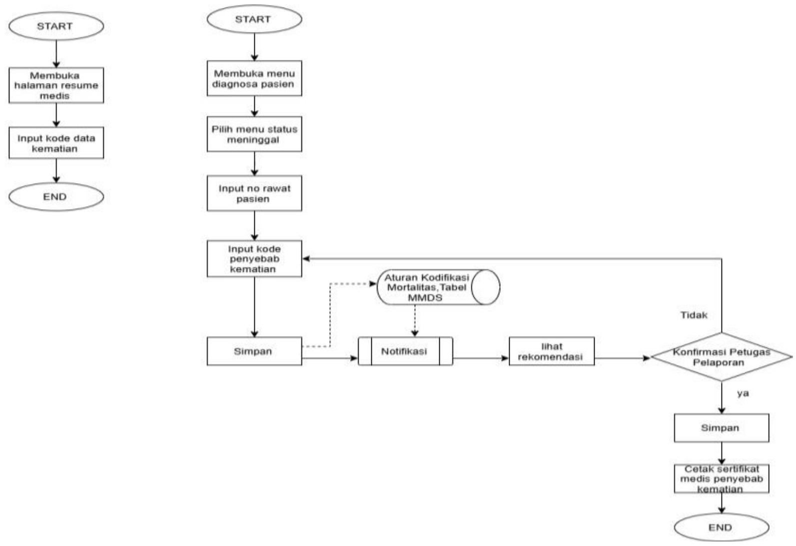

Figure 1. This is a Figure for Flowchart

b. Use Case Diagram

The reporting officer is the person responsible for inputting deceased patient data, including filling in the cause of death code and receiving information from the CDSS system. The initial activity of the officer accessing the system begins with the user case opening the patient diagnosis menu. Then the user case selects the death status menu, the user case inputs the basic data of the deceased patient, the user case inputs the cause of death code starting from the basic cause, intermediate, direct and other conditions. After that, the user case checks the mortality codification rule and the MMDS table verifies the cause of death code based on applicable provisions. The final process of the user case is printing the medical certificate form for the cause of death.

c. Activity Diagram

This activity diagram begins with the reporting officer opening the patient diagnosis menu. The system responds by displaying the patient diagnosis page. Next, the officer selects the death status menu and the system displays the status page. The officer then inputs the patient's hospital number, which is then displayed by the system. After that, the officer continues by inputting the cause of death code. After all data is inputted, the officer presses the save button. The system then processes the data by checking it against the mortality codification rules and the MMDS table stored in the database. Based on the check results, the system displays a recommendation notification regarding the UCOD determination. The officer can view the recommendation and print the output as the final step of the process.

d. Class Diagram

The class diagram consists of four entities: mortality codification, reporting officer, CDSS, and report. The mortality codification entity has attributes such as direct cause code, intermediate cause code, and basic cause code. The reporting officer entity has attributes such as officer ID, officer name, username, and password. The CDSS entity has attributes such as mortality rule and MMDS table. The report entity has attributes such as medical record number, time of death, age, basic cause code, intermediate cause code, immediate cause code, and other condition code. The class diagram can be seen as follows:

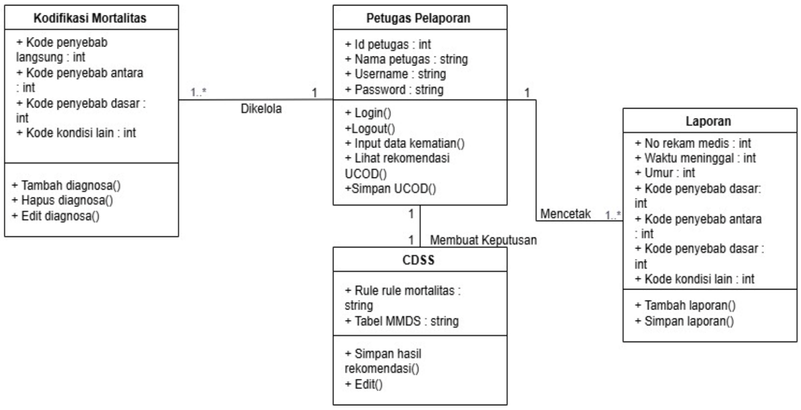

Figure 2. This is a figure for Class Diagram

e. Data Flow Diagram

In the CDSS design data flow diagram, the reporting officer acts as a user, entering data in the form of a patient's admission number and cause of death code into the system. The entered data is then processed by the system to generate relevant information. The system provides feedback to the officer in the form of a patient diagnosis and recommendations for mortality codification rules. The system also produces output in the form of a medical certificate of cause of death that can be printed by the reporting officer.

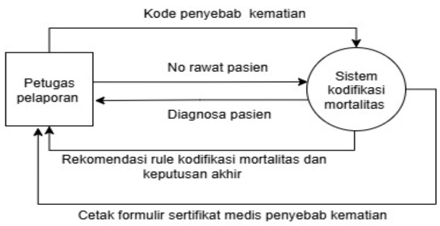

Figure 3. This is a Figure for Data Flow Diagram

f. Prototype

In the prototype design stage, the initial design screen displays a patient diagnosis menu. This feature offers options for outpatient, inpatient, and deceased patient status. If deceased status is selected, the system adjusts the display for the death recording and reporting process. Next, patient data is automatically displayed based on the patient ID. The officer then enters the cause of death code, which includes direct, intercurrent, underlying causes, and other conditions. Once the input is complete, the officer presses the save button. The CDSS system then automatically processes the data based on the codification rules and MMDS tables embedded in the database. The result of this processing is the appearance of a notification feature with recommendations regarding the underlying cause of death that has been analyzed by the system, to support decision-making for reporting officers. The CDSS recommendation notification can be seen in the image below:

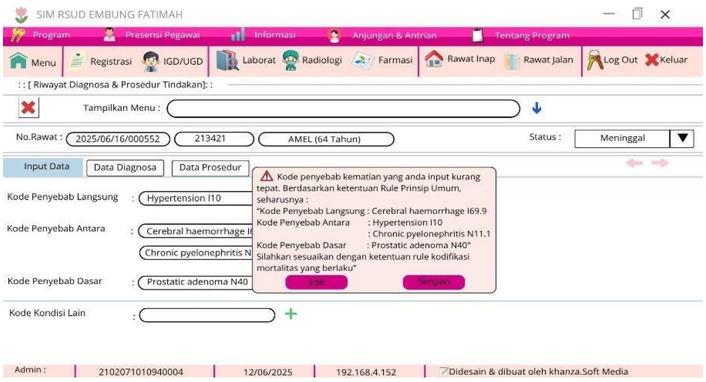

Figure 3. This is a Figure for CDSS Output

In the display above, if the cause of death code previously entered by the officer still contains errors or does not comply with the codification rules, the system will issue a warning. This notification provides the officer with two options. First, they can select the edit data feature based on the system's recommendations. Second, they can select the save feature and re-enter the cause of death code from the beginning. If they choose to follow the CDSS recommendations, they simply copy the system's recommendations into the provided fields and then save the data. Once the data is saved, the system will provide a feature to print the final result in the form of a medical certificate of cause of death.

Taking Action

The next step, the taking action phase, was carried out by collaborating with IT to build and test a mortality CDSS prototype according to the SIMRS workflow through internal testing. Based on the initial testing results, users provided several inputs that were then refined, and the prototype was retested internally by the Head of IT and the IT Team. The results showed that the prototype design met requirements and was declared successful.

Evaluation Action

As a final step, the Evaluation Action stage is carried out to objectively measure the level of usability and acceptance of the system by users. The assessment uses the System Usability Scale (SUS) method, a commonly used approach to assess product quality through a questionnaire that measures the level of user satisfaction and perception of the product's interface and functionality (Prayoga & Kristiana, 2024).

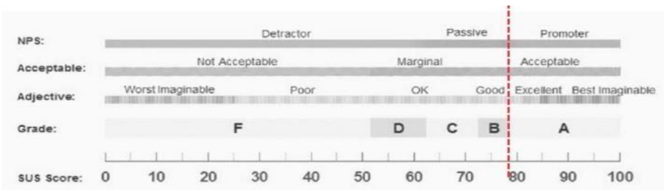

Figure 5. Evaluation Assessment Score Using The SUS Method

The evaluation results showed an average score of 77, which is in the acceptability range with an acceptable category, a grade scale with a B category, and an adjective rating of excellent. The highest scores in the evaluation were obtained for the indicators of ease, features, consistency, and speed, while the lowest score was for the indicator of getting used to the system before using the system. Respondents also provided input for the development of the CDSS system with the addition of more comprehensive features to increase efficiency and effectiveness.

3.2. Discussion

Determining the Underlying Cause of Death (UCOD) at Embung Fatimah Regional General Hospital in Batam faces challenges in terms of human resources, namely that reporting officers still rely on the doctor's final diagnosis without implementing international codification rules. This is in line with research (Zahra et al., 2022) which revealed that inaccuracy in coding the cause of death reached 22.8%. Meanwhile, according to research [7], 56.5% of inaccurate cause of death codes were caused by officers not fully understanding the procedures or correct methods for codifying mortality. In addition, the lack of specific training on mortality codification is also an obstacle in improving the accuracy of UCOD determination (Rusdi et al., 2022). Research by Rina Andalia and Elsari found that inaccurate diagnosis codes for causes of death were caused by several factors: staff had not attended workshops/training on the coding rules for the underlying cause of death, the absence of MMDS tables, files that did not contain the diagnosis code for the underlying cause of death, and the absence of a standard operating procedure (SOP) for coding underlying causes of death in the ICD-10 Volume 2 (Andalina & Elsari, 2019) .

The challenges from the material aspect include incomplete medical resumes, which make it difficult for officers to understand the patient's condition history. The unavailability of medical certificates for the cause of death also poses a barrier because the reporting process is not standardized. In line with the results of research (Lavender et al., 2023), it shows that incomplete filling in medical resumes is caused by a lack of knowledge, commitment, motivation, and high workload. In addition, research (Marwin et al., 2024) also states that the absence of a cause of death column according to ICD-10 guidelines on medical certificates can result in inaccurate determination of the underlying cause of death, resulting in mortality data being less than optimal and less reliable for health planning. The third challenge comes from the work procedure aspect (method), namely the lack of implementation of mortality codification rules based on international standards, so that the reporting process is not systematic and consistent. Most death certificates also do not match the underlying cause of death because hospitals have not yet implemented mortality rule guidelines and MMDS tables comprehensively, resulting in low accuracy in determining the UCOD and affecting the quality of mortality data.

Interview results indicated that users expected the CDSS system to include mortality codification rules, MMDS tables, and recommendation features that generate mortality rules. This requirement suggests that the system must be designed to suit user workflows, consistent with research showing that user-needs-based systems are proven to be more effective and easily accepted

(Nugroho et al., 2020). According to (World Health Organization, 2010), the MMDS table is used to assist in determining the correct UCOD and the appropriate multiple cause codes. This decision table is a collection of lists that provide guidance and direction in applying the selection and modification rules published in ICD-10 Volume 2. This decision table is very useful in assisting coders with determining which sequences can and cannot be used. Therefore, to minimize the number of inaccurate codes for the primary cause of death, coders must use ICD-10 Volume 2 and the MMDS table as cross-checking tools (Patricia et al., 2023).

The CDSS for determining UCOD was designed to consist of flowcharts, use case diagrams, activity diagrams, class diagrams, data flow diagrams, and a prototype. The prototype features included a warning about inaccurate cause of death coding and recommendations for mortality codification rules. This design also aligns with research explaining that an ideal CDSS has five main components: a database, knowledge base, instrument, inference engine, and user interface, all of which are included in the prototype (Singgih et al., 2024).

In the final action research stage, the researcher conducted an evaluation to obtain user assessments regarding the usability of the designed system using the SUS (System Usability Scale) evaluation method. The evaluation stage was carried out after the CDSS feature had been designed and users could see the design overview through the user interface design with the assumption that through the user interface design users could feel the performance of the CDSS feature (Pradita et al., 2023). The evaluation of the CDSS system using SUS resulted in a score of 77, which is at the Acceptability level, grade B, and an excellent adjective rating. This score is in the range of 72.6–84, which is included in the category of usable with a good user experience (Damayanti et al., 2024). Based on respondents' suggestions, the system should be developed with more complete features to be more efficient and effective. This is in line with research that states that many systems are not well received by users because their features are inaccurate and incomplete (McGraw & Harbison, 2020). User evaluation is very important in system design to align with the main purpose of the CDSS, which is to assist healthcare providers in decision-making, with knowledge integrated into the system, which aims to prevent medical errors and provide automated recommendations based on patient medical records (Gholamzadeh et al., 2023). Clinical Decision Support Systems (CDSS) have been implemented in healthcare for decades. Systematic reviews of CDSS have shown significant improvements in the quality of care (Cockburn et al., 2024).

4. Conclusions

Challenges in determining the Underlying Cause of Death (UCoD) at Embung Fatimah Hospital, Batam, are seen from the human aspect, namely the lack of understanding of reporting officers and the absence of special training in mortality codification, secondly, the material aspect is the incompleteness of the medical resume and the absence of a medical certificate for the cause of death, the method aspect has not been optimally implemented according to international codification rules. CDSS is designed using a UML modeling approach that includes flowcharts, use case diagrams, activity diagrams, class diagrams, data flow diagrams, and prototype creation. Evaluation with the System Usability

Scale (SUS) produces a score of 77, which can be categorized as acceptable with a grade B and an excellent rating. For further researchers, it is recommended to develop a more complex decision-making support system that can be implemented and integrated with Electronic Medical Records (EMR) or Health Information System to support the real-time mortality coding process and minimize errors in determining mortality coding.

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Institutional Review Board Statement: The study was approved by The Institutional Ethics Committee of Awal Bros University with number 0035/UAB1.20/SR/KEPK/05.25.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data presented in this study are available on request from the corresponding author. The data are not publicly available due to ethical and privacy concerns related to patient information.

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Conflicts of Interest: The authors declare no conflict of interest.

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