2-23-2022

Tele-ICU in the Unites States: Is a cost-effective model?

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Recommended Citation
Michael Robie, E., Cole, S., Suwal, A., & Coustasse, A. (2022). Tele-ICU in the Unites States: Is a cost-effective model?. International Journal of Healthcare Management, 1-8.

TELE-ICU IN THE UNITES STATES: IS A COST-EFFECTIVE MODEL?

ABSTRACT

Introduction: The United States Society of Critical Care Medicine has announced a shortage of all critical care intensivists due to the increased need for critical care for the aging population with comorbidities and improved life expectancy. This shortage has led to tele-ICU programs that have allowed intensivists to care for patients simultaneously remotely. Methods: This study aimed to assess the potential for the hospital implementation of tele-ICU to determine its overall healthcare cost-effectiveness. The methodology was a review that followed a systematic search approach utilizing 42 sources. Results: The study findings showed that tele-ICU contributed to reduced hospital LOS by 36% and positive financial outcomes of return of investment and cost-effectiveness. These reduced LOS stay times have allowed for savings up to $11.5 million. Discussion: The Tele-ICU program's implementation has positively impacted financial and clinical areas, reducing mortality and reduced hospital LOS. Furthermore, it has reduced improved patient safety, care quality, and decreased ventilator days, contributing to a cost-efficient technology.

Keywords: Telehealth, Telemedicine, Tele-ICU, Critical care, Financial Impact, Cost, quality

INTRODUCTION Tele-ICUs has been defined as using an off-site command center by critical care intensivists and critical care nurses through real-time video or audio method. Tele-ICU critical care team have access to all patient data to provide appropriate treatment. As the United States (U.S.) had continued to age, there had been a noticeable increase in the Intensive Care Unit (ICU) beds utilization. [1] The intensive care department is the most expensive hospital department. In the U.S., the annual critical care medicine costs nearly doubled from $56.6 to an

estimated amount of $108 billion. [2] The U.S. Society of Critical Care Medicine has retorted there would be a shortage of all critical care intensivistsdue to the increased need for critical care for the aging population with comorbidities and improved life expectancy. From critical care medicine statistics 2018 data, more than five million patients have been admitted to ICUs throughout the U.S. every year. [3] Between 2000 to 2020 U.S. population over 65 years or older was projected to grow by 50%, as predicted by the U.S. Department of Health and Human Services. Approximately ICU-related admission has accounted for about one out of five deaths in hospitals. [4] The high rate has been due to the ICU stands one of the sites where medical errors have been most likely to occur because of the complexity of care, and the severely ill patient population undergoes multiple complex interventions at the same time, these patients were extremely vulnerable to experiencing adverse outcomes. [5] A 2011 review of hospital admission data from 29 states showed that 26.9% of hospital stays involved time in an ICU. The highest rate of ICU use was at 93.3% for respiratory disease with ventilator support.

Additionally, hospital Length of Stay (LOS) involved in ICU care was 2.5 times costlier than other hospital stays. [6] In the early 2000s, only 37% of all ICU patients in the U.S. were cared for by intensivists in general. [7] In2011, it was estimated that only 14% of ICUs practice a bedside, intensivist-led ICU model. [8] A shortage of intensivists has led to the development of tele-ICU programs that have allowed intensivists to care for patients simultaneously remotely. However, Tele-ICU programs have been expanding at a slower pace despite scant evidence on their effectiveness and cost-effectiveness. [9] As of 2018, only 26.5% of hospitals had initiated a tele-ICU service. [10] The cost of installing a tele-ICU has ranged from $2-$5 million for setting upwards to $1.5 million to operate it annually. [11] The high price of the initial set up has slowed the expansion and adoption of tele-ICU. Besides, other factors, such as state policies on

regulation, have slowed the adoption of tele-ICU. [12] As of late 2012, 42% of hospitals had adopted some form of telemedicine in their healthcare systems. It was found that rural hospitals were more likely to initiate a tele-ICU program with the desire to improve access.

Four ways that Tele-ICU teams have supplied services have been documented in the literature: 1) dissemination of evidence-based practice, 2) specialist advice and guidance, 3) supervision for physiological deterioration, and 4) collection, analysis, and quality performance reporting[46, 47]

APPs (NP, CNS, and PA roles) APPs have been being utilized as a flexible expert clinical

resource that supports the interprofessional team through direct care, surveillance, emergency response, and outcome optimization.

This study's research purpose was to assess the potential for the hospital implementation of tele-ICU to determine its overall healthcare cost-effectiveness.

METHODOLOGY

The methodology for this was a literature review, which followed a systematic search and analysis approach. This study’s primary hypothesis was that tele-ICU would be linked with lower ICU LOS and hospital mortality rates among critically ill patients.

Researchers studying telemedicine implementation typically compose their understanding of the challenges and factors influencing the adoption of technology by identifying and listing “barriers” and “benefits. For example, some enablers cited are developing organizational protocols, adequate funding and support, user training plans, and change management plans. Common barriers reported are lack of technological compatibility, resistance to change, scarcity of adequate reimbursement, lack of usability, and medico-legal and liability matters. . To

research the impact of tele-ICU implementation to improve healthcare practices and outcomes, it was primarily essential to identify and analyze its utilization and implementation in the current healthcare industry. Moreover, issues that could hinder its adoption must be discussed. By utilizing this approach, the benefits and barriers of using tele-ICU could be identified, and a determination could be made as to whether its use should be promoted. The utilization of this approach in several prior studies has supported the internal validity of this research framework. The systematic search and analysis of the literature was conducted in distinct stages as outlined by the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA) diagram (Figure 1[13]), including 1) Literature identification and collection, 2) Establishing inclusion and exclusion criteria, 3) Categorization of literature

Step 1: Literature identification and collection:

A mix of databases and online sources was used to compile a set of references covering academic peer-reviewed research and practitioner literature. It was believed that this approach would help create the most comprehensive and up-to-date review. The search engine utilized for this study were PubMed, EBSCOhost, Google Scholar, Google Search, ProQuest, and JSTOR. The most cited telehealth journals were searched: *Journal of Telemedicine and Telecare, Telemedicine Journal and e-Health, Telemedicine and e-Health,* and *Telemedicine Journal and professional journals as Critical care Medicine, Chest and others medical journals.* Relevant keywords (a combination of free-text and MeSH terms) were used in the database search included "telehealth" OR "telemedicine" OR" or telecare OR ehealth OR "tele-ICU AND "length of stay" OR "LOS" OR "mortality rates" OR "financial impact" OR "cost" OR "cost savings" OR "reimbursement" AND "Hospitals" AND "USA" were used to search for peer-reviewed literature.

Consequently, several published results were collected, which were then systematically processed (Figure 1). Since the search was related to telemedicine's history and its application in the ICU to ascertain the scope of data available and determine significant issues on this topic, financial statistics dominated the information found. To keep the review reflective of current issues concerning tele ICU services and organizational contexts, the search was limited to articles published between 2004 and 2022.

Step 2: Establish inclusion and exclusion criteria:

It was examined peer-reviewed articles for review if they met the following inclusion criteria: 1) examined health care services using information communication technology (e.g., videoconference or store-and-forward systems) that enable virtual interactions between patient and critical care providers for remote care diagnosis and treatment of patients at a distance: 2) reported or described the evaluation of pilot studies and/or implementation tele ICU services and 3) articles related to the financial management of tele ICU.

Once the literature of interest was collected from the search engine, the researchers established criteria that would screen the collected publications based on this literature review's requirements. This preliminary screening removed the literature irrelevant to this study. All literature published in the English language was included, and all other languages were excluded. Any research that discussed the technical aspect of tele-ICU implementation was excluded since technical discussions were beyond this study's scope. Furthermore, 15 articles from online sources were added to the full review since they were relevant to this study's discussion. As a result of establishing the inclusion and exclusion criteria, 42 works of literature were identified, subject to full-text review, and these citations were included in the data abstraction and analysis. Two reviewers independently reviewed each record at abstract and article-level using

predetermined inclusion/exclusion criteria while a third author validated it, acting as a second reader, and verified the references met the research study inclusion criteria. Any discrepancies in applying the inclusion criteria were resolved through additional review and discussion until an agreement was reached.

Step 3: Categorization of literature:

Once the researchers filtered the initial search to only include articles relevant to this study, they were categorized. The first level of categorization of the articles was conducted based on the type of the research design, which led to the articles being divided into four categories, Original Research (20), Review Articles (13), News articles (5), and Books (1). The articles included in Original Research were further categorized based on the type of research design used. The led to the articles being divided into six categories, Case-Control Studies (3), Cohort Studies (2), Experimental Studies (5), Observational Studies (1), Qualitative Studies (4), and Surveys and Interviews (5) (see Figure 1). This categorization of the articles allowed the researchers to review the literature better and further enhance its efficacy. Once the filtered articles were categorized, the researchers subjected the articles selected to a full-text review. Following this review, 17 sources were used in the results section, and 25 references included the rest of the text for a total of 42 references which were used throughout this study (see Figure 1)

RESULTS

Financial Impact of Tele-ICU Use in Critical Care

The capital investment of the tele-ICUs has been relatively high for the initial setup, and the return of investment (ROI) has been a debate. The ROI of a tele-ICU program has consistently ranged from 3:1 to 6:1 across various implementations, and achieving this ROI is not as simple

as installing remote monitoring technology and observing the financial benefits and clinical outcomes. [16,42] These factors have slowed the adoption of the expansion of this program. However, even in ICUs settings, a large proportion of materials cost constitutes a significant proportion of the expenses. [14, 41] Overall, Tele- ICU has been known to boost revenue growth and savings by avoiding the Locums Tenens, reducing unnecessary patient transfer to other hospitals, reducing the length of stay, and profoundly reduced severity-adjusted LOS.[17,43] Furthermore, reduced mortality, improve patient safety and care quality, and decreasing the number of ventilator days, which overall contribute to cost-efficient. [18]

In 2011, the University of Minnesota Medical Center's Fairview Health System began employing tele-ICU within facilities. This study of the 106-bed ICU Fairview Program was conducted to review the initial cost of implementation, and the annual operating costs of a teleICU program were ranged between $2,000,000 and $6,000,000. Fairview's capital cost was $1,186,220. Furthermore, the average combined implementation and first-year operation cost per tele-ICU bed ranged between $50,000 and $100,000. Fairview's combined implementation and first-year operational cost per tele-ICU bed were $45,117. Its annual operational cost for one tele-ICU bed was $23,150 (Table 1). [19]

The Fairview researchers also reviewed and compared data from the Veterans Health Administration (VHA) hospitals. In their study, these facilities had a combined capital and first-year operational cost per tele-ICU bed, ranging from $70,000 to $87,000. [19] Additional VHA data showed a tele-ICU program initiated in 7 separate VHA hospitals, containing 74 ICU beds. The total cost of implementation for the program and the first-year operating costs of the off-site monitoring hub was $9,097,410. [20] The total cost for technology, including hardware, software, operating equipment, networking, and licensure requirement fees, was $5,196,661 (see Table 1).

The approximate cost for staffing and operating the monitoring site for the first year of implementation was $3,300,000, or $123,000, per ICU-bed. [20] (Table 1).

According to Barnes, in 2018, [21], the use of tele-ICU was measured for cost savings adjusted life years, a measure of disease burden (pain,) and healthcare's ability to sustain life. Variables such as staffing and mortality rate were also considered. The findings were that the cost of the tele-ICU care was $45,320 per adjusted life year. This amount was not a benchmark of $100,000 to be labeled cost-effective than the change for dialysis at approximately $129,092. These study findings reported that tele-ICUs yielded cost savings in only 37% of the 1,000 scenarios assessed. [21]

In an effort to offer the most accessible and cost-Effective treatment options, Emory developed a tele Health program that offered many different care options for patients both in the hospital and in the ambulatory set ting. The Emory Tele-ICU Center was the first synchronous care delivery method utilized by Emory Healthcare. The Tele-ICU Center was implemented in March 2013 in one hospital and grew to cover patients in four Emory hospitals and an extramural hospital in South Georgia by November 2014[46] , and, during an independent audit of this program that spanned 15-months leading up to 2017, the cost savings were $4.6 million from Medicare payments. [22] During the monitoring process, the program at Emory Healthcare included 136 beds at five hospital locations, compared to 9 other hospitals in the Atlanta area to determine its success. Relative to the comparison group, the total savings included: a decrease of $1,486 in average Medicare spending per 60-day episode, a 4.9% increase in discharges to home healthcare, a 6.9% decrease to skilled nursing facilities and long-term care hospitals, and a 2.1% decrease in the rate of 60- day inpatient readmissions. [22]

Another study, in 2007, Resurrection Health Care in Des Plaines, IL, implemented the use of the tele-ICU program into 14 ICUs. Cost savings of $3 million was reported in the first six months. 13 These cost savings included $11,200 from a 7% decrease in blood transfusions and a 38 % decrease in ICU LOS. By 2011, tele-ICU support for patients across the implemented system resulted in 9000 ICU days saved. This finding was translated as an estimated cost savings of $11.5 million. 13 Similarly, the implementation of tele-ICU, examined by Kumar, Merchant, and Reynolds [20], found a 10% reduction in ICU LOS. These savings allowed for one new patient per day and resulted in a Present Net Value of $2.5 million. ICU costs decreased by 25% to 31% during the intervention period, while total hospital costs decreased by 12% to 19%. Besides, the cost of care per day of service was considered. This list included equipment, staffing, and miscellaneous costs associated with managing a tele-ICU system. The results were a 24.6% decrease in variable costs per patient. [20] Tele-ICU program has benefit in reaching the rural areas, and ICU staff in rural areas has viewed that Tele-ICU as a significant benefit for their facility that has included where recruitment of staff can be challenging provides extra support for day shifts and evening, night, and weekend shifts and improve the standardization of care. [23] The introduction of tele-ICU in the rural areas has shown a reduction in the number of inter-hospital transfers of sick patients to a large tertiary hospital in the community, which results in impacts of cost-saving in travel expenses and low wages. [24]

Benefits of Tele-ICU in reducing Mortality and LOS

One clinical measure used to assess the effectiveness of care in the ICU has been mortality and LOS. [25] Examined the implementation of a tele-ICU program at a large community-based hospital. This retrospective study of 2,823 patients took 630 pre-intervention patients and 2,193 tele-ICU and controlled them for baseline characteristics Acute Physiologic and Chronic Health

Evaluation IV (APACHE IV) and Acute Physiologic Scores (APS). ICU mortality dropped from 7.9% in the pre-intervention group and 3.8% during the tele-ICU period. Overall, hospital mortality dropped from 8.8% to 6.9%. [25] Another retrospective study was conducted to examined pre-and post-implementation of a tele-ICU program. This study controlled the groups with APS and APACHE IV scores. In the pre-implementation period, the mortality of 21.4% was reported. After implementation, the crude mortality was 14.7%. Furthermore, it was found that, in the pre-implementation group, 36.1% of patients required a ventilator, compared to 31.5% in the tele-ICU group. [26]

Sadaka and colleagues in 2013 25 found a decrease in ICU (LOS) from 2.7 days to 2.2 days in the tele-ICU group; however, an increase in the overall LOS from 5.2 days to 6.2 days was regarded. McCambridge also in 2010, [26] found similar findings with ICU LOS from 4.06 days to 3.77 days. It was also noted an increase in total hospital LOS from 9.15 days to 9.21 days. Cummings, Krsek, Vermoch, and Matuszewski in 2007, [27] reported a decrease in mortality by 27% and decreased ICU LOS by 16% for the group using telemedicine technology. [27] Kahn and his colleagues (2016) examined 521 hospitals using 2001-2010 Medicare claim data linked to a national survey identifying U.S. hospitals that had adopted the tele-ICU method, and it was found that, overall, 3.8% of the 5,650 hospitals had adopted tele-ICU programs. After exclusion criteria were applied, 132 tele-ICU hospitals were compared to 389 control hospitals. The findings were that 12.1% of the tele-ICU hospitals had a statistically significant mortality reduction; out of 21.1%, 81.1% had no reduction, and 6.1% had increased mortality. [28]

Young and his colleague in 2011 performed a meta-analysis that included 35 ICUs. All evaluations were done before and after comparison. A large patient population of 41,374 patients was found to have reduced ICU mortality but not in-hospital mortality. This study also showed a

reduction in ICU length of stay of mean -1.26 days. The difference with hospital length of stay was only a mean difference of 16 days. [29] The use of tele-ICU has allowed small community and rural hospitals to have care managed by intensivists rather than general providers. This type of coverage has been called closed ICU. In 2011, Gasper examined the impact of a unit with Acute Lung Injury (ALI) patients, a lung disorder typically caused by infection. After correcting the patients for variables, it was found that the closed units had a 26% less chance of (ALI). [30]

DISCUSSION

This study aimed to assess the potential for the hospital implementation of tele-ICU to determine its overall healthcare cost-effectiveness. This review results suggested that hospitals who employed the use of tele-ICU generated a substantial return-on-investment besides some barrier in the implementation.

Financial Impact of Tele-ICU Use in Critical Care

The review results of the actual higher cost to implement the tele-ICU program was expected but remarkable. The cost to establish this program ranged from $2,000,000 to $6,000,000, regardless of facility type. [19] This vast outlay was setup cost only and did not include annual operational costs such as administrative expenses, intensivist fees, or equipment maintenance. The combined capital and first-year operational cost remained comparable across all facility types, ranging from $50,000 to $100,000 per tele-ICU bed. [19] In further reviewing the financial material associated with tele-ICU implementation, the documented findings related to overall cost savings were promising. Regardless of the initial setup cost, other barriers such as technical difficulties were also less than 4%. [31] Tele-ICUs have allowed for significant decreases in ICU LOS. These

reduced stay times have allowed for a savings of $11.5 million. [13] This innovative technology has further translated to savings in care per day of service per patient, with a significant decrease of 24.6% and inter-hospital transfer expenses in rural areas to a more prominent center. [16] Langabeer in 2017, [32] found a 6.7% absolute reduction in potentially medically unnecessary E.D. visits and a 44-minute reduction in total ambulance back-in-service times. This finding concurs with other studies found in the literature. [13, 40]. Furthermore, the average cost for a tele-ICU patient was $167, which was statistically significantly $103 less than the control group. The program produced a $928,000 annual cost savings from the societal perspective, or $2468 cost savings per E.D. visit averted. Applying the tele-ICU program solution to a low-risk cohort with no prior admission history would result in a $2502 cost increase per person over the 1-year time frame with 0.01 life-year gain. [33]

Return on Investment (ROI) is a performance measure utilized to assess an investment's efficiency or analyze several different investments' efficiency. ROI attempts to directly measure the amount of return on a particular investment relative to its cost. In tele ICU, the ROI has been merely calculated using indirect clinical effects and the expected LOS reduction. Furthermore, the payback period or net present value (NPV) should be the ROI indicators[44]. Further research in this area is needed.

Impact of Tele-ICU Use in Critical Care:

Tele-ICU implementation has shown a substantial decrease in mortality, both in the hospital and, more significantly, in the ICU (pre-intervention of 7.9% versus post-intervention of 3.9%). [25] The closer monitoring and quicker interventions allowed by the tele-ICU showed a significant decrease in acute lung injury. This decrease was found to show an adjusted odds ratio of 0.68 in the high-intensity group, compared to 0.98 in the control group. [30] LOS in the ICU also has had a

significant impact on clinical outcomes and mortality[38]. For example, decreased LOS would diminish the likelihood of developing any hospital-acquired infections, sepsis and ventilator acquired pneumonia leading to mortality and reduced crude mortality from 21.4% to 14.7%. Another benefit of tele-ICU implementation has been an expansion of markets; the teleICUs have allowed healthcare facilities to take care of more patients, decreasing geographic barriers and allowing the provision of ICU services into previously inaccessible markets as those in rural areas. [26-34] From academic health centers to startups, numerous organizations offer low-cost virtual visits (less than $50 per visit) around the clock for the most common, most irritating, most inconvenient conditions. [35] Other factor was patient safety in tele-ICU; patients were pleased with these new technologies. Most patients had positive attitudes towards patient safety culture environment and had much room for improvement. [36-37, 39]

Tele IUCU is a possible solution to delivering regular care without the risk for COVID-19 exposure and enabling access to critical care specialists to meet ICUs' staffing needs. However, the availability of established infrastructure for services at hospitals with ICUs with tele-ICU capabilities reported in 2018 was 26.8% across U.S. hospitals.

On the other hand, almost all of the associations between the organizational factors and satisfaction are mediated by communication, but there are some direct effects of organizational characteristics, notably trust. Therefore, ICUs and tele-ICUs should optimize communication to show confidence among them[45].

This review had limitations concerning the standardization of the actual implementation of the tele-ICU programs. This lack of standardization could have caused some unforeseen differences when comparing clinical and financial data. The services offered with tele-ICU also differed between some studies. This fact could have caused effects when comparing clinical data.

Despite the study limitations, the benefits of tele-ICU are still encouraging in both the financial and clinical areas. In a specialty such as critical care with increasing demand, the increase of the aging population, and the scarcity of critical care intensivist tele-ICU could be a viable option for reaching inaccessible and cost-efficient areas. Tele-ICU might seem to provide a potential solution in reaching the geographical barriers and cost-effectiveness and concurs with existing evidence that Tele-ICU has improved access to high-quality critical care through diverse IT solutions [48].

This research study was conducted with limitations. This review was limited due to search procedures such as the number of databases used, sources utilized, and distinguishing between keywords. Also, researchers' bias and publication bias cannot be ruled out. This review attempted to identify scientifically sound evidence on tele ICU intervention programs and synthesize and critically assess the published literature in this area. In part, this review also can assist in identifying possible directions for future studies.

CONCLUSION

The findings suggested that tele-ICU systems' implementation can positively impact financial outcomes such as decreased ICU LOS. Furthermore, it has reduced ICU mortality, improved patient safety, care quality, and decreased ventilator days, contributing to a cost-efficient technology. Tele ICU is a possible solution to delivering regular care, enabling critical care specialists to meet ICUs' staffing needs.

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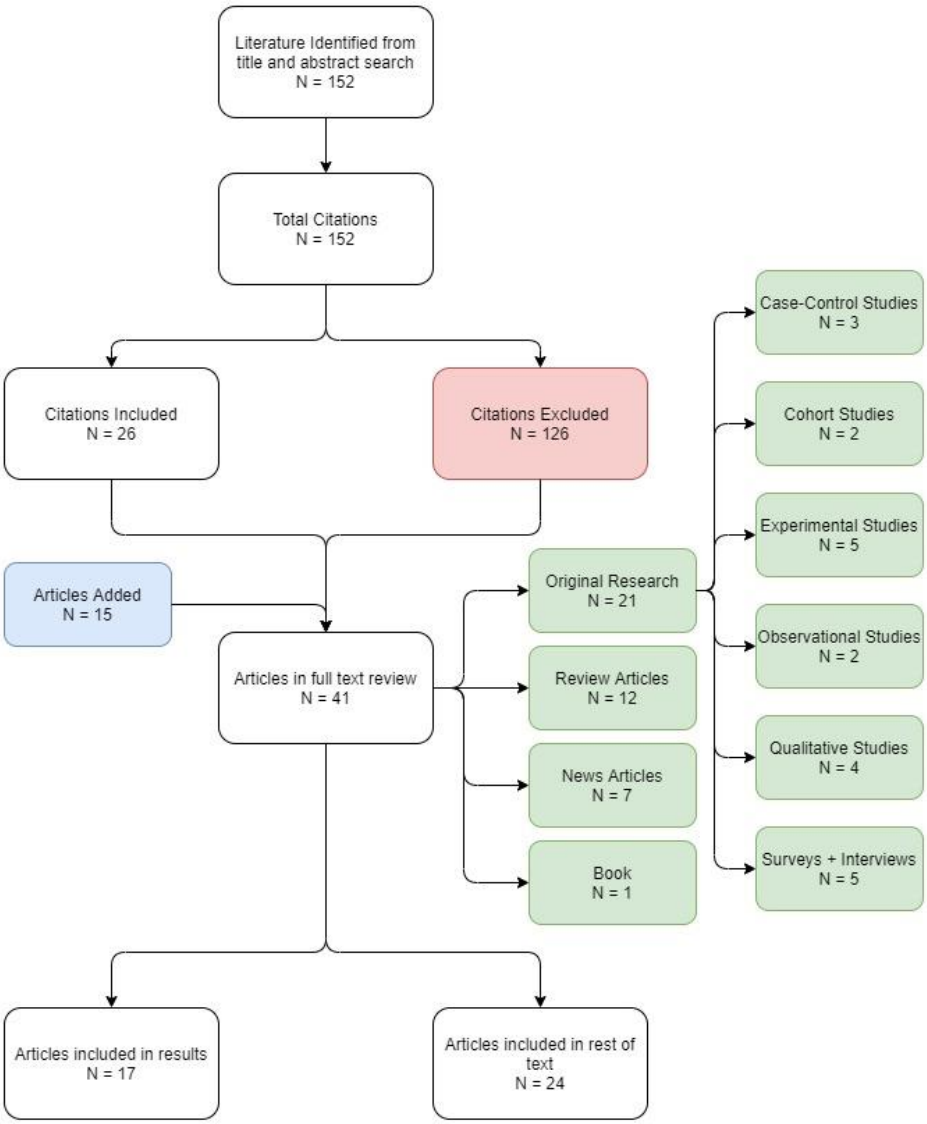

Figure 1: Overview of literature evaluation following PRISMA Approach Used with Categorization by Research Design and Research Sources[13].