7-13-2023

# Orthostatic Vital Signs in Bone Marrow Transplant Patients

Julianne Tomac
*University of Missouri-St. Louis*, jkkv5@umsystem.edu

**Orthostatic Vital Signs in Bone Marrow Transplant Patients**

Julianne Tomac

B. S. Nursing, University of Missouri-St. Louis, 2019

A Dissertation Submitted to The Graduate School at the University of Missouri-St. Louis

in partial fulfillment of the requirements for the degree

Doctor of Nursing Practice with an emphasis in Family Nurse Practitioner

August 2023

Advisory Committee

Vanessa Loyd, PhD, DNP

Chairperson

Tonya Haynes DNP, RN

Samantha Chappell MSN, RN

## Abstract

**Background:** Orthostatic hypotension is a potentially serious risk factor that can cause falls in adults, especially those receiving a bone marrow transplant. The odds of falling increase if diagnosed with a hematological form of cancer while receiving treatment due to side effects of chemotherapy and medications.

**Methods:** This retrospective record review investigated the completion rate of orthostatic vital signs in bone marrow transplant patient's days 10 to 17. The aim was to discover 2% of positive orthostatic cases in a 6-month period. The primary outcome measures included the number of orthostatic vital signs obtained and secondary outcome measures included the number of falls.

**Results:** The overall findings included 33 females and 50 males ($N$=83) in a 6-month period. There were 18 different diagnoses that were treated with 5 different types of bone marrow transplants. In October-December 2022, there was a total compliance rate of 50% and from January-March 2023 there was a compliance rate of 53%. A total compliance rate for a 6-month period of 51%. A chi-square analysis was performed on the data from 2022 vs 2023 and $p=.904$. The orthostatic compliance was not significantly significant. There were 106 positive orthostatic cases caught which reached the discovery of 2% of cases. There were also 8 total falls, and 3 falls were between the 10 through 17-day timeframe within the 6-month time frame.

**Implications for Practice:** Overall, the results were not statistically significant, but future PDSA cycles will help to facilitate earlier identification of patients who are orthostatic, prompting timely intervention, and subsequent fall and injury prevention.

## Orthostatic Vital Signs in Bone Marrow Transplant Patients

Many healthcare institutions report falls as a major safety concern that can cause fatal and nonfatal adverse events. The Centers for Disease Control [CDC] (2020) reported a 30% increase in falls from 2007 to 2016 for older adults. A fall is typically described as an unplanned downward movement to the floor with or without injuries (WHO, 2021). The consequences of falls can include bone fractures, lacerations, or head injuries. These adverse events can lead to high morbidity and mortality rates, increased financial costs, and a lower quality of life (Kuhlenschmidt et al., 2016). The consequences of falls come with an even greater risk for patients with bone marrow transplants due to thrombocytopenia which can cause serious injuries. A bone marrow transplant can cost a minimum of $289,000 with a median stay of 36 days and a fall can increase the length of stay in the hospital by a minimum of six days and add $14,000 to the hospital stay (Broder et al., 2017; CDC, 2020). In the United States, fatal falls cost approximately $28.9 billion and nonfatal falls were estimated to be $754 million for a total of $50 billion (CDC, 2020; Florence et al., 2018).

Falls are a major concern and bring even more concern to those individuals with cancer due to its effects and treatment. The odds of falling increase by 172% if diagnosed with a hematological form of cancer and have undergone a bone marrow transplant (Weed-Pfaff et al., 2016). People with a cancer diagnosis are at increased risk for falls in the hospital while receiving treatment due to their treatment plan which includes chemotherapy, medications, and their side effects. Some side effects during cancer treatment include nausea, vomiting, diarrhea, hypovolemia, peripheral neuropathy, deconditioning, and orthostatic hypotension.

Orthostatic hypotension is defined as the decrease in systolic blood pressure by 20mmHg and 10mmHg in diastolic blood pressure after standing for 3 minutes (Ringer & Lappin, 2022). Orthostatic hypotension can be caused by nausea, vomiting, diarrhea, and hypovolemia, which can lead to dehydration. Certain medications such as benzodiazepines, sedatives, antiemetics, and anxiolytics place patients at greater risk for falls due to orthostatic hypotension (Vela et al., 2018). In addition, polypharmacy is a contributing factor to orthostatic hypotension due to the interaction of multiple medications. Physiological signs and symptoms of orthostatic hypotension include blurred vision, dizziness, light-headedness, nausea, and fainting. These symptoms are caused by a decrease in perfusion and oxygenation of the brain which qualifies as a high fall risk.

Oncology patients' perceptions can contribute to falls due to the lack of identifying fall risk factors and education regarding fall risks. Additionally, patients may view themselves as fit and healthy upon admission which can lead to a skewed perception of falls (Kuhlenschmidt et al., 2016). Older adults may underestimate their state of health and misjudge their fall risk. Patients may deny that they are a fall risk until a fall happens. This may lead to hesitations, which can inhibit activities of daily living (Kuhlenschmidt et al., 2016). Early identification and education in cancer patients are needed to prevent falls and injury (Kuhlenschmidt et al., 2016).

On a bone marrow transplant (BMT) floor in a midwestern hospital, there is room for improvement regarding fall prevention. The Institute for Healthcare Improvements Model for Change functioned as the framework for this quality improvement project using the Plan Do Study Act (PDSA) cycle. This topic is appropriate for PDSA cycle

because it applies small tests of change to improve a method. The purpose of this project was to determine the compliance rate of orthostatic vital signs in bone marrow transplant patients and days 10 through 17. This project aimed to discover positive orthostatic cases in bone marrow transplant patients for six months through orthostatic vital sign monitoring. The primary outcome measures included the number of orthostatic vital signs completed days 10 through 17 after transplant occurring over six months. Secondary outcome measures include the number of falls. The question of study is: In patients that are 18-80 years old who are days 10 through 17 post a bone marrow transplant, what is the compliance rate of obtaining orthostatic vital signs (blood pressure and heart rate) using a standardized orthostatic assessment tool over six months?

## Review of Literature

A literature search was conducted using PubMed, CINAHL, and Cochrane as databases to review studies that assessed the use of standardized fall risk interventions and orthostatic vital sign monitoring on fall rates in the oncology populations. The Clinical Journal of Oncology Nursing was also utilized. The following key search terms and Boolean operator phrases were used: orthostatic hypotension AND postural hypotension and falls, bone marrow transplant AND falls, oncology patients OR cancer patients OR patients with cancer, orthostatic hypotension and falls, and multiple independent words such as *fall prevention, orthostatic hypotension, falls, oncology patients.* Using a broad search, 331 articles were identified. The inclusion criteria included ages 18 years and older, with a hematological cancer diagnosis, admitted to the hospital requiring a bone marrow transplant. The exclusion criteria involved people less than 18 years, without a hematological cancer diagnosis, not admitted to the hospital for a

bone marrow transplant, re-admissions, immobility, and at end-of-life/hospice criteria. The search was refined, 268 articles were identified, 11 studies were chosen, two meta-analyses, one quasi-experimental study, four retrospective record reviews, one mixed method study, two randomized case-control studies, and one literature review by their relevance to falls in oncology patients between the dates 2016-2022.

Primary prevention for falls in bone marrow transplant patients upon admission is imperative to increase awareness and reduce falls overall by educating about falls and fall risk. Upon admission, bone marrow transplant patients may not realize that they are at an increased risk for falls having inaccurate perceptions regarding their own fall risk (Grady et al., 2020; Knox, 2018). A patient's perception of being a fall risk includes being of advanced age, using an assistive device, and being unsteady. Unfortunately, the active problem is the lack of education or forgetfulness in bone marrow transplant patients about fall risks and fall prevention. Standard education should include the teach-back method, fall prevention strategies, and a fall risk handout (Knox, 2018).

Knox (2018) completed a mixed methods study to examine patients' perception of fall risks and found patients have inaccurate perceptions regarding their fall risks. Many patients reported not hearing or remembering staff talking about fall prevention. Other patients reported themselves as being low fall risk and feelings "stable" (Knox, 2018). There was a statistically significant association between the initial perception of fall risk and the nurse's fall risk score ($p$=0.03). There was also a statistically significant correlation between patient awareness and the nurses' opinion of fall risk scores after the follow-up timeframe ($p$=0.0009) (Knox, 2018). Comparatively, Kuhlenschmidt et al. (2016) completed a two-group prospective randomized control to determine the effect of

nurse education compared to a control group, on fall risk perceptions. Like Knox (2018), Kuhlenschimdt also found statistically significant differences between patients who perceived themselves as a high fall risk but a low risk for intervention ($p$= 0.01), and no significant changes were found between perception, self-confidence, or readiness in patients (Kuhlenschmidt et al., 2016). These findings suggest the need for enhanced education and instruction to teach patients about fall risk (Knox, 2018; Kuhlenschmidt et al., 2016).

Dee et al. (2017) conducted a retrospective case-control study on patients who received an autologous stem cell transplant and assessed fall risk using the Morse Fall Risk Score (MFS). Sometimes standard fall scales and fall interventions are not appropriate for specific patient populations, like oncology patients. The MFS is a standardized tool used in many electronic medical record systems to assess fall risk. The MFS is used on admission, daily, after a fall, and when a significant change occurs in a patient's condition (Dee et al., 2017). Accurately assessing fall risk is essential for preventing falls, since fall risk interventions are only put in place when someone meets the criteria for being a moderate/high fall risk (Dee et al., 2017; Spanolios et al., 2022).

Standard fall risk interventions are inadequate for transplant patients due to having other risk factors not identified by the current assessment tools available. The MFS is used as a fast tool to detect fall risk and assesses the history of falling, secondary diagnoses, ambulatory aid usage, intravenous access, gait, and mental status (Dee et al., 2017). The results of the study had two common outcomes. There were eight patients who fell and four patients who did not fall had a high MFS score and were 5.3 times more likely to fall compared to patients with low MFS scores. The second commonality

was between the fallers and non-fallers and the number of days of diarrhea that patients had was statistically significant. For example, every episode of diarrhea increased their fall risk by 1.2 times (Dee et al., 2017). The study identified that even though the MFS is a standardized fall risk tool, it is insufficient by itself because other physiological risk factors in transplant patients occur that are not identified in this tool (Dee et al., 2017; Spanolios et al., 2022).

Spanolios et al. (2022) used a descriptive design and a retrospective review to recognize the characteristics of inpatients with cancer who fell. In this study, the MFS was used, and seven patients were categorized as forgetting limitations on the mental status assessment of the MFS. Additionally, 34% of patients were perceived as having cognitive impairments, therefore, the MFS is not a reliable tool for patients with blood cancer. The study discovered that many patients were receiving chemotherapy, antihypertensives, opiates, and antiemetics, which can all lower blood pressure. Of these patients, 28 patients who fell had no injury and 19 experienced a minor injury (Spanolios et al., 2022). Added knowledge gained by this study highlighted that chemotherapy-induced peripheral neuropathy was another contributing factor to falls in patients with hematological cancer. Further research into a fall risk tool for transplant patients should be warranted due to other physiological risk factors that are specific to the oncology population.

Comparably, Francis-Coed et al. (2020) conducted a secondary analysis from a case-control study on a medical-oncology unit and identified the number of fall prevention interventions in place and the number of falls continuing to occur. Findings confirmed that using the MFS tool to identify risk scores was not valuable in delivering

fall management. Almost half of the patients analyzed were considered low-risk and all patients recognized as high-risk were more likely to receive fall prevention interventions. The study also confirmed that risk scores are a suggestion because they do not accurately predict which patients are at risk of falls. The MFS is a suggestion to initiate fall interventions and can identify some risk factors (Dee et al., 2017; Francis-Coad et al., 2020; Spanolios et al., 2022). Likewise, despite their limitations, other standard fall prevention interventions can be effective when combined with strategies to educate medical staff on fall risk awareness. Moreover, differences in fall risk perception compound failures in fall management for transplant patients.

Harden et al. (2021) conducted a similar retrospective case-control study on patients who received an autologous stem cell transplant assessed fall risk using the MFS and found two outcomes that suggest additional fall risk interventions are necessary. A visual rounding tool was utilized to communicate to personnel what patients' needs were completed. Using the visual rounding tool, call light usage significantly decreased by 12%, falls decreased by 31%, and the number of falls with injury decreased by 50% (Harden et al., 2021). Constant re-education, monitoring, and reinforcement were required for workers to continue this multifaceted tool, but the practices were not maintained long-term after the study concluded. Altogether, this study demonstrated that continuing standard fall prevention interventions like hourly rounding is an essential piece of fall prevention (Harden et al., 2021).

Seow et al. (2021) conducted a retrospective study reviewing the success of a three-mode bed exit alarm and fall rates. The bed alarms showed an improvement in fall incidence from 0.23% in July 2016 to 0.11% in December 2016. The study mentioned

that their fall rates were reasonably low and had to adjust their analyses (Seow et al., 2021). The study demonstrated that bed exit alarms are proven to reduce falls but is also important to consider alarm fatigue and the ability of nurses to respond to the alarm quickly.

Bed alarms have been considered one of the gold standards to reduce falls, but they can also cause "false alarms" and contribute to alarm fatigue throughout the patient's stay. Morris et al. (2022) conducted a systematic review and meta-analysis regarding standardized fall prevention interventions. In their research, bed alarms and chair alarms were not associated with a reduction in falls and revealed higher fall rates with bed/chair alarms initiated. Bed alarms are a useful tactic to alert staff that a patient is ambulating without assistance but are unlikely to be an effective impediment to fall prevention.

In addition to standard fall risk interventions, there is current literature providing insight into a patient's physiological symptoms that may indicate a patient is a fall risk. More specifically, orthostasis has been identified in patients receiving chemotherapy treatments. Grady et al. (2020) conducted a retrospective chart review on newly admitted patients undergoing a bone marrow transplant using a pre/post-test program initiating a Moffitt BMT-CI Orthostatic Vital Signs Algorithm. The chart review focused on 25 patients who fell and data before the algorithm indicated a 3.7% fall rate which was 28 out of 757 patients (Grady et al., 2020). Baseline falls related to orthostatic hypotension decreased from 2.2% to 0% which was statistically significant (Grady et al., 2020). In addition, postimplementation fall frequency decreased from 5.38% to 3.4% (Grady et al., 2020). No falls occurred due to orthostatic hypotension during the study period. This

study is limited by its patient population, but the data can still aid in future research regarding specific symptoms that led to falls. All patients, whether in oncology or not, can be assessed for orthostasis, which could potentially result in fall prevention. The orthostatic vital signs algorithm can enhance knowledge, skills, and adherence and ultimately reduce falls in these fragile patients by honing in on physiological fall risk factors. Bone marrow transplant patients and orthostatic hypotension is known to be positively correlated with falls.

Mol et al. (2019) completed a systemic review and meta-analysis to assess orthostatic hypotension and falls. The results emphasized the importance of vital sign monitoring throughout the hospital stay to reduce falls (Harden et al., 2021; Mol et al., 2019). A key limitation of this systemic review was the studies used for analysis were of moderate to low quality and cannot confirm a causal relationship between orthostatic hypotension and falls (Mol et al., 2019). Even though the review had low to moderate-quality studies, it included many studies and diverse populations where orthostatic hypotension was positively associated with falls and needed to be investigated (CI 1.50-1.99) (Mol et al., 2019).

Vela et al., (2018) analyzed medication side effects and potential other fall risk factors were analyzed on an inpatient BMT floor. Of many fallers (48 patients), 81% experienced a fall post-stem cell transplant. Research has concluded that the use of antidepressants ($p$=0.0019), anticonvulsants ($p$=0.0211), and benzodiazepines ($p$=0.0238) increased the risk of falling (Vela et al., 2018). Opioids independently did not reach statistical significance ($p$=0.1389) which differed from other studies that stated opioids had a bigger impact. Medications that were administered before the fall event are of

substantial importance for fall risk factors. Fallers were accompanied by the advanced use of central nervous stimulation agents like antidepressants, blood pressure agents, sedatives, and benzodiazepines which all increase the risk for falls due to their effects on blood pressure and heart rate (Vela et al., 2018). Even though the study explored multiple factors contributing to falls, they were unsuccessful in matching the type of transplant or cancer diagnosis to falls (Vela et al., 2018).

The Institute for Healthcare Improvements Model for Change was the framework chosen to test the change. The Plan-Do-Study-Act cycle was chosen because of the constant circular motion for re-evaluation. This model specifically accomplishes change and by utilizing it consecutively can fine-tune the intervention and expand the scope. More specifically, the model can help to identify existing problems, reduce the number of errors, change existing processes, prevent surprises and shocks, and help to ensure profit (Roy, 2018). This could aid in further evaluation of the project to promote safe and effective care for professionals and patients.

It is important to teach patients about the risks of falling and preventing falls, but it is also vitally important for a patient to understand that they are a fall risk. There were gaps in the literature that specifically omitted fall prevention in bone marrow transplant patients, but the literature did highlight a correlation between fall risks and hematological cancer diagnosis. A nurse's assessment of fall risk and a patient's perception of a fall risk may differ; however, it is vital to educate patients about the potential fall risk factors that occur with a cancer diagnosis and treatment. The patient's awareness may change their perceptions about fall risks and ensure they are more cautious of their surroundings and ask for assistance. Additionally, orthostatic hypotension has been positively associated

with falls in older adults. Therefore, orthostatic vital sign monitoring is essential especially while patients are receiving chemotherapy treatment and prescribed blood pressure-lowering medications. Utilizing the PDSA cycle assisted in discovering a solution to fall prevention by constantly re-evaluating and finding improvements. Falls will occur, but it is imperative to attempt to intervene and prevent falls before they happen.

## Methods

### Design

This QI project utilized a retrospective record review from October 2022-March 2023. Descriptive statistical data analysis was conducted using a chi-square analysis regarding the number of orthostatic vital signs completed and the number of positive orthostatic instances. The number of falls was also reported.

### Setting

This quality improvement project occurred in a hospital located in the metropolitan area that employs 30,000 employees. The inpatient floor was on an adult bone marrow transplant floor that holds 32 patients.

### Sample

A convenience sample was used of patients aged 18-80 years of age admitted for a stem cell transplant. The inclusion criteria included ages 18 years and older, admitted to the hospital for a bone marrow transplant with a hematological form of cancer. The exclusion criteria include ages less than 18 years, not being admitted to the hospital for a bone marrow transplant, re-admissions, immobile patients, and end-of-life/hospice

criteria. Patients received orthostatic vital signs twice daily on days 10 through 17 after the transplant.

**Procedures**

Registered nurses received a CDC-generated document regarding how to properly obtain orthostatic vital signs (See Appendix A). Patients were evaluated for orthostatic hypotension via assessment of orthostatic vital signs twice daily between days 10 through 17 after the transplant. Blood pressure and heart rate were taken after a patient was lying for at least five minutes, standing for one minute, and standing for an additional two minutes (a total of 3 minutes standing). Orthostasis is the decrease in systolic blood pressure by 20mmHg and 10mmHg in diastolic blood pressure after standing for 3 minutes (Ringer & Lappin, 2022). Following the medical record review, the researcher collected and analyzed the orthostatic vital sign data using descriptive statistics and chi-square analysis.

**Data Collection/Analysis**

Data was collected regarding the number of orthostatic vital signs completed, the number of positive orthostatic instances, and the number of falls. Demographic variables include age, gender, diagnosis, and transplant type. All vital signs were documented in the electronic medical record (EMR) and became a part of the patient's medical record. Patients were de-identified by applying a numerical identifier (i.e., PT 1). To analyze the data, Microsoft Excel and SPSS were utilized for data collection and a chi-square analysis was computed (Appendix B).

### Approval Process

Formal, written approval was obtained by the committee members, the participating hospital, and the graduate institutional review board before implementation. There are minimal risks to obtaining vital signs while lying and standing. The benefits outweigh the risks by identifying patients who are at risk for falling and minimizing post-fall complications.

## Results

### Demographics

The sample included (*N*=94) patients aged 23 to 79 years old. Eleven patients (*n*=11) were excluded from the data due to clinical instability to obtain orthostatic vital signs. A new sample size was calculated and (*N*=83) patients were studied with an average age of 56 years (*SD*=14.9). A retrospective chart review was conducted from October 2022, through December 2022, which was 3 months after the implementation of obtaining orthostatic vital signs on transplant patients. Additional data was collected from January 2023 through March 2023, for data comparison 6 months after implementation. This QI project was able to identify the day shift nurses' compliance rate in obtaining orthostatic vital signs. Night shift orthostatic compliance results were omitted from this project due to the inability to determine compliance. Demographic data including age, gender, diagnosis, and transplant type is reported in Table 1. There were 40% (*n*=33) females and 66% (*n*=50) male transplant patients, and 28% (*n*=23) patients discharged before or during days 10 through 17 after the transplant that were still included in the data collection.

### Transplants

There were five different types of transplants given to (*N*=83) patients including 29 haploidentical (35%), 21 matched unrelated donors (25%), 27 chimeric antigen receptor T cell therapy (CART) (33%), 5 sibling allogenic (.06%), and 1 tumor-infiltrating leukocyte (0.01%) while 18 different diagnoses were treated. There were (*n*=8; 0.09%) post-transplant falls during the time of implementation and (*n*=3; 0.04%) falls between days 10 through 17 post-transplant.

### Compliance Rates

Compliance rates were calculated regarding the number of orthostatic vital signs completed on day shift. There was a total of 128 completions for day shift to obtain orthostatic vital signs and 255 opportunities. Therefore, there was a 50% compliance rate for October-December 2022 and a 53% compliance rate for January-March 2023. There were 106 instances of positive orthostatic vital signs identified out of a total of 510 opportunities available over 6-months for day shift to complete. Out of 510 opportunities, 262 orthostatic vital signs were completed. A chi-square analysis of the compliance rate was also computed over 6-months and was found not to be not statistically significant (*p=.904*). Moreover, the total 6-month compliance rate yielded 51%.

## Discussion

Implementation of this QI project accomplished the ability to screen for orthostasis in post-transplant patients and identify positive cases. There were 106 positive orthostasis cases identified with a 6-month compliance rate of 51%. The literature shows that in post-transplant patients, the mean number of days that orthostasis occurs is around day 14 and patients who fell were days 1-20 post-transplant (36%) (Vela et al., 2018). In

future research projects utilizing the tools presented in this study could further identify orthostatic patient's post-transplant. A second PDSA cycle should be utilized to obtain more statistical data including patient refusals of orthostatic vital signs.

The purpose of this study was to determine nursing compliance rates on orthostatic vital signs. Some perceived limitations include time constraints, patient refusals, staffing, and education. Nurses had complaints that they did not have enough time during morning rounds to do orthostatic vital signs on patients. Vital signs are initially taken during morning rounds and the average time for orthostatic vital sign completion is about 4 minutes. Patients also had the option to refuse orthostatic vital signs, which were documented in the EMR, but not an outcome measure that was recorded. All orthostatic vital signs were taken without the patient's expressing any distress or discomfort. Another limitation identified during this QI project was extensive orientation was inconsistent with traveling nurses. Patient care technicians were also expected to obtain orthostatic vital signs, but compliance was low and expected nursing to complete the task. In the literature, compliance rates were higher due to staff education, early chart audits, and twice-daily huddles on the importance of orthostatic vital signs (Vela et al., 2018). In future studies, more daily check-ins, huddles, and education should be provided to nursing and support staff to increase compliance rates.

Recommendations for future studies include data collection on pre-implementation and post-implementation orthostatic vital sign monitoring. Collecting data on other risk factors including patient refusals, incontinence, and specific medication usages that are known to cause orthostasis. These medications might be benzodiazepines, corticosteroids, antidepressants, antiemetics, and analgesics (Vela et al., 2018). Also,

findings from night shift compliance were significantly low and this could be because of less staff on night shift than day shift. To improve compliance on night shift, staff nurses could obtain orthostatic vital signs at shift change to reduce the number of opportunities missed. In future studies, more daily check-ins, huddles, and education should be provided to nursing and support staff to increase compliance rates.

### Implications for Practice

Implementing orthostatic vital sign monitoring can be used for early identification of inpatients who are at high risk for falling. Orthostasis can be identified by a drop in blood pressure and early intervention is key. This QI project did not reveal statistical significance but found clinical significance. Grady et al., (2020) did indicate statistical and clinical significance when monitoring for orthostatic hypotension.

## Conclusion

In this quality improvement project, the implementation of orthostatic vital sign monitoring in patients who are days 10 through 17 post bone marrow transplant displayed encouraging results in identifying physiological risk factors for falls. Due to the limited timeframe of this project, future PDSA cycles and data collection should take place for ongoing QI analysis to prove significance in obtaining orthostatic vital signs in post-transplant patients. This could help to facilitate earlier identification of patients who are orthostatic, prompting timely intervention, and subsequent fall and injury prevention.

## References

Broder, M. S., Quock, T. P., Chang, E., Reddy, S. R., Agarwal-Hashmi, R., Arai, S., & Villa, K. F. (2017, October). The cost of hematopoietic stem-cell transplantation in the United States. *American health & Drug Benefits*. Retrieved October 23, 2022, from https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5726064/.

Centers for Disease Control and Prevention. (2017). *Assessment: Measuring Orthostatic Blood Pressure* [Online Image]. https://www.cdc.gov/steadi/pdf/STEADI-Assessment-MeasuringBP-508.pdf

Centers for Disease Control and Prevention. (2020). *Older adult fall prevention: Cost of falls. U.S. Department of Health and Human Services*. https://www.cdc.gov/falls/data/fall-cost.html

Dee, V., Toro, J., Shuko Lee, & Sherwood, P (2017). Autologous Stem Cell Transplantation: The Predictive Value of the Morse Fall Scale in Hospitalized Patients. *Clinical Journal of Oncology Nursing*, 21(5), 599–604. https://doi.org /10.1188/17.CJON.599-603

Florence, C. S., Bergen, G., Atherly, A., Burns, E., Stevens, J., & Drake, C. (2018). Medical Costs of Fatal and Nonfatal Falls in Older Adults. *Journal of the American Geriatrics Society*, *66*(4), 693–698. https://doi.org/10.1111/jgs.15304

Francis-Coad, J., Hill, A. M., Jacques, A., Chandler, A. M., Richey, P. A., Mion, L. C., & Shorr, R. I. (2020). Association Between Characteristics of Injurious Falls and Fall Preventive Interventions in Acute Medical and Surgical Units. *The Journals of Gerontology: Series A, Biological Sciences and Medical Sciences*, *75*(10), e152–e158. https://doi.org/10.1093/gerona/glaa032

Grady, L., Klein, J., Patterson, A. E., Pompos, C., Reich, R., & Mason, T. (2020). Orthostatic vital signs algorithm: Decreasing falls in patients undergoing blood and marrow transplantation or treatment with cellular immunotherapy. *Clinical Journal of Oncology Nursing*, *24*(5), 489–494. https://doi.org/10.1188/20.cjon.489-494

Harden, K. L., Wall, P., Galunas, L., Eastman, D. J., & Frederick, T. S. (2021). Managing falls: Implementation of a three-intervention initiative to improve quality of care for patients with cancer. *Clinical Journal of Oncology Nursing*, *25*(2), 188–193. https://doi.org/10.1188/21.CJON.188-193

Knox, A. (2018). Fall Risk Perceptions: A study of hospitalized patients with hematologic malignancies. *Clinical Journal of Oncology Nursing*, *22*(6), E159–E165. https://doi.org/10.1188/18.CJON.E159-E165

Kuhlenschmidt, M. L., Reeber, C., Wallace, C., Yanwen Chen, Barnholtz-Sloan, J., & Mazanec, S. R. (2016). Tailoring Education to Perceived Fall Risk in Hospitalized Patients with Cancer: A Randomized, Controlled Trial. *Clinical Journal of Oncology Nursing*, *20*(1), 84–89. https://doi.org /10.1188/16.CJON.84-89.

Morris, M. E., Webster, K., Jones, C., Hill, A.-M., Haines, T., McPhail, S., Kiegaldie, D., Slade, S., Jazayeri, D., Heng, H., Shorr, R., Carey, L., Barker, A., & Cameron, I. (2022). Interventions to reduce falls in hospitals: A systematic review and meta-analysis. *Age and Ageing*, 51(5). https://doi.org/10.1093/ageing/afac077

Mol, A., Bui Hoang, P. T. S., Sharmin, S., Reijnierse, E. M., van Wezel, R. J. A., Meskers, C. G. M., & Maier, A. B. (2019). Orthostatic Hypotension and Falls in Older Adults: A Systematic Review and Meta-analysis. *Journal of the American*

*Medical Directors Association*, 20(5), 589. https://doi.org /10.1016/j.jamda.2018.11.003

Ringer, M., & Lappin, S. (2022). Orthostatic Hypotension. *National Library of Medicine*. Retrieved October 23, 2022, from https://www.ncbi.nlm.nih.gov/books/NBK448192/.

Seow, J. P., Chua, T. L., Aloweni, F., Lim, S. H., & Ang, S. Y. (2021). Effectiveness of an integrated three-mode bed exit alarm system in reducing inpatient falls within an acute care setting. *Japan Journal of Nursing Science*, 19(1). https://doi.org/10.1111/jjns.12446

Spanolios, A., Rogers, L., Hartranft, S., Reich, R., Trudeau, J., Utaegbulam, E., Smith, K., & Lile, W. (2022). Characteristics of inpatients with blood cancers who experience a fall: A retrospective study. *Clinical Journal of Oncology Nursing*, 26(2), 204–209. https://doi.org/10.1188/22.cjon.204-209

Vela, C.M., Grate, L.M., McBride, A., Devine, S., & Andritsos, L.A (2018). A retrospective review of fall risk factors in the bone marrow transplant inpatient service. *Journal of Oncology Pharmacy Practice*, 24(4): 272-280. doi:10.1177/1078155217697485

Weed-Pfaff, S., Nutter, B., Bena, J., Forney, J., Field, R., Szoka, L., Karius, D., Akins, P., Colvin, C., & Albert, N. (2016). Validation of predictors of fall events in hospitalized patients with cancer. Clinical Journal of Oncology Nursing, 20(5). https://doi.org/10.1188/16.cjon.e126-e131

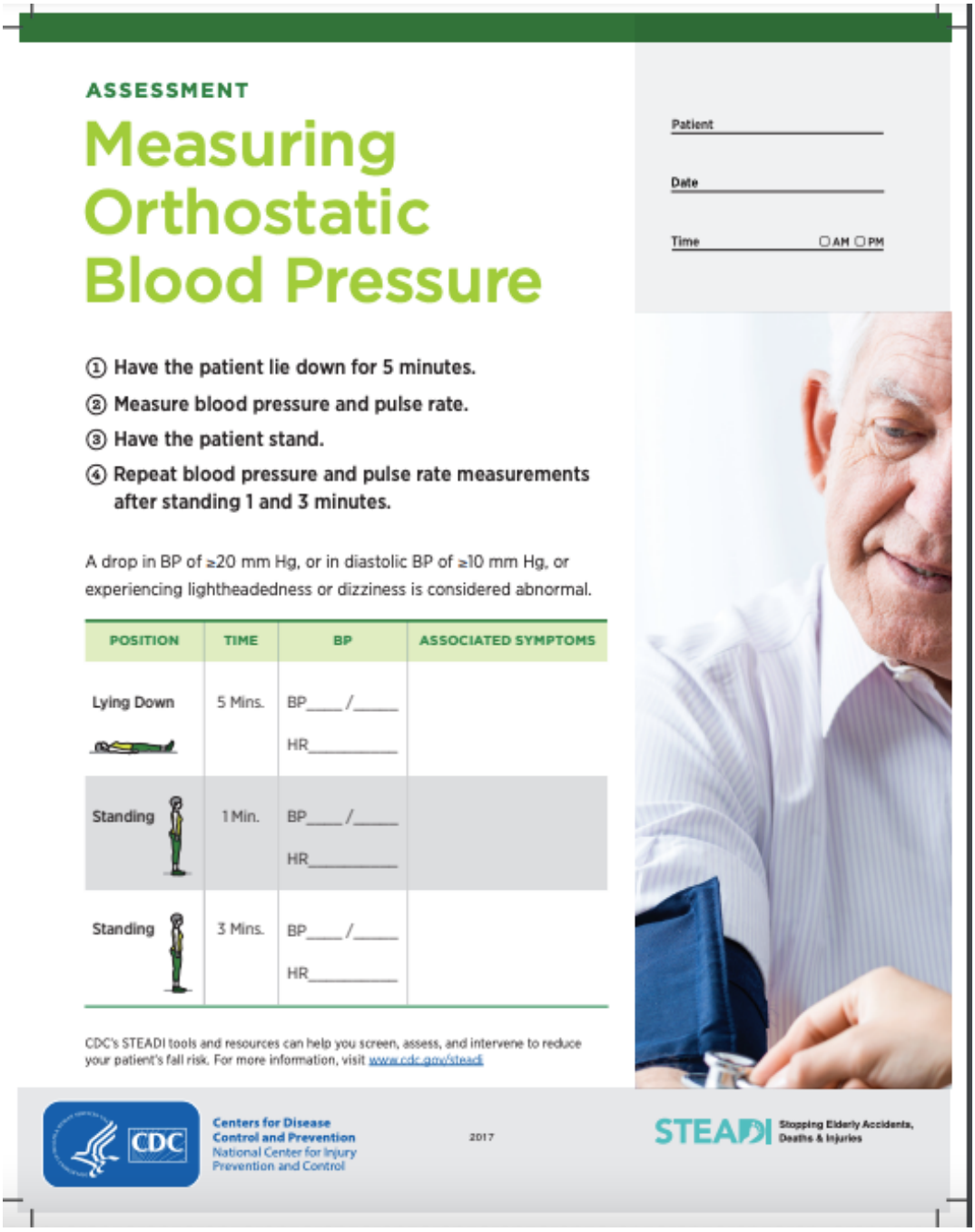
World Health Organization [WHO]. (2021, April). Falls. *World Health Organization*. Retrieved October 23, 2022, from https://www.who.int/news-room/fact-

sheets/detail/falls#:~:text=A%20fall%20is%20defined%20as,though%20most%20are%20non%2Dfatal.

Appendix A

**Figure 1**

*Measuring Orthostatic Hypotension*



ASSESSMENT

# Measuring Orthostatic Blood Pressure

Patient _____

Date _____

Time _____ ☐ AM ☐ PM

① Have the patient lie down for 5 minutes.
② Measure blood pressure and pulse rate.
③ Have the patient stand.
④ Repeat blood pressure and pulse rate measurements after standing 1 and 3 minutes.

A drop in BP of ≥20 mm Hg, or in diastolic BP of ≥10 mm Hg, or experiencing lightheadedness or dizziness is considered abnormal.

| POSITION | TIME | BP | ASSOCIATED SYMPTOMS |
|---|---|---|---|
| Lying Down | 5 Mins. | BP____/____ HR_____ | |
| Standing | 1 Min. | BP____/____ HR_____ | |
| Standing | 3 Mins. | BP____/____ HR_____ | |

CDC's STEADI tools and resources can help you screen, assess, and intervene to reduce your patient's fall risk. For more information, visit www.cdc.gov/steadi

CDC Centers for Disease Control and Prevention National Center for Injury Prevention and Control

2017

STEADI Stopping Elderly Accidents, Deaths & Injuries

Appendix B

**Figure 2**

*Orthostatic Vital Sign Data Collection Tool*

| Pt # | Month | Gender | Age | Diagnoses | Tx Day? | Orthostatics Completed Upon Admit? | Of the patients who got orthostatics on admission, was patient orthostatic? (7) | Orthostatic Atleast Once During Day 10-17 Transplant Window? | How many orthostatics were completed for transplants (days 10-17) /16 | Compliance Rate % | Day Shift Compliance % /8 | Night Shift Compliance % /8 | Chemotherapy | Comorbiditie | Hbg, IVF, Diarrhea |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | | | | | | | | | | | | | | | |
| 20 | | | | | | | | | | | | | | | |
| 30 | | | | | | | | | | | | | | | |
| 40 | | | | | | | | | | | | | | | |
| 50 | | | | | | | | | | | | | | | |
| 60 | | | | | | | | | | | | | | | |
| 70 | | | | | | | | | | | | | | | |
| 80 | | | | | | | | | | | | | | | |
| 90 | | | | | | | | | | | | | | | |
| 100 | | | | | | | | | | | | | | | |
| 110 | | | | | | | | | | | | | | | |
| 120 | | | | | | | | | | | | | | | |
| 130 | | | | | | | | | | | | | | | |

Appendix C

Table 1:
*Demographic Characteristics of Participants, n = 83*

| Characteristics | *n* | *%* | *M* | *SD* |
|---|---|---|---|---|
| Age | 83 | | 56.6 | 15.02 |
| Gender | | | | |
| Female | 33 | 39% | | |
| Male | 50 | 66% | | |
| Diagnosis | | | | |
| MM | 3 | 3% | | |
| DLBCL | 21 | 25% | | |
| MDS | 11 | 13% | | |
| ALL | 1 | 1.2% | | |
| AML | 25 | 30%% | | |
| CML | 2 | 2.4% | | |
| B Cell ALL | 2 | 2.4% | | |
| B Cell Lymphoma. | 1 | 1.2% | | |
| CMML | 2 | 2.4% | | |
| Myelofibrosis | 3 | 3% | | |
| T Cell ALL | 1 | 1.2% | | |
| T Cell Lymphoma | 1 | 1.2% | | |
| Melanoma | 1 | 1.2% | | |
| Follicular | 2 | 2.4% | | |
| Lymphoma | 2 | 2.4% | | |
| Hodgkin's | 2 | 2.4% | | |
| Mantle Cell | 1 | 1.2% | | |
| TCP | 1 | 1.2% | | |
| SCID | | | | |
| | | | | |
| Transplant Type | 29 | 35% | | |
| Haplo | 27 | 77% | | |
| CART | 21 | 25% | | |
| MUD | 5 | 6% | | |
| Sib Allo | 1 | 0.1% | | |
| TIL | | | | |