Attitudes and practices towards vital signs monitoring on paediatric wards: Cross-validation of the Ped-V scale

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Abstract

Purpose: To develop and psychometrically test an instrument measuring the attitudes and practices towards vital signs (VS) monitoring in nurses caring for children on paediatric wards (Ped-V scale).

Design and Methods: This is a multicentre cross-validation study with a cross-sectional design. The Ped-V scale was developed by adapting the V-scale to the paediatric context and administered to a convenience sample of clinical nurses working in paediatric wards from January to May 2020. The content validity of the Ped-V scale was evaluated by a group of 10 experts. The psychometric properties of the scale were tested through Exploratory Factor Analysis (EFA) and Confirmatory Factor Analysis (CFA).

Results: Overall, 10 Italian hospitals participated in the study, and 640 questionnaires were completed (87% female). At EFA a 30-item version of the scale and four factors emerged. This solution was confirmed at CFA: F1) 'Inaccuracy of VS monitoring and workload'; F2) 'Clinical competence and communication'; F3) 'Standardization and protocol adherence'; F4) 'Misconceptions about key indicators'. Cronbach's alpha ranged between 0.63 and 0.85.

Conclusions: The Ped-V scale is valid and reliable for use in the paediatric context to identify barriers concerning nurses' self-efficacy, competences, and knowledge of clinical indicators of paediatric critical deterioration, attitudes towards accuracy, standardization, communication to senior team members and the appropriate use of technology in paediatric VS monitoring.

Practice Implications: The Ped-V scale may assist in identifying gaps in nurses' attitudes and devising strategies to change nurses' beliefs, knowledge, skills and decreasing individual, local cultural or organizational barriers towards VS monitoring.

Keywords: vital signs, physiologic monitoring, behavior rating scale, validation study, pediatric nursing

Introduction

Paediatric patients admitted to hospital wards are at risk of clinical deterioration and urgent intensive care admissions because of increased severity of illness, complexity of care, increased complexity of medical and surgical interventions, and earlier patient discharge from intensive care units (ICU) (Brekke et al., 2019; Downey et al., 2018). In-hospital cardiac arrests are preceded by abnormal vital signs (VS) measures, up to 24 hours before (Franklin & Mathew, 1994; Kause et al., 2004; Tume, 2007). Moreover, in children clinical deterioration can evolve more rapidly than adults because of their reduced ability to physiologically compensate for severe illness, leaving less time to act to prevent critical conditions (Convertino et al., 2016). In paediatrics, the variation of heart rate, respiratory rate, and blood pressure normal ranges according to the child's age increases the complexity of the interpretation of VS monitoring (Bonafide et al., 2013; Fleming et al., 2011; O'Leary et al., 2015). In addition, most of the children are non-verbal or rely on their parents to communicate their health condition to the healthcare team, making detection of clinical deterioration more complex.

Patient observation and VS monitoring is performed by nurses through a complex process of auscultation, observation, palpation, and electronic monitoring (Aylott, 2006; Royal College of Nursing, 2017). VS are the main clinical indicators of paediatric track and trigger tools (PTTT), devised to prevent clinical deterioration events on paediatric wards by establishing the criteria for activating rapid response systems (RRSs) or advanced care (Armitage et al., 2007; Gawronski et al., 2021; Oliver et al., 2010). In the paediatric context, the aim is to determine baseline VS values at admission for healthy children needing hospital interventions or children with acute conditions, to evaluate the progression of the health status, and to plan for action and reduce the risk of clinical deterioration (Oliver et al., 2010; Royal College of Nursing, 2017; Tysinger, 2015). VS monitoring supports nursing clinical judgement of deteriorating patients and can enhance nurses' role in clinical decision-making (Jensen et al., 2019).

According to Reasoned-action approach (RAA) theory, used as the theoretical framework for this study, nurses' attitudes, perceived skills and beliefs towards paediatric VS monitoring on the hospital wards predict behaviours towards this practice (Fishbein & Ajzen, 2010). According to RAA, intentions predict individuals' behaviours. Three key factors guide a person's current behaviour, determining one's intentions: attitude towards a behaviour, perceived norms, and perceived behavioural control, all based on beliefs. Attitude towards a behaviour is based on positive or negative experiences related to the behaviour; perceived norms are related to the expectations of significant others over the behaviour, personal motivation, and the degree of identification with

others; perceived behavioural control is related to perceived skills, barriers, and facilitators by the level of control over those factors. In change theory, RAA supports changing intentions by changing beliefs over a behaviour, increasing skills, or decreasing barriers (Bartholomew et al., 2011).

Conflicting nurses' attitudes towards VS monitoring have been reported. Not all nurses, potentially hindering the timeliness, accuracy and response to deteriorating children, consider VS monitoring as a relevant activity in their practice (Jensen et al., 2019). VS monitoring is perceived to increase their workload without significantly contributing to improved care (Dall'Ora et al., 2019). A relevant proportion of nurses believe that too much time is spent in VS monitoring and that routine monitoring is often unnecessary in stable paediatric patients (Burchill et al., 2015; Dall'Ora et al., 2021).VS are often incomplete or omitted from clinical records (Bagnasco et al., 2018; Chapman et al., 2019; Dall'Ora et al., 2019). In some instances, nurses perform VS monitoring as a routine action, without attributing significant value. Even when the frequency of VS assessment is not codified in a policy, nurses have been found to perform VS assessments in pre-established ways (Burchill & Polomano, 2016). Moreover, VS monitoring is often delegated to less experienced non-registered nursing staff who might not have the ability to recognise abnormal values, potentially delaying the response to deteriorating children (Liaw et al., 2011; Odell et al., 2009). As VS interpretation in paediatrics is based on the knowledge of age-related normal thresholds, nurses may have limited ability in recognizing the clinical deterioration of a child and escalating care (Jensen et al., 2019).

Within the RAA framework, identifying nurses' attitudes and practices towards VS monitoring in paediatrics wards may assist in identifying gaps in clinical nurses' beliefs, knowledge, clinical and communication skills, as well as decreasing organizational or cultural barriers towards VS monitoring in children on the hospital wards. This is essential to improve the response of the afferent limb of rapid response systems in the domains of the recognition of deteriorating patients, the interpretation of VS and the communication to senior team members. However, to date, no validated instrument is available to assess nurses' attitudes and practices towards VS monitoring in the paediatric in-patient population.

Aim

To develop and psychometrically test an instrument measuring the attitudes and practices towards vital signs monitoring in nurses caring for children on paediatric wards (Ped-V scale). In particular, this study aimed to evaluate the content validity, construct validity, and reliability of the Ped-V scale.

Methodology

Design

This was a multicentre cross-validation study with a cross-sectional design on nurses' attitudes and practices towards VS monitoring of children admitted to hospital wards in Italy. In the first phase, the Ped-V scale was developed by adapting the V-scale to the paediatric context. In the second phase, the Ped-V scale was administered to a large sample of general nurses and paediatric nurses caring for children on hospital wards, to evaluate its psychometric properties and describe nurses' attitudes and practices towards VS monitoring. In particular, construct validity was evaluated through a cross-validation process, which first involved exploring the factor structure using exploratory factor analysis (EFA) in a first subsample and subsequently validating that structure by conducting a confirmatory factor analysis (CFA) in a different subsample (Mokkink et al., 2019). The study was performed from July 2019 to February 2020.

Ethical considerations

The study was approved by the Ethics Committee of the coordinating centre [Registration number: 1665_OPBG_2018] followed by approval from the other participating hospitals. Participants were informed about the purpose and methods of the study by the research coordinators. Responding to the questionnaire was voluntary and considered as consent to participation in the study. Collected data were anonymous, securely stored, and treated confidentially.

Phase 1: Development of the Ped-V scale from the V-Scale

Following a review of the literature, a tool aimed at exploring nurses' attitudes towards vital signs monitoring in detecting clinical deterioration in adult patients in general ward settings was identified and considered relevant for this study, the V-scale (Ertuğ, 2018; Mok et al., 2015). The V-scale consists of 16 items scored on a four-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = agree, 4 = strongly agree). The V-scale was originally developed and validated on a group of 234 nurses caring for adult patients in an acute tertiary care hospital in Singapore. Five factors were found following an EFA: key indicators, knowledge, communication, workload, and technology, which explained 56.27% of the total variance. The internal consistency of the 16-item scale was sufficient (Cronbach's alpha = 0.71) and item subscale correlations were strong (0.56-0.89).

The Ped-V scale was developed by adapting the V-scale by Mok et al. (2015) to the paediatric context, after receiving permission from the authors (Figure1). In addition, items specific for the paediatric context were integrated to assess nurses' attitudes and practices towards VS monitoring in hospitalized children. First, the V-scale was translated in Italian through a backtranslation process, according to international recommendations for translation and cultural adaptation developed by Wild et al. (2005). Secondly, in order to identify the key aspects regarding paediatric patient's observation and monitoring, we conducted individual interviews with a group of 10 expert clinical nurses, lasting between 30 and 45 minutes, and 1 focus group with 12 nurses, which lasted 90 minutes (Furr, 2011). The interviews explored nurses' attitudes and behaviours towards VS monitoring in paediatrics, specific characteristics of the clinical observation of the child, clinical indicators of paediatric deterioration, healthcare providers' roles involved in this activity, skills required to accurately monitor VS, and other organisational aspects. Participants emphasized key differences in paediatrics, such as the parent's involvement in the child's monitoring, challenges in the interpretation of VS according to child's age, children's increased risk of severe deterioration due to reduced compensatory mechanisms compared to adult patients, and the significance of respiratory effort or capillary refill in a child. Moreover, behaviours related to the communication of VS to the multidisciplinary team, adherence to hospital standardized VS timelines according to the patient trajectory, and beliefs about the responsibilities for VS monitoring were found to be relevant within the group of experts. Therefore, 25 specific items that were not included in the original V-scale were added to develop the Ped-V scale according to the RAA theory (Fishbein & Ajzen, 2010).

The initial item bank of the Italian version of the Ped-V scale consisted of a total of 41 items, including the 16 items of the original V-scale (Figure1). All the items were scored on a five-point Likert scale. Two areas (Standardization and processes of VS monitoring; roles and responsibilities in VS monitoring) were added to the original V-scale subscales (Key indicators of paediatric clinical deterioration; knowledge; communication; workload; technology) based on the interviews with clinical nurses and literature review.

Phase 2: Content and face validity of the Ped-V Scale

The content validity of the 41-item version of the Ped-V scale was evaluated by a group of 10 expert clinical nurses from different paediatric specialties. They were asked to rate the relevance and clarity of each item using a 4-point ordinal scale from 1 (not relevant) to 4 (highly relevant). The content validity index (CVI) was computed for each item (I-CVI) and the overall scale (S-CVI) (Polit & Beck, 2006). An I-CVI<0.80 was

considered inadequate. Moreover, the experts were asked to comment on the items and to suggest how they could be improved or add new items.

Pilot testing for face validity. Pilot testing was performed with a draft scale including 40 items after content validation, on 11 ward nurses. Comprehensiveness, comprehensibility, and response time were evaluated through cognitive interviews. Time for completion was about 15 minutes. Suggestions for improving readability and editing were collected.

Phase 3: Cross-validation of the Ped-V scale

Participants. The 40-item version of the Ped-V scale was administered to a convenience sample of nurses caring for children on paediatric wards from 10 Italian hospitals from January to May 2020. Hospitals were enrolled through the Italian Association of Paediatric Hospitals (AOPI) and the Italian Society of Paediatric Emergency Urgency Medicine (SIMEUP) networks. Each participating hospital enrolled in the study clinical nurses from one medical, one surgical, one paediatric medical/surgical specialty, and one intermediate care paediatric ward, if available.

Data collection. Descriptive data on each participating hospital were compiled by the local study coordinator thorough an electronic survey. Data included hospital location, bed capacity, availability of a Paediatric critical care service and a PTTT. Then, the Ped-V Scale was completed by all the ward nurses who agreed to participate in the study. The questionnaire was administered online or paper and pencil, according to the preference of the local study coordinators. The link to the online questionnaire was sent to the ward nurses by the nurse managers of the participating ward. Paper questionnaires were administered by the ward nurse manager or research nurses and sent to the Coordinating Centre to enter the data into an excel database. A reminder was sent by email after 15 days and responses were collected within a total of 30 days. Respondents' demographic data on age, gender, education, work experience, and type of paediatric ward were also collected.

Data analysis. To determine the adequate sample size for the study, we considered 7 subjects for each of the 40 items of the Ped-V scale to conduct cross-validation through factor analysis in two different subsamples, resulting in an expected total of at least 560 participants (n = 280 for each subsample) (Mokkink et al., 2019). Descriptive statistics were calculated for the socio-demographic and clinical characteristics of the sample. For each item of the Ped-V scale, we computed medians, interquartile ranges (IQR), and percentages, as well as skewness and kurtosis indices to determine the normality of the distribution. To evaluate construct validity, a

cross-validation approach was used. In particular, we split the entire sample (n = 640) into two subgroups according to odd and even code cases. In the first subsample (n = 320), we performed EFA and in the second subsample (n = 320) CFA. Data factorability was preliminarily ascertained through the Kaiser Meyer Olkin (KMO) index of sampling adequacy (values ≥ 0.60 are acceptable) and Bartlett's test of sphericity. To identify the number of factors to retain in the final solution multiple criteria were adopted, such as the analysis of eigenvalues, factor simplicity (factor loadings > 0.30 and no cross-loadings), interpretability, and theoretical sense of the solution (Comrey & Lee, 2013). EFA was conducted using the oblique rotation of GEOMIN, which can accommodate the data better than an orthogonal rotation when the underlying factors are correlated. EFA and CFA were performed using the robust maximum likelihood (MLr) estimator of Mplus to account for the non-normal distribution of the items (Muthén & Muthén, 1998). Model fit was tested using both omnibus fit indices, such as the chi-square (χ^2) test (values from 1 to 3 of normed chi-square, which is chi-square/df, are recommended), and incremental fit indices such as the Root Mean Square Error of Approximation (RMSEA; values ≤ 0.08 indicate a good fit), the Comparative Fit Index (CFI; values ≥ 0.90 indicate an acceptable fit), the Tucker and Lewis Index (TLI; values ≥ 0.90 indicate a good fit), and the Standardized Root Mean Square Residual (SRMR; values ≤ 0.08 indicate an acceptable fit) (Bollen & Long, 1993; Hoyle, 1995; Hu & Bentler, 1998). Reliability was assessed through Cronbach's Alpha (values > 0.7 indicate satisfactory internal consistency), factor score determinacy coefficients, and composite reliability (values > 0.6 are acceptable) (Bagozzi & Yi, 2012; Fornell & Larcker, 1981). Scores were computed as means and standard deviations. Correlations between factors were performed: values of 0.10–0.29 were considered as weak, 0.30–0.49 as moderate, and 0.50 or greater as strong (Cohen, 2013). The data analysis was performed using the Stata statistical software version 12 and Mplus 6.1 (Muthèn & Muthèn Los Angeles, California 2012).

Results

Content validity of the Ped-V Scale

The S-CVI of the 40-item version of the Ped-V Scale was 0.964 after removing one item because of its poor I-CVI (< 0.78).

Sample characteristics and setting

In the 10 enrolled hospitals, a total of 1,093 questionnaires were administered to nurses working on paediatric wards, 640 questionnaires were completed, with a response rate of 58.6%. About 46% (n =2 97) were from the hospital that coordinated the study, and 54% (n = 343) were from the other nine centres. Most of the participating hospitals were in the north of Italy (n = 6, 60%), the median hospital bed number was 178 (range = 16-607), 9/10 (90%) hospitals had a paediatric ICU, and 3/10 had a paediatric early warning system in place. As shown in Table 1, participants were mainly female (n = 555, 86.7%), 34.4% (n = 220) of them were aged between 30 and 39 years, > 70% had at least a Bachelor's Degree in Nursing, the median length of working experience in the field of paediatric nursing was 10 years (IQR = 3-20).

Construct validity of the Ped-V Scale

Item descriptive statistics. The mean and standard deviation for each item of the 40-item version of the Ped-V scale for the entire sample (n = 640) are shown in Table 2, and the frequencies, median and the IQR in Table S1. The item distribution did not approach univariate normality, as several indices of skewness and kurtosis were > |1|. Higher median scores (= 5) were observed for items 21 and 30.

Construct validity: EFA. Since Bartlett's test of sphericity was significant (χ^2 = 3468, *df* =780, $p < 0.001$) and the KMO index of sampling adequacy was good (0.78), data were considered suitable for factor analysis. A four-factor solution of the 40-item version of the Ped-V scale was found at EFA and considered clinically meaningful and simpler, as well as in line with the scree-plot and eigenvalues, as shown in Table 3. The following fit indices were found: chi-square (df: 626) = 1198.838, p < 0.001 (normed chi-square = 1.92); RMSEA = 0.053 (90% CI = 0.049 - 0.058); CFI = 0.776; TLI = 0.721; SRMR = 0.048. Most of the items showed loadings higher than |0.30|, except for 9 items (item 1, 11, 12, 13, 16, 20, 24, 25, and 40), which were therefore eliminated. In addition, we decided to eliminate item 23 because of its cross-loading. Overall, 10 items were eliminated: 9 items because of poor factor loading and 1 item because of cross-loading. Thirty items were then evaluated for fit.

The EFA solution of the 30-item version (Table 3) yielded the following fit indices: chi-square (df: 321) = 679.946, p < 0.001 (normed chi-square = 2.12); RMSEA = 0.059 (90% CI = 0.053 - 0.065); CFI = 0.834; TLI = 0.775; SRMR = 0.044. The variance explained by each factor was as follows: 8% for factor 1; 14% for factor 2; 6% for factor 3; and 6% for factor 4. Overall, the four factors explained 34% of the total variance. Factor 1 (F1), loaded by 6 items, was labelled *'Inaccuracy of VS monitoring and workload*'; factor 2 (F2), loaded by 12 items,

was labelled *'Clinical competence and communication*'; factor 3 (F3), loaded by 6 items, was labelled *'Standardization and protocol adherence*'; and factor 4 (F4), loaded by 6 items, was labelled *'Misconceptions about key indicators*'. Higher values indicate a careful/positive attitude toward VS monitoring for F2 and F3, while they indicate a negative attitude for F1 and F4.

Construct validity: CFA. The construct validity of the 30-item version of the Ped-V scale was tested through CFA in the second subsample, based on the solution that emerged with EFA (Figure 2).

Figure 2. The Confirmatory Factor Analysis model of the Ped-V-Scale (n = 320)

Legend: VS = vital signs. This figure describes the latent dimensions of the Ped-V Scale, the items' factor loadings on each dimension, the correlations between dimensions and correlation between residuals.

The fit indexes of the four-factor model were as follows: chi-square (df: 399) = 777.772, $p < 0.001$ (normed chi-square = 1.95); RMSEA = 0.054 (90% CI = 0.049 - 0.060); CFI = 0.828; TLI = 0.812; SRMR = 0.072. To further improve fit, based on the similarity in meaning and modification indices, four covariances between residuals were specified: item 3 *'Complete and accurate vital signs monitoring is neglected due to time constraints*' with item 4 *'I feel overwhelmed trying to complete the different frequency of vital signs collection*'; item 5 '*Respiratory rate value is usually estimated for stable patients during routine VS monitoring*' with item 6 '*Electronic vitals monitoring results in casual monitoring (i.e. counting) of respiratory rate*'; item 28 '*I monitor vital signs according to a hospital protocol or procedure*' with item 29 '*I consult a reference table with normal vital sign ranges based on children's ages to be aware of vital signs alterations*'; and item 8 '*I am confident to report deteriorating VS in a way that will get a team doctor/RN in-charge to review the patient*' with item 21 '*I will repeatedly inform the team doctor/RN in-charge of VS changes if prompt actions are acted on*' (Figure 2). The fit indexes of the final model were: chi-square (df: 395) = 690.075, $p < 0.001$ (normed chi-square = 1.75); RMSEA = 0.048 (90% CI = 0.042 - 0.054); CFI = 0.866; TLI = 0.852; SRMR = 0.068. The 30-item version of the Ped-V scale based on the dimensions is shown in Table 4.

Scores and correlations. For the total sample, the mean scores of each factor were: 2.59 (SD = 0.79) for F1; 4.18 (SD = 0.51) for F2; 3.71 (SD = 0.65) for F3; 2.05 (SD = 0.66) for F4 (Table 5). Higher values indicate a careful/positive attitude toward VS monitoring, except for the items from the F1 and F4 domains.

The correlation between F2 and F3 was strong ($r = .60$, $p < .001$), the correlation between F2 and F4 was moderate ($r = -.47$, $p < .001$), the correlation between F1 and F4 was moderate ($r = .48$, $p < .001$), the correlation between F1 and F2 was moderate ($r = -.30$, $p = <.001$), the correlation between F1 and F3 was moderate ($r = -.32$, $p < .001$) the correlation between F3 and F4 was not significant (Table 5).

Reliability of the Ped-V Scale

Cronbach's alpha coefficients were 0.73 for F1, 0.85 for F2, 0.63 for F3, and 0.72 for F4. Internal consistency was therefore satisfactory (values > 0.7) for all the factors, except for F3. The composite reliability coefficient was 0.66 for F1, 0.87 for F2, 0.57 for F3, and 0.75 for F4, indicating that composite reliability was acceptable (values > 0.6) for all the factors, except for F3. Factor score determinacy was 0.81 for F1, 0.95 for F2, 0.83 for F3, and 0.88 for F4. Therefore, the common variance of the factor score predictor with the corresponding factor was good (> .80) for all the factors (Bagozzi & Yi, 2012; Fornell & Larcker, 1981).

Discussion

The present study aimed to develop the Ped-V scale to assess nurses' attitudes and practices towards VS monitoring on hospitalized paediatric patients. The Ped-V scale was developed by adapting the V-scale by Mok et al. (2015) to the paediatric context; the resulting Ped-V scale was psychometrically tested on a large sample of nurses in 10 Italian hospitals. Using a cross-validation approach, we performed an EFA on the 40-item version of the Ped-V scale and then a CFA on the 30-item version, which confirmed a four-factor model with an adequate fit with the data. The four factors – *Inaccuracy of VS monitoring and workload (F1), Clinical competence and communication (F2), Standardization and protocol adherence (F3), and Misconceptions about key indicators (F4)– can reliably* differentiate across different aspects of nurses' attitudes and practices towards VS monitoring on paediatric wards. The simplicity of the solution, its meaningfulness, and the adequate fit with the data make the Ped-V scale a valid instrument. Three dimensions of the Ped-V scale (F1, F2, F4) showed good internal consistency, as shown by Cronbach's alpha > 0.70 and composite reliability coefficients > 0.60. In addition,

correlations between the estimated factor scores match the correlations between the factors themselves, shown by an adequate factor determinacy score for all dimensions (>.80) (Ferrando & Lorenzo-Seva, 2018).

In the Ped-V Scale, several differences were found compared to the five-factor solution by Mok et al. (2015). The important constructs of the previous version (Workload, Technology, Communication, Knowledge, Key indicators) were integrated or modified according to the differences in the items that were found relevant to paediatrics, and statistically significant to EFA. The first dimension *'Inaccuracy of VS monitoring and workload'* synthesises two of Mok's dimensions: 'workload' and 'technology', with the removal of item 1 from the 'workload' dimension of the V-Scale and the shift of item 34 from the 'technology' dimension of the V-Scale into the *'Misconceptions about key indicators'* dimension of the Ped-V Scale. The *Inaccuracy of VS monitoring and workload* refers to nurses' attitude towards accurate VS monitoring related to issues of workload distribution, staffing, inappropriate use of electronic devices, or wrong assumptions on normal observations.

The second dimension *'Clinical competence and communication'* includes 8 new items and 4 items from Mok's dimensions *communication* and *knowledge*. This dimension refers to nurses' abilities in VS monitoring and their attitude towards patient referral or consulting with other health professionals. Our scale included items on observations specific to the paediatric patient population, such as respiratory effort or the ability to recognize and interpret VS values according to the child's age, which are core competencies for paediatric nursing assessments on the hospital wards (Royal College of Nursing, 2017).

The dimension *Standardization and protocol adherence* (F3) showed a sub-optimal internal consistency. This dimension consists of newly developed items capturing the timeliness of VS monitoring according to the child's trajectory of care and standardization of VS monitoring, which can vary across centres. Inter-relatedness of the items can be below expected values because this dimension explores two main aspects: attitudes towards the use of hospital VS guidelines and age-related VS frameworks that define abnormal VS thresholds, typically embedded in PTTT; and the standardization of VS monitoring at significant moments of the hospital admission. First, PTTT were not widespread at the time of this study among this sample of nurses, possibly determining a mismatch in the responses provided within this dimension that might have affected its internal consistency. Second, nurses have been reported to show different attitudes towards protocol adherence in VS monitoring based on their level of expertise and working experience in the paediatric setting (Redfern et al., 2019). More expert nurses have been found to rely less on VS protocols, as opposed to personal clinical judgement, compared to

junior nurses (Tysinger, 2015). Our results possibly reflect the integrated and flexible use of clinical judgement, intuition, and protocol adherence which is warranted for appropriate decision-making (McGaughey et al., 2017).

The fourth dimension *'Misconceptions about key indicators'* includes three items loading on Mok's dimension *'Key Indicators'* (Mok et al., 2015), one item loading on Mok's dimension '*Technology*', and two newly developed items on the need for patient observation vs reliance on electronic monitoring and capillary refill time, specific for the paediatric context. This dimension refers to nurses' lack of knowledge and misconceptions regarding some key indicators of clinical deterioration, including the potential misuse of technology in VS monitoring and patient observations. Nurses have been reported to rely on electronic monitoring more than bedside patient observation, at the expense of relevant signs of deterioration such as respiratory rate and work of breathing (Dall'Ora et al., 2020; Odell et al., 2009).

The implications of using the Ped-V Scale for clinical practice are manifold. Nurses' attitudes towards VS monitoring were satisfactory since the mean scores of each factor were greater than the scale's central value (F2 and F3 > 3, F1 and F4 < 3). We found a relatively high level of knowledge about the key indicators of paediatric clinical deterioration (F4) and of perceived self-efficacy and communication skills (F2). Moreover, when comparing F1 with F4, our findings showed that nurses' knowledge about the key indicators of paediatric clinical deterioration and clinical competencies were higher than their attitude towards the accuracy of VS monitoring while their perception of the effect of workload on this activity was high. Overall, the level of accuracy of paediatric VS monitoring might be improved by using novel electronic solutions such as physiological surveillance systems (Sefton et al., 2017), despite the potential risk of reducing bedside patient observations (Chua & Liaw, 2016), and other technological barriers that might affect the efficiency of nursing documentation (Yeung et al., 2012). Organizational and human factors potentially affecting accuracy, perceived workload or self-efficacy might be improved by managing nurse-patient ratios, nursing skill mix, workload distribution, nursing continuing education or team and ward cultures (Bagnasco et al., 2020; Chua et al., 2013; McGaughey et al., 2017; Ogero et al., 2018; Redfern et al., 2019; Shearer et al., 2012).

The Ped-V Scale is the first that evaluates nurses' attitudes and practices towards VS monitoring in the paediatric setting. Future studies are recommended to evaluate the responsiveness of the Ped-V Scale with different subgroups of nurses with varying levels of paediatric clinical experience and the transcultural validity of the Ped-V scale internationally. Lastly, the reliability of the dimension *Standardization and protocol adherence*

(F3) should be further evaluated on a sample of ward nurses from homogenous organizational contexts or be redesigned by splitting the two competing components.

Limitations

This study describes the self-reported perceptions of nurses' attitudes and practices towards VS monitoring, which might not be fully reflective of the actual behaviour and clinical practices in paediatric wards. The response rate of 59% might have generated a selection bias, as nurses with a better attitude towards VS monitoring might have responded with more likelihood to the questionnaire. The variance explained by the Ped V Scale (34%) was lower than that of the V-Scale (56%) and some values related to the fit indices, specifically CFI and TLI, were slightly below recommended levels. This may be due to the moderate correlations between factors. As a result, computing a total score is not recommended, but we suggest computing an individual score for each of the four factors. Concerning the internal consistency of the Ped-V scale, Cronbach's alpha and composite reliability for the dimension *Standardization and protocol adherence* (F3) were suboptimal. Therefore, we advise further testing of this dimension to be currently used with caution, while confidently using F1, F2, and F4 for clinical practice.

Conclusions

We found that the Ped-V scale was a valid, reliable, and useful tool to accurately assess nurses' attitudes and practices towards paediatric VS monitoring on hospital wards. The relevance of this scale is related to the potential improvement of the afferent limb of paediatric response systems by identifying barriers concerning nurses' perceived self-efficacy, competences and knowledge of clinical indicators of paediatric critical deterioration, attitudes towards accuracy, standardization and the use of technology in paediatric VS monitoring. Therefore, the Ped V-Scale might be a useful instrument to identify behavioural gaps to target educational interventions, audits of VS observation charts, case reviews of deteriorating patients alongside organisational interventions to balance skill mix, workload and address team cultures that might be influencing nurses' attitudes and practices towards vital signs monitoring.

Conflict of interest statement

The authors declare no conflict of interest regarding the publication of this article.

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Attitudes and practices towards vital signs monitoring on paediatric wards:

Cross-validation of the Ped-V scale

Table 1. Characteristics of the nurses that responded to the questionnaire (n = 640)

	N	%
Gender (female)	555	86.7
Age		
20-29	121	18.9
30-39	220	34.4
40-49	146	22.8
≥ 50	153	23.9
Type of paediatric ward		
General paediatrics	126	19.7
Any paediatric specialty	197	30.8
Paediatric surgery	168	26.3
Intermediate Care Units	149	23.3
Ward beds (mean, SD)	19.3	7.3

Table 2. Item descriptive statistics of each item of the 40-item version of the Ped-V scale (n = 640)

Item		Mean	SD
1[a]	It is time consuming to perform VS monitoring.	2.90	1.09
2[a]	VS monitoring is a boring task.	2.05	1.07
3[a]	Complete and accurate VS monitoring is neglected due to time constraints.	2.82	1.23
4[a]	I feel overwhelmed trying to complete the different frequency of VS collection (i.e. hourly, 2 hourly, 4 hourly, etc.) of my patients.	2.85	1.22
5[b]	Respiratory rate value is usually estimated for stable patients during routine VS monitoring.	3.03	1.29
6[b]	Electronic vitals monitoring results in casual monitoring (i.e. counting) of respiratory rate.	2.49	1.29
7[†b]	I usually record respiratory rate as standard rate according to the child's age if SpO_2 is within normal range.	2.29	1.19
8[c]	I am confident to report deteriorating VS in a way that will get a team doctor/RN in-charge to review the patient.	4.35	0.82
9[†d]	Changes in VS were interpreted accurately by nurses (i.e. no absence or delay of appropriate nursing actions).	4.33	0.71
10[*]	I am confident to evaluate changes in the ventilation and its severity by observing the respiratory effort of a child.	4.10	0.75
11[*]	I entrust VS assessment to healthcare assistants (auxiliary nurses, carers, students).	2.68	1.22
12[*]	Frequency of VS assessment of children with complex conditions or treatments is prescribed by doctors.	3.17	1.21
13[*]	Nurses are accountable for planning the frequency and type of vital signs to be monitored.	3.59	1.04
14[*]	Before calling the MET/RRT when a child clinically deteriorates, I consult first with the physician in charge on the ward.	4.25	0.89
15[*]	I document on the chart if a child is restless during VS monitoring and observations if I feel that this might have altered its values.	4.34	0.79
16[*]	When a child deteriorates, I have less time to respond compared to an adult patient because the compensation mechanisms are more limited.	3.40	1.16
17[*]	I am accountable for the child's clinical monitoring even when the parents would like to reduce the VS assessments on the child.	4.37	0.72
18[d]	I can relate VS readings to physiology and pathophysiology of presenting diseases.	4.00	0.69

19*	I am confident when I evaluate VS because I know the normal VS ranges according to the child's age.	4.20	0.76
20[d]	My knowledge in interpreting VS to identify clinical deterioration is limited.	1.91	0.96
21[c]	I will repeatedly inform the team doctor/RN in-charge of VS changes if prompt actions are acted on.	4.44	0.76
22*	I contact the physician in charge on the ward according to my clinical judgement when VS are altered rather than according to a hospital protocol or guideline.	3.83	1.02
23*	I call the RRT/MET according to my clinical judgement when VS are altered rather than a hospital protocol.	3.02	1.26
24*	I involve the parent in VS monitoring to increase the chance of the child's collaboration.	3.54	1.23
25*	Sometimes documented VS are not reliable because the child might have been in distress during the assessment.	3.08	1.12
26*	I observe the behaviour and appearance of the child to understand if a child is deteriorating.	3.79	1.00
27*	Standardised vital signs monitoring is important for clinical decision making.	3.87	0.86
28*	I monitor VS according to a hospital protocol or procedure.	3.52	1.23
29*	I consult a reference table with normal VS ranges based on children's ages to be aware of VS alterations.	3.40	1.27
30*	I assess VS at the child's ward admission.	4.42	0.85
31*	I assess VS at the child's discharge or transfer to another unit.	3.58	1.18
32*	I set the VS alarms on the electronic monitor based on VS normal ranges according to child's age and disease.	4.22	0.94
33*	VS monitoring is useful on patients in stable conditions.	3.48	1.10
34[b]	The use of pulse oximetry to monitor SpO_2 will reduce the need to count respiratory rates.	1.99	1.08
35*	Electronic VS monitoring reduces the need for patient observation.	1.84	1.02
36[e]	SpO_2 is a more reliable indicator in reflecting early signs of respiratory dysfunction than respiratory rate.	2.37	1.14
37[e]	Blood pressure is often the first parameter that reflects abnormality when a patient deteriorates.	2.38	1.03
38[e]	Respiratory rate value is the least important sign of deterioration.	1.81	0.90
39*	Capillary refill time is a negligible indicator to assess perfusion.	1.88	0.96
40*	Respiratory effort is a more reliable indicator of respiratory distress than SpO_2.	3.58	1.08

[*] Newly developed items; [†] Revised items from the V-scale; [a] Workload (Mok et al., 2015); [b] Technology (Mok et al., 2015); [c] Communication (Mok et al., 2015); [d] Knowledge (Mok et al., 2015); [e] Key indicators (Mok et al., 2015); VS = vital signs; RN = registered nurse; MET = medical emergency team; RRT = rapid response team.

Table 3. EFA solutions of the 40-item and the 30-item versions of the Ped-V-Scale in the first subsample (n = 320)

Item	F1	F2	F3	F4	F1	F2	F3	F4
#1	0.236*	-0.045	-0.147	-0.009	-	-	-	-
#2	**0.498***	-0.028	-0.191*	0.043	**0.485***	-0.026	-0.200*	0.049
#3	**0.535***	-0.082	-0.052	0.074	**0.482***	-0.088	-0.054	0.092
#4	**0.423***	-0.054	-0.166	0.019	**0.397***	-0.062	-0.159	0.023
#5	**0.753***	0.059	0.021	-0.039	**0.773***	0.066	0.002	-0.043
#6	**0.780***	0.016	0.033	-0.009	**0.822***	0.028	0.021	-0.035
#7	**0.447***	-0.014	0.224*	0.235*	**0.460***	-0.024	0.231*	0.207*
#8	-0.082	**0.728***	-0.005	0.054	-0.069	**0.746***	-0.026	0.081
#9	-0.162*	**0.608***	-0.01	-0.039	-0.140*	**0.636***	-0.03	-0.005
#10	-0.072	**0.637***	-0.036	-0.015	-0.029	**0.643***	-0.037	-0.013
#11	0.191*	-0.065	0.057	-0.03	-	-	-	-
#12	-0.044	0.221*	0.045	0.168*	-	-	-	-
#13	0.097	0.258*	-0.128	-0.122	-	-	-	-
#14	0.110	**0.429***	-0.131	-0.071	0.114	**0.454***	-0.16	-0.037
#15	0.082	**0.397***	0.152	-0.055	0.092	**0.414***	0.125	-0.058
#16	0.081	0.223*	0.007	0.132	-	-	-	-
#17	0.03	**0.618***	0.106	-0.057	0.062	**0.611***	0.114	-0.073
#18	-0.094	**0.583***	0.09	-0.041	-0.061	**0.588***	0.085	-0.049
#19	-0.067	**0.663***	0.043	0.07	-0.044	**0.688***	0.022	0.102
#20	0.042	-0.238*	-0.047	0.211	-	-	-	-
#21	-0.017	**0.633***	0.028	0.01	0.004	**0.622***	0.032	0.005
#22	0.058	**0.522***	-0.364*	0.056	0.089	**0.481***	-0.306*	0.043
#23	0.029	**0.341***	-0.243*	0.114	-	-	-	-
#24	0.104	0.147	0.097	-0.067	-	-	-	-
#25	0.116	0.267*	-0.063	0.175*	-	-	-	-
#26	0.045	**0.420***	-0.138	0.027	0.035	**0.413***	-0.136	0.056
#27	0.058	0.231*	**0.407***	0.023	0.064	0.227*	**0.433***	0.02
#28	0.054	-0.034	**0.590***	0.028	0.009	-0.033	**0.584***	0.043
#29	0.170*	0.027	**0.513***	0.067	0.158*	0.01	**0.532***	0.046
#30	0.032	0.312*	**0.314***	-0.149	0.018	0.314*	**0.297***	-0.144
#31	-0.137	0.03	**0.447***	0.080	-0.145	0.039	**0.430***	0.061
#32	-0.164*	**0.436***	0.225*	-0.06	-0.150*	**0.441***	0.214*	-0.068
#33	-0.138	-0.002	**0.457***	-0.043	-0.137*	-0.002	**0.469***	-0.057
#34	0.224*	-0.029	0.000	**0.460***	0.224*	-0.041	0.023	**0.453***
#35	0.074	-0.083	-0.122	**0.467***	0.05	-0.098	-0.102	**0.470***

#36	0.04	0.048	0.16	**0.666***	0.055	0.066	0.14	**0.662***
#37	-0.038	0.054	0.047	**0.546***	-0.037	0.057	0.038	**0.545***
#38	-0.082	-0.041	-0.094	**0.540***	-0.088	-0.021	-0.107	**0.564***
#39	0.011	-0.057	-0.159	**0.343***	0.017	-0.042	-0.175	**0.337***
#40	0.289*	0.203*	0.008	-0.067	-	-	-	-

Note: Factor 1 *'Inaccuracy of VS monitoring and workload*' = F1; Factor 2 *'Clinical competence and communication*' = F2; Factor 3 *'Standardization and protocol adherence*' = F3; Factor 4 *'Misconceptions about key indicators*' = F4.

Table 4. The 30-item version of the Ped-V scale based on the dimensions

Dimension	N	Ex	Item
Inaccuracy of VS monitoring and workload	1	2[a]	VS monitoring is a boring task.
	2	3[a]	Complete and accurate VS monitoring is neglected due to time constraints.
	3	4[a]	I feel overwhelmed trying to complete the different frequency of VS collection (i.e. hourly. 2 hourly. 4 hourly. etc.) of my patients.
	4	5[b]	Respiratory rate value is usually estimated for stable patients during routine VS monitoring.
	5	6[b]	Electronic vitals monitoring results in casual monitoring (i.e. counting) of respiratory rate.
	6	7[†b]	I usually record respiratory rate as standard rate according to the child's age if SpO_2 is within normal range.
Clinical competence and communication	7	8[c]	I am confident to report deteriorating VS in a way that will get a team doctor/RN in-charge to review the patient.
	8	9[†d]	Changes in vital signs were interpreted accurately by nurses (i.e. no absence or delay of appropriate nursing actions).
	9	10[*]	I am confident to evaluate changes in the ventilation and its severity by observing the respiratory effort of a child.
	10	14[*]	Before calling the MET/RRT when a child clinically deteriorates. I consult first with the physician in charge on the ward.
	11	15[*]	I document on the chart if a child is restless during vital signs monitoring and observations if I feel that this might have altered its values.
	12	17[*]	I am accountable for the child's clinical monitoring even when the parents would like to reduce the VS assessments on the child.
	13	18[d]	I can relate vital signs readings to physiology and pathophysiology of presenting diseases.
	14	19[*]	I am confident when I evaluate VS because I know the normal VS ranges according to the child's age.
	15	21[c]	I will repeatedly inform the team doctor/RN in-charge of vital sign changes if prompt actions are acted on.
	16	22[*]	I contact the physician in charge on the ward according to my clinical judgement when VS are altered rather than according to a hospital protocol or guideline.
	17	26[*]	I observe the behaviour and appearance of the child to understand if a child is deteriorating.
	18	32[*]	I set the VS alarms on the electronic monitor based on VS normal ranges according to child's age and disease.
	19	27[*]	Standardised VS monitoring is important for clinical decision making.
	20	28[*]	I monitor VS according to a hospital protocol or procedure.

Standardization and protocol adherence	21	29*	I consult a reference table with normal VS ranges based on children's ages to be aware of VS alterations.
	22	30*	I assess VS at the child's ward admission.
	23	31*	I assess VS at the child's discharge or transfer to another unit.
	24	33*	VS monitoring is useful on patients in stable conditions.
Misconceptions about key indicators	25	34[b]	The use of pulse oximetry to monitor SpO_2 will reduce the need to count respiratory rates.
	26	35*	Electronic VS monitoring reduces the need for patient observation.
	27	36[e]	SpO_2 is a more reliable indicator in reflecting early signs of respiratory dysfunction than respiratory rate.
	28	37[e]	Blood pressure is often the first parameter that reflects abnormality when a patient deteriorates.
	28	38[e]	Respiratory rate value is the least important sign of deterioration.
	30	39*	Capillary refill time is a negligible indicator to assess perfusion.

**Newly developed items; †Revised items from the V-scale; VS = vital signs; RN = registered nurse; MET = medical emergency team; RRT = rapid response team; [a] Workload (Mok et al., 2015); [b] Technology (Mok et al., 2015); [c] Communication (Mok et al., 2015); [d] Knowledge (Mok et al., 2015); [e] Key indicators (Mok et al., 2015);*

Table 5. Scores and correlations

	Mean	SD	F1	F2	F3
F1	2.59	0.79	1		
F2	4.18	0.51	-.300*	1	
F3	3.71	0.65	-.319*	.602*	1
F4	2.05	0.66	.478*	-.467*	-.200

Note: SD = Standard deviation; *p < .001. F1 = *'Inaccuracy of VS monitoring and workload*'; F2 = *'Clinical competence and communication*'; F3 = *'Standardization and protocol adherence*'; F4 = *'Misconceptions about key indicators*'.