

## Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN in ICU

Dr. Elife Ozkan<sup>1</sup>, Gizem Uzunoglu, RPh<sup>2</sup>, Zehra Eraltug, RPh<sup>3</sup>

<sup>1,2,3</sup> Tire State Hospital, Izmir, Turkey; Ödemiş State Hospital Izmir Turkey; Tepecik Training and Research Hospital Izmir Turkey

**ABSTRACT:** Total parenteral nutrition (TPN) is the treatment modality of providing intravenous nutrition for patients who cannot get oral feeding. Physicians use standard scales, such as NRS-2002 and NUTRIC, for TPN orders. The usage of NRS-2002 in public hospitals has been mandatory in Turkey since 2015. The quality management department of Izmir Tire Public Hospital recognized that TPN consumption increased dramatically since 2015. The orders, which increased in direct proportion to the number of patients, showed that it should be investigated by evaluating their necessity according to nutritional practice standards. The objective of this study is to research the effect of e-orders incorporated with a clinical decision support system on TPN consumption. We digitalized the NRS-2002 form and added a clinical decision support system to calculate the score and calorie requirements. We found that the total number of NRS-2002 forms completed by physicians increased by 95%, the number of TPN orders decreased by 41%, and the cost decreased by 38% in 2018. This study showed that e-ordering of TPN combined with a clinical decision support system is beneficial for decreasing costs.

**KEYWORDS:** Parenteral nutrition (PN), Clinical decision support system (CDSS), intensive care unit (ICU), CPOE, HIMSS, EMRAM

---

### INTRODUCTION

Parenteral nutrition (PN) is the part of treatment supplying intravenous nutrition to patients when they cannot be fed orally and/or they are unable to meet their required calorie through the enteral path. The malnutrition frequency for such patients is between 25% and 50%, especially in specific patient groups such as oncology and geriatric patients. PN is invasive, costly, and associated with potentially severe and harmful difficulties.<sup>1</sup> Total parenteral nutrition (TPN) related complications are infection, hepatic dysfunction, hyperlipidemia, fluid overload, hyperglycemia, refeeding syndrome, azotemia, and respiratory failure<sup>2,3</sup>. The TPN team is responsible for minimizing these risks and ensuring the maximum benefit from the application. The TPN team manages the implementation decision and the evaluation process using international standard scales<sup>4,5</sup>. Two crucial factors should be noticed when deciding on nutrition risk and proficiency of EN (enteral nutrition) in convention energy and protein aims. The Nutrition Risk Screening (NRS-2002) and the Nutrition Risk in the Critically Ill (NUTRIC) elements are used for nutrition risk assessment and identified by American Society for Parenteral and Enteral Nutrition (ASPEN) for that goal<sup>6</sup>.

It is important to use standard scales in reducing complications that may occur in TPN application<sup>7</sup>. In standard scales, the use of electronic solutions is particularly effective in reducing the problems caused by individual information deficiencies, different applications, and errors<sup>8</sup>. Many studies show that applications managed by using electronic orders lead to reduced errors, decreased costs, and increased patient care quality and employee satisfaction<sup>9,10</sup>. With the help of Information & Communication Technology (ICT) and the internet, the business and service delivery models of today's global environment have been improved rapidly. Hospital Information Systems (HIS), as a product of ICT and Internet, provide many benefits starting from operations, administration, control, health care, cost control, and efficiency<sup>11</sup>.

The clinical decision support system (CDSS) has been a trendy concept for years in the healthcare information technology (IT) domain. Computerized Physician Order Entry (CPOE) is also capable of offering CDSS functions during the order entry in different ways, such as suggesting predefined order sets, proposing risk assessment before ordering, and estimating the appropriate diagnosis for the specific case<sup>12</sup>. Many studies show the benefits of using CDSS in healthcare quality indicators<sup>12,13</sup>. Practically, the importance of CDSS has

## Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN inICU

grown enormously, especially when hospitals finalize digital transformation to include Electronic Health Records (EHR) and Clinical Information Systems (CIS). Although there is more than one definition for CDSS, it has already been seen as an essential part of EHR applications<sup>14</sup>.

CPOE in healthcare is a way to enter orders directly to computers instead of using paper-based forms<sup>15</sup>. CPOE enables clinicians to order diagnostic tests directly via a computer without needing paper-based test orders, thereby decreasing transcribing errors<sup>16</sup>. CPOE is also seen as one of the most critical electronic health records components in a hospital<sup>17</sup>. The healthcare quality problems incorporated with healthcare services orders are recognized into three categories: underuse, overuse, and misuse<sup>18</sup>. Even though physicians generally spend more time in CPOE than handwriting orders<sup>19,20</sup>, many studies showed that CPOE is a very efficient way of decreasing overuse, underuse, and misuse in orders<sup>21</sup> and in decreasing medication errors<sup>22</sup>. In addition to physicians, many actors within the hospital that are involved in the medication order management process triggered by CPOE, such as pharmacists, nurses, unit desk clerks, etc. Despite its complexity, the speed of this process is often critical to patient care<sup>17</sup>.

The use of CPOE encompasses a useful process both for patient care and for the user. Closed Loop Medication Administration (CLMA) provides a safe medication administration system in hospitals and requires the use of CPOE. CPOE is an inseparable part of the CLMA system. Studies with CLMA reveal the benefits of CPOE. In one of our earlier studies, it was observed that the rate of drugs not transferred to the claim in 2015, when CLMA was not applied, was 4.4%, while this rate decreased to 0.5% in 2018, when CLMA was applied, in the whole hospital, and the loss of income due to claims loss decreased by 83.8%<sup>23</sup>.

### PROBLEM DEFINITION

Studies have been conducted to determine the use of standards, complications, level of knowledge, and errors regarding TPN application in Turkey<sup>24,25</sup>. However, while there are common standards and practices to reduce errors or complications in TPN applications, no study integrated these with the order system. When hospital records where the study was conducted are analyzed retrospectively, a significant increase is observed in TPN order records. (Figure 1). The Ministry of Health's mandatory policy had an effect on this increase.

The Ministry of Health of Turkey issued a decree at the end of 2015 requiring that TPN requirement of each hospitalized patient be assessed using the NRS-2002 form. However, the follow-up and evaluation responsibilities were left to the hospitals. In a Turkish public hospital, Izmir Tire Hospital, the NRS-2002 form was added to the hospital's information system (HIS) just after this decree, and physicians were informed about the usage and importance of the form. In 2016, the Clinical Nutrition Support Unit (CNSU) was established, and a nutrition nurse was appointed for patient evaluations. The evaluation procedure for this nurse was also defined.<sup>26</sup>

Another remarkable point is that the study hospital is validated according to the electronic medical record adoption model (EMRAM)<sup>27</sup> of health and information management systems society (HIMSS)<sup>28</sup> as Stage 7 in 2016, which means the hospital is a fully digital hospital engaging EHR functions to improve patient safety and healthcare quality<sup>29</sup>.

The CNSU has been continuously monitoring the number of NRS-2002 forms fulfilled by the physicians, and it was growing as expected after the Ministry of Health decree as demonstrated in Figure 1.

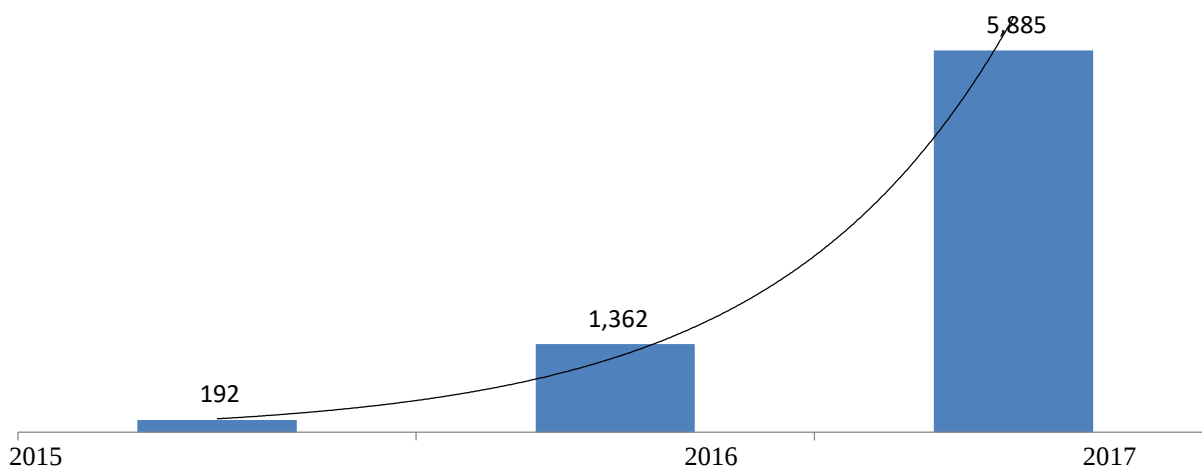


Figure 1. The number of NRS-2002 forms completed by physicians

## Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN inICU

The CNSU recognized in 2018 that the utilization of TPN had been remarkably growing over the last three years. The number of TPN orders from 2015 to 2017 was 569,426, 621,539, and 632,196 correspondingly. Since physicians have been using the NRS-2002 form to assess the patients' TPN requirement, this rapid growth was expected to be related to some other indicators. The CNSU tried to clarify whether the rise in TPN orders is reasonable and related to the patient density and variety of patients in relevant years. Table 1 represents some numbers such as length of stay, bed occupancy, occupancy rate in the ICU, and inpatients per year. As shown in Table 1, the total amount of TPN consumed and the number of TPN in relevant years independently increased because of other indicators.

**Table 1. Indicators related to TPN consumption**

| Indicator                              | 2015       | 2016         | 2017         |
|----------------------------------------|------------|--------------|--------------|
| Number of Patients                     | 569,426    | 621,539      | 632,196      |
| Number of Adult Inpatient              | 11,362     | 10,716       | 10,792       |
| The occupancy rate at ICU              | 83.9       | 87.3         | 93.3         |
| The bed occupancy rate at the hospital | 88.8       | 84.1         | 88.08        |
| Average Length of stay                 | 5.1        | 4.9          | 4.9          |
| <b>Amount of TPN</b>                   | <b>735</b> | <b>1,075</b> | <b>1,458</b> |
| <b>Amount of TPN per inpatient</b>     | <b>97</b>  | <b>150</b>   | <b>202</b>   |

As depicted in Figure 1, the number of NRS 2002 fulfilment has been continuously increasing, we recognized that the NRS- 2002 form is not mandatory for TPN orders within HIS, and some TPN orders have been dispensed without NRS-2002 assessment in 2015, 2016, and 2017. Thus, it can be suggested that most TPN orders are not appropriate to NRS-2002 criteria. It is thought that the CPOE will be effective in solving this problem and it has been integrated into the system.

## METHODS

In this study, quantitative methods and before and after comparisons were done. First, the number of NRS-2002 forms were counted manually for the years between 2015 and 2017. Then, total TPN consumption was calculated for the same period from the HIS database. Then the HIS was modified to incorporate CPOE for TPN orders, and all TPN orders can be given if, and only if, the physician completed the NRS-2002 form electronically.

Additionally, the CDSS was included in the NRS-2002 form to calculate the NRS-2002 score and the calories that the patient needs according to Harris-Benedict and Schofield scores automatically<sup>30</sup>. Patients given a score of three or above were reevaluated by the nutritional nurse using HIS. If TPN was not indicated or the calorie calculation was missing, the nutrition nurse contacted the physician to reach a final decision. HIS enabled an environment for better communication and cooperation between physicians and nutrition nurse. Then the results of this application were monitored in 2018, and the data (i.e., number of NRS-2002 forms fulfilled and the total TPN consumption) was gathered from the database of HIS. The results are compared here with the previous three years.

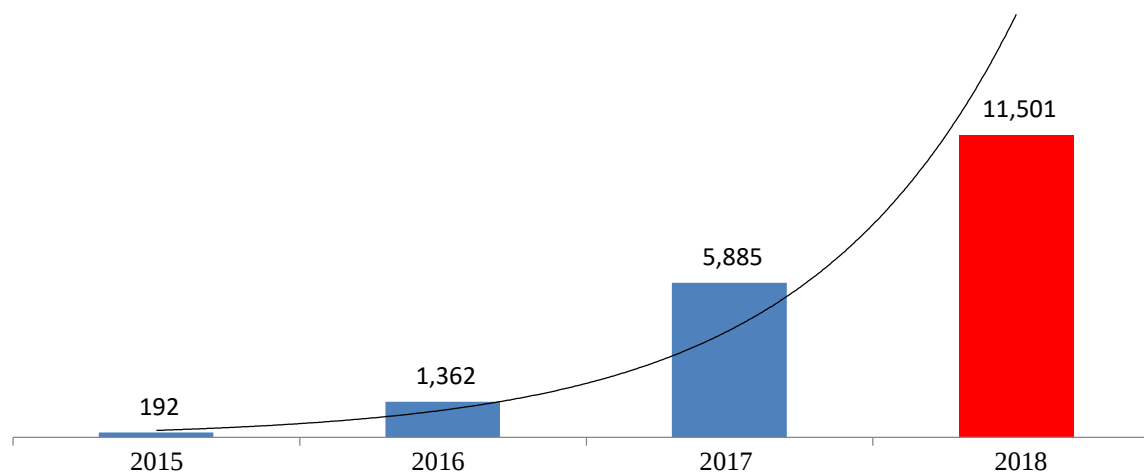
Since the study is quantitative and the scope of data does not cover any patient information directly, all calculations are handled anonymously (i.e., the patient identities and demographic information have not been incorporated into any of the calculations).

## RESULT

After implementing mandatory usage of the HIS and NRS-2002 form for all TPN orders, the new procedure yielded a significant increase

## Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN inICU

in the number of NRS-2002 forms completed by physicians by 95% in 2018 over 2017. Figure 2 shows that the number of NR2002 forms completed in 2018 is even 54% more than the total number of NRS-2002 fulfilled in the previous three years combined.



**Figure 2. The increase in the number of completed NRS-2002 forms in 2018**

This strict control and evidence-based approach yielded a high decrease in TPN consumption in 2018. Although the other indicators that can affect TPN consumption are not changed noteworthy in 2018 concerning the previous three years, the number of TPN orders and the amount of TPN per patient significantly decreased in 2018, as indicated in Table 2.

**Table 2. TPN consumption change in 2018**

| Indicator                   | 2015    | 2016    | 2017    | 2018    |
|-----------------------------|---------|---------|---------|---------|
| Number of Patients          | 569,426 | 621,539 | 632,196 | 634,373 |
| Number of Adult Inpatients  | 11,362  | 10,716  | 10,792  | 10,130  |
| ICU Occupancy Rate          | 83.9    | 87.3    | 93.3    | 94.6    |
| Hospital Bed Occupancy Rate | 88.8    | 84.1    | 88.08   | 84.08   |
| Average Length of Stay      | 5.1     | 4.9     | 4.9     | 5.1     |
| Amount of TPN               | 735     | 1,075   | 1,458   | 853     |
| Amount of TPN per inpatient | 97      | 150     | 202     | 126     |

Table 2 shows that although the number of patients in 2018 and 2017 are nearly the same, the amount of TPN decreased by 41%. The total cost of TPN delivered in 2017 was calculated as 182,250 TL, while it was 106,625 TL in 2018. Thus, the cost saving is 75,625 TL (approximately 10,500 USD), a 38% savings. This demonstrates that the use of inappropriate TPN has been prevented by usage of the HIS with CPOE and CDSS.

## DISCUSSION

Trice et al. indicated that the TPN tends to be associated with higher infectious complications and higher therapeutic costs than enteral nutrition. Thus physicians should only order TPN in cases in which it is indeed indicated <sup>31</sup>. It has been shown in many studies over the years that a nutrition support team recommendations reduce inappropriate TPN orders and hospital costs. One of the earliest studies on this topic was published by Roberts and Levine in 1992. According to this study, 14 out of 176 patients had been ordered TPN

## Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN inICU

inappropriately, which caused a total net loss of 62,919 USD <sup>5</sup>. Similarly, in 2000, Goldstein et al. found that proper staffing reduces TPN costs and complications <sup>32</sup>. A more recent study, in 2014, found that TPN decreased by 29% when the physicians and nutrition staff are well-educated and encouraged to use guidelines for TPN orders <sup>33</sup>.

Additionally, CPOE and CDSSs have been demonstrated to have a role in decreasing costs in many areas in healthcare, such as pharmacy clinical interventions <sup>34</sup>, inpatient services <sup>35</sup>, prescriptions <sup>36,37</sup>, surgical operations <sup>38</sup>, and treatment of diseases (i.e., cardiovascular diseases, hypercholesterolemia, asthma, etc.) <sup>38,40</sup>.

In addition to these studies, our study, for the first time, found that the CPOE, one of the most critical EHR functions, when supported by a CDSS, was also very beneficial by applying clinical guidelines and decreasing unnecessary TPN costs by 38%. Our study shows that although there is a nutrition staff, well-designed guidelines, and the health authority regulations (i.e., MoH) to require the implementation of those guidelines, lack of digitalization may result in health professionals not applying those guidelines correctly. Moreover, TPN consumption may increase out of control even if there is a nutrition committee (i.e., CNSU).

## CONCLUSION

Although paper-based clinical forms are sufficient to assess clinical conditions, they cannot be applied in complex processes efficiently and are more open to negligence and errors. Moreover, as seen in this case, the practice can be far from the situation as expected by regulation authorities like the Ministry of Health. This study concludes that using CPOE, incorporated with CDSS in HIS, is a very beneficial function to decrease the overuse and misuse of TPN in the ICU, the related costs and increase healthcare quality. Healthcare authorities, aiming to increase the healthcare quality indicators, should seriously consider disseminating CPOE and CDSS in all hospitals.

## REFERENCES

- 1) Kraft M, Gärtner S, Simon P, et al. Quality control of parenteral nutrition in hospitalized patients. *Nutrition*. 2014;30(2):165-168. doi:10.1016/j.nut.2013.07.010
- 2) Cekmen N, Dikmen E. Yoğun Bakım Hastalarında Enteral Ve Parenteral Nutrisyon. *Toraks Cerrahisi Bul.* 2014;5(3):187-197. doi:10.5152/tcb.2014.030
- 3) Löser C. Malnutrition in hospital: prevalence, clinical consequences and relevant costs. *DMW - Dtsch Medizinische Wochenschrift*. 2001;126(24):729-734. doi:10.1055/s-2001-15034
- 4) Bozzetti F. Parenteral nutrition. *Nutrition*. 2019;66:101-107. doi:10.1016/j.nut.2019.03.013
- 5) Roberts MF, Levine GM. Nutrition Support Team Recommendations Can Reduce Hospital Costs. *Nutr Clin Pract*. 1992;7(5):227-230. doi:10.1177/0115426592007005227
- 7) Elhassan AO, Tran LB, Clarke RC, Singh S, Kaye AD. Total Parenteral and Enteral Nutrition in the ICU: Evolving Concepts. *Anesthesiol Clin*. 2017;35(2):181-190. doi:10.1016/j.anclin.2017.01.004
- 8) Worthington PH, Gilbert KA. Parenteral nutrition: Risks, complications, and management. *J Infus Nurs*. 2012;35(1):52-64. doi:10.1097/NAN.0b013e31823b98ef
- 10) Crews J, Rueda-de-Leon E, Remus D, Sayles R, Mateus J, Shakeel F. Total Parenteral Nutrition Standardization and Electronic Ordering to Reduce Errors. *Pediatr Qual Saf*. 2018;3(4):e093. doi:10.1097/pq9.0000000000000093
- 11) Mummadi SR, Mishra R. Effectiveness of provider price display in computerized physician order entry (CPOE) on healthcare quality: A systematic review. *J Am Med Informatics Assoc*. 2018;25(9):1228-1239. doi:10.1093/jamia/ocy076
- 12) Lyons AM, Sward KA, Deshmukh VG, Pett MA, Donaldson GW, Turnbull J. Impact of computerized provider order entry (CPOE) on length of stay and mortality. *J Am Med Informatics Assoc*. 2017;24(2):303-309. doi:10.1093/jamia/ocw091
- 13) Balaraman P, Kosalram K. E –Hospital Management & Hospital Information Systems – Changing Trends. *Int J Inf Eng Electron Bus*. 2013;5(1):50-58. doi:10.5815/ijieeb.2013.01.06
- 14) Kawamoto K, Houlihan CA, Balas EA, Lobach DF. Improving clinical practice using clinical decision support systems: a systematic review of trials to identify features critical to success. *BMJ*. 2005;330(7494):765. doi:10.1136/bmj.38398.500764.8F
- 15) Johnston ME, Langton KB, Haynes RB, Mathieu A. Effects of computer-based clinical decision support systems on clinician performance and patient outcome. A critical appraisal of research. *Ann Intern Med*. 1994;120(2):135-142. doi:10.7326/0003-4819-120-2-199401150-00007
- 16) Alther M, Reddy CK. Clinical decision support systems. *Healthc Data Anal*. 2015;(May 2014):625-656. doi:10.1201/b18588

## Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN inICU

- 17) Sittig DF, Stead WW. Computer-based Physician Order Entry: The State of the Art. *J Am Med Informatics Assoc.* 1994;1(2):108-123. doi:10.1136/jamia.1994.95236142
- 18) Dana T, Talsma A, Nicholas R, Kritine K, Rhonda S. Nursing Medication Administration and Workflow Using Computerized Physician Order Entry. *CIN Comput Informatics.* 2011;29(7):401-410. doi:10.1097 / NCN.0b013e318205e510
- 19) Cartmill RS, Walker JM, Blosky MA, et al. Impact of electronic order management on the timeliness of antibiotic administration in critical care patients. *Int J Med Inform.* 2012;81(11):782-791. doi:10.1016/j.ijmedinf.2012.07.011
- 20) Chassin MR, Galvin RW. The Urgent Need to Improve Health Care Quality: Institute of Medicine National Roundtable on HealthCare Quality. *JAMA.* 1998;280(11):1000. doi:10.1001/jama.280.11.1000
- 21) Shu K, Shu K, Boyle D, et al. Comparison of Time Spent Writing Orders on Paper with Computerized Physician Order Entry. *Medinfo.* 2001;(100):1207-1211. doi:10.3233/978-1-60750-928-8-1207
- 22) Bates DW, Boyle DL, Teich JM. Impact of computerized physician order entry on physician time. In: *Annual Symposium on Computer Applications in Medical Care.* American Medical Informatics Association; 1994:996. <http://www.ncbi.nlm.nih.gov/pubmed/7950101>. Accessed August 3, 2019.
- 23) Kuperman GJ, Gibson RF. Computer Physician Order Entry: Benefits, Costs, and Issues. *Ann of Internal Med.* 2003;139:31-39.
- 24) www.annals.org. Accessed May 12, 2017.
- 25) Wolfstadt JI, Gurwitz JH, Field TS, et al. The Effect of Computerized Physician Order Entry with Clinical Decision Support on the Rates of Adverse Drug Events: A Systematic Review. *J Gen Intern Med.* 2008;23(4):451-458. doi:10.1007/s11606-008-0504-5
- 26) Eraltug Z, Uzumoglu G, Bolat O, Ozkan E, Aydin N, Kose I. Effect of closed-loop medication administration on medication billing leakage : A case study. 2020;(15).
- 27) Türkylmaz C, Bilgen H, Kültürsay N. Turkish neonatal society guideline on the parenteral nutrition in preterm infants. *TurkPediatri Ars.* 2018;53:S119-S127. doi:10.5152/TurkPediatriArs.2018.01812
- 28) Kalender N, Tosun N, Kilic S. Determination of the Level of Knowledge of Nurses Working at an Education Hospital About Total Parenteral Nutrition. *Turkiye Klin J Nurs.* 2015;7(1):10-19. doi:10.5336/nurses.2013-34534
- 29) Batu Z, Ustun M. *Nütr İ Syon Kilavuzu.*; 2016.
- 30) HIMSS Analytics. *Electronic Medical Record Adoption Model.* HIMSS Analytics.
- 31) HIMSS. About. <https://www.himss.org/>.
- 32) Kose I, Rayner J, Birinci S, et al. Adoption rates of electronic health records in Turkish Hospitals and the relation with hospital sizes. *BMC Health Serv Res.* 2020;20:967. doi:https://doi.org/10.1186/s12913-020-05767-5
- 33) Madden AM, Morgan MY. Resting energy expenditure should be measured in patients with cirrhosis, not predicted. *Hepatology.* 1999;30(3):655-664. doi:10.1002/hep.510300326
- 34) Trice S, Melnik G, Page CP. Complications and Costs of Early Postoperative Parenteral Versus Enteral Nutrition in Trauma Patients. *Nutr Clin Pract.* 1997;12(3):114-119. doi:10.1177/088453369701200303
- 35) Goldstein M, Braitman LE, Levine GM. The Medical and Financial Costs Associated with Termination of a Nutrition Support Nurse. *J Parenter Enter Nutr.* 2000;24(6):323-327. doi:10.1177/0148607100024006323
- 36) van Schaik R, Niewold TA. Quality improvement and cost savings by dietitians through follow-up of patients with total parenteral nutrition during hospital admission. *ESPEN J.* 2014;9(2):e59-e62. doi:10.1016/J.CLNME.2014.02.003
- 37) Calloway S, Akilo HA, Bierman K. Impact of a Clinical Decision Support System on Pharmacy Clinical Interventions, Documentation Efforts, and Costs. *Hosp Pharm.* 2013;48(9):744-752. doi:10.1310/hpj4809-744
- 38) Vermeulen KM, van Doormaal JE, Zaal RJ, et al. Cost-effectiveness of an electronic medication ordering system (CPOE/CDSS) in hospitalized patients. *Int J Med Inform.* 2014;83(8):572-580. doi:10.1016/J.IJMEDINF.2014.05.003
- 39) McMullin ST, Lonergan TP, Ryneerson CS, Doerr TD, Veregge PA, Scanlan ES. Impact of an evidence-based computerized decision support system on primary care prescription costs. *Ann Fam Med.* 2004;2(5):494-498. doi:10.1370/AFM.233
- 40) McMullin ST, Lonergan TP, Ryneerson CS. Twelve-Month Drug Cost Savings Related to Use of an Electronic Prescribing System With Integrated Decision Support in Primary Care. *J Manag Care Pharm.* 2005;11(4):322-332. doi:10.18553/jmcp.2005.11.4.322
- 41) Okumura LM, Veroneze I, Burgardt CI, Fragoso MF. Effects of a computerized provider order entry and a clinical decision

## **Presenting the Role of CPOE Incorporating with CDSS in Decreasing the Costs of TPN inICU**

support system to improve cefazolin use in surgical prophylaxis: a cost saving analysis. Pharm Pract (Granada). 2016;14(3):717.doi:10.18549/PharmPract.2016.03.717

- 43) Jacob V, Thota AB, Chattopadhyay SK, et al. Cost and economic benefit of clinical decision support systems for cardiovascular disease prevention: a community guide systematic review. J Am Med Informatics Assoc. 2017;24(3):ocw160.doi:10.1093/jamia/ocw160
- 44) Plaza V, Cobos A, Ignacio-García J, et al. Cost-effectiveness of an intervention based on the Global INitiative for Asthma (GINA) recommendations using a computerized clinical decision support system: a physicians randomized trial. Med Clin (Barc). 2005;124(6):201-206. doi:10.1157/13071758
- 45) Cobos A, Vilaseca J, Asenjo C, et al. Cost Effectiveness of a Clinical Decision Support System Based on the Recommendations of the European Society of Cardiology and Other Societies for the Management of Hypercholesterolemia. Dis Manag Heal Outcomes. 2005;13(6):421-432. doi:10.2165/00115677-200513060-00007