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ORIGINAL RESEARCH: EMPIRICAL RESEARCH – QUANTITATIVE

Evaluation of the internal and external responsiveness of the Pressure Ulcer Scale for Healing (PUSH) tool for assessing acute and chronic wounds

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Abstract

Aim. To examine the internal and external responsiveness of the Pressure Ulcer Scale for Healing (PUSH) tool for assessing the healing progress in acute and chronic wounds.

Background. It is important to establish the responsiveness of instruments used in conducting wound care assessments to ensure that they are able to capture changes in wound healing accurately over time.

Design. Prospective longitudinal observational study.

Method. The key study instrument was the PUSH tool. Internal responsiveness was assessed using paired t-testing and effect size statistics. External responsiveness was assessed using multiple linear regression. All new patients with at least one eligible acute or chronic wound, enrolled in the Nurse and Allied Health Clinic-Wound Care programme between 1 December 2012 – 31 March 2013 were included for analysis (N = 541).

Results. Overall, the PUSH tool was able to detect statistically significant changes in wound healing between baseline and discharge. The effect size statistics were large. The internal responsiveness of the PUSH tool was confirmed in patients with a variety of different wound types including venous ulcers, pressure ulcers, neuropathic ulcers, burns and scalds, skin tears, surgical wounds and traumatic wounds. After controlling for age, gender and wound type, subjects in the 'wound improved but not healed' group had a smaller change in PUSH scores than those in the 'wound healed' group. Subjects in the 'wound static or worsened' group had the smallest change in PUSH scores. The external responsiveness was confirmed.

Conclusion. The internal and external responsiveness of the PUSH tool confirmed that it can be used to track the healing progress of both acute and chronic wounds.

Keywords: acute wound, chronic wound, nursing, responsiveness, wound assessment

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Why is this research or review needed?

- A generic and easy-to-use wound assessment instrument that can be used on a variety of wound types can enable interdisciplinary teams to assess and compare wounds more efficiently.
- The PUSH tool has not been evaluated in patients with acute wounds previously.
- The external responsiveness of the PUSH tool has not been evaluated in patients with chronic wounds.

What are the key findings?

- The internal responsiveness of the PUSH tool was confirmed in patients with acute and chronic wounds by paired t-test and effect size statistics.
- The external responsiveness of the PUSH tool was confirmed in patients with acute and chronic wounds by multiple linear regression.
- The PUSH tool can be used for assessing and monitoring the wound healing progress of both acute and chronic wounds.

How should the findings be used to influence policy/practice/research/education?

- The PUSH tool can help nurses who are not specialized in wound care to monitor wound healing progress in different wound types commonly encountered in routine clinical practice
- In clinical trials, the extended application of the PUSH tool allows pooling of data obtained from patients with different wound types and be used to conduct subgroup analyses.
- From a health services perspective, the PUSH tool can be used as a standardized outcomes indicator for evaluating the quality of care of wound care programmes.

Introduction

As a result of the global increase in chronic disease due to population ageing (Dall *et al.* 2013, Wu *et al.* 2013), it is foreseeable that there will be a concomitant increase in the number of people with wounds secondary to chronic disease. An important component of wound care management involves regular wound assessments to monitor healing progress (Greatrex-White & Moxey 2015). Using validated instruments to perform and record wound care assessments helps to provide a more standardized method for documentation and communication of the wound condition between healthcare providers and over time (Mullins *et al.* 2005, Arndt & Kelechi 2014). Several wound assessment tools have been developed for clinical and research use (Pillen *et al.* 2009). Most however have been developed for use on specific wound types, for example, the Leg Ulcer Measurement Tool (LUMT) was developed specifically for patients with leg ulcers (Woodbury *et al.* 2004).

In recent years, a community-based multidisciplinary team approach has been widely adopted for delivery of wound care services (Abrahamyan *et al.* 2015). A generic and easy-to-use wound assessment instrument that is applicable to a variety of wound types would be a useful tool enabling multidisciplinary wound care teams to assess and compare wounds more efficiently (Greatrex-White & Moxey 2015). This is particularly relevant for wound care management delivered in primary care and community settings, where wound care providers often encounter patients with diverse wound types that may range from acute post-surgical wounds to chronic ulcers (Friman *et al.* 2011, Dutton *et al.* 2014). The added benefit of using a validated generic wound assessment instrument is that it can be used to assess and compare the efficacy or effectiveness of wound care interventions for patients with different wound types. Furthermore, a generic wound assessment instruments could be used as an outcome indicator for evaluating the quality of care of wound care services (Chin *et al.* 2011). In other words, using a generic wound assessment instrument that can be applied to a wide range of wound types can be used as a standardized outcome measure in clinical trials and clinical audits. It can also facilitate the comparison and pooling of results.

Background

A recent review of instruments used for wound and skin assessments reported that the Pressure Ulcer Scale for Healing (PUSH) tool is the most frequently referenced instrument of wound healing (Arndt & Kelechi 2014). The PUSH tool was initially developed by the National Pressure Ulcer Advisory Panel to track the healing of pressure ulcers. It consists of three parameters, namely wound size, the amount of exudate and tissue type (Stotts *et al.* 2001). A survey on PUSH tool users in the USA found that 79 of 103 respondents reported that the PUSH tool is a quick and easy-to-use instrument to assess wound condition and 27% used the PUSH tool to monitor different wound types (Berlowitz *et al.* 2005). Moreover, the PUSH tool has been used by physicians, nurses and other allied healthcare providers for both clinical and research purposes in a variety of settings including nursing homes, rehabilitation and acute settings (Berlowitz *et al.* 2005). The PUSH tool appears to be more easily incorporated into routine clinical practice than many other

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wound assessment instruments because it has fewer items, takes less time and effort to complete, and does not require intensive user training (McHorney & Tarlov 1995).

As the parameters measured by the PUSH tool are not only aetiology-specific, the instrument should theoretically be applicable not only to pressure ulcers but also to other wound types where the three parameters are measureable. To date, the PUSH tool has been validated and shown to be responsive for monitoring wound healing progress of pressure, diabetic and venous ulcers (Ratliff & Rodeheaver 2005, Hon *et al.* 2010). However, the responsiveness of the PUSH tool in acute wounds remains unknown.

It is important that wound assessment tools can detect change over time (responsiveness). Responsiveness is defined as the ability of an instrument to detect clinically important changes over time, even if these changes are small (Guyatt *et al.* 1989). Ideally, the responsiveness of all wound assessment tools should be confirmed before they are applied in clinical practice and research as it can substantially affect the result of wound interventions in both clinical practice and research. The use of a wound assessment tool that is not responsive to change over time can lead to type II errors (Testa & Nackley 1994). A wound care assessment instrument needs to be sensitive enough to detect clinically important changes that result from wound care interventions so that it can be used to track wound healing progress over time. Two different approaches can be used to evaluate the responsiveness of an instrument: internal responsiveness and external responsiveness. Internal responsiveness is the ability of an instrument to detect change over time brought on by an intervention that has been shown to be effective. External responsiveness refers to the ability of an instrument to detect a clinically important change over time with reference to an external anchor (Guyatt *et al.* 1987, Husted *et al.* 2000, Revicki *et al.* 2006, 2008).

The PUSH tool has previously been shown to be internally responsive in assessing pressure ulcers, diabetic ulcers and venous ulcers. However, the external responsiveness of the tool has not yet been evaluated. Furthermore, the internal and external responsiveness of the PUSH tool has been not evaluated in patients with acute wounds. The rationale for this study is to strengthen the evidence for using the PUSH tool for assessing a broader range of wound types.

Nurse and Allied Health Clinic-Wound Care (NAHC-WC) programme description

The NAHC-WC programme is a service offered by the Hong Kong Hospital Authority, the body responsible for delivery of public-sector healthcare services across Hong Kong. They provide primary care wound care services with the main objective of treating hard-to-heal wounds by increasing healing rates and reducing wound pain. Wound care is provided by nurses with wound care qualifications (such as enterostomal therapists). Patients with prolonged wound healing or complicated wounds are referred to the service either by their primary care doctor or by a general primary care nurse. NAHC-WC nurses provide wound assessments and deliver protocol-driven evidence-based wound care treatments together with patient education.

The study

Aim

The aim of this study was to broaden the applicability of the PUSH tool across a variety of acute and chronic wounds, with the specific objective of examining the internal and external responsiveness of the PUSH tool. It was hypothesized that:

- Overall, the PUSH tool would be an internally responsive wound assessment tool.
- After controlling for age, gender and wound type, 'wound improved but not healed' group should have less improvement in the PUSH score than 'wound healed' group. 'Wound static or worsened' group should have the least improvement in the PUSH score.

Design

A prospective, longitudinal observational study was conducted.

Participants

This study was conducted in the Hong Kong Hospital Authority's Government Out-patient primary care clinics located territory wide across Hong Kong. Patients were recruited from 27 Nurse and Allied Health-Wound Care (NAHC-WC) clinics (Chin *et al.* 2011). All new patients with at least one eligible acute or chronic wound, enrolled in the NAHC-WC service between 1 December 2012 – 31 March 2013 were included for analysis. Eligible chronic wounds included: venous ulcers, pressure ulcers and neuropathic ulcers. Eligible acute wounds included: burns and scalds, skin tears, surgical wounds and traumatic wounds. Patients were excluded if they were aged <18 years old or had no wound (e.g. attended the clinic only for measurement of compression stockings). As sample sizes for malig-

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nant wounds and arterial ulcers were too small, participants with these wound types were excluded from analysis.

Instruments

Pressure Ulcer Scale for Healing (PUSH)

The PUSH tool was developed by the National Pressure Ulcer Advisory Panel to monitor the change in pressure ulcer status over time (Stotts *et al.* 2001). The tool consists of three parameters: (i) wound surface area (ranging from 0-10); (ii) exudate amount (ranging from 0-3); (iii) tissue type (range from 0-4). The scores of the three questions can be summed to give a total score (ranging from 0-17), with lower scores indicating better wound conditions.

- For wound surface area, users need to use a centimeter ruler to measure the greatest length (head to toe) and the greatest width (side to side). Multiplying the length and the width can obtain an estimate of surface area in square centimeters.
- For exudate amount, users need to estimate the amount of exudate (none, light moderate or heavy) after removing the dressing and before applying any topical agent to the wound.
- Tissue types of the wound bed include necrotic tissue (black, brown, or tan tissue), slough (yellow or white tissue in strings or thick clumps), granulation tissue (pink or beefy red tissue with a shiny, moist, granular appearance), epithelial tissue (new pink or shiny tissue that grows in from the edges or as islands on the wound surface) and closed wound (the wound is completed covered with epithelium)

Data collection

This investigation was conducted as part of a larger study on the quality of care of primary care nurse and allied health clinics (Chin *et al.* 2011). To evaluate the responsiveness of the PUSH tool across different wound types, the NAHC-WC nurses were asked to assess and document each wound using the PUSH tool at both the initial assessment consultation and again at the final discharge consultation using a standardized case record form. In patients with multiple wounds, the wound with the poorest condition at baseline was chosen as the index wound for study purposes. At the final (discharge) consultation, the NAHC-WC nurse was asked to clinically categorize the wound healing status into three groups: (i) 'wound healed'; (ii) 'wound improved but not healed' and (iii) 'wound static or worsened' and recorded it in the subject's the discharge case record form. Patients whose wounds were assessed as 'not healed' after receiving NAHC-WC treatments were referred for further advanced wound management in hospital-based specialist clinics.

All anonymous data, including basic social-demographics and clinical data were directly extracted from the computerized clinical management system of the Hospital Authority.

Data analysis

Descriptive statistics (mean and standard deviation) and percentage of subjects who achieved the floor or ceiling score of the PUSH tool were calculated. A total of 15% was used as the threshold for a significant floor or ceiling effect (McHorney & Tarlov 1995).

Agreement between PUSH score and wound healing status judged by nurses

Kappa statistics were used to compare the agreement between wound healing status judged clinically by NAHC-WC nurses and wound healing status as defined by the PUSH scores. The wound healing status judged by nurses was dichotomized into 'healed' and 'non-healed'. Non-healed wounds included both the wounds that had improved but had not fully healed and the wounds that had remained static or worsened. Participants were also dichotomized into two groups by their PUSH score. Participants with PUSH scores = 0 at discharge were considered to have a fully healed wound. Conversely, participants with PUSH scores ≥ 1 at discharge were considered to have a non-healed wound.

Responsiveness

In this study, the methods as recommended by Husted *et al.* (2000) were followed up for assessing the responsiveness of the PUSH tool. First, paired *t*-test and effect size statistics were used to assess the internal responsiveness, overall. Next, multiple linear regression which controlled for age, gender and wound type was used to further quantify the impact of wound healing status on the change in PUSH score to confirm the external responsiveness.

i. Internal responsiveness by paired t-test

We hypothesized that there would be a statistically significant change in PUSH scores between baseline and discharge. Therefore, the mean PUSH score changes between baseline and discharge were analysed by paired *t*-testing. The results of paired *t*-test should be supplemented with effect size statistics because statistical significance of the paired *t*-test can be affected by sample size. Effect size

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statistics are not affected by the sample size and can provide direct information on the magnitude of change measured. The PUSH score differences between baseline and discharge were evaluated by the Cohen's d effect size (ES) (Cohen 1988), standardized effect size (SES) (Guyatt *et al.* 1987) and standardized response mean (SRM) (Liang *et al.* 1990). Since the most appropriate effect size for calculating responsiveness statistics remains controversial, three effect sizes were used (Husted *et al.* 2000).

- ES = $(\text{Mean}_{\text{Followup}} - \text{Mean}_{\text{Baseline}})/\text{Standard deviation}_{\text{pooled}}$
- SES = $(\text{Mean}_{\text{Followup}} - \text{Mean}_{\text{Baseline}})/\text{Standard deviation}_{\text{Baseline}}$
- SRM = $(\text{Mean}_{\text{Followup}} - \text{Mean}_{\text{Baseline}})/\text{Standard deviation}_{\text{Followup-Baseline.}}$

The values of ES, SES and SRM were interpreted as trivial (<0·2), small (≥0·2 and <0·5), moderate (≥0·5 and <0·8) and large (≥0·8) as recommended by Cohen (Cohen 1988) and Liang (Liang *et al.* 1990). Internal responsiveness was supported if the difference is interpreted as small or the above. 95% bootstrap bias-corrected and accelerated confidence intervals for ES, SES and SRM were calculated using the bootstrapping estimation method with 2000 replications (Efron 1987).

ii. External responsiveness by multiple linear regression

External responsiveness was determined by multiple linear regression as recommended by Husted *et al.* (2000). The external criterion for assessing the external responsiveness of the PUSH tool was the wound healing status as judged by the NAHC-WC nurses at discharge: (i) 'wound healed'; (ii) 'wound improved but not healed' and (iii) 'wound static or worsened'.

It was hypothesized that: (i) wound healing status would be a factor associated with the change in the PUSH score; (ii) compared with the 'wound healed' group, the 'wound improved but not healed' group would have a smaller change in the PUSH score; and (iii) that the 'wound static or worsened' group would have the smallest change in the PUSH scores. To test these hypotheses, a multiple linear regression analysis was performed to explore the association between wound healing status and change in PUSH scores as the interpretation of this model was more straightforward.

In the multiple linear regression model, the explanatory variable was set as wound healing status including (i) 'wound healed', (ii) 'wound improved but not healed' and (iii) 'wound static or worsened' while the response variable was the change in PUSH score between baseline and discharge. In this regression model, age, gender and wound types were controlled.

The assumptions of the model for normality and heteroscedasticity of residuals, and multicollinearity were checked by Q-Q plot, scatter plots of residuals against the predicted values and variance inflation factor, respectively. Goodness-of-fit of the model was assessed by R^2. All statistical analyses were conducted by the Stata 13 (StataCorp, College Station, TX, USA) (StataCorp 2013) with P values <0·05 indicating statistical significance.

Sample size calculation

Previous literature has shown that the effect size of the PUSH score change between baseline and discharge across diverse clinical settings was 0·97 (Hon *et al.* 2010). Using this reference, a large effect size of 0·8 was assumed and it was calculated that the minimum sample size of 23 subjects was needed to detect a difference by paired *t*-test with power of 95% and a two-tailed significance of 0·05. With 30% attrition rate, at least 33 subjects were required for the analyses.

Reliability and validity for data collection and analysis

All NAHC-WC nurses involved in the study received postregistration training in wound care. They were experienced wound care nurses with prior experience in using the PUSH tool. They were briefed by the study team about its use as part of a research investigation and understood that they were to use the PUSH tool in a standardized manner for all wound types where it was feasible to be used. For quality control purposes, data were entered twice by two independent research assistants and checked for inconsistencies. Data analysis was done by an independent statistician who was not involved in data collection.

Ethics considerations

The study protocol was approved by the institutional review boards: HKU/HA HKW Cluster (UW 10-369), the HA HKE Cluster (HKEC-2010-093), the CUHK-NTE Cluster (CRE-2010·543) on 04 January, 2011, the HA KE/KC Cluster (KC/KE-10-0210/ER-3), the HA KW Cluster (KW/EX/10-137 (34-04)) and NTW Cluster (NTWC/CREC/912/11).

Results

During the study period, 1,433 new patients were enrolled in the NAHC-WC programme. Of these, 541 subjects

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(37·8%) had a valid PUSH score recorded at baseline and discharge. In terms of gender, 57·9% (N = 313) were male. The mean age was 57·7 years. The average duration between baseline and discharge consultation was 41·7 days. In terms of wound types, 79·3% (N = 429) of subjects had acute wounds and while 20·7% (N = 112) had chronic wounds. The demographic characteristics of the subjects included in the analyses are shown in Table 1.

The mean PUSH score and the percentage of subjects who achieved floor or ceiling PUSH score at baseline are shown in Table 2. No statistically significant floor and ceiling effects were seen for the PUSH score among any of the wound subtypes.

Agreement between the nurses' judgment and PUSH scores

Comparing the agreement between the nurse's judgment of the wound healing status at discharge (healed wound, n = 350 vs. non-healed wound, n = 191) and PUSH scores at discharge (zero score, n = 343 vs non-zero score, n = 198), the kappa statistics was 0·9719 indicating a very strong agreement between these measures.

Internal responsiveness

Table 3 shows the results of the paired t-test and effect size statistics of the PUSH score. Overall, there was a statistically significant improvement in the PUSH score between baseline and discharge (P < 0·001). The Cohen's effect size was 1·92. The standardized effect size was 2·03. The standardized response mean was 1·59.

External responsiveness

Table 4 shows the results of the multiple linear regression analysis. The variance inflation factor ranged from 1·04-2·61 indicating the absence of multicollinearity. The Q-Q plot and the scatter plots of residuals against the predicted values did not reveal any substantial deviation from the normality and homogeneity of variance of the residuals of the models, satisfying the model assumptions. After controlling for age, gender and wound type, wound healing status at discharge was found to be a statistically significant factor associated with the change in PUSH scores. Subjects in the 'wound improved but not healed' group had a smaller change in PUSH scores than those in the 'wound healed' group. Subjects in the 'wound static or worsened' group had the smallest change in PUSH scores. The result of R^2 showed that the factors explained 45·6% of the total variation in the model.

Discussion

To our knowledge, this was the first study to evaluate the internal and external responsiveness of the PUSH tool across a variety of acute and chronic wound types commonly encountered in primary care settings. The methods used to

Table 1 Subject characteristics (N = 541).

Age, Mean (SD)	57·7 (18·5)
Gender (%, *n*)	
Female	42·1% (228)
Male	57·9% (313)
Duration in programme (day), Mean (SD)	41·7 (44·7)
Wound dressing frequency, Mean (SD)	0·4 (0·2)
Wound type (%, *n*)	
Chronic*	20·7% (112)
Venous ulcer	15·5% (84)
Pressure ulcer	2·0% (11)
Neuropathic	3·1% (17)
Acute†	79·3% (429)
Burn and scald	12·4% (67)
Skin tear	8·9% (48)
Surgical	36·6% (198)
Traumatic	21·4% (116)

*Chronic wound includes venous ulcer, pressure ulcer and neuropathic wounds.
†Acute wound includes burn & scald, skin tear, surgical and traumatic wounds.
SD, standard deviation.

Table 2 The baseline PUSH score.

	PUSH score		
	Floor effect (%)	Ceiling effect (%)	Mean (SD)
Total group	0·2	0·2	9·00 (3·28)
Chronic*	0·0	0·0	9·45 (3·08)
Venous ulcer	0·0	0·0	9·54 (3·18)
Pressure ulcer	0·0	0·0	9·55 (2·88)
Neuropathic	0·0	0·0	8·94 (2·79)
Acute†	0·2	0·2	8·88 (3·33)
Burn and scald	0·0	0·0	11·30 (3·21)
Skin tear	0·0	0·0	8·48 (3·18)
Surgical	0·5	0·0	7·99 (3·07)
Traumatic	0·0	0·9	9·17 (3·18)

*Chronic wound includes venous ulcer, pressure ulcer and neuropathic wounds.
†Acute wound includes burn and scald, skin tear, surgical and traumatic wounds.
SD, standard deviation.

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Table 3 Internal responsiveness of the PUSH tool by paired *t*-test.

PUSH score				
Mean change (SD)	*P* value*	ES (95% CI)†	SES (95% CI)†	SRM (95% CI)†
6·66 (4·20)	<0·001	1·92 (1·76, 2·08)	2·03 (1·89, 2·16)	1·59 (1·47, 1·69)

*Paired *t*-test was used to compare the PUSH scores between baseline and discharge assessments.
†95% confidence interval were constructed by the 95% bootstrap bias-corrected and accelerated with 2000 replications.
SD, Standard Deviation; ES, effect size; SES, standardized effect size; SRM, standardized response mean; CI, confidence interval.

Table 4 External responsiveness of the PUSH tool by multiple linear regression.

Factors	Change in PUSH tool Coeff. (95% CI)	*P* value
Wound condition at discharge (reference: Healed)		
Improved but not healed	−5·42 (−5·99, −4·84)	<0·001*
Static or worsen group	−8·14 (−9·78, −6·50)	<0·001*
Wound type (reference: burn and scald)		
Venous ulcer	−2·40 (−3·43, −1·38)	<0·001*
Pressure ulcer	−1·66 (−3·68,0·36)	0·107
Skin tear	−3·09 (−4·27, −1·92)	<0·001*
Surgical	−2·77 (−3·66, −1·89)	<0·001*
Traumatic	−1·99 (−2·93, −1·04)	<0·001*
Neuropathic	−2·53 (−4·22, −0·85)	0·003*
Age	0·02 (0·00,0·03)	0·025*
Gender (reference: female)		
Male	0·004 (−0·54,0·55)	0·988
Constant	9·846 (8·65,11·04)	<0·001*
Goodness-of-fit		
R^2	45·6%	

The more negative the coefficient, the fewer the change in the PUSH score.
*Significant with *P* value <0·05 by multiple linear regression.
Coeff, coefficient; CI, confidence interval.

evaluate the internal responsiveness (by paired *t*-test and effect size statistics) and external responsiveness (by regression model) of the PUSH tool is recommended by Husted *et al.* (2000) and has been extensively used in previous studies (Husted *et al.* 2000, Tveitå *et al.* 2008, Hon *et al.* 2010, Choi *et al.* 2015). We found that the PUSH tool was both internally and externally responsive to changes between baseline and discharge in wound care clinic patients with various wound types including burns and scalds, skin tears, postsurgical wounds, traumatic wounds, venous ulcers, pressure ulcers and neuropathic ulcers.

Unlike the study by Hon *et al.* (2010), we did not performed multiple subgroup analyses by wound type and healing status to evaluate the responsiveness of the PUSH tool because multiple testing can lead to type 1 errors, and may be difficult to interpret. We only evaluated the overall internal responsiveness of the PUSH by paired *t*-test and effect size statistics. Subsequently, multiple linear regression was performed to explore the association between the change in the PUSH score and the wound healing status (external anchor) so as to confirm the external responsiveness. The interpretation of this model is less complicated.

With regard to the internal responsiveness of the PUSH tool, large ES, SES and SRM of the PUSH scores were found. The PUSH tool performed well in detecting changes over time and there was a large difference between baseline and discharge PUSH scores (as evidenced by the effect size statistics). The study by Hon *et al.* (2010), which examined the responsiveness of the PUSH tool in patients with diabetic, venous and pressure ulcers also found a larger difference between baseline and follow-up assessment (effect size: 1·3 and standardized response mean: 1·15). This study supplements earlier studies which have only evaluated the responsiveness of the PUSH in chronic wounds (Hon *et al.* 2010) and provides evidence to expand the application of the PUSH tool to monitor acute wounds including, burns and scalds, skin tears, surgical wounds and traumatic wounds.

Our present study also showed that the PUSH tool was externally responsive to external criterion, namely the wound healing status judged clinically by the wound care nurses. By using multiple linear regression analysis, we found a statistically significant association between the external anchor (wound healing status) and the change in PUSH scores. As reflected by the regression coefficients, subjects in the 'wound improved but not healed' group had a smaller change in PUSH scores than those in the 'wound healed' group. Subjects in the 'wound static or worsened' group had the smallest change in PUSH scores, compared with those in 'wound healed group' and 'wound improved but not healed group'.

Implications

The PUSH tool is an easy-to-use bedside wound assessment tool which can be used to monitor the wound heal-

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ing process for a wide variety of wound types in routine clinical practice. Although the PUSH tool cannot replace an in-depth wound assessment for guiding treatment planning and clinical decision-making, the PUSH tool can help nurses who are not specialized in wound care to measure different wound types more accurately and easily particularly in community settings where the number of certified wound care nurses is limited. In clinical trials, the PUSH tool can be used as an outcome measure. The extended application of the PUSH tool can allow pooling of data obtained from patients with different wound types and be used to conduct subgroup analyses. From a health services prospective, the proportion of patients who have and improvement in PUSH scores after receiving treatment can be used as a standardized outcome indicator to evaluate the quality of care of wound care services.

Limitations

The major strength of this study was our large sample size which was representative of the types of patients requiring primary care wound care interventions. As we included patients with a broad range of wound types, we were able to extend the applicability of the PUSH tool in evaluating to a wide range of wound pathologies typically encountered in primary care settings.

There were some notable limitations. First, this study only evaluated the internal and external responsiveness of the PUSH tool. Further studies are required to confirm the inter-rater stability and stability of this instrument over time. Second, the results of agreement and external responsiveness should be interpreted by caution. The same nurses scored the wound by the PUSH tool and assessed the wound healing status at discharge. There might be a potential bias. In future study, nurses who assessed the wound healing status should be blinded to the PUSH score. Third, the applicability of the PUSH for malignant wounds and arterial wounds still needs to be established. Finally, this study was conducted in the primary care setting using protocol-based nurse-led wound care interventions and may not be applicable to tertiary settings where surgical interventions may be provided.

Conclusion

The PUSH tool appears to be an internally and externally responsive wound assessment tool. Our findings support the applicability of the PUSH for the assessment and monitoring of acute wounds including burns and scalds, skin tears, postsurgical wounds and traumatic wounds. We recommend that the PUSH tool be used both in clinical practice and in research as an outcome measure for wound care interventions and as an outcome indicator for quality of care of wound care services.

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Conflict of interest

No conflict of interest has been declared by the authors.

Author contributions

All authors have agreed on the final version and meet at least one of the following criteria [recommended by the ICMJE (http://www.icmje.org/recommendations/)]:

- substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data;
- drafting the article or revising it critically for important intellectual content.

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