ABSTRACT. Objective. To determine the construct, content, and convergent validity of 2 self-report pain scales for use in the untrained child in the emergency department (ED).

Methods. A prospective study was conducted of all children who presented to an urban ED between 5 and 16 years of age inclusive after written informed consent was obtained. Children were excluded if they were intoxicated, had altered sensorium, were clinically unstable, did not speak English, or had developmental delays. Children marked their current pain severity on a standardized Color Analog Scale (CAS) and a 7-point Faces Pain Scale (FPS). They were then asked whether their pain was mild, moderate, or severe. Children were then administered an analog scale at the discretion of the attending physician and asked to repeat these measurements. For assessing content validity, the scales were also administered to age- and gender-matched children in the ED for nonpainful conditions. Convergent validity was assessed by determining the Spearman correlation coefficient between the 2 pain scales.

Results. A total of 60 children were enrolled, 30 with pain and 30 without, with a mean age of 9.3 ± 3.3 years. Boys accounted for 58 of the enrollees (63.3%). The median score before analgesic administration was 6.0 cm (interquartile range [IQR]: 4.0–8.0) on the CAS and 3.0 faces (IQR: 2.0–5.0) on the FPS; after analgesic administration, the median scores decreased to 3.1 cm (IQR: 1.1–4.3) and 2.0 faces (IQR: 1.0–3.0), respectively. As the reported pain intensity increased, so did the scores on the 2 pain scales. The 30 children with no pain had a median score on the CAS of 0.0 (IQR: 0.0–1.0) and on the FPS of 0.0 (IQR: 0.0–1.0), whereas the 13 children with severe pain had a median CAS of 7.0 (IQR: 6.0–8.0) and a median FPS of 5.0 (IQR: 4.0–6.0). The Spearman correlation coefficient between the CAS and the FPS was positive and strong (r = 0.894).

Conclusion. The CAS and the FPS exhibit construct, content, and convergent validity in the measurement of pain scales. The 30 children with no pain had a median score on the CAS of 0.0 (IQR: 0.0–1.0) and on the FPS of 0.0 (IQR: 0.0–1.0), whereas the 13 children with severe pain had a median CAS of 7.0 (IQR: 6.0–8.0) and a median FPS of 5.0 (IQR: 4.0–6.0). The Spearman correlation coefficient between the CAS and the FPS was positive and strong (r = 0.894).

ABBREVIATIONS. ED, emergency department; CAS, Color Analog Scale; FPS, Faces Pain Scale; IQR, interquartile range; CI, confidence interval; ACCS, Analog Continuous Chromatic Scale.

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The analog scales were presented to the children in a random-
ized manner. First, the research nurses alternated the order in
which the 2 scales were presented to the children. Second, the
order in which the 2 endpoints were presented to the children
were alternated (ie, the end marked as the “worst pain” versus the
end with “no pain”).

Children were then asked whether their pain was mild, mod-
erate, or severe. Pain scales were presented first in all cases. The
research assistant then asked the children whether they had “a lot
of pain” (severe), “a little bit of pain” (mild), or “somewhere in
between” (moderate). As was done with the analog scales, the
order in which these descriptors were presented to the children
was alternated to avoid inadvertently guiding children to a level
based on what the research assistant observed. A data collection
sheet was used for obtaining following information for each child:
age, gender, previous visits to the ED, chief complaint, and any
procedures performed in the ED.

Construct validity was assessed using the assumption that
analgesics should reduce pain, and, therefore, pain scores should
be lower in children after the administration of an analgesic.
Analgesic administration was at the discretion of the attending
physician, who was blinded to the pain scale score. Children who
received an analgesic were then asked to repeat the measurements
on the pain scales 30 minutes later to allow time for the analgesic
to be effective. For preventing bias, the order in which the 2 scales
were presented to the children was randomized.

For assessing content validity, the scales were also adminis-
tered to children in the ED with nonpainful conditions. These
children were matched for gender and age. For every child who
presented to the ED with a painful condition, the next child of the
same gender and within 6 months of age with a nonpainful
condition was enrolled after obtaining consent, the hypothesis
being that children who complain of pain should score higher than
those who report no pain if the scales are measuring pain. This
was also done to ensure that a confounder such as fear or anxiety
was not influencing the measurement of pain by these scales.

Convergent validity in this context refers to measuring pain
with 2 different tools, both of which are purported to measure
pain intensity. If there is convergent validity, then these different
measures should reveal similar results. Convergent validity was
assessed by correlation of the scores of the CAS and the FPS. If
there was a positive correlation between the scores obtained on
the 2 scales, then it would support convergent validity.

Data were entered into a spread sheet program and analyzed
with the use of a statistical software package (SAS; SAS, Inc, Cary,
NC) by a trained biomedical statistician. Data analysis involved
simple descriptive statistics to describe the characteristics of the sample. Spearman correlation coefficients were used to assess the relationship between the 2 pain scales. Wilcoxon signed-rank tests were used to determine the differences in pre- and postanalgesic scores. Because the FPS is an ordinal measure, medians rather than mean scores were calculated with interquartile ranges (IQRs). For comparability, the median and IQR are also presented for the CAS in addition to the mean data.

A previous study revealed that a clinically significant reduction in pain was associated with a decrease of 2 cm using the CAS and 1 face using the FPS. With the use of the traditional methods of comparing paired means, it was calculated that 22 children would be needed to find a difference of 2 cm on the CAS with 90% power and a 2-tailed $\alpha$ of 0.05. For the FPS, a total of 28 children would be needed to detect a 1-face difference with 90% confidence and a 2-tailed $\alpha$ of 0.05.

RESULTS
A total of 60 children were enrolled, 30 with pain and 30 matched control children without pain. The mean age was 9.3 ± 3.3 years (range: 5–16 years), and 38 were boys (63.3%). Forty-four children (75.9%) had been seen in the ED before, 14 had not (23.3%), and the data were missing for 2. Of the 14 children who were not previously seen in an ED, 8 had pain and 6 did not ($P = .48$).

Construct validity was tested by examining the difference in pain scale scores before and after analgesic administration. Self-reported pain intensity scores should be lowered after analgesic administration if these tools indeed exhibit construct validity. All 30 children with pain were treated with 1 or more forms of analgesia: intravenous opioid (10), fracture immobilization (9), acetaminophen (7), oral opioid (6), topical anesthetic (2), and others (2).

The mean pain score before analgesic administration was 5.7 cm (95% confidence interval [CI]: 4.8–6.6) on the CAS with a median of 6.0 cm (IQR: 4.0–8.0). After the analgesic administration, the mean score decreased to 3.1 (95% CI: 2.0–4.1) with a median score of 3.1 cm (IQR: 1.1–4.3) as illustrated in Fig 3. The median pain score on the FPS was 3.0 faces (IQR: 2.0–5.0) before analgesic administration, which decreased to 2.0 faces (IQR: 1.0–3.0) after analgesic administration (Fig 4). In all 30 children, the pain scores were lower after analgesic administration. No child had difficulty in using the scales secondary to medication side effects. The median change in scores was statistically significant for both scales ($P < .001$).

Thirty children initially complained of pain; of these, 3 reported mild pain, 14 reported moderate pain, and 13 reported severe pain. Cause of the painful conditions was as follows: abdominal pain (10), fractures (7), soft tissue injuries (5), lacerations (3), headache (2), dental abscess (1), chest pain (1), and corneal abrasion (1). As the reported pain intensity increased, so did the scores on the 2 pain scales (Table 1). The 30 children with no pain had median scores on both scales of 0.0, whereas at the other end of the spectrum, children who complained of severe pain had median scores of 7.0 cm on the CAS and 5.0 faces on the FPS. Children with fractures, lacerations, and migraines considered pain to be severe, whereas children with fever and rash considered their pain to be absent (Table 1).

The 2 pain scales were also compared to determine convergent validity. A scattergram comparing the raw data for the CAS with the corresponding data for the FPS is shown in Fig 5. The Spearman correlation coefficient between both the CAS and the FPS was positive and strong ($r = 0.894; P < .0001$).

DISCUSSION
The measurement of pain intensity requires a child to choose on a rating scale a level that best matches the amount of pain that he or she is experiencing. The CAS provides gradations in color and area as well as length, so it is easy to see how different scale positions would reflect different levels in pain intensity. The numerical rating scale on the back facilitates its use in clinical studies. The FPS is a 7-point ordinal scale with scores ranging from 0 to 6. The first face is equal to no pain, and the seventh face is the most

Fig 3. Box and whisker plot of pre- and postanalgesic CAS scores. The horizontal line within each box represents the mean pain score. The outer margins of the box represent the 95% CI, and the whiskers represent the range of pain scores.
pain. The premise behind the FPS is that children as young as 4 years can distinguish between different facial features and patterns that exhibit basic emotions. This scale is simple, is easy to use, and requires minimal instruction, making it attractive for use in the ED, where time is a constraint. Both of these pain scales have been validated for use in children aged 5 years and older in the nonacute setting.3,4

It is worth mentioning that these results do not necessarily apply to other faces pain scales with different psychometric properties.13 The Bieri scale used in this study uses a relatively neutral face for “no pain,” rather than a “smiley” face as chosen by Wong and Baker.14 Chambers and Craig13 showed that children with no pain will often choose the second or third face on the Wong and Baker scale as if to state that there is nothing happy about being in the hospital regardless of whether there is pain.

Pain is a subjective experience. As such, self-report is the gold standard for its assessment. A previous study of postoperative children aged 3 to 7 years after surgery compared the Analog Continuous Chromatic Scale (ACCS) to the Oucher scale.10 The ACCS predated the CAS and was very similar in design.15 Good agreement was found between the ACCS and the Oucher, despite poor agreement with the Children’s Hospital of Eastern Ontario Pain Scale behavioral scale. This emphasizes the importance of trying to use self-report whenever possible. However, without evidence of validity, data derived from a pain scale to assess acute pain in children must be interpreted cautiously.16,17

There are several types of validity: construct, content, convergent, and discriminant.1 Construct validity examines whether data derived from a pain measurement tool conforms to a specific predetermined relationship. Construct validity can be assessed using the assumption that analgesics should reduce pain and therefore pain scores should be lower in children after the administration of an analgesic.6,12 The construct validity of these 2 pain scales is supported by the significant difference obtained from the comparison of the scores obtained before and after the administration of an analgesic intervention (Figs 3 and 4). Convergent validity is present when 2 different tools that measure the same concept, in this case, pain, produce similar results. Applying the CAS and the FPS to the same group of children should result in highly correlated scores because they both are intended to measure pain intensity. The correla-
tion coefficients for the CAS and the FPS were strong and positive, providing evidence of convergent validity. It is possible that there is a systematic offset in the values at some ages but not others (e.g., among 12- to 16-year-olds vs 5- to 7-year-olds). However, our sample size was not sufficiently large enough to examine this specifically. Content validity refers to the comprehensiveness and adequacy with which the instrument covers the phenomenon of interest, in this case pain. It examines whether a pain scale actually measures pain and not something else. Both of these pain scales have been previously determined to have content validity. We attempted to test content validity by administering these scales to several groups of children. Intuitively, a group of children with fractures should score higher on a pain intensity scale than a second group with rashes, as was the case in this study.

The premise of evidence-based medicine is that the results of quality research should improve clinical practice. Without effective tools to measure pain intensity, the results of research that uses self-report must be interpreted cautiously. To the best of our knowledge, this is the only validation study of pain scales performed in children in the ED. Our findings should be generalizable to other ED settings as we had a large mix of ages, genders, and causes of pain. However, all children were English speaking, which is a limitation. These scales are easy to use, are efficient, and offer values of pain intensity that can be statistically analyzed to determine the efficacy of a pain treatment intervention.

A chief criterion of the validity of a pain scale is that it actually measure pain. Possible confounding factors are fear and anxiety. These are especially relevant when considering children who are waiting to be seen in a hospital ED. Discriminant validity refers to the ability of a child to differentiate between the concept being measured (pain) from a similar concept (fear). To state that a pain measurement tool has discriminant validity, there should be a low correlation between the measures of pain and fear. Discriminant validity could have been assessed by applying a measure such as the Child Medical Fear Scale, but because of the time needed to administer this scale and the need to provide analgesics to children in pain, this was not believed to be practical. However, we did administer the pain scale to 30 children who were not complaining of pain and the scores were very low. Future studies could look at applying the Child Medical Fear Scale.

Another limitation of this study was the inability to assess reliability. Reliability is the property of a method of measurement that ensures that it is repeatable. Reliability is at best difficult and perhaps impossible to determine for pain scales because

Fig 5. Scattergram of raw data with CAS data on x-axis and corresponding FPS data on y-axis.

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pain intensity does not remain constant long enough to allow inter- or intraobserver comparisons. Pain is a dynamic state and changes in intensity over brief periods of time.\(^1\)

Pain is a multidimensional experience, and these scales cannot differentiate the varying cultural, psychological, and emotional contributions to the pain experience. These scales measure pain intensity only. There was no attempt made to consider factors such as the behavioral or physiologic responses to pain.

**CONCLUSION**

The assessment and treatment of pain in children is an important component of pediatric practice. Failure to provide children with significant pain relief is inappropriate. Self-report is the gold standard in the assessment of pain intensity. This study provides validation for 2 tools with which to assess pediatric pain in the acute setting.

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