Journal of Pediatric Nursing 67 (2022) 34–37

Contents lists available at ScienceDirect

Journal of Pediatric Nursing

journal homepage: www.pediatricnursing.org

The revised Humpty Dumpty Fall Scale: An update to improve tool performance and predictive validity

Danielle Altares Sarik, PhD, APRN, CPNP-PC [a,*], Deborah Hill-Rodriguez, MBA, MSN, APRN, NE-BC [a], Karina A. Gattamorta, PhD [b], Jacqueline L. Gonzalez, DNP, APRN, MBA, NEA-BC, FAAN [a], Jenny Esteves, MBA, MHSA, LBBP [a], Katherine Zamora, BSN, RN, CPHON [a], Jennifer Cordo, DNP, APRN, NE-BC [a]

[a] Nicklaus Children's Hospital, USA
[b] University of Miami School of Nursing and Health Studies, USA

ARTICLE INFO

Article history:
Received 25 May 2022
Revised 15 July 2022
Accepted 19 July 2022

Keywords:
Pediatrics
Falls
Humpty dumpty
Risk classification
Risk factors
Practice measures

ABSTRACT

Purpose: The purpose of this study was to identify potential modifications to the Humpty Dumpty Fall Scale (HDFS) in order to enhance the accuracy of fall prediction in the pediatric population, thus contributing to the safest possible environment for the hospitalized child.
Design and methods: A secondary analysis of data collected by Gonzalez et al. (2020), including a total of 2428 patients, was conducted for this study. Multiple logistic regression was used to examine the relationship between each parameter of the HDFS (e.g., age, gender, diagnosis, cognitive impairments, environmental factors, response to surgery/sedation/anesthesia, and medication usage) and the outcome of fall status.
Results: After reviewing associations between HDFS parameters and fall risk, neither gender nor medication use were found to be associated with fall risk. These two parameters were removed from the scoring algorithms, and the HDFS was modified to a minimum score of 5 and maximum score of 20, with a score of 12 or above indicative of high risk of fall. The modified scale demonstrated a sensitivity of 84% and specificity of 57%.
Conclusions: These revisions are anticipated to help support clinical practice and improve fall prevention, thus supporting a safer pediatric environment for the hospitalized child.

© 2022 Elsevier Inc. All rights reserved.

Introduction

The Humpty Dumpty Falls Prevention Scale (HDFS) and Program was developed in 2005, addressing an unmet need to identify the pediatric population at risk for a fall event while hospitalized. The program, which consists of a risk identification scale and associated risk reduction protocols, is currently utilized in over 1500 institutions across six continents and translated into 15 languages. The HDFS is globally recognized as the leading tool for identification and prevention of pediatric falls.

As the Program has matured, so has the knowledge of pediatric falls and the rationale behind why children fall while hospitalized. Preventing injury in hospitalized children is a key patient safety focus, and nursing research, evidence-based practice, and quality improvement work are all needed to help guide interventions (Benning & Webb, 2019; Christian, 2022). As a result, the HDFS is routinely evaluated for refinements based on evidence-based outcomes and research.

The purpose of this study is to identify potential modifications to the scale in response to published critiques, as well as to enhance the accuracy of fall prediction in the pediatric population, thus contributing to the safest possible environment for the hospitalized child.

Literature review

Several articles have been published focusing on the Humpty Dumpty Falls Prevention Program (HD Program), performance of the HDFS, and potential gaps (AlSowailmi et al., 2018; Ciofi et al., 2020; Craig et al., 2018, Gonzalez et al., 2020; Kim, Kim, et al., 2019; Kim, Lim, et al., 2019; Kim, Lim, et al., 2021; Kim, Kim, & Lim, 2021). A review of fall assessment risk factors and associated fall prevention interventions for hospitalized children recognized that the HDFS included prudent prevention measures utilized for children classified as being high-risk for fall (Brás et al., 2020). Studies have also demonstrated that comprehensive scoring components of the HDFS have adequately predicted hospitalized children at risk for falls, in comparison to other pediatric fall risk assessment tools that did not demonstrate the same or better results (Craig et al., 2018; McNeely et al., 2018).

Additional studies have identified opportunities to enhance the HDFS scoring components to include additional risk factors for children at risk of falls. Having a family member present at the bedside, for

* Corresponding author at: 3100 SW 62nd Ave., Miami, FL 33155, USA.
E-mail address: Danielle.sarik@nicklaushealth.org (D.A. Sarik).

https://doi.org/10.1016/j.pedn.2022.07.023
0882-5963/© 2022 Elsevier Inc. All rights reserved.

example, can cause a false sense of protection & safety (Brás et al., 2020). As the HD Program has gained international attention, additional aspects or demographics could be incorporated into the revamped program to meet the fully diverse international perspectives of fall prevention. The cross cultural-dialectal validation of the HDFS in Italian and Arabic revealed most falls in children below age six were associated with motor disorders, enuresis, single-room occupancy, entry to the neuropsychiatry/neurology unit, and neurological disorders (AlSowailmi et al., 2018; Ciofi et al., 2020). Craig et al. (2018) reported that pediatric patients in either low- or high-risk groups demonstrated an HDFS total score negatively correlated with the child's age and gender score, thus indicating the need to review the parameters of fall risk for these factors.

Gonzalez et al. (2020) further examined these identified concerns, with several identified modifications proposed for the HDFS. Gonzalez et al. (2020) demonstrated pediatric fall events, while rare, were associated with most scale elements, with the exception of gender and medication usage. The developmental characteristics of the pediatric child and the variation of what is defined or classified as a fall by each hospital may influence the scoring of falls using the HDFS. Gonzalez et al. (2020) determined the HDFS resulted in predictive validity (71.34%), specificity (36.85%), and internal consistency (0.46) in congruence with those identified by Kim, Kim, and Lim (2021) systematic review of the HDFS, demonstrating the scale's high sensitivity and low specificity.

Methods

Data collection and sample characteristics

A secondary analysis of data collected by Gonzalez et al. (2020), that included data from multiple international sites, was conducted for this study. Sixteen national and international institutions (Appendix A), represented by either inpatient pediatric units within an adult facility ($N = 11$) or free-standing pediatric hospitals ($N = 5$), participated in the original study. Inclusion criteria for the sample included all patients, aged 1–21 years, who experienced a fall during the study period. These individuals were identified by the Risk Department at each study site. A cohort of patients hospitalized during the same time frame who did not experience a fall was also selected for inclusion.

A total of 2428 patients were assessed using the HDFS, where half of the sample experienced a fall ($N = 1220$) and the other half did not ($N = 1218$). This sample size varies from that reported in Gonzalez et al. (2020), as the original sample excluded some hospitals with low response rate. HDFS total as well as individual item scores were recorded from the most recent assessment prior to the recorded fall, or from the second assessment post-admission for the control group. The sample analyzed for the current study consisted of slightly more males (53.2%) than females (46.8%). Approximately 30% of the sample was under 3 years of age, 21% was between 3 and 7 years, 19% was between 7 and 12 years, and 30% was 13 years or older. Additional information regarding the data collection and sample characteristics is provided in Gonzalez et al. (2020).

Data analysis

Multiple logistic regression was used to examine the relationship between each parameter of the HDFS (e.g., age, gender, diagnosis, cognitive impairments, environmental factors, response to surgery/sedation/anesthesia, and medication usage) and the fall status outcome. Any parameters that did not significantly predict falls based on an alpha level of 0.05 (e.g., gender and medication use) were removed from further analytic steps. Subsequently, the odds ratios and significance values of individual criteria within each of the parameters that remained in the model were evaluated to determine whether the scoring for each criterion required modification. It is worth noting that while individual criteria (i.e., categories) within each parameter did not change, the score assigned to each category may have changed based on the logistic regression analysis. Using these data, multiple scoring algorithms were proposed and tested to determine which one was most predictive of falls using receiver operator characteristic (ROC) analysis using Statistical Package and Service Solutions (SPSS) (IBM Corp, 2017). Scoring algorithms were then compared to determine which was most predictive of falls. The results of this analysis were evaluated and a new scoring algorithm was established. After the updated scoring algorithm was established, the cut-off parameter for patients considered at high risk of a fall was identified. To complete this final step, several cut-off scores were evaluated based on the new scoring algorithm. In addition, fall sensitivity, percent classified as at risk, and overall percent correct were examined.

Results

Results of the multiple logistic regression analysis, based on the original scoring, are found in Table 1. When examining the associations between parameters and fall risk, neither gender nor medication use were found to be associated with fall risk. As a result, these two parameters were removed from the scoring algorithms. In addition, the individual criteria within each of the remaining parameters was examined to assess the association with fall risk in order to determine which criteria should be weighted more heavily within each parameter. In this step, while the scoring for the criteria within environmental factors remained the same, the weights for the criteria within all other parameters (e.g., age, diagnosis, cognitive impairments, and response to surgery/sedation/anesthesia) were modified based on the odd ratios (ORs) from the multiple logistic regression framework. Three alternative scoring algorithms were compared to the original HDFS scoring. While all three algorithms were found to have higher specificity than the original

Table 1
Results of Chi-Square and Logistic Regression Models Predicting Falls using Original Scoring.

Variable	*B*	*SE*	*OR*	*p*
Age				**0.007**
<3 years old (reference group)				
3–7 years old	0.35	0.15	1.42	0.018
7–12 years old	0.12	0.16	1.13	0.457
13 years and above	0.40	0.16	1.49	0.012
Gender				**0.057**
Male (reference group)				
Female	−0.15	0.09	0.86	0.076
Diagnosis				**<0.001**
Neurological diagnosis (reference group)				
Alterations in Oxygenation	−0.82	0.14	0.044	<0.001
Psych/behavioral Disorders	−0.40	0.24	0.67	0.096
Other Diagnosis	−0.19	0.11	0.83	0.094
Cognitive Impairments				**<0.001**
Oriented to own ability	−0.11	0.14	0.90	0.433
Forgets limitations	0.85	0.14	2.33	<0.001
Not aware of limitations (reference group)				
Environmental Factors				**0.003**
History of falls or infant-toddler placed in bed (reference group)				
Outpatient area	−0.58	0.31	0.56	0.56
Patient placed in bed	−0.63	0.16	0.54	<0.001
Patient uses assistive devices or infant-toddler crib	−0.18	0.16	0.84	0.244
Response Sedation				**<0.001**
Within 24 h (reference group)				
Within 48 h	0.60	0.26	1.82	0.022
> 48 h	0.88	0.13	2.42	<0.001
Medication Usage				**0.061**
Multiple uses of sedatives/hypnotics/barbiturates (reference group)				
One of the medications listed	−0.32	0.15	0.73	0.035
Other medications or none	0.38	0.14	0.69	0.008

Note: *p* values that appear in **bold** are derived from bivariate Chi-Squared models while *p* values not in bold are derived from logistic regression models.

HDFS scoring, one proposed scoring algorithm was found to be superior with an area under the curve of 0.642 compared to 0.526 for the original scoring and an overall model quality of 0.62 compared to 0.50 for the original scoring. After analytic review and consensus by the research team, the results of this analysis confirmed that the updated scoring algorithm was conceptually and statistically sound. The final scoring can be found in Table 2 and yields a total score that ranges from 5 to 20 differing from the original scoring of 7 to 23.

The final step in the analysis was to establish a new score to classify patients as at risk of falls. In this step, multiple cut-offs were assessed by calculating sensitivity, overall percentage classified correctly, and the percentage classified as at risk. The original scoring of the HDFS (12 or above on a 7–23 point scale indicates high risk) resulted in 67% of cases flagged as at risk of a fall, and yielded a sensitivity of 71%, with 54% of patients classified correctly. Using the updated scale (5–20 points), a high-risk score of 12 increased sensitivity to 84% and the overall percent correctly identified increased to 57%. However, it should be noted that based on the new scoring, an additional 10% of patients would be classified as at risk compared to the original HDFS scoring.

Discussion

The HD Program has been implemented widely since its creation in 2005, including use of the scale in over 250 international organizations. The purpose of this work was to further analyze HDFS with the aim of increasing specificity, sensitivity, and predictive validity based on previously identified challenges with the HDFS (Gonzalez et al., 2020). The tool has also been reviewed for internal consistency, with the goal of identifying potential enhancements to scoring parameters and tool refinement/implementation as needed. An analysis of the characteristics associated with having a fall event was completed, yielding changes in the overall low and high total score parameters. Although the parameter points have been adjusted, due to the changes in weighting, it is suggested to maintain the high-risk point of 12 in alignment with the original high-risk baselinescore of 12. Overall scoring adjustments resulted from the elimination of two parameters from the scoring algorithm (gender and medication), as they were found not to be predictive of fall risk (Gonzalez et al., 2020).

Table 2
Revised Scoring for The Humpty Dumpty Fall Scale.

Falls Assessment Tool		
The Humpty Dumpty Fall Scale- Inpatient (REVISED)		
Parameter	Criteria	Score
Age	13 years and above	4
	3 to <7 years old	3
	7 to <13 years old	2
	<3 years old	1
Diagnosis	Neurological Diagnosis	4
	Other Diagnosis	3
	Psych/Behavioral Disorders	2
	Alteration in Oxygenations (Respiratory Diagnosis, Dehydration, Anemia, Anorexia, Syncope/Dizziness)	1
Cognitive Impairments	Forgets Limitations	4
	Not Aware of Limitations	2
	Oriented to own ability	1
Environmental Factors	History of Falls or Infant-Toddler Placed in Bed	4
	Patient uses assistive devices or Infant-Toddler in Crib or Furniture/Lighting (Tripled room)	3
	Patient Placed in Bed	2
	Outpatient	1
Response to Surgery/Sedation/Anesthesia	>48 h/None	4
	Within 48 h	2
	Within 24 h	1

Maximum Score 20; Minimum Score 5.
At risk for falls if score is 12 or Above.

To continue to promote internal consistency in tool use, the caregiver's skill, competency and consistency in identifying patient characteristics and environmental characteristics must be validated routinely across users via skills check offs, simulation, or other means. Importantly, a key aim of patient safety in fall prevention is tool refinement, which included enhancing specificity in patient assessment scoring along with the use of age-appropriate interventions, such as providing pediatric patients with skid-proof slippers (Table 3).

While the scale has been altered, including scale items and scoring parameters, it is important to note that these changes require further investigation. Prior to widespread change, the new HDFS will be piloted with a large, retrospective data set in order to determine performance. Tool refinement may occur as a result. Additionally, as the current scale is in use in thousands of hospitals globally, ensuring accurate and complete communication around changes to the tool, and how to train nurses on use of the new scale, will be essential.

Practice implications

These proposed changes to the Humpty Dumpty Fall Scale, while minimal, significantly improve the sensitivity, specificity, and predictive validity of the tool. These changes will allow practicing clinicians using this tool to guide patient care and provide interventions for reducing fall risk with more confidence. Additionally, the tool now has two fewer scoring categories, therefore simplifying patient assessment for front-line nurses.

The updated HDFS represents an improvement for patient safety, as it provides an opportunity to identify patients who are more at risk for falling. This increased risk assessment has the potential to significantly decrease the number of falls that occur during pediatric hospitalizations, thus contributing to patient safety outcomes globally.

In order to successfully implement and sustain the revised HDFS, the competency and consistency of nurses and other clinicians who are regularly using the tool must be ensured through ongoing education. Empowerment and engagement of clinical nursing staff has been demonstrated to improve compliance with fall assessment, supportive

Table 3
Patient Falls Safety Protocol.

Low Risk Protocol (score 5–11)

- Orientation to room
- Bed in low position, brakes on
- Side rails x2 or 4 up, assess for large gaps, such that a patient could get extremity or other body part entrapped, use additional safety measures
- Use non-skid footwear for ambulating patients
- Use appropriate-size clothing to prevent the risk of tripping
- Assess elimination needs frequently, assist as needed
- Call light is within reach, educate patient and family on its functionality
- Environment clear of unused equipment, furniture is out of walk path, and area is clear of hazards
- Assess for adequate lighting, leave nightlight on
- Patient and family education available to parents and patient
- Document fall prevention teaching and initiate/update plan of care

High Risk Protocol (score 12–20)

- All low-risk protocol components
- Identify patient with "high risk for falls" wrist band, bedside signage, and within the medical record
- Educate patient/parents of high risk protocol precautions
- Check patient minimum of every 1 h
- Accompany patient with ambulation, utilizing gait belts as appropriate
- Place patient in a developmentally appropriate bed
- Consider moving patient close to the nurses' station
- Assess the need to provide 1:1 sitter supervision
- Evaluate medication administration times
- Remove all unused equipment from the room or patient care area
- Protective barriers to close off spaces or gaps in the bed
- Keep the door open at all times unless specified by isolation precautions
- Keep the bed at the lowest level, unless patient is directly attended

interventions, and subsequently decrease risk of pediatric fall (Benning & Webb, 2019). Providing templates to teach nursing staff and ensure standardized scoring of the algorithm can assist in supporting consistent assessment and intervention. Through the use of the electronic health record, it is important that databases are updated to reflect the new scoring algorithms and cut-off limits.

Limitations

Several limitations have been identified. Data were collected from multiple national and international hospitals, and variability in the implementation and use of the HDFS in these settings is possible. Additionally, this secondary analysis used data collected in 2010–2015. Hospitals and healthcare systems have experienced many changes since the beginning of the COVID-19 pandemic, including policies that restrict family members at the bedside. Therefore, the factors contributing to falls, as well as types of falls experienced, may be impacted.

Conclusions

While the Humpty Dumpty Fall Scale is globally used and accepted, opportunities to improve the predictive ability, sensitivity, and specificity of the tool were identified. Using data collected by Gonzalez et al. (2020), a secondary analysis was performed, resulting in the removal of two parameters from the tool and the identification of a new consolidated weighting system for the remaining parameters. With these revisions, the new tool yielded a sensitivity of 84% and specificity of 57%, improving overall tool performance. These changes are anticipated to help support clinical practice and improve fall prevention, thus supporting a safer pediatric environment for the hospitalized child.

Credit author statement

Danielle Altares Sarik PhD, APRN, CPNP-PC: Supervision, project administration, writing original, conceptualization, methodology.

Deborah Hill-Rodriguez MBA, MSN, APRN, NE-BC: Writing original, conceptualization, resources, funding.

Karina A. Gattamorta PhD: Formal analysis, writing original, conceptualization, methodology.

Jacqueline L. Gonzalez DNP, APRN, MBA, NEA-BC, FAAN: Writing original, conceptualization, resources, funding.

Jenny Esteves, MBA, MHSA, LBBP: Project administration, writing – revise, data curation, investigation.

Katherine Zamora BSN, RN, APHON: conceptualization, writing - revise.

Jennifer Cordo DNP, APRN, NE-BC: Writing –revise, conceptualization.

Declaration of interest

None.

Acknowledgments

Many thanks to Calvina Hunt for her help with literature searching, and to Tatiana Consuegra for her assistance with formatting. This work was supported by the ANCC Magnet Award.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.pedn.2022.07.023.

References

AlSowailmi, B. A., AlAkeely, M. H., AlJutaily, H. I., Alhasoon, M. A., Omair, A., & AlKhalaf, H. A. (2018). Prevalence of fall injuries and risk factors for fall among hospitalized children in a specialized children's hospital in Saudi Arabia. *Annals of Saudi Medicine*, *38*(3), 225–229.

Benning, S., & Webb, T. (2019). Taking the fall for kids: A journey to reducing pediatric falls. *Journal of Pediatric Nursing*, *46*, 100–108. https://doi.org/10.1016/j.pedn.2019.03.008.

Brás, A. M. R., Quitério, M. M. d. S. L., & Nunes, E. M. G. T. (2020). Nurse's interventions in preventing falls in hospitalized children: Scoping review. *Revista Brasileira de Enfermagem*, 73.

Christian, B. J. (2022). Translational research - promoting patient safety in hospitalized children: A paramount concern for pediatric nursing. *Journal of Pediatric Nursing*, *63*, 156–158. https://doi.org/10.1016/j.pedn.2022.02.015.

Ciofi, D., Albolino, S., Dagliana, G., Biermann, K., Savelli, A., Frangioni, G., ... Festini, F. (2020). Prevalence and multicenter observational study on falls of hospitalized children and italian, linguistic-cultural validation of the humpty dumpty fall scale. *Professioni Infermieristiche*, *73*(4), 296–304.

Craig, F., Castelnuovo, R., Pacifico, R., Leo, R., & Trabacca, A. (2018). Falls in hospitalized children with neurodevelopmental conditions: A cross-sectional, correlational study. *Rehabilitation Nursing Journal*, *43*(6), 335–342.

Gonzalez, J., Hill-Rodriguez, D., Hernandez, L. M., Cordo, J. A., Esteves, J., Wang, W., ... Sarik, D. A. (2020). Evaluating the humpty dumpty fall scale: An international, multisite study. *Journal of Nursing Care Quality*, *35*(4), 301–308.

IBM Corp (2017). *IBM SPSS statistics for MacIntosh, version 25.0.* Armonk, NY: IBM Corp.

Kim, E., Kim, G., & Lim, J. (2021). A systematic review and meta-analysis of fall prevention programs for pediatric inpatients. *International Journal of Environmental Research and Public Health*, *18*(11), 5853.

Kim, E. J., Lim, J. Y., Kim, G. M., & Lee, M. K. (2019). Meta-analysis of the diagnostic test accuracy of pediatric inpatient fall risk assessment scales. *Child Health Nursing Research*, *25*(1), 56–64. https://doi.org/10.4094/chnr.2019.25.1.56.

Kim, E. J., Lim, J. Y., Kim, G. M., & Min, J. (2021). An electronic medical record-based fall risk assessment tool for pediatric inpatients in South Korea: Improved sensitivity and specificity. *Child Health Nursing Research*, *27*(2), 137.

Kim, J., Kim, S., Park, J., & Lee, E. (2019). Multilevel factors influencing falls of patients in hospital: The impact of nurse staffing. *Journal of Nursing Management*, *27*(5), 1011–1019. https://doi.org/10.1111/jonm.12765.

McNeely, H. L., Thomason, K. K., & Tong, S. (2018). Pediatric fall risk assessment tool comparison and validation study. *Journal of Pediatric Nursing*, *41*, 96–103.