DNP Project: Assessment of Risk Analysis Tools for Febrile Neutropenia in Geriatric Cancer Patients in the Community Setting

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Abstract

*Background:* Febrile neutropenia is an emergent complication of chemotherapy and has been historically managed in the hospital. It has been established that a subset of cancer patients with febrile neutropenia are stable enough to be managed as outpatients. Unfortunately, geriatric cancer patients are perceived as high risk based on their chronologic age and continue to be admitted. The MASCC risk index and CISNE are validated tools that assist clinicians in identifying stable febrile neutropenic patients who may not require admission for management. The effectiveness of these tools has not been evaluated specifically in geriatric cancer patients being treated in the community setting.

*Local Problem:* The current practice within the OHSU community-based oncology clinics is to send all patients that present with a fever and neutropenia to the emergency room (ER). The majority of geriatric patients sent to the ER are admitted.

*Methods:* A retrospective chart review was performed to evaluate cancer patients age 65 and older with febrile neutropenia who were admitted to three community-based hospitals from September 2017 through September 2019. Febrile neutropenia was defined as a fever of greater than or equal to 100.4°F with an absolute neutrophil count (ANC) of less than 1000 cells/μL. Subjects must have had chemotherapy within 28 days and diagnoses of leukemia and myelodysplastic syndrome were excluded. MASCC risk index and CISNE scores were calculated for each patient based on their admission data and were evaluated for negative outcomes. These were defined as any admission complication, such as transfer to the intensive care unit (ICU), post-admission deep vein thrombosis (DVT) or pulmonary embolism (PE), sepsis, and hospital-acquired infections. Length of stay and a loss of pre-admission function were recorded for a post-hoc, secondary analysis.

*Results:* A total of 50 patients age 65 and older were admitted with chemotherapy-induced, febrile neutropenia during the time period studied. The CISNE identified 22 patients as low risk and 28 patients as high risk. It had a sensitivity of 82.61%, specificity of 88.89%, and an AUROC of 0.857. The MASCC risk index identified 3 low risk patients and 47 high risk patients. It had a sensitivity of 8.70%, specificity of 96.30%, and an AUROC of 0.525. Secondary analysis results were *X*2 (1, n = 50) = 19.78, p < .001.

*Conclusion:* The results of this project suggest that the CISNE has a better discriminatory ability than the MASCC risk index in identifying low risk geriatric cancer patients that present with febrile neutropenia. A significant correlation was found between a length of stay of greater than 3 days and a loss of pre-admission function.

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Febrile neutropenia is an emergent complication of chemotherapy in the treatment for solid tumor malignancies and lymphomas. It has been estimated that one percent of patients treated with chemotherapy will develop febrile neutropenia (Klastersky et al., 2016). Without urgent assessment and management of this complication, patients are at high risk for systemic infections, sepsis, and death (Weycker et al., 2014). Historically, most patients that presented with febrile neutropenia were admitted to the hospital and remained there until their absolute neutrophil count (ANC) recovered to above 1,000 cells/μL and their fever resolved (Goodman et al., 2017). However, current literature has confirmed that not all patients require admission for treatment and that an unnecessary hospital stay has associated risks for this population (Pherwani et al., 2015).

The American Society of Clinical Oncology (ASCO) and Infectious Disease Society of America (IDSA) have published a shared guideline recommending that patients who are clinically stable with febrile neutropenia be treated in the outpatient setting (Taplitz et al., 2018). They also recommend using validated risk assessment tools to aide providers in identifying clinically stable patients. The Multinational Association for Supportive Care in Cancer (MASCC) risk index score and the Clinical Index of Stable Febrile Neutropenia (CISNE) have both been validated in identifying low risk patients with febrile neutropenia and are commonly used in oncology practices (Carmona-Bayonas et al., 2011; Klastersky et al., 2000). Prior studies have shown that these tools are effective for use in the general oncology patient population, but there has not been a specific assessment of the usefulness of these tools in geriatric cancer patients (Ahn et al., 2017; Coyne et al., 2017; Moon et al., 2018; Mohindra et al., 2019).

It was important to assess these tools in geriatric cancer patients because they are less likely to be offered outpatient treatment (Flores & Ershler, 2010). Which is due to an inherent assumption that they are high risk based on their chronologic age alone (Penson, Daniels, & Lynch, 2004). For example, the current policy within the community hematology oncology (CHO) clinics for the Oregon Health and Science University is to send any patient that presents with a fever to the emergency department (ED). Eighty to ninety percent of the febrile neutropenia patients aged 65 and older are admitted for management and have an average length of stay of three days. It is important to recognize that chronologic, physiologic, and functional age are not always synonymous (Swaminathan & Swaminathan, 2015). By continuing to hospitalize the majority of geriatric patients with febrile neutropenia, they are being unnecessarily put at risk for nosocomial infections and a loss of pre-admission functionality (Flores & Ershler, 2010). Therefore, it is imperative that this population is assessed for clinical stability regardless of age and provided with all available treatment options.

**Literature Review**

There are currently two risk analysis tools that are regularly used to identify stable, febrile neutropenia patients. The Multinational Association for Supportive Care in Cancer (MASCC) risk index score and the Clinical Index of Stable Febrile Neutropenia (CISNE) have both been validated in identifying low risk patients with febrile neutropenia (Ahn et al., 2018). However, there have not been any studies that evaluate the reliability of these tools specifically in community-based, geriatric cancer patients. There are four recent studies that compared the accuracy of the MASCC risk index to the CISNE score in general adult oncology populations. Ahn et al. (2018) and Coyne et al. (2017) applied the two tools retrospectively based on patient admission data. These studies included subgroup analyses to further compare the measured categorization based on cancer diagnosis. Koppaka et al. (2018) and Mohindra, Mathew, Yadav, and Aggarwal (2019) performed single center prospective studies. The risk assessment scores were calculated at presentation to assess for clinical stability and then the subjects’ clinical course was followed prospectively during hospitalization.

Ahn et al. (2018) reported that the MASCC risk index had better discriminatory power in identifying clinically stable patients with febrile neutropenia than did the CISNE. They came to this conclusion by performing a receiver operator curve (ROC) analysis from the results of both tools. The MASCC risk index had an area under the ROC (AUROC) of 0.772 with a 95 % confidence interval (CI) of 0.726-0.891. The CISNE score had an AUROC of 0.681 with a 95% CI of 0.626 to 0.737. Numerically, the MASCC risk index performed better. A comparative analysis was not performed to assess for a statistically significant difference in predictive value of the two tools. It was concluded that it was reasonable to use either tool for the identification of stable febrile neutropenic patients.

Coyne et al. (2017) reported that the CISNE had specificity of 98.3% (95% CI 89.7% to 99.9%) and positive predictive value (PPV) of 98.1% (95% CI 88.6% to 99.9%). The MASCC risk index had a specificity of 54.2% (95% CI 40.8% to 67.1%) and a PPV of 84.0% (95% CI 77.4% to 89.0%). An analysis statistically compare the difference in the scores was not performed. Koppaka et al. (2018) measured the sensitivity, specificity, PPV and negative predictive value (NPV) of both tools. They performed an ROC analysis and compared the AUROC of both tools using the Hanley method. The CISNE had an AUROC of 0.846 (95% CI 0.781 to 0.911) and the MASCC had an AUROC Of 0.686 (95% CI 0.581 to 0.792). It was found to be a statistically significant difference. Both studies reported that the CISNE outperformed the MASCC risk index and recommended the CISNE be primarily utilized for patients presenting with febrile neutropenia.

The three studies discussed above all used in-hospital complications as the primary outcome measurement. Mohindra et al. (2019) used 30-day mortality as the primary outcome measurement in their prospective study. They reported that the CISNE had a high specificity, but low sensitivity when compared to the MASCC risk index, but concluded that both tools were equally useful.

**Rationale and Specific Aim**

This project was relevant for several reasons. First, identifying a risk assessment tool that can accurately classify geriatric cancer patients as appropriate for outpatient management could reduce unnecessary admissions. This subpopulation is at a higher risk for in-hospital complications such as nosocomial infections, thromboembolic events, and a loss of function (Flores and Ershler, 2010). By preventing an admission, patients have an increased likelihood of avoiding additional comorbidities that could have a negative effect on their oncology treatment plan. It could also help them maintain their functional independence. The community setting was chosen because the majority of cancer treatment is provided in the outpatient arena and most geriatric patients live in rural and suburban communities (Hermann, 2019; Weycker et al., 2014). This setting will allow the results of this project to be more generalizable to the current geriatric oncology population.

Furthermore, it has been established that the cost of outpatient management of febrile neutropenia is about one third of the cost inpatient care for the same diagnosis (Teuffel et al., 2011). Given that 60% of cancer patients are older adults, the reduction of both public and private healthcare dollars utilized for this cancer-related complication may be significant (Marosi and Keller, 2016). Finally, this project was the starting point for future plans in the advancement of care for geriatric cancer patients. The final goal is to develop an outpatient protocol for the management of febrile neutropenia in the CHO clinics. The specific aim of this project was to identify which risk assessment tool more accurately identifies low risk geriatric cancer patients with febrile neutropenia in order to decide which tool to ultimately recommend for clinical use.

**Methods**

**Study Design and Setting**

A retrospective chart review was performed to evaluate patients age 65 and older who were admitted with febrile neutropenia to three community-based hospitals within the same health system from September 2017 through September 2019.

**Subject Selection**

An initial search of the electronic medical record (EMR) was performed by Dr. Shaban Demirel using the age parameter of 65 and older and admission ICD-10 codes for “neutropenic fever”, “febrile neutropenia”, “neutropenia, unspecified”, and “chemotherapy-induced pancytopenia”. All charts were reviewed by myself to evaluate which subjects met the inclusion or exclusion criteria that had been determined previously. Patients were included if they were age 65 and older, were outpatient prior to presentation, had a solid tumor diagnosis or transplant-ineligible lymphoma or multiple myeloma, received systemic chemotherapy within 28 days of presentation, had an absolute neutrophil count (ANC) of less than 1,000 cells/μL, and a documented temperature greater than 100.4°F. Exclusion criteria included age less than 65, fever and/or neutropenia that was unrelated to chemotherapy treatment, or having a leukemia or myelodysplastic syndrome diagnosis (MDS). Patients with leukemia and MDS were excluded because they are innately high risk for admission complications.

**Data Collection**

Every patient chart was reviewed to ensure all inclusion criteria were met prior to study enrollment. Subjects that were enrolled had basic demographic data recorded which included patient age at time of encounter, sex, cancer diagnosis, number of days since last treatment with chemotherapy, temperature at admission, ANC at admission, hospital length of stay (LOS), prior to admission living situation and functional status, and all patient-specific data needed to calculate the MASCC risk index and CISNE scores (Figure 1). Admission complications that were defined as a transfer to the intensive care unit (ICU), post-admission deep vein thrombosis (DVT) or pulmonary embolism (PE), hospital-acquired infections including but not limited to pneumonia, bacteremia, urinary tract infection, and *clostridium difficile*, and death were recorded for the primary outcome analysis. Subjects that had a length of stay greater than three days and had a loss of pre-admission function regardless of their risk category were also recorded for a post-hoc secondary analysis. Subjects were considered to have a loss of pre-admission function if they required physical therapy post-discharge or if they were discharged to a higher level of care than they had previously been pre-admission. For example, if they were living at home and were discharged to a skilled nursing facility that would be considered a loss of function. A length of stay of three days was chosen as the threshold because it has been reported to be the average amount of time patients are admitted for febrile neutropenia (Durani & Go, 2016).

The CISNE score calculation requires an Eastern Cooperative Oncology Group (ECOG) performance status for each subject. If the ECOG was not available in the ED admission note, then this data was collected from the patient’s most recent oncology clinic visit note. If it was not recorded in the last clinic note, then the subject’s score was estimated based on the ED admission note. If the patient presented independently and did not require assistance with ambulation then they were given a score of 0 to 1. If they were brought in by ambulance or were unable to ambulate independently then they were given a score of 2. The CISNE score also requires the patient’s grade of mucositis. The status of the subject’s mucous membranes was collected from the admission physical exam. These findings were graded using the National Cancer Institute (NCI) mucositis grading scale (NCI, 2017). If mucous membranes were not directly commented on, then it was recorded as no mucositis was present.

In order to calculate the MASCC score, subjects’ symptom burden related to their febrile neutropenia had to be classified as none to mild or moderate. The estimation of this factor was based on the admitting provider’s note. A subject was classified as having zero/none or mild symptom burden if they were in no acute distress and their symptoms did not interfere with their baseline functional status. Subjects were classified as having a moderate symptom burden if they were described as in clinical distress which includes, but is not limited to, profound fatigue, mental status change, or an acute change in their functional status (ie. arrived by ambulance when previously independent). Patients were also classified as “dehydrated requiring intravenous (IV) fluids” if dehydration was in the problem list and IV fluids were administered. Both tools have elements of medical history as factors for score calculation. Each subject’s medical history was reviewed from the admission note and the “history” tab in the EMR. Patients who had signs of instability on presentation (ie. sepsis, severe infection, evidence of acute organ failure) were automatically considered high risk for both tools.

|  |  |
| --- | --- |
| **Apply CISNE Score** | **Points** |
| ECOG PS≥2 | 2 |
| Stress-induced hyperglycemia | 2 |
| COPD | 1 |
| Chronic CVD | 1 |
| NCI Mucositis grade ≥2 | 1 |
| Monocytes < 200 μL | 1 |

**Figure 1.**

Chart of subject enrollment and risk categorization using CISNE and MASCC risk index

CISNE 0-1

Low Risk

n=22

CISNE ≥ 2

High Risk

n=28

MASCC > 21

Low Risk

n=3

MASCC ≤ 21

High Risk

n=47

50 subjects’ charts reviewed to calculate risk scores and record outcome variables

Subjects with ANC <1000 cells/μL, fever (temp≥100.4°F), and receiving chemotherapy

n=62

12 subjects excluded because chemotherapy given >28 days prior to presentation

|  |  |
| --- | --- |
| **Apply MASCC Score** | **Points** |
| No or mild symptoms | 5 |
| SBP > 90 mmHg | 5 |
| No COPD | 4 |
| No HX of invasive fungal infection | 3 |
| No IV fluids | 3 |
| Moderate symptoms | 3 |
| Outpatient status | 3 |
| Age <60 | 2 |

*Note:* Stress-induced hyperglycemia was a blood glucose ≥ 121mg/dL or ≥ 250 mg/dL if the patients has a known diagnosis of diabetes or was receiving steroids. Grade 2 mucositis was moderate pain of the oral mucosa with or without visible ulcers that did not interfere with oral intake, but a modified diet was indicated.

**Data Analysis**

All data was recorded using Microsoft Excel, version 16.16.2. All statistical analyses was completed in IBM SPSS Statistics, version 26. Descriptive statistics were reported for demographic variables and admission complications of all subjects (Table 1 and 2). Each subject was categorized as high or low risk by the MASCC risk index and the CISNE. Next, subjects were classified as having an admission complication or not having one. Patients that were categorized as low risk and did not have an admission complication were recorded as true positives. Patients that were categorized as low risk, but had an admission complication were recorded as false positives. Patients that were categorized as high risk and had an admission complication were recorded at true negatives and those that were recorded as high risk, but did not have an in-hospital complication were recorded as false negatives. Subjects that were categorized as low risk, but had a hospital-acquired infection (ie. admission cultures and/or chest x-ray were negative) were kept as low risk without complications. This is because the infection was a result of the admission and they were low risk at presentation. Risk category and complications data for all subjects were compiled and displayed in frequency tables for each tool (Table 3 and 4). Subjects that had a length of stay of greater than three days and also had a loss of function were recorded. A Chi-squared analysis was performed in order to assess for a significant correlation between these variables.

**Ethical Considerations**

This study was a retrospective chart review and all patient data was de-identified. Therefore, no actual intervention was applied and there was no conflict of interest or ethical concerns.

**Results**

The initial query of the Legacy EMR returned 1076 potential subjects. After each chart was reviewed for inclusion and exclusion criteria, 62 subjects were enrolled. During the collection of patient data, an additional 12 patients were excluded because their most recent treatment was greater than 28 days prior and it was deemed unlikely that their neutropenia was the result of cytotoxic therapy. A total of 50 patients were included in the final analysis. The average age of all subjects was 75 and 56% (n=28) of all subjects were age 75 or older. There was a higher proportion of female subjects (66%, n=33) than male subjects (34%, n=17). Subjects with lymphoma, either Hodgkin’s or non-Hodgkins were the most prevalent (36%, n=18). The most common solid tumor diagnosis of all subjects was breast cancer, both male and female (18%, n=9). However, there was an overall higher percentage of patients with a solid tumor diagnosis (52%, n=26) than a hematologic malignancy (48%, n=24). The most frequent admission complication recorded was sepsis.

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| **Table 1. General Characteristics** | | | | |
| **Characteristic** | |  | **Number** | **Percentage** |
| **Gender** |  |  |  |  |
| Male |  |  | 17 | 34% |
| Female |  |  | 33 | 66% |
| **Age** |  |  |  |  |
| <75 |  |  | 22 | 44% |
| ≥75 |  |  | 28 | 56% |
| **Primary Cancer Diagnosis** | | |  |  |
| Lymphoma, any |  |  | 18 | 36% |
| Breast |  |  | 9 | 18% |
| Lung |  |  | 8 | 16% |
| Multiple Myeloma |  |  | 6 | 12% |
| Anal |  |  | 2 | 4% |
| Ovarian |  |  | 2 | 4% |
| Prostate |  |  | 2 | 4% |
| Pancreatic |  |  | 1 | 2% |
| Head & Neck |  |  | 1 | 2% |
| Uterine |  |  | 1 | 2% |
| **Type of Malignancy** |  |  |  |  |
| Solid Tumor |  |  | 26 | 52% |
| Hematologic | |  | 24 | 48% |
| |  |  |  |  | | --- | --- | --- | --- | | **Table 2. Admission Complications** | | | | | **Type of Complication** | | **Number** | **Percentage** | | Sepsis | | 17 | 34% | | Infection, other | | 9 | 18% | | Pneumonia |  | 7 | 14% | | Bacteremia | | 6 | 12% | | Transfer to the ICU | | 6 | 12% | | PE/DVT | | 3 | 6% | | Death |  | 2 | 4% | | |  |  |  |

The final classification of subjects by each risk assessment tool and the presence or absence of an in-hospital complication are presented in Table 3 and 4. The primary outcome analysis found the CISNE score to have a 88.9% specificity (95% confidence interval [CI] 70.8% to 97.7%) in patients identified as low risk and did not experience any in-hospital complication. The sensitivity was slightly lower at 82.6% (95% CI 61.2% to 95.1%). The positive predictive value (PPV) was 86.3 (95% CI 68.2% to 94.9%) and the negative predictive value (NPV) was 85.7 (95% CI 70.9% to 93.7%). The MASCC score was found to have a very high specificity of 96.3% (95% CI 81.0% to 99.9%), but its’ sensitivity was very low at 8.7% (95% CI 1.1% to 28.0%). The PPV of the MASCC was 66.7% (95% CI 16.2% to 95.4%) and the NPV was 55.3% (95% CI 51.7% to 58.9%). This data is also presented in Table 5.

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| --- | --- | --- | --- |
| **Table 3. Results of CISNE tool application** | | | |
| **CISNE score** | **No Complication** | **Complication** | **Total** |
| Low Risk (0-1) | 19 | 3 | 22 |
| High Risk (≥2) | 4 | 24 | 28 |
| **Total** | 23 | 27 |  |

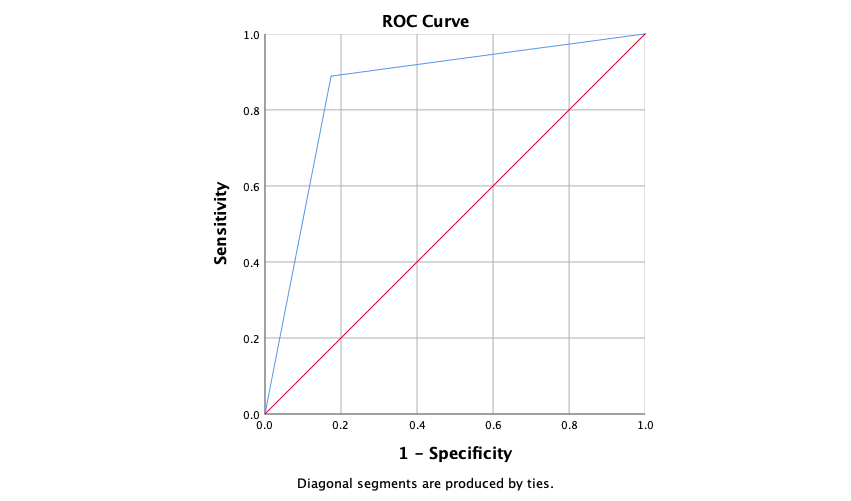
|  |  |  |  |
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| **Table 4. Results of MASCC tool application** | | | |
| **MASCC score** | **No Complication** | **Complication** | **Total** |
| Low Risk (≥21) | 2 | 1 | 3 |
| High Risk (<21) | 21 | 26 | 47 |
| **Total** | 23 | 27 |  |

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Table 5. Descriptive statistics for CISNE and MASCC for identification of low-risk subjects** | | | | |
| **Risk Assessment Tool** | **Sensitivity**  **(95% CI), %** | **Specificity**  **(95% CI), %** | **PPV**  **(95% CI), %** | **NPV**  **(95% CI), %** |
| CISNE | 82.6 (61.2-95.1) | 88.9 (70.8-97.7) | 86.3 (68.2-94.9) | 85.7 (70.9-93.7) |
| MASCC | 8.7 (1.1-28.0) | 96.3 (81.0-99.9) | 66.7 (16.2-95.4) | 55.3 (51.7-58.9) |

A receiver operating characteristic (ROC) curve was plotted and the area under the ROC curve (AUROC) was measured for each tool as well (Figure 2 and 3). The CISNE score was found to have an AUROC of 0.857 (95% CI 0.743 to 0.972) with a standard error of 0.058. The MASCC score had a lower AUROC of 0.525 (95% CI 0.362 to 0.687) with a standard error of 0.083.

**Figure 2.**

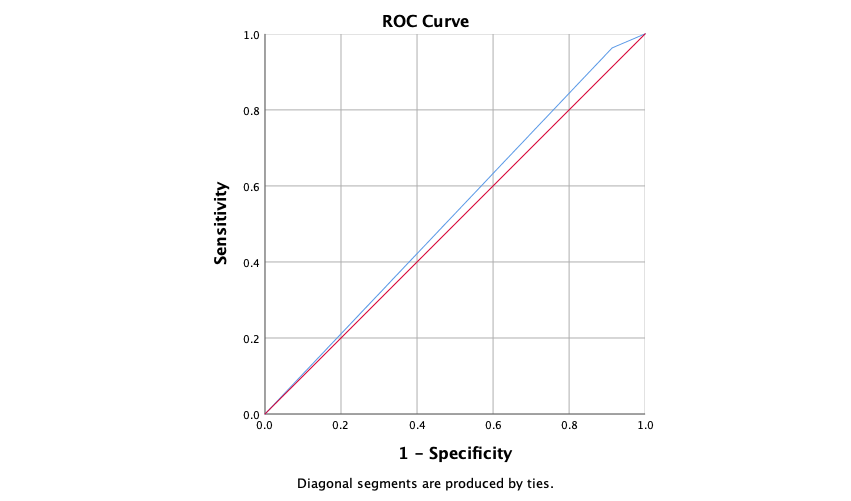
ROC Curve for CISNE score results

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*Note:* Area under the ROC curve (AUROC) was 0.857 (95% CI 0.743 to 0.972).

**Figure 3.**

ROC Curve MASCC score results



*Note:* Area under the ROC curve (AUROC) was 0.525 (95% CI 0.362 to 0.687).

As a post-hoc, secondary analysis, Chi-squared test was performed to assess for a significant correlation between a hospital length of stay greater than three days and a loss of function upon discharge. A total of 26 patients had a length of stay greater than three days and 24 patients had a length of stay equal to three days or less. Of the 26 patients that had an extended length of stay, 15 patients had a loss of function and 11 did not. Zero patients had a length of stay of three days or less and a loss of function. The relationship between an extended length of stay and a loss of pre-admission function was found to be significant, *X*2 (1, n = 50) = 19.78, p < .001.

**Discussion**

In comparison to recent literature, the results of the primary analysis had some similarities, but there were also some major differences. Previous studies have reported the CISNE has a specificity in the 90-95% range and a sensitivity in the 20-30% (Ahn et al., 2017; Coyne et al., 2017; Moon et al., 2018; Mohindra et al., 2019). This project found an almost equal sensitivity and specificity with both being above 80%. There are a couple of key differences in this project that could explain the increased sensitivity. First, unlike prior studies, this project did not include patients with leukemia or MDS because they are innately high risk due to their disease. They have prolonged neutropenia and have higher rates of in-hospital complications (Livio et al., 2018). By decreasing the overall number of potentially high-risk subjects, the false negative rate will be lower allowing for an increase in sensitivity. Furthermore, this project also had a subject age limit of 65 years and older. Age is not a factor in the CISNE score, but factors commonly present in geriatric patients, like a history of CVD or COPD and higher ECOG scores, are included (Repetto et al., 2000). Subjects that did not have these factors were commonly scored as low risk and most did not experience admission complications. This could mean that comorbidities and functional status may be a better indicator of risk category than age alone. Furthermore, via this study, the CISNE has identified a population of geriatric cancer patients that may be suitable for outpatient management of febrile neutropenia. This is an important finding not only because it may prevent unnecessary admissions, but it also aides in breaking down the ageism that is present in the care of geriatric patients. The specificity of the CISNE measured in this project is comparable to that of prior studies.

The MASCC risk index was measured to have a very low sensitivity of less than 10%. In previous studies, the sensitivity was about 95% (Ahn et al., 2017; Moon et al., 2018). This is because there was a very high rate of false negatives (ie. subjects that were classified as high risk and did not experience a complication). In applying the MASCC risk index, if a patient was age 60 or above and required IV fluids, they were categorized as high risk. This project only enrolled subjects that were older than 60 and most received IV fluids at time of presentation which would explain why 97% (n=47) of subjects were categorized as high risk. The specificity of this tool was measured to be 96.3% which also differs from current literature as it has previously been measured to be between 14 and 25% (Ahn et al., 2017; Moon et al., 2018; Mohindra et al., 2019). This also relates to the large proportion of patients that were classified as high risk, but, in this case, did experience an admission complication. The true negative rate was high because the MASCC risk index has the inherent assumption that patients over age 60 are more likely to be high risk. It is important to note that both tools were applied in accordance with the patient populations in which they were initially developed. Specifically, the CISNE which was not validated in hematologic malignancy patients.

The AUROC measurements of both the CISNE and the MASCC risk index differed from previous studies. Previously, the CISNE’s AUROC has been reported to be between 0.64 and 0.77 and the MASCC risk index was reported to be between 0.66 and 0.68 (Ahn et al., 2017; Moon, et al., 2018; Mohindra et al., 2019). This project found the CISNE to have a much higher AUROC of 0.857. The MASCC risk index was much lower and had an AUROC of 0.525. A statistical analysis was not needed to appreciate the difference between the two tools. This analysis showed that the CISNE has a moderately high accuracy in this specific population, while the MASCC risk index does not. This analysis confirms that the CISNE has an overall better performance in identifying low-risk febrile neutropenic patients in the geriatric oncology population.

In regards to the secondary analysis, there was a significant correlation between an extended length of stay and loss of pre-admission function. Van Vliet, Huisman, and Deeg (2017) previously found that a length of stay of less than three days was associated with a slower rate of decline in geriatric patients. In order to relate this analysis to the primary objective of this project, the raw data was reviewed to see if there were any patients that were identified as low risk, by either tool, that had an LOS less than three days and a loss of pre-admission function. There were 2 patients identified. Therefore, it could be suggested that identifying low risk patients may not just avoid a hospital admission, but may also preserve a patient’s functional ability.

**Project Limitations**

There are several limitations in regards to this project. First, it was a retrospective chart review and the collected data is dependent on the accuracy of the medical record. Another limitation of this project is that it was a single researcher that performed all data collection, score calculation, and statistical analysis. This leaves the project vulnerable to sampling bias, observer bias, and interpretation bias. It was attempted to avoid these biases by strictly following inclusion and exclusion criteria, having concrete definitions for each category in both tools, and using a binary system to input data for analysis. Finally, this project was performed in a single health system and the sample size was small. However, this project is hypothesis generating and suggests the need for an expanded prospective study in order to validate the results.

**Conclusion**

This project has provided evidence to support the notion that there is a subpopulation of geriatric cancer patients that could be treated in the outpatient setting for febrile neutropenia. It has already been established that an unnecessary hospital admission for these patients can lead to a detrimental impact on their physical health and psychosocial well-being. It is unlikely that all clinicians receive the same training when it comes to the management of febrile neutropenia. It is also unlikely that ED providers in community-based hospitals have consistent exposure to this population. This is why it is important to have a reliable tool that can assist providers in their decision making when trying to decide if a patient requires admission.

I would recommend the CISNE over the MASCC risk index for use in the community setting. The results of this project suggest that the CISNE has a better discriminatory ability in identifying low risk geriatric cancer patients that present with febrile neutropenia. It not only had a relatively high sensitivity and specificity, but it had a high accuracy as well. I think the CISNE performed well in this population because age was not taken into account when calculating the patient’s risk. By removing the assumption that geriatric patients are high risk based on their chronologic age, a subpopulation of low risk patients was able to be identified. The MASCC risk index is not a useless tool for geriatric patients. With such a high specificity, the tool is erring on the side of caution and a patient may be admitted unnecessarily. However, this also means that there is a low likelihood that a high risk patient would be sent home.

In regards to the secondary analysis, it is not surprising that there is a significant correlation between an extended length of stay and a loss of pre-admission functionality. I think this result was important because it highlights the downstream benefits of utilizing tools like the CISNE and MASCC risk index. For example, there were two patients that had been scored as low risk and experienced a loss of function. It is possible that, had they been treated as an outpatient, they might have been able to maintain their independence. This not only saves money for the patient, but also for the healthcare system as a whole. The median Medicare payment per stay in a skilled nursing facility (SNF) was about $18,000 in 2018 (MedPAC, 2019). It was also estimated that about one-fifth of patients on Medicare were discharged to a SNF.

**Summary and Future Directions**

In summary, the CISNE outperformed the MASCC risk index in identifying low risk geriatric cancer patients with febrile neutropenia in this particular retrospective study. It is the tool I would recommend for use in the OHSU CHO clinics and community-based hospital EDs. Going forward, I would like to perform a prospective, observational study by having providers apply the CISNE upon patient presentation. Then I could follow subjects’ hospital course to assess for tool accuracy. Ultimately, I would like the CISNE to be a part of a febrile neutropenia outpatient protocol for the CHO clinics, but in order for that goal to come to fruition, the data is needed first.

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