INTENSIVE CARE INFORMATION SYSTEM IMPACTS

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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 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.

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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.
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, stroke 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 Xplore 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 documenta tion 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. The flow diagram of identifying eligible articles for this study is shown in Figure 2.

**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 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 planned patient care in 14% of cases. In 9% of cases, moreover, ICIS

| 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                  |
| Threame                                | 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

(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 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 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 planned patient care in 14% of cases. In 9% of cases, moreover, ICIS

Figure 1: Intensive Care Information System Impacts
standardized intensive care as well as careful analyzing of the care process. It stratified mortality risk, reduced it, 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 systems was discussed in 20 articles (Table 3). Of these, according to the outcomes order of priority, 18 articles focused on the electronic document and automated reporting (2, 3, 5-11, 13-15, 18-22), 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 48% 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 (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.

Table 2: Description of the 22 studies’ clinical outcomes

| Clinical Outcomes | Articles |
|-------------------|---------|
| Anticipating outcomes | Ballermann et al., 2010 |
| Reducing mortality | Hristos et al., 2001, Ballermann et al., 2010 |
| Standardizing of care | Meyerfroidt et al., 2006, Junger et al., 2009 |
| Careful analysis of the care process | Meyfroidt et al., 2009, Junger et al., 2009 |
| Specifying patient needs | Meyfroidt et al., 2009, Junger et al., 2009 |
| Care planning | Meyfroidt et al., 2009, Junger et al., 2009 |
| Overview patient data and new conditions | Colpaert et al., 2010, Steurbaut et al., 2011 |
| Patientizing time-care | Ballermann et al., 2010, Steurbaut et al., 2011 |
| Clinical consultation | Meyfroidt et al., 2009, Junger et al., 2009 |
| Reflects reality | Meyfroidt et al., 2009, Junger et al., 2009 |
| Patients tracking | Meyfroidt et al., 2009, Junger et al., 2009 |
| Improving medication administration | Meyfroidt et al., 2009, Junger et al., 2009 |
| Interfacing with clinical devices | Meyfroidt et al., 2009, Junger et al., 2009 |
| Strasifying mortality risk | Meyfroidt et al., 2009, Junger et al., 2009 |
| Improving ICU performance | Meyfroidt et al., 2009, Junger et al., 2009 |
| Preventing Clinical alerts | Meyfroidt et al., 2009, Junger et al., 2009 |
| Evaluating quality of care | Meyfroidt et al., 2009, Junger et al., 2009 |
| Improving quality of care | Meyfroidt et al., 2009, Junger et al., 2009 |
| Improving communication | Meyfroidt et al., 2009, Junger et al., 2009 |
| Improving evidence based medicine | Meyfroidt et al., 2009, Junger et al., 2009 |
| Reducing clinical risk | Meyfroidt et al., 2009, Junger et al., 2009 |
| Anticipating care taking | Meyfroidt et al., 2009, Junger et al., 2009 |
| Reducing medical errors | Meyfroidt et al., 2009, Junger et al., 2009 |
| Preventing patient outcome | Meyfroidt et al., 2009, Junger et al., 2009 |
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 Outcomes                        | Articles                                                                 |
|-----------------------------------------|--------------------------------------------------------------------------|
| Antimicrobial management                 | berger et al., 2006                                                      |
| Reducing mortality                       | Nowroozi et al., 2009                                                    |
| Standardization of care                  | Bosman et al., 2003                                                      |
| Care planning                            | Meyrick et al., 2009                                                    |
| Specifying patient needs                 | Decruyenaere et al., 2003                                                |
| Improving patients’ satisfaction         | Hravnak et al., 1992                                                    |
| Improving medication administration      | Nowroozi et al., 2009                                                    |
| Interfacing with clinical devices        | Röhrig et al., 2003                                                      |
| Straining mortality risk                 | Meyfroidt et al., 2003                                                   |
| Improving ICU performance                | Decruyenaere et al., 2003                                                |
| Presenting clinical alerts               | Hravnak et al., 1992                                                    |
| Evaluating quality of care               | Arts et al., 2002                                                        |
| Improving quality of care                | Kaesermann et al., 2002                                                  |
| Improving (multidisciplinary) communication | -                                                                       |
| Improving evidence based medicine        | -                                                                       |
| Measuring clinical risk as improving patient safety | -                                         |
| Clinical calculating                     | -                                                                       |
| Reducing medical errors                  | -                                                                       |
| Predicting patient outcome               | -                                                                       |

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

| Study | Increasing data quality | Measure and transfer 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., 2006 | - | - | - | - | - | - | - |
| Nowroozi et al., 2009 | - | - | - | - | - | - | - |
| Bosman et al., 2003 | * | - | - | - | - | - | * |
| Meyrick et al., 2009 | - | - | - | - | - | - | - |
| Decruyenaere et al., 2003 | - | - | - | - | - | - | - |
| Hravnak et al., 1992 | - | - | - | * | - | - | - |
| Nowroozi et al., 2009 | - | - | - | - | - | - | - |
| Arts et al., 2002 | * | - | - | - | - | - | * |
| Kaesermann et al., 2002 | - | - | - | - | - | - | - |
| Leenaarsma et al., 2006 | - | - | - | - | - | - | - |
| Skouroliakou et al., 2001 | - | - | - | - | - | - | - |
| Leenaarsma et al., 2002 | - | - | - | - | - | - | - |
| Meyrick et al., 2009 | - | - | - | - | - | - | - |
| Kaesermann et al., 2002 | - | - | - | - | - | - | - |
| Junger et al., 2001 | - | - | - | - | - | - | - |
| Lepage et al., 2002 | - | - | - | - | - | - | - |
| Meyrick et al., 2009 | - | - | - | - | - | - | - |
| Kaesermann et al., 2002 | - | - | - | - | - | - | - |
| Xin et al., 2012 | - | - | - | - | - | - | - |
| Mador et al., 2009 | - | - | - | - | - | - | - |
| Issar et al., 2009 | - | - | - | - | - | - | - |
| Lee et al., 2002 | - | - | - | - | - | - | - |
| Junger et al., 2002 | - | - | - | - | - | - | - |
| Lemo et al., 2005 | - | - | - | - | - | - | - |

Table 3. Description of the 22 studies’ information management outcomes
Table 4. Description of the 22 studies' clinical outcomes (continued)

| Clinical Outcomes                  | Ilan et al., ** 2012 | Mader et al., ** 2009 | Steenbank et al., * 1980 | Ue Keizer et al., ** 1998 | Junger et al., ** 2002 | Liaw et al., ** 2005 |
|------------------------------------|----------------------|-----------------------|---------------------------|---------------------------|-----------------------|----------------------|
| Antibiotic management              | *                    | *                     | -                         | -                         | -                     | -                    |
| Reducing mortality                 | *                    | *                     | -                         | -                         | -                     | -                    |
| Standardizing of care              | *                    | *                     | -                         | -                         | -                     | -                    |
| Careful analysis of the care process | *                   | *                     | -                         | -                         | -                     | -                    |
| Specifying patient needs           | *                    | *                     | -                         | -                         | -                     | -                    |
| Care planning                      | *                    | *                     | -                         | -                         | -                     | -                    |
| Overview patient and new conditions | *                   | *                     | -                         | -                         | -                     | -                    |
| Providing tele-care                | *                    | *                     | -                         | -                         | -                     | -                    |
| Clinical consultation              | *                    | *                     | -                         | -                         | -                     | -                    |
| Refeets reactly                    | *                    | *                     | -                         | -                         | -                     | -                    |
| Patients tracking                  | *                    | *                     | -                         | -                         | -                     | -                    |
| Improving medication administration| *                    | *                     | -                         | -                         | -                     | -                    |
| Interfacing with clinical devices   | *                    | *                     | -                         | -                         | -                     | -                    |
| Stratifying mortality risk         | *                    | *                     | -                         | -                         | -                     | -                    |
| Improving ICU performance          | *                    | *                     | -                         | -                         | -                     | -                    |
| Preventing clinical alerts         | *                    | *                     | -                         | -                         | -                     | -                    |
| Evaluating quality of care         | *                    | *                     | -                         | -                         | -                     | -                    |
| Improving quality of care          | *                    | *                     | -                         | -                         | -                     | -                    |
| Improving multidisciplinary        | *                    | *                     | -                         | -                         | -                     | -                    |
| communication                       | *                    | *                     | -                         | -                         | -                     | -                    |
| Improving evidence based medicine  | *                    | *                     | -                         | -                         | -                     | -                    |
| Reducing clinical risk and improving patient safety | * | * | - | - | - | - |
| Clinical calculating               | *                    | *                     | -                         | -                         | -                     | -                    |
| Reducing medical errors            | *                    | *                     | -                         | -                         | -                     | -                    |
| Predicting patient outcome         | *                    | *                     | -                         | -                         | -                     | -                    |

Table 2. Description of the 22 studies' saving tips outcomes

clinical alerts and thus considerably reduce medical errors. In addition, the system not only provides an evaluation 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.

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