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Intensive Care Information System Impacts

Asghar Ehteshami[1], Farahnaz Sadoughi[2], Maryam Ahmadi[2]; Parviz Kashefi[3]
Department of Health Information Management, School of Health Management and Information Sciences, Tehran University of Medical Sciences, Tehran, Iran[1]
Department of Health Information Management, School of Health Management and Information Sciences, Tehran University of Medical Sciences, Tehran, Iran[2]
Department of Intensive Care Medicine and Anesthesia, Faculty of medicine, Isfahan University of Medical Sciences, Isfahan, Iran[3]

Corresponding Author: Associate prof. Farahnaz Sadoughi, PhD. Department of Health Information Management, School of Health Management and Information Sciences, TUMS, No. 6, Rashid Yasemi St., Vali-e-asr Ave., Tehran, Iran. Email: f-sadoughi@tums.ac.ir

Original Paper
ABSTRACT
Introduction: Today, intensive care needs to be increased with a prospect of an aging population and socioeconomic factors influencing health intervention, but there are some problems in the intensive care environments, it is essential to resolve. The intensive Care information system has the potential to solve many of ICU problems. The objective of the review was to establish the impact of intensive care information systems on the practitioners practice, patient outcomes and ICU performance. **Methods:** Scientific databases and electronic journal citations was searched to identify articles that discussed the impacts of intensive care information system on the practices, patient outcomes and ICU performance. A total of 22 articles discussing ICIS outcomes was included in this study from 609 articles initially obtained from the searches. **Results**: Pooling data across studies, we found that the median impact of ICIS on information management was 48.7%. The median impact of ICIS on user' outcomes was 36.4%, impact on saving tips by 24%, clinical decision support by a mean of 22.7%, clinical outcomes improved by a mean of 18.6%, and researches improved by 18%. **Conclusion:** The functionalities of ICIS are growing day by day and new functionalities are available with every major release. Better adoption of ICIS by the intensive care environments emphasizes the opportunity of better intensive care services through patient oriented intensive care clinical information systems. There is an immense need for developing guidelines for standardizing ICIS to to maximize the power of ICISs and to integrate with HISs. This will enable intensivists to use the systems in a more meaningful way for better patient care. This study provides a better understanding and greater insight into the effectiveness of ICIS in improving patient care and reducing health care expenses.
Key words: ICU, ICIS, Information System, Outcome, Impact.

1. INTRODUCTION

Today, intensive care needs to be increased with a prospect of an aging population and socioeconomic factors influencing health intervention, and there are some problems in the ICUs, it is essential to resolve (1, 2, 3); Such as: Beds and skilled manpower shortcoming, Exorbitant cost of treatment, High rates of mortality, Severe Nosocomial infections, High LOS, Low compliace with standards, Low quality of care and improvements, Epidemic of medical and medication errors, Poor coordination of intensive care team, and the lack of information required for clinical and managerial decisions (4, 5, 6). Also, Some problems must be considered such as automatic scoring systems failure to predict disease severity and mortality, real time documentation of clinical data, Inefficiency of integrated clinical alerts, Significant clinical workflow interruptions, and Resource constraints (7, 8, 9).

In developing countries, not to provide the information required by health plans often lead to unbalanced allocation of resources (10-12). Some factors affecting the quality of intensive care are as the followings: Lack of accurate information upon infections and its inflicted heavy losses in lives and property in intensive care, Irrational prescribing antibiotics in the ICU, ICU Nurses great errors in the calculation of the drugs dosage, inaccessibility of standard clinical guidelines and knowledge at the point of care, and lack of identifiable factors can increase ICU mortality (13-14). ICIS has the potential to improve Intensive care (15, 16) and is considered as the necessary solution for the Intensive care clinical practice (16, 17). At the point of care, this system can perform multiple tasks: Storing and processing Clinical data and transform it to the suitable formats for clinical decision making, Bringing distant data to the bedside through an integrated HIS, Monitoring vital parameters and detecting the specific problems, reminding guidelines to intensive care team, improving decisions and clinical guidelines fulfillment, reporting resources utilization and epidemiology, and allow comparing of hospital costs (18-19). In addition, This system is responsible for other duties including interface with bedside devices, physiological data capturing automatically, computerized physician order entry, simplifying and effecting processes, clinical alerting, Reducing diagnosis and treatment time and optimizing them, and preventing of common medication errors and adverse effects in ICU (4, 17). Also, the following functions are per-

formed by ICISs: Improving medication safety by BCMA, reducing interruptions, appropriate tracking and improving quality of care, reducing costs, reducing mortality and morbidity rates, reducing the nutritional calculation time, reducing ICU-LOS, controlling processes and clinical instabilities, controlling personal therapeutic styles, automatic charting of patient data and eliminating redundancies, increasing direct care time, and better coordinating between caregivers (15, 16, 17, 18, 19). ICIS can improve quality of care by using sensor technology in real-time monitoring and analyzing activities and clinical staff training, real-time access to the laboratory results at the point of care and performing many of the tests on the patient's bedside, stoke control and reducing the risk of ICU requirements lacks. Using handheld computers for fast access to patient information, reference information, guidelines, formularies, and tracking the educational experience of learners and linking with a CIS, Graphical display of physiological data and transmit the data to the central knowledge base systems for medical reasoning and hence, reducing the need for mechanical ventilation and reducing mortality rates (18, 19, 20, 21, 22). This literature review concentrated on scientific articles and conducted a critical analysis of the methods and results of each article that met the inclusion criteria in order to better understand the impact of an ICIS on these variables. Current gaps in the literature are highlighted and directions for future research are suggested.

2. METHODS

In this study, we present a literature review of Intensive Care Information System impacts. The original review considered only English language publications. Scientific databases and electronic journals citations including PubMed, Science Direct, Cochrane Library, Wiley, Wiley InterScience, Wiley Cochrane Library, Ebsco, MD Consult, Web of Science, Web of knowledge, Up To Date, Mosby Nursing Consult, Proquest, Scopus, Elsevier, Springer, Springer and Kluwer, Ovid, Oxford Journals, Thieme, American Institute of Physics (AIP), Biological abstracts, CINAHL, Google scholar, and IEEE Xplor were the starting point for the search which searched in May 2012 for articles that discuss the impacts of Intensive Care Information System in all areas. The MeSH vocabulary, which is used to index MEDLINE articles, does not contain "Intensive care Information System" or "Critical Care Information System". However, since the MeSH terms "critical care" and "Intensive Care" are synonymous, the terms "Intensive Care Information System", "Critical Care Information System" and their abbreviations ("CCIS" and "ICIS" [All Fields]) were used to search the articles with a focus on the impacts of this system. The search criteria did not include any limitation on publication date. The reference lists of included articles were also searched systematically. The particular difficulties of searching the Intensive care information system literature are the lack of full text for much of the work.

Inclusion/Exclusion Criteria

This study mainly focused on the impact of intensive care software within the scope of health care, especially hospital. As such, the inclusion criteria for the articles were the followings:

Type of Settings: The type of settings included was Intensive Care units.

Type of Intervention: Intensive Care Information System includes all qualified Information systems and software which were implemented in intensive care units, especially Critical Care Information System and Patient Data Management System.

We excluded the following systems: a) Systems designed for roistering or workload measurement; Such as Nursing Management System, Nursing record system, Workload management system; b) Some generally used technologies such as Artificial intelligence, Barcode Medication administration, Clinical information technology, Telemedicine, Medical informatics, Handheld Computers

Systems generally used in hospitals and not specifically in ICU; like Clinical decision Support systems, Clinical Information System, Computerized Medical Records, Computer generated reminders, Computerized provider order entry, Electronic Medical Records, Electronic Patient Records System, Medical knowledge based system, Real time data acquisition system, Patient Medical Records, Uniform diagnostic coding system, Rapid response system, Picture Archiving and Communication System, Medical Information System, Clinical management database Calculation systems such as Web based insulin dose calculator, Critical Care Computing Scoring and prediction systems such as Logistic organ dysfunction score, Prediction Models

Alerting systems such as Electronic alerting, Wireless alert system

Conventional documentation systems such as Electronic documentation system, Other Intensive Care systems like Critical Care network, Digital ICU system, ICU safety reporting system, Intensive care monitoring (system), National ICU dataset

Emergency information system

Types of outcome: We included studies if they gave outcomes such as clinical outcomes, saving tips, information management, clinical decision support, improving researches, and user outcomes (Figure 1).

Literature screening: During the search, we found 609 manuscripts (Table 1). We reviewed the criteria for inclusion and exclusion of articles in two steps. In the first step, we screened titles for duplicate articles and the study criteria that 452 articles excluded. In the second step, we reviewed the inclusion and exclusion criteria (setting, intervention, outcomes) in 157 potentially relevant full texts and the abstracts that 135 articles excluded: (a) No access to 37 full texts after contact the author three times. (b) Not focus on the Intensive Care Information system in from 98 potentially article And, at the end step, we reviewed articles' bodies. Finally, 22 articles included in our study.

Data collection and analysis: Two reviewing authors (in two pairs) reviewed all relevant articles and independently assessed the quality of each study and extracted relevant data on the impacts of ICIS in them, resolving any differences by discussion among all reviewing authors.

We entered extracted data in data extraction form, designed in Spss v. 20 software, and analyzed it with descriptive statistics.

3. RESULTS

The literature searches resulted in a total of 609 articles, which were then initially screened based on the titles and duplication, resulting in the exclusion of 452 articles. The remaining 157 articles were then reviewed in full text and abstract, and 135 articles were excluded because in 37 articles we did not access to full text after even contact the authors after 3 times, and, they did not have focus on Intensive Care Information System but used this system for other purposes. A total of 22 articles, discussing Intensive care Information System, Critical Care Information System, and Patient Data Management System, met the eligibility criteria. The impacts were grouped into six groups by system outcomes: (1) Clinical outcomes, (2) Information management, (3) Saving tips, (4) Clinical decision support, (5) User outcomes, and (6) Improving researches. Some outcomes fall into more than one group; such as "clinical calculating". Pooling data across studies, we found that the median impact of ICIS on information management was 48.7%. The median impact of ICIS on user' outcomes was 36.4%, impact on saving tips by 24%, clinical decision support by a mean of 22.7%, clinical outcomes improved by a mean of 18.6%, and researches improved by 18%.

4. CLINICAL OUTCOMES

The Clinical outcomes of intensive care information system were discussed in 21 out of the 22 articles reviewed (Table 2). Of these, according to the outcomes order of priority, 14 articles reported the improving quality of care (2, 3, 4, 5-15), 10 articles discussed the improving ICU Performance (2, 5-7, 11-13, 15-18), and other clinical outcomes were as follows: eight articles on the reducing medical errors (2, 5, 7-9, 11, 15, 17), seven articles on the presenting clinical alerts (3, 5, 6, 8, 11, 15, 18), six articles on the evaluating quality of care (2, 8, 13, 15, 17, 19), five articles on the clinical calculating (5, 7, 16, 18, 20), five articles on the improving medication administration (7, 8, 11, 15, 21), four articles on the interfacing with clinical devices (3, 8, 9, 21), four articles on the patient tracking (2, 5, 11, 15), four articles on the predicting patient outcome (2, 8, 16, 20), four articles on the providing tele-care (8, 13, 15, 19), four articles on the specifying patient needs (8, 13, 16, 17), three articles on the reducing clinical risk and improving patient safety (2, 8, 9), three articles on the antibiotic management (5, 15, 16), three articles on the overview patient old and new conditions (13, 16, 21), three articles on the improving (multidisciplinary) communication (9, 13, 22)", three articles on the care planning (9, 13, 19), two articles on the careful analysis of the care process (5, 13), two articles on the standardizing of care (13, 14), one article on the clinical consultation (2), one article on the improving evidence based medicine (8), one article on the stratifying mortality risk (8), and one article on the reducing mortality (17)". Content analysis of the study showed that the quality of intensive care improved by 64%, ICU Performance improved by 45%, medical errors reduced by 36%, in 32% of cases the clinical alert presented, the quality of care evaluation facilitated in the 27% of cases, the clinical calculation was performed and medication administration improved in 23% of cases. Also, ICIS interfaced with clinical devices, tracked the patients, specified their needs, and predicted patient outcome as well as providing tele-care in 18% of cases. Furthermore, ICIS reduced clinical risk, improved patient safety, managed antibiotics, facilitated patient old and new conditions overviews, improved multidisciplinary communications and planed patient care in 14% of cases. In 9% of cases, moreover, ICIS standardized intensive care as well as careful analyzing of the care process. It stratified mortality risk, reduced it,

Database or e-Journal	Number of articles
Web of science	18
Pub Med	10
Science Direct	75
Scopus	14
Proquest	11
Springer	33
American Institute of Physics (AIP)	17
Biological Abstracts	1
CINAHL	7
Cochrane Library	1
Ebsco	20
Elsevier	5
Google scholar	181
IEEE Xplor	4
MD consult	6
Mosby nursing consult	3
OVID	74
Oxford journals	1
Springer and Kluwer	5
Thieme	37
UP to Date	22
Wiley	27
Wiley Cochrane library	1
Wiley InterScience	36

Table 1. results of primary search in the databases and e-journals

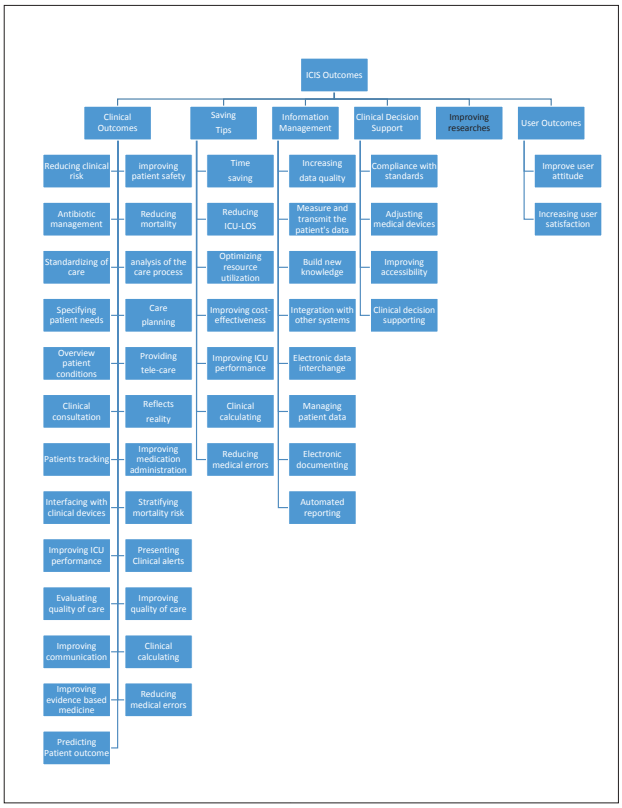

Figure 1: Intensive Care Information System Impacts

Clinical Outcomes	Articles							
	Ballermann et al., [75] 2011	Skouroliakou et al., [35] 2008	Steurbaut et al., [58] 2012	Hristoskova et al., [68] 2010	Junger et al., [59] 2001	Colpaert et al., [60] 2010	Meyfroidt et al., [61] 2009	Ballermann et al., [62] 2009
Antibiotic management	-	-	*	*	-	-	-	-
Reducing mortality	-	-	-	-	-	-	-	-
Standardizing of care	-	-	-	-	-	-	-	-
Careful analysis of the care process	-	-	*	-	-	-	-	-
Specifying patient needs	-	-	-	*	-	-	*	-
Care planning	-	-	-	-	-	-	-	*
Overview patient old and new conditions	-	-	-	*	-	-	-	-
Providing tele-care	-	-	-	-	-	-	*	-
Clinical consultation	-	*	-	-	-	-	-	-
Reflects reality	-	-	-	-	-	-	-	-
Patients tracking	-	*	*	-	-	-	-	-
Improving medication administration	-	-	-	-	-	*	*	-
Interfacing with clinical devices	-	-	-	-	-		*	*
Stratifying mortality risk	-	-	-	-	-	-	*	-
Improving ICU performance	-	*	*	*	*	*	-	-
Presenting Clinical alerts	-	-	*	-	*	-	*	-
Evaluating quality of care	-	*	-	-	-	-	*	-
Improving quality of care	-	*	*	-	*	*	*	*
Improving communication	*	-	-	-	-	-	-	*
Improving evidence based medicine	-	-	-	-	-	-	*	-
Reducing clinical risk	-	*	-	-	-	-	*	*
Clinical calculating	-	-	*	*	-	*	-	-
Reducing medical errors	-	*	*	-	-	*	*	*
Predicting Patient outcome	-	*	-	*	-	-	*	-

Table 2. Description of the 22 studies' clinical outcomes

and improved clinical consultation as well as evidence based medicine and, too. We found a significant correlation between clinical outcomes and the followings: saving tips outcomes (r = 0.755, Sig. = 0.000), information management outcomes (r = 0.622, Sig. = 0.002) and clinical decision support outcomes (r = 0.509, Sig. = 0.016), but, no significant correlation with user' outcomes (r = 0.414, Sig. = 0.055) and researches improvement (r = 0.360, Sig. = 0.098).

Information Management

A total of 7 Information management outcomes of intensive care information system was discussed in 20 articles (Table 3). Of these, according to the outcomes order of priority, 18 articles focused on the electronic documenting and automated reporting (2, 3, 5-11, 13, 15-22), 18 articles on the Managing patient data (1, 2, 3, 5-11, 13-16, 19-22), 12 articles on the increasing data quality (2, 3, 7, 8, 11, 13-17, 19, 21), nine articles on the electronic data interchange (2, 5-11, 16), seven articles on the patient's data measure and transmit (2, 5, 6, 10, 11, 13, 20), six articles on the ICIS integration with other information systems (1, 6-9, 11), and, six articles on the building new knowledge from the gathered data (2, 5-8, 21). Analysis of the content showed that ICIS documented clinical data electronically, automated reporting and managed patient data in 82% of cases. It, also increased data quality and interchanged data electronically in 55% and 41% of cases, respectively. ICIS, moreover, measured and transmitted patient data in 32% of cases, integrated with other information systems and built new knowledge from the gathered data in 27% of cases. We found no significant correlation between information management outcomes and the followings: user' outcomes (r = 0.303, Sig. = 0.171), clinical decision support outcomes (r = 0.316, Sig. = 0.152), researches improvement outcomes (r = 0.214, Sig. = 0.338). But, we found a significant correlation between information management outcomes and saving tips outcomes (r = 0.453, Sig. = 0.034).

Saving tips

Saving tips outcomes in ICIS were discussed in 17 articles (Table 4). Of these, 11 articles discussed the improving cost-effectiveness (2, 3, 5, 7, 8, 10, 13-16, 21) 10 articles on the time saving (3, 4, 5, 6, 8, 9, 14, 15, 18, 20), eight articles on the optimizing resource utilization (2, 7, 8, 11, 13, 15, 16, 18), two articles on the reducing medical errors (2, 8), two articles on the clinical Calculating (5, 20), two articles on the reducing ICU length of stay (LOS) (2, 15), and, two articles on the improving ICU performance (8, 15). Content analysis of the study showed that ICIS improved cost-effectiveness of intensive care and time saving, respectively in 50% and 45% of cases. Also, it optimized resource utilization, reduced medical errors as well as ICU LOS, and improved ICU performances by 36%, 9% and 9%, respectively. We found a significant correlation between saving tips outcomes and the followings: user' outcomes (r = 0.458, Sig. = 0.032) and researches improvement outcomes (r = 0.426, Sig. = 0.048), but no significant correlation with clinical decision support outcomes (r = 0.418, Sig. = 0.053).

Clinical decision support

Clinical Decision Support in intensive care information systems was discussed in the 13 articles (Table 5). Of these, 10 articles discussed clinical decision support (1, 5, 6, 8, 11, 13, 15, 16, 19, 21), six articles on the improving accessibility (1, 6, 8, 13, 18, 22), three articles on the Compliance with standards set (8, 14, 15) and one article on the adjusting medical devices (8).

According to analysis of content, ICIS supported clinical decisions in 45% of cases. It also improved practitioners' accessibility to the information, compliance with standards and adjusted medical devices, respectively, by 27%, 14%, and 5%. We found a significant correlation between clinical decision support outcomes and user' outcomes (r = 0.496, Sig. = 0.019), but no significant correlation with research improvement outcomes (r = 0.280, Sig. = 0.207).

User Outcomes

13 articles discussed user outcomes

Clinical Outcomes	Articles							
	Berger et al., [71] 2006	Röhrig et al., [72] 2009	Bosman et al., [42] 2003	Meyfroidt et al., [74] 2009	Decruyenaere et al., [64] 2003	Hravnak et al., [33] 1992	Röhrig et al., [63] 2011	Arts et al., [69] 2002
Antibiotic management	*	-	-	-	-	-	-	-
Reducing mortality	-	-	-	-	-	-	-	*
Standardizing of care		-	-	-	-	-	-	-
Careful analysis of the care process	-	-	-	-	-	-	-	-
Specifying patient needs	-	-	-	-	-	-	-	-
Care planning	-	*	-	-	-	-	-	-
Overview patient old and new conditions	-	-	-	*	-	-	-	-
Providing tele-care	*	*	-	-	-	-	-	-
Clinical consultation	-	-	-	-	-	-	-	-
Reflects reality	-	-	-	-	-	-	-	-
Patients tracking	*	-	-	-	*	-	-	-
Improving medication administration	*	-	-	*	*	-	-	-
Interfacing with clinical devices	-	-	-	*	-	-	-	-
Stratifying mortality risk	-	-	-	-	-	-	-	-
Improving ICU performance	-	-	-	-	*	-	-	*
Presenting Clinical alerts	-	-	*	-	-	-	-	-
Evaluating quality of care	*	*	-	-	-	-	-	*
Improving quality of care	*	-	*	-	*	-	*	-
Improving (multidisciplinary) communication	-	-	-	-	-	-	-	-
Improving evidence based medicine	-	-	-	-	-	-	-	-
Reducing clinical risk & improving patient safety	-	-	-	-	-	-	-	-
Clinical calculating	-	-	-	-	-	-	-	-
Reducing medical errors	*	-	-	-	*	-	-	*
Predicting Patient outcome	-	-	-	-	-	-	-	-

Table 2. Description of the 22 studies' clinical outcomes (continued)

of ICIS (Table 5). All of these, discussed the increasing user satisfaction (1, 2, 6, 8-11, 13-16, 18, 22). Also, three of these focused on the improving user attitude (2, 8, 14). Content analysis of the study showed that ICIS increased the users' satisfaction by 59%. It also improved their attitude in 14% of cases. We found a significant correlation between user' outcomes and the followings: clinical decision support outcomes (r = 0.496, Sig. = 0.019) and saving tips (r = 0.458, Sig. = 0.032), but, we found no significant correlation between user' outcomes and the followings: research improvement outcomes (r = 0.359, Sig. = 0.101), information management outcomes (r = 0.303, Sig. = 0.118) and clinical outcomes (r = 0.414, Sig. = 0.055).

Improving research

Four articles reported impact of intensive care information system on the improving research (2, 8, 18, 21) (Table 5). According to an analysis of the content, ICIS, in 18% of cases, helped to perform researches.

We found a significant correlation between research improvement outcome and saving tips (r = 0.426, Sig. = 0.048), but we found no significant correlation with the followings: clinical decision support outcomes (r = 0.280, Sig. = 0.207), user' outcomes (r = 0.359, Sig. = 0.101), information management outcomes (r = 0.214, Sig. = 0.338) and clinical outcomes (r = 0.362, Sig. = 0.098).

5. DISCUSSION

For several years, the number of intensive care clinical information systems has been spreading rapidly. Some of the most putative appealing advantages of such systems are: electronic documentation and automated reporting, patient data management, improving practitioners' satisfaction, quality of care as well as data, increasing cost effectiveness, time saving, decision supporting and improving researches. ICIS has many clinical outcomes. According to the study, this system improves the quality of care and the performance of the ICU. Also, it is able to provide clinical alerts and thus considerably reduce medical errors. In addition, the system not only provides an eval-

Studies	Increasing data quality	Measure and transmit the patient's data	Build new knowledge from the gathered data	Integration with other information system	Electronic data interchange	Managing patient data	Electronic documentation and automated reports
Berger et al., [71] 2006	-	-	-	-	-	-	*
Röhrig et al., [72] 2009	*	-	-	-	-	*	*
Bosman et al., [42] 2003	*	-	-	-	-	*	*
Meyfroidt et al., [74] 2009	*	-	*	-	-	*	*
Decruyenaere et al., [64] 2003	*	*	-	*	*	*	*
Hravnak et al., [33] 1992	-	-	-	*	-	*	-
Röhrig et al., [63] 2011	-	*	-	-	*	*	*
Arts et al., [69] 2002	*	-	-	-	*	*	*
Ballermann et al., [75] 2011	-	-	-	-	-	*	*
Skouroliakou et al., [35] 2008	*	*	*	-	*	*	*
Steurbaut et al., [58] 2012	-	*	*	-	*	*	*
Hristoskova et al., [68] 2010	*	-	-	-	-	*	*
Junger et al., [59] 2001	-	*	*	*	*	*	*
Colpaert et al., [60] 2010	*	-	*	*	*	*	*
Meyfroidt et al., [61] 2009	*	-	*	*	*	*	*
Ballermann et al., [62] 2009	-	-	-	*	*	*	*
Ilan et al., [65] 1012	-	-	-	-	-	-	-
Mador et al., [44] 2009	-	-	-	-	-	-	-
Slosarik et al., [70] 1980	*	-	-	-	-	-	*
De Keizer et al., [66] 1998	*	*	-	-	-	*	*
Junger et al., [73] 2002	-	*	-	-	-	*	*
LISING et al., [67] 2005	*	-	-	-	-	*	-

Table 3. Description of the 22 studies' information management outcomes

Clinical Outcomes	Articles					
	Ilan et al., [65] 2012	Mador et al., [44] 2009	Slosarik et al., [70] 1980	De Keizer et al., [66] 1998	Junger et al., [73] 2002	LISING et al., [67] 2005
Antibiotic management	-	-	-	-	-	-
Reducing mortality	-	-	-	-	-	-
Standardizing of care	-	-	-	*	-	*
Careful analysis of the care process	-	-	-	*	-	-
Specifying patient needs	-	-	-	*	-	-
Care planning	-	-	-	*	-	-
Overview patient old and new conditions	-	-	-	*	-	-
Providing tele-care	-	-	-	*	-	-
Clinical consultation	-	-	-	-	-	-
Reflects reality	-	-	-	-	-	-
Patients tracking	-	-	-	-	-	-
Improving medication administration	-	-	-	-	-	-
Interfacing with clinical devices	-	-	-	-	-	-
Stratifying mortality risk	-	-	-	-	-	-
Improving ICU performance	*	-	*	*	-	-
Presenting Clinical alerts	-	-	*	-	-	-
Evaluating quality of care	-	-	-	*	-	-
Improving quality of care	*	*	-	*	-	*
Improving (multidisciplinary) communication	-	-	-	*	-	-
Improving evidence based medicine	-	-	-	-	-	-
Reducing clinical risk & improving patient safety	-	-	-	-	-	-
Clinical calculating	-	-	*	-	*	-
Reducing medical errors	-	-	-	-	-	-
Predicting Patient outcome	-	-	-	-	*	-

Table 2. Description of the 22 studies' clinical outcomes (continued)

In addition, ICIS is able to save time and to increase the cost-effectiveness of intensive care as well as optimizing resource utilization and reducing ICU LOS. This system enables clinicians to improve accessibility to patient information. It is able to improve the compliance with standards as well as adjusting medical devices. Furthermore, ICIS increases the satisfaction of nurses and intensivists, and improves their attitude. Also, it facilitates performing the clinical researches. There is the some significant correlation between various impacts of ICIS. We think if clinical outcomes improve in ICIS, saving tips, information management and clinical decision support outcomes will improve. Also, if we encourage saving tips outcomes in ICIS, it will be improved clinical, information management and users' satisfaction as well as improving researches. Moreover, if we strengthen the information management outcomes, clinical outcomes and Savings tips will improve, too. In addition, If in the system upgrading, we have special attention to clinical decision support, thus, the nurses and intensivists satisfaction will be

uation of quality of care, but also performs the clinical calculations as well as improving medication administration, manages antibiotics and interface with medical devices. It is able to predict patient outcome(s), determine his/her needs and track him/her and also it can provide tele-care in some cases. In addition, it is able to reduce clinical risk and thus bring patient safety. It also provides reviews of previous and current status of the patient to practitioners, plans patient care, improves multidisciplinary communication, standardizes the intensive care and analyzes the care process carefully. ICIS can stratify mortality risk and thus reduce the ICU mortality rate. It moreover is able to improve Evidence-based medicine as well as medical consultations. ICIS impacts on information management. It measures some of patient data and increases their quality as well as capturing them. It integrated with other hospital existing information systems; thus, exchanges the data between them and builds new knowledge from the pooled data.

Studies	Time saving	Reducing ICU-LOS	Optimizing resource utilization	Improving cost-effectiveness	Improving ICU performance	Clinical calculating	Reducing medical errors
Berger et al., [71] 2006	*	-	*	-	-	-	-
Röhrig et al., [72] 2009	-	-	-	-	-	-	-
Bosman et al., [42] 2003	*	-	-	*	-	-	-
Meyfroidt et al., [74] 2009	-	-	-	*	-	-	-
Decruyenaere et al., [64] 2003	-	-	*	-	-	-	-
Hravnak et al., [33] 1992	-	-	-	-	-	-	-
Röhrig et al., [63] 2011	-	-	-	*	-	-	-
Arts et al., [69] 2002	-	-	*	*	-	-	-
Ballermann et al., [75] 2011	-	-	-	-	-	-	-
Skouroliakou et al., [35] 2008	-	*	*	*	-	-	*
Steurbaut et al., [58] 2012	*	-	-	*	-	*	-
Hristoskova et al., [68] 2010	*	*	*	*	*	-	-
Junger et al., [59] 2001	*	-	-	-	-	-	-
Colpaert et al., [60] 2010	-	-	*	*	-	-	-
Meyfroidt et al., [61] 2009	*	-	*	*	*	-	*
Ballermann et al., [62] 2009	*	-	-	-	-	-	-
Ilan et al., [65] 1012	-	-	-	-	-	-	-
Mador et al., [44] 2009	*	-	-	-	-	-	-
Slosarik et al., [70] 1980	-	-	-	-	-	-	-
De Keizer et al., [66] 1998	-	-	*	*	-	-	-
Junger et al., [73] 2002	*	-	-	-	-	*	-
LISING et al., [67] 2005	*	-	-	*	-	-	-

Table 4. Description of the 22 studies' saving tips outcomes

Studies	Clinical decision support				Users		Research
	Compliance with standards	Adjusting medical devices	Improving accessibility	Clinical decision making	Improve user attitude	Increasing user satisfaction	Improving researches
Berger et al., [71] 2006	-	-	*	-	-	*	*
Röhrig et al., [72] 2009	-	-	-	-	-	-	-
Bosman et al., [42] 2003	-	-	-	-	-	-	-
Meyfroidt et al., [74] 2009	-	-	-	-	-	-	*
Decruyenaere et al., [64] 2003	-	-	-	*	-	*	-
Hravnak et al., [33] 1992	-	-	*	*	-	*	-
Röhrig et al., [63] 2011	-	-	-	-	-	*	-
Arts et al., [69] 2002	-	-	-	*	-	*	-
Ballermann et al., [75] 2011	-	-	*	-	-	*	-
Skouroliakou et al., [35] 2008	-	-	-	-	*	*	*
Steurbaut et al., [58] 2012	-	-	-	*	-	-	-
Hristoskova et al., [68] 2010	*	-	-	*	-	*	-
Junger et al., [59] 2001	-	-	-	*	-	*	-
Colpaert et al., [60] 2010	-	-	-	-	-	-	-
Meyfroidt et al., [61] 2009	*	*	*	*	*	*	*
Ballermann et al., [62] 2009	-	-	-	-	-	*	-
Ilan et al., [65] 1012	-	-	-	-	-	-	-
Mador et al., [44] 2009	-	-	-	-	-	-	-
Slosarik et al., [70] 1980	-	-	-	-	-	-	-
De Keizer et al., [66] 1998	-	-	*	*	-	*	-
Junger et al., [73] 2002	-	-	-	-	-	-	-
LISING et al., [67] 2005	*	-	-	-	*	*	-

Table 5. Description of the 22 studies' outcomes related to clinical decision support, researches, and users

provided as well as clinical outcomes.

5. CONCLUSION

The functionalities of the systems are growing day by day and new functionalities are available with every major release. The work of intensivists and ICU nurses is very specific in nature. ICIS enable for electronic documentation and automated reporting, patient data management, improving practitioners' satisfaction, quality of care as well as data, increasing cost effectiveness, time saving, decision supporting and improving researches. Better adoption of ICIS by the intensive care environments emphasizes the opportunity of better intensive care services through patient oriented intensive care clinical information systems, for example clinical decision making, clinical calculating, and remote monitoring of patients. There is an immense need for developing guidelines for standardizing intensive care applications so that the application is used seamlessly for ICU environment purposes and are integrated with HISs such as EMR and patient monitoring systems to maximize the power of ICISs. This will enable intensivists to use the systems in a more meaningful way for better patient care. Intensive care applications get more attention on hospital day by day; the full potential of ICIS has yet to be exploited.

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