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Simplified Assessment of Pressure Ulcer Risk in Hospitalized Children: Development of The Pediatric Pressure Ulcer Trigger Tool (PPUTT)

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Abstract

Purpose: Complicated existing valid tools proved problematic when the hospital census and patient-to-nurse ratio were high. The purpose of this study is to develop a screening tool that can be learned easily and implemented quickly relative to the Braden Q Scale.

Material and Methods: We developed the Pediatric Pressure Ulcer Trigger Tool (PPUTT) with three trigger questions following consensus method, which was used to select the questions, refine the language used (in Chinese), and determine face validity. The resulting PPUTT was then refined to include more explanations for each question based on input from nursing leaders and a pediatric physician, and revalidated by a team of experienced pediatric nurses. Bedside nurses and a domain expert completed the PPUTT and the Braden Q Scale for a series of pediatric inpatients at a large tertiary care hospital in China through August 8th to 15th of 2017, the time required to perform the assessment was measured, and implementation barriers were noted.

Results: 184 pediatric patients from the pediatric wards (n=171) and pediatric intensive care unit (n=13) ware accessed by using PPUTT and Braden Q Scale. The mean time required for each assessment was 12.10±3.87 seconds for the PPUTT and 42.36±8.16 seconds for the Braden Q Scale, t=46.9, P<0.001.

Conclusions: Implementation of PPUTT was feasible for pediatric inpatients in China and could be performed in 12 seconds by bedside nurses after minimal training. Future research is needed to evaluate the sensitivity and specificity of PPUTT to predict pressure ulcers.

Keywords: Pediatric; Pressure Ulcer; Trigger Tool; Simplified

Introduction

Avoidance of pressure-related injuries and maintaining tissue integrity are important goals of care for children and infants (Figure 1) [1,2]. Recent studies have indicated that pressure ulcers are also common in hospitalized pediatric patients, with prevalence ranging from 3% to 43%, and incidence of 0.29% to 7.3% in Pediatric Intensive Care Units (PICUs), and higher than 10% among critically ill infants and children [3-10]. The Care of patients' skin was established as a nurse-sensitive outcome measure by the American Nurses Association, appropriate care can improve the comfort of patients and halt additional pain.10 Accurate assessment of patients' risk for pressure ulcers is the first step to guide appropriate nursing interventions that prevent pressure ulcers. Effective and timely risk assessment for pressure ulcers can help staff recognize high-risk patients and take action as soon as possible.

The Braden Q Scale for pressure ulcer risk assessment was introduced to the pediatric department in 2014, with initial training sessions for all existing staff, and subsequent orientation sessions containing pressure ulcer risk assessment training for new nurses from then on. Although the prevalence of pressure ulcer was not high, several were thought to have been preventable, and the low concordance of risk assessment using the Braden Q score could have contributed by misclassifying patients' risk and therefore not planning for appropriate skin care and family education. In June 2017, a nursing quality audit was carried out in the pediatric

department in our hospital in China. The prevalence of pressure ulcers was 3.64% (4/115) while the concordance rate of pressure ulcer risk assessment, one of the process quality indicators, was only 76% (32 of 42 charts which were selected at random during an audit). A root cause analysis by a nursing quality improvement committee (6 pediatric nursing managers and 4 experienced pediatric nurses) of the pediatric department, identified "complicated risk assessment instruments" and "shortages of nurses" to be the most important issues.

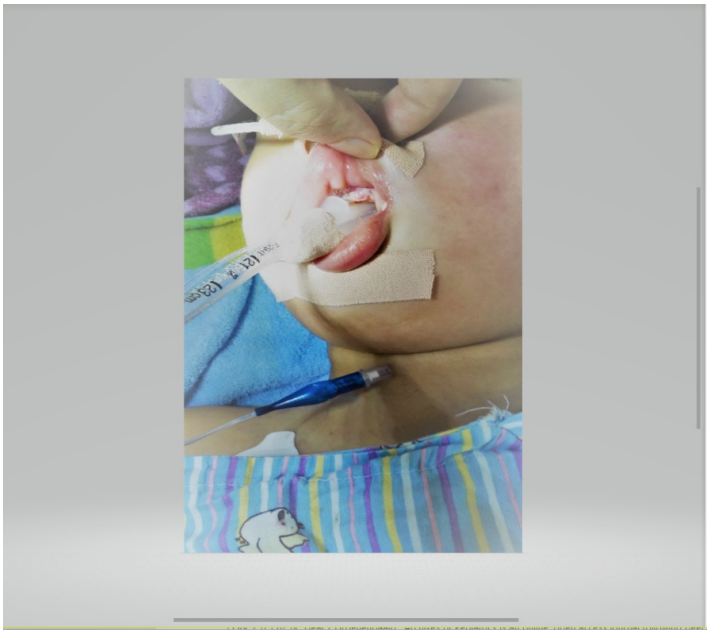

Figure 1: Gingival pressure ulcer caused by pressure from the endotracheal tube on the gums of a sedated child in the pediatric intensive care unit (original photo taken by Xiumei Qi on 1st August 2017).

The total nurse-to-bed ratio was 0.42: 1 in pediatric department of our hospital, similar with the ratio of 0.40:1 in Sichuan Province of China, slightly lower than that of Japan (0.53: 1) and far below that of European countries [11,12]. The nurse-to-patient ratio in our PICU is 1: 4, but in the regular inpatient wards, the ratio varies by season. During the summer, the ratios are 1:8 during the day shift and 1:20 during the night shift, but during the winter, the ratios are often 1:9 during the day shift and 1:25 during night shift because the pool of available nurses is fixed, but the number of inpatients rises dramatically due to increases in infections and respiratory diseases. These nurse-to-patient ratios are far lower than California's minimum nurse-to-patient ratios of 1:2 in the intensive care unit and 1:4 in the pediatric wards, and lower than ratios reported in New Jersey and Pennsylvania (PICU 1:2.5 and 1:2.3, respectively and pediatric wards 1:4.6 and 1:4, respectively) [13,14].

The nurse-to-patient ratio does account for nurse fatigue, which may play a role in the ability to deliver care. To achieve the ratios described with the limited number of available nurses, each week nurses work 3 to 4 day shifts (7:30 am to 5:30 pm) and 2 night shifts (5 pm to 8 am), which may even require 24 hours of consecutive work when a day and night shift are adjacent in sick season. Finally, in China, nurses have extensive clinical and non-clinical duties. They must not only carry out their clinical duties related to patient care, admitting and discharging patients, cleaning, medication administration, nutrition management, collecting samples, patient education, acting as a preceptor for nursing students, and documentation, but must also verify the patients' daily bill for services, supplies provided, and document a number of administrative metrics [15-17]. Thus, implementation of new mandatory clinical assessments, such as performing a pressure ulcer risk assessment on each patient, have the potential to distract from other critical tasks. Therefore, we assembled a specialty panel to evaluate validated assessment tools with the goal to develop a method to identify pediatric patients at greatest risk for pressure ulcer development as quickly and accurately as possible.

Validated Pressure Ulcer Risk Assessment Scales (PURAS) for Pediatric Patients

Pressure Ulcer Risk Assessment Scales (PURAS) have become key tools for assessment, but few have been evaluated for their sensitivity and specificity to predict pressure ulcers. The Braden Q Scale, Glamorgan Scale, Neonatal Skin Risk Assessment Scale (NSRAS), and Pediatric Pressure Ulcer Prediction and Evaluation Tool (PPUPET) are widely used and their properties are summarized in Table 1 [18-22].

Author	Instrument	Settings	Based on	Subscales	Scoring	Results
Curley et al. [19] (2003)	Braden Q Scale	Pediatric intensive care unit, mean age 3 years (21 days to 8 years)	Adult Braden and Expert panel	Seven subscales: Patient mobility, Patient activity, Sensory perception, Moisture, Friction and shear, Nutrition Tissue perfusion and oxygenation	Each subscale incurs a score of 1~4, the total score varies from 7 to 28, with the critical cut off point of ≤16 indicating "at risk".	Incidence 86/322 (26.7%); for stage II and higher PUs AUC = 0.83. at a cut-off 16 sensitivity = 0.88, specificity = 0.58,
Willock et al. [20] (2009)	Glamorgan Scale	Pediatric patients; Age from 1 day to 17 years 11 months	Literature review, Expert panel, and Pediatric pressure ulcer risk factors study	Ten subscales: Mobility, Equipment/ objects/hard surface pressing or rubbing on skin, Significant anemia (Hemoglobin<9g/dl), Persistent pyrexia (temperature>38˚C for more than 4 hours), Poor peripheral perfusion (cold extremities/ capillary refill > 2seconds or cool mottled skin), Inadequate nutrition (discuss with dietician if doubt), Low serum albumin (<35 g/l), Weight < 10th percentile, Incontinence (inappropriate for age)	The item 'Mobility' has four categories that can be rated with 0 (normal mobility for age), 10 (some mobility, but reduced for age), 15(unable to change his/her position without assistance/ cannot control body movement) and 20 (child cannot be moved without great difficulty). The item 'Equipment/ objects/hard surface pressing or rubbing on skin' can be rated with 0 (no) or 15 (yes) points. Remaining dichotomous items are rated with 0 or 1. Total score: 0~42, the higher the sum score, the higher the pressure ulcer risk.	Incidence 61/336(18.15%) AUC=0.91 At a cut-off 15, sensitivity =0.98 specificity = 0.67

Huffines and Logsdon. [22] (1997)	Neonatal Skin Risk Assessment Scale (NSRAS)	Neonates, mean age 33 weeks' gestation	Adult Braden	Six subscales: General Physical Condition, Mental State, Mobility, Activity, Nutrition, Moisture.	All subscales are rated on a scale ranging from 1 to 4, and Potential scores range from 6 to 24, with higher scores indicating lower levels of risk.	Incidence 6/32(19%) Using only the subscales of general physical condition, activity, and nutrition, and having a cut off score of 5, sensitivity =0.83, Specificity =0.81. Interrater reliability was 0.97.
David. et al. [23] (2014)	Pediatric Pressure Ulcer Prediction and Evaluation Tool	Pediatric patients, age from birth to 18 years	Braden Q Scale, literature review and expert panel	Nine subscales: Seven Subscales of Braden Q Scale, Adding "external medical devices" and "Skin condition".	Each item of the subscale has a minimum score of 1 (less risk) and a maximum score of 2 or 3, the range of scores is 9-26.	Incidence 59/273(21.61%) with the critical cut off point of ≥18 or nutrition score = 2; or any item score = 3] puts a patient at risk, sensitivity= 74.58% specificity =57.94%

Table 1: Pediatric pressure ulcer risk assessment tools.

The Braden Q Scale has been validated in infants and children aged 21 days to 18 years [23]. Despite promising results [19, 24, 25], some researchers indicated that the value of the Braden Q Scale in PICU patients was relatively poor and that it should be optimized before being used in Chinese pediatric patients [26,27]. Nursing staff indicated that the Braden Q tools were not intuitive in scoring, as the higher the score the lower the risk of developing a pressure ulcer [22]. Still, the Braden Q Scale remains globally one of the most widely used risk assessment tools, which was the reason for selecting it for our hospital in 2014 [8,24].

The Neonatal Skin Risk Assessment Scale (NSRAS) was designed for neonates, which was not the target population for our quality improvement efforts in skin care. The Pediatric Pressure Ulcer Prediction and Evaluation Tool (PPUPET), which was newly developed and based on the Braden Q scale but added "external medical devices" and "skin condition" as two subscales, performed well for screening the risk of PUs in children and adolescents, but required more training prior to use and more time for each assessment [22].

The Glamorgan Scale predicts both immobility-related and device-related pressure ulcers and had good predictive validity and reliability for children [1,28]. Although Jan Kottner et al. [29] indicated that the Glamorgan Scale was unable to make clear distinctions in a low-risk setting, recent research in Britain indicated that the Glamorgan risk assessment scale had a higher predictive ability than the Braden Q in the pediatric population [30]. Currently, there is no validated Chinese version of the Glamorgan risk assessment scale. In clinical practice, use of complex and time-consuming scales makes it difficult for nursing staff to screen patients accurately and frequently, and may paradoxically result in decreased identification of patients at high risk for pressure ulcers [23,28,31]. For example, Leonard et al. [32] and Willock et al. [23] documented poor compliance by nursing staff when using the Glamorgan Scale and Braden Q Scale in Australia because of the complexity of the Scales.

Trigger Tools for Pediatric Patients

The term "trigger tool" was first applied by Classen to identify adverse drug events in large groups of hospitalized patients and have been advocated for identifying sentinel events of various kinds [33,34]. The Institute for Clinical Systems Improvement (ICSI) suggests developing trigger questions to identify patients who require further assessment for pressure ulcer risk. They proposed 3 trigger questions for evaluating pressure ulcer risk in outpatients (see Table 2), but did not evaluate pediatric patients [35].

Bette Shumacher et al. [36] developed the trigger questions used in the Neonatal Intensive Care Unit (NICU) (see Table 2). It was short and by using this trigger tool, NICU nurses began to take early measures to prevent pressure ulcer even before consulting with the Wound, Ostomy and Continence (WOC) nurse and pressure

ulcer prevalence remained low (0.01 per 1000 patient days).

Existing pediatric pressure ulcer risk trigger tools do not include the "pressure of medical device." a noteworthy omission since a survey in 11 hospitals indicated that more than 50% of pediatric PUs were related to medical devices, such as the oxygen saturation probe, the fixing band for the tracheotomy tube, the nasogastric tube, plywood and gypsum bandage [37,38]. These devices on the skin were the most important pressure ulcer risk factors in children and infants, and nurses should consider all patients with a medical device to be at risk for medical device–related pressure injuries [8,39]. Pediatric medical-device-related hospital-acquired pressure ulcers are becoming more prevalent, and the authors of the NICU trigger tool recommend including a trigger for patient devices [36,40]. Therefore, we tried to develop a short, rapid screening tool that can be easily learned and quickly implemented with a high degree of accuracy relative to established screening tools and to document the time required to conduct the screening assessments in the real-world setting.

Materials and Methods

Study Design

A multi-phase consensus method was utilized to develop the trigger tool and its feasibility was evaluated by having bedside nurses use it in patients for whom the Braden Q score was also measured by a domain expert in skin assessment and care.

Study Setting

Three pediatric regular wards and a PICU in a university-affiliated hospital in China participated in this prospective cohort study. All three wards have a total of 115 beds, and the PICU has 12 beds, including 6 critical care beds and 6 step-down beds.

Subjects Used for the Implementation Cohort

A cohort of patients older than 28 days, without existing pressure ulcers, who were inpatients from August 8th through 15th of 2017 were evaluated by their bedside nurse and by a skin care domain expert.

Ethical Considerations

The hospital ethics committee exempted the study from review because it was considered to have low risk of patient harm. Parents verbally consented prior to the extra skin evaluation by the domain expert.

Development of PPUTT

Conceptual Framework

The theoretical model for the causal pathway for pressure ulcer development elucidated by Susanne et al. [41] was used as the basis of the design of PPUTT, with one question for each of the 3 major risk factors (immobility, poor perfusion, and mechanical friction). Because any one risk factor category is sufficient to trigger a positive PPUTT score and lead to more detailed assessment and skin care planning, we anticipate a high sensitivity of the tool to identify patients at sufficient risk to develop pressure ulcers to warrant additional screening or proactive risk reduction.

Consensus Methodology

A consensus method (Figure 2) was used to select the questions, refine the language used (in Chinese), and determine face validity. We searched Medline, PubMed, Embase, OVID and CNKI to build the item pool, and limited mobility, reduced perception, inadequate tissue perfusion, equipment pressing or rubbing on skin, and skin status were involved in the item pool. Diverse stakeholders, including nurses certified in acute and critical care; wound, ostomy and continence; and pediatric nurses then decided the 3 items included in the trigger tool and provided input into the clarity and utility of each question. Once consensus was achieved, the resulting PPUTT was then refined to include more explanations for each question (for training prior to use) based on input from nursing leaders and a pediatric physician, and revalidated by a team of experienced pediatric nurses.

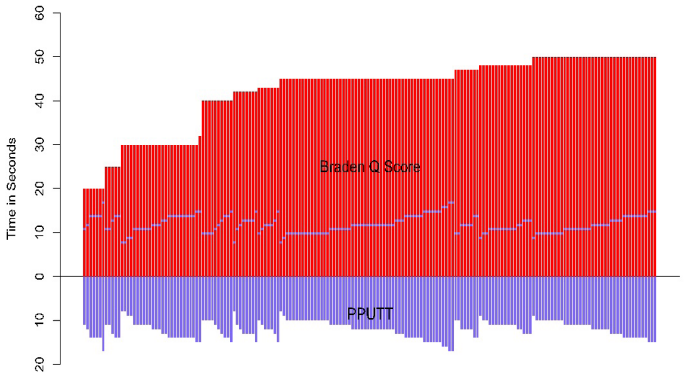

Figure 2: Consensus methodology used to develop the Pediatric Pressure

Ulcer Trigger Tool.

The Pediatric Pressure Ulcer Trigger Tool (PPUTT)

The characteristics of the Pediatric Pressure Ulcer Trigger Tool (PPUTT) are summarized in Table 2. PPUTT has the following distinguishing features:

	Item	Trigger Tool of ICSI[36]	Trigger Tool of NICU[37]	PPUTT	Explanation vision of PPUTT
Is the patient	Mobility	Moving extremities and/or body appropriately for developmental age?	Moving extremities and/or body appropriately for developmental age?	Limited mobility (unappropriated for developmental age/ weak/cannot change position/cannot control posture/under sedation or anesthesia/ body restrain, et al)?	Limited mobility (Answering "Yes" to any of the following questions: Does the patient have developmental delay that impacts mobility? Is the patient weak? Does the patient have difficulty changing position? Can the patient not control her/ his own posture? Is the patient sedated or anesthetized? Is the patient in restraints? Does the patient have any other factor that would limit mobility?)
	Responsiveness	Responding to discomfort in a developmentally appropriate manner?	Responding to discomfort in a developmentally appropriate manner?	X	X
	Tissue perfusion	Demonstrating inadequate tissue perfusion with evidence of skin breakdown?	Demonstrating adequate tissue perfusion based on the clinical formula (mean arterial pressure, gestational age and/or capillary refill<3s)?	Demonstrating inadequate tissue perfusion (capillary refill time >2 s /cool mottled skin)?	Demonstrating inadequate tissue perfusion (CRT>2 s /cool mottled skin)?
	Abrasion	X	X	Equipment/objects/ hard surface pressing or rubbing on skin?	Equipment/objects/hard surface pressing or rubbing on skin?
Scoring system		If any of the 3 criteria are met, the patient is considered to be at risk	If any of the 3 criteria are met, the patient is considered to be at risk	If any of the 3 criteria are met, scored 1, and represents a patient at risk. The total score of PPUTT was 3.	If any of the 3 criteria are met, scored 1, and represents a patient at risk. The total score of PPUTT was 3.

X, No trigger question in this item. ICSI, Institute for Clinical Systems Improvement. NICU, Neonatal intensive care unit. PPUTT, Pediatric pressure ulcer trigger tool.

Table 2: Pressure ulcer trigger tools.

1. Limited mobility was selected because it impacts all components of the causal pathway for pressure ulcer development and is included in all screening and risk stratification tools published to date. It is also a common risk factor in clinical practice, especially in the neurology and PICU settings (See Table 3).1 Indeed "restrained movement" was the strongest predictive factor for both the Glamorgan and Braden Q Scale, and in one study of children with pressure ulcers 92% had reduced mobility [7,28,30,42]. The term "limited mobility" in Chinese was selected after interviews with bedside nurses and discussion during the consensus process since it was easy to be understand and could be classified with high inter-rater concordance by the nurses in informal assessment.

Variable	Number	Percentage (%)
Gender		
Male	99	53.8
Female	85	46.2
Department		
Regular ward	89	48.4
Neurology ward	33	17.9
Oncology ward	49	26.6
PICU	13	7.1
Disease		
Respiratory tract infection	112	60.9
Cancer	39	21.2
Central neurologic disease	20	10.9
Diarrhea	6	3.3
Other diseases	7	3.7
Age (Year)		
Median	1.8	
Inter quartile range	1~3.9	

Table 3: General information of participants (n=184).

2. We did not include "Is the patient responding to discomfort in a developmentally appropriate manner?" (See Table 2 for details), because many patients and nurses were unable to properly differentiate discomfort from pressure from discomfort and from other unpleasant feelings, and this item depended to some extent on both developmental status and ability to communicate, both of which can be problematic in the neurology ward and PICU. Furthermore, observers described the "response" of the child based on their verbal expression (speech or crying) and movement (eluding, changing position or posture), which can be confounded by other factors, including limited mobility.
3. Pressure caused by medical devices was included because it is a common and important risk factor for pediatric pressure ulcers (10, 20, 37, 40, 43). It has also been validated in the Glamorgan Scale (see Table 1), using the description "Equipment/objects/hard surface pressing or rubbing on skin", which was easy to understand in Chinese, and had high rates of concordance among different nurses, even those with different levels of experience.
4. Because of its importance in the physiology of pressure ulcer development and predictive value in other pressure ulcer risk scales, we included "inadequate tissue perfusion" as a trigger question, and provided a description of how to assess tissue perfusion [41].

Data Collection

Before data collection, 8 bedside nurses from 3 wards and PICU were educated by the domain expert about the need for a simplified risk assessment tool and the reason for each component of the PPUTT (see Table 2), and were instructed in its use.

The data collection forms included demographic variables, the Braden Q Scale (assessed by the domain expert), the PPUTT (assessed by one of the 8 participating bedside nurses), and how to time each assessment. The researcher, who had 7 years of experience in pressure ulcer risk assessment, performed a complete assessment using the Braden Q Scale. Bedside-nurses assessed the same patients using the PPUTT. The domain expert and bedside nurses separately assessed each child's pressure ulcer risk by observing mobility and objects or medical devices in contact with the child's skin and checking capillary refill time on the child (but not moving or undressing the child). If the child was asleep, mobility was assessed once he or she woke up.

Assessors recorded the time of each assessment in seconds, from the beginning of checking the first item to completion of writing the total score on the sheet at patient's bedside.

Data Analysis

The time required for each assessment was transferred from the bedside paper document into the Statistical Product and Service Solutions (SPSS) version19.0). Paired t-test was used to compare the PUTT and Braden Q. All analyses were performed using SPSS or R-3.4.0 (https://www.R-project.org/).

Results

On the days the survey was conducted, 197 patients were available in the wards. However, 4 had existing pressure ulcers and were excluded, 6 patients declined participation, 1 patient was not available for participation at the time of survey, and 2 patients did not participate for other reasons. Thus, 184 participants were included in the study; the demographic data is shown in Table 3.

All of the 184 participants in 4 wards were assessed using the PPUTT and Braden Q Scale by 8 nurses and 1 domain expert, separately. The mean time required for each assessment was 12.10 ± 3.87 seconds for the PPUTT and 42.36 ± 8.16 seconds for the Braden Q Scale, t=46.9 (P<0.001) (Figure 3).

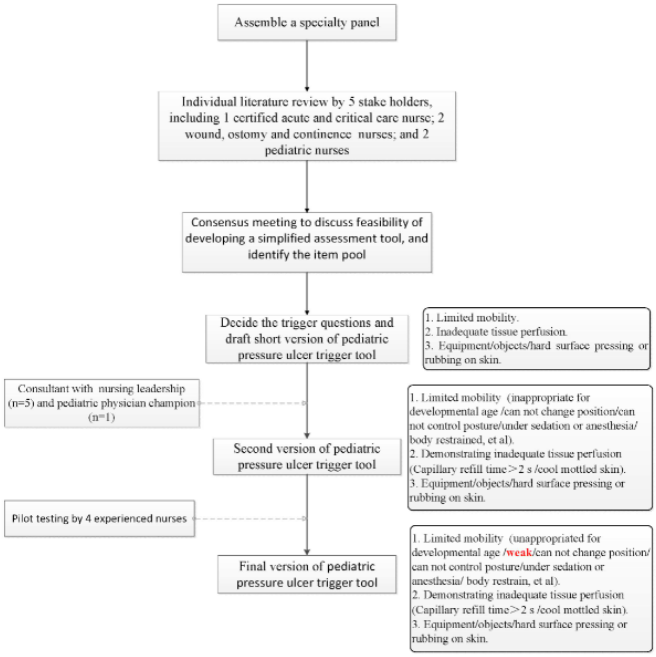

Figure 3: Time (seconds) required to assess pressure ulcer risk using the Pediatric Pressure Ulcer Trigger Tool (PPUTT, blue) or the Braden Q Scale (red).

Discussion

Pressure ulcer risk assessment is an essential component of patient care to identify patients who need preventive strategies to reduce their risk. Several assessment tools for pediatric pressure ulcer assessment are widely used for hospitalized children to predict, prevent, and detect pressure ulcers [44,45]. PPUTT, a rapid assessment tool sufficient to risk-stratify inpatients, allowed documentation of pressure ulcer risk even when nurses have a very low nurse-to-patient ratio that precludes spending a lot of time for each component of the physical assessment and documentation.

We found that three trigger questions: "Does the patient have limited mobility?" "Does the patient exhibit signs of inadequate tissue perfusion?" and "Is there equipment, objects, or a hard surface pressing or rubbing against the patient's skin?" were sufficient to identify patients at risk. These three items could be rapidly assessed by bedside nurses with minimal training. Nursing staff provided positive feedback about the PPUTT, noting that it was simple, easy to remember, time-saving, and reproducible. The ability to quickly learn and apply the PPUTT were considered essential features, given the extreme nursing shortage at our hospital.

The development of pressure ulcer is multifactorial and other scales include several dimensions. However, the PPUTT has only three trigger questions, each of which indicates direct or indirect factors effecting the development of pressure ulcer. By allowing any positive answer to trigger the classification of high risk for pressure ulcers, nurses can rapidly identify patients who need a more detailed assessment, immediate intervention, or consultation with skin care experts. The ability to rapidly learn and implement the PPUTT was gratifying for the staff, but we should note that all staff had received education about pressure ulcers at various time points over the years, and the baseline general knowledge likely facilitated the rapid uptake and high reproducibility.

According to the theoretical model for the causal pathway for pressure ulcer development, moisture and poor nutrition are two key indirect causal factors of skin breakdown and pressure ulcer development [42]. These, however, were not incorporated in the trigger questions because in many clinical situations in which pediatric patients have excessive skin moisture or edema, pressure ulcers would not generally develop without some degree of immobility. Furthermore, no published clinical trials have examined the relationship between nutrition and pressure ulcer occurrence in pediatric patients to determine their independent prognostic value [7].

However, in this study, we just discussed the development and feasibility of implementing a pressure ulcer trigger tool in a pediatric setting where nurses have very high patient loads, future research will evaluate the sensitivity and specificity of PPUTT to predict pressure ulcers, assess the utility of each of the trigger questions independently and in pairs, and compare it to other standard assessment tools.

Conclusions

The implementation of PPUTT was feasible for pediatric inpatients in China, was performed in 12 seconds by bedside nurses after minimal training, and was positively received by clinical staff. Future research is needed to evaluate the sensitivity and specificity of PPUTT to predict pressure ulcers.

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