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Measuring clinical capacity to sustain Pediatric Early Warning Systems (PEWS) in resource-limited hospitals: A Spanish-language tool

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Abstract

Background: Pediatric Early Warning Systems (PEWS) improve identification of deterioration, however, their sustainability has not been studied. Sustainability is critical to maximize impact of interventions like PEWS, particularly in low-resource settings. This study establishes the reliability and validity of a Spanish-language Clinical Sustainability Assessment Tool (CSAT) to assess clinical capacity to sustain interventions in resource-limited hospitals.

Methods: Participants included PEWS implementation leadership teams of 29 pediatric cancer centers in Latin America involved in a collaborative to implement PEWS. The CSAT, a sustainability assessment tool validated in high-resource settings, was translated into Spanish and distributed to participants as an anonymous electronic survey. Psychometric, confirmatory factor analysis (CFA), and multivariate analyses were preformed to assess reliability, structure, and initial validity. Focus groups were conducted after participants reviewed CSAT reports to assess their interpretation and utility.

Results: The CSAT survey achieved an 80% response rate (n=169) with a mean score of 4.4 (of 5; 3.8-4.8 among centers). The CSAT had good reliability with an average internal consistency of 0.77 (0.71 to 0.81) and CFA analyses supported the seven-domain structure (comparative fit index 0.825, RMSEA score 0.067, and SRMR score 0.067). CSAT results correlated with respondent's perceptions of the evidence for PEWS, its implementation and use in their center, and their assessment of the hospital culture and implementation climate. The mean CSAT result was higher among respondents at centers with longer time using PEWS ($p<0.001$). Focus group participants noted the CSAT report helped assess their center's clinical capacity to sustain PEWS and provided constructive feedback for improvement.

Conclusions: We present validation of the CSAT tool, the first Spanish-language instrument to assess clinical capacity to sustain evidence-based interventions in hospitals of variable resource-levels. This assessment demonstrates a high capacity to sustain PEWS in these resource-limited centers with improvement over time from PEWS implementation.

Strengths and Limitations of this Study

- The Clinical Sustainability Assessment Tool (CSAT) was translated to Spanish and edited for clarity and syntax by regional group of experts, ensuring cultural appropriateness.
- The CSAT was administered to the multidisciplinary Pediatric Early Warning System (PEWS) implementation leadership teams of 29 diverse pediatric cancer centers in Latin America implementing PEWS, adding to generalizability of results.
- Analysis focused on establishing reliability (psychometric, confirmatory factor analysis) and initial validity of the CSAT, as well as describing the clinical capacity to sustain PEWS in participating centers.
- Diversity of participants and centers allowed for evaluation of individual and hospital characteristics associated with evaluation of clinical capacity for sustainability as assessed by the CSAT.
- Qualitative focus groups to evaluate the utility of the CSAT report to interpret center CSAT results.

Background

Pediatric Early Warning Systems (PEWS) are evidence-based bedside assessment tools to identify early clinical deterioration in hospitalized children.[1] PEWS are particularly useful for hospitalized children with cancer, who frequently experience clinical deterioration resulting in preventable mortality,[2] especially in resource-limited hospitals.[3-6] PEWS implementation improves patient outcomes through promoting interdisciplinary communication between nurses and physicians, leading to quicker identification of clinical deterioration and prompt intervention to address complications.[6-11] In 2017 Proyecto EVAT, a quality improvement collaborative of Latin American pediatric oncology centers, was formed to improve survival of hospitalized children with cancer through PEWS implementation.[6,12] Currently, Proyecto EVAT has 60 centers in 19 countries; to-date 37 have successfully implemented PEWS.[13] Despite the potential benefit of PEWS over time, the long-term sustainability of PEWS is not yet established.

Many clinical interventions like PEWS lack evidence demonstrating their sustainability. Sustainment, or the maintenance of an intervention over time, is critical to maximize benefits of evidence-based interventions,[14-17] particularly in low-resource settings.[18,19] Theoretically, sustainment is associated with greater hospital clinical capacity to maintain an intervention, including skilled staff, adequate finances, and engaged leadership.[20,21] Implementing new interventions is costly, and if they are not sustained, then initial investments are lost.[22,23] Premature abandonment of effective interventions may lead to staff frustration, damaged relationships with patients, and a loss of general capacity to provide services.[24] For these reasons, understanding sustainment of evidence-based interventions is extremely important, particularly in low-resource settings where resources available for intervention implementation are constrained.[22] Unfortunately, there is little empirical evidence about factors that contribute to intervention sustainment in hospital settings, in part due to a lack of measurement tools.[25]

In this study, we describe the development and testing of a Spanish-language version of the Clinical Sustainability Assessment Tool (CSAT), a theoretically-informed, reliable measure of

clinical capacity for intervention sustainment.[26,27] Currently available in English, the CSAT can be completed either individually or as a group in 15 minutes or less. Upon completion, a complementary CSAT report is generated that summarizes the responses to the tool and helps identify areas for improving clinical capacity.[28] The CSAT is being used increasingly in a variety of clinical settings and used to evaluate diverse interventions, indicating it is a useful measure of sustainability for researchers, evaluators, and clinicians. The goal of this study was to evaluate the usability, reliability, and validity of a Spanish-language CSAT and demonstrate its use to evaluate capacity for sustaining PEWS in resource-limited hospitals participating in Proyecto EVAT.

Methods

Proyecto EVAT

Escala de Valoración de Alerta Temprana (EVAT) is a Spanish-language PEWS composed of a five-component scoring tool (Neurologic, Cardiovascular, Respiratory, Staff concern, and Family concern) associated with an escalation algorithm that guides the clinical team in the treatment of a deteriorating patient.[9] Through collaboration between St. Jude Global at St. Jude Children's Research Hospital (SJCRH) and local stakeholders, Proyecto EVAT was formed in 2017 with the goal to improve survival in hospitalized pediatric oncology patients through implementation of PEWS.[12,29] As part of Proyecto EVAT, each hospital assembles a local PEWS implementation leadership team, adjusting the size to account for local needs. In collaboration with the EVAT Steering Committee, a 26-member multidisciplinary team of nurses and physicians from 11 hospitals in 8 countries in Latin America, Proyecto EVAT provides hospital-to-hospital mentorship through a 3-phase implementation process, including planning, piloting, and outcome assessment, to help establish the resources and processes necessary to implement and maintain PEWS. A center is considered to have completed PEWS implementation when

they achieved an error rate, as indicated by incorrect calculation of PEWS or algorithm use, of less than 15% for at least 2 months.[13]

In the first 3 years of the program, we successfully supported PEWS implementation in 37 hospitals of varying resources.[13] Of these, 29 centers from 14 countries completed implementation prior to June 2020, when this study was conducted (**Figure 1**). These centers represent diverse hospital organization, including pediatric multidisciplinary, dedicated oncology, and general (adult and pediatric) hospitals with private, public, and mixed (public-private) funding structures, including hospitals with or without dedicated pediatric oncology units. Together, these hospitals manage approximately 4,300 annual new diagnoses of childhood cancer annually (**Supplemental Table 1**). While all hospitals are mentored through the same 3-step phase implementation process, our previous experience suggests that centers face a variety of sustainability challenges, including turnover of PEWS leadership teams, variable hospital leadership support for the program, and human and material resource limitations. No formal assessment of PEWS sustainability, however, has been conducted.

CSAT Adaptation

We adapted the CSAT, a brief and reliable instrument consisting of 35 items within seven domains to assess an institution's capacity for sustaining a clinical practice.[10, 12] These domains include Engaged Staff & Leadership, Engaged Stakeholders, Organizational Readiness, Workflow Integration, Implementation & Training, Monitoring & Evaluation, and Outcomes & Effectiveness.[26,27,30] Each domain includes 5 items that are scored on a Likert scale from 1 to 7 (35 questions total), where 7 indicates an individual believes their institution has that domain to a great extent. CSAT development and testing demonstrated excellent internal consistency and several trends towards discriminant validity.[27] For this survey, we also include several validating questions taken from existing measures including the organizational readiness to change assessment (ORCA)[31] and the Change Process Capability Questionnaire,[32] which bear conceptual overlap with the CSAT and include indications of intervention implementation as

well as quality improvement. The survey was translated to Spanish by bilingual staff at SJCRH, iteratively edited for clarity and syntax, and back-translated to confirm accuracy. Based on feedback from the EVAT Steering Committee and the research teams' experience with prior surveys in Latin America, the Likert scale was adjusted from the 7-point original scale to a 5-point scale. This is modification is consistent with literature demonstrating that reduction of Likert anchors resolved ambiguities and improved validity, reliability, and response rates among Latino populations within the United States.[33,34] An electronic version of the Spanish tool was reviewed by 19 members of the EVAT Steering Committee, representing countries in Mexico, Central and South America, to establish baseline acceptability within the context of Proyecto EVAT. During testing, survey completion took 10-15 minutes. Feedback was integrated into the final version of the Spanish CSAT tool. The Spanish CSAT is available at https://sustaintool.org; the English version used in this study is included in **Supplement Figure 1**.

CSAT Pilot Testing and Data Collection

After initial translation and testing, the adapted Spanish CSAT was distributed through an anonymous electronic survey on Qualtrics[35] to PEWS implementation leadership teams of 29 centers completing implementation by July 2020 (**Supplemental Table 1**). The PEWS implementation leadership team consists of the core individuals (physicians, nurses, and administrators) responsible for implementing and maintaining PEWS at their center, as identified by each site leader working with our program. This included an average of 7 (range 4-15) individuals per center, with a total 210 participants surveyed. The assessment consisted of the CSAT (35 questions) as well as demographic questions about the individual, intervention, and organization (**Supplemental Figure 1**). The survey remained open for 1 month following distribution and weekly reminders were sent to participants. Center-specific data were collected from PEWS implementation site leader at each participating center. Time since implementation of PEWS was calculated from the date of implementation completion (as defined above) to when the survey was completed (August 1st, 2020). After completing the

assessment, each participant was provided a Spanish-language center-specific CSAT report summarizing results from their hospital (see **Supplemental Figure 2** for English example).

Data Management and Analyses

The survey data were analyzed using R (Version 4.0.4). Initially, descriptive analyses were used to explore the responses. Psychometric and multivariate analyses using R package Lavaan were conducted to assess CSAT reliability and validity characteristics. Reliability analyses focused on the internal consistency (i.e., Cronbach's alpha) for each of the seven CSAT domains. Internal consistency measures the extent to which individual items in a subscale measure the same underlying construct.[36] Confirmatory factor analysis was conducted to confirm the subscale structure and assess the fit of the items within their hypothesized latent domains. In the confirmatory factor analyses, we used traditional fit indices to assess the adequacy of the CSAT structural model, including the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR),[37] as well as the Vuong model fit test.[38] Analysis of Variance (ANOVA) was used to assess initial validity of the measure. This was conducted using demographic characteristics of the setting, PEWS intervention, and participants. ANOVA was used to study the association between center and respondent characteristics and CSAT results.

Focus Groups

Following survey administration and distribution of center CSAT reports, all participants were invited to participate in focus groups to discuss the CSAT tool and report, focusing on usability. From those volunteering to participate, three focus groups were organized to be homogenous by discipline: nursing, pediatric floor physicians, and intensivists. This focus group structure encouraged open and honest discussions. A focus group facilitator guide was developed to assess participants' ability to interpret the CSAT report and to elicit constructive feedback to improve its usability. This guide was translated into Spanish by bilingual members of the

research team. A pilot focus group was conducted including 7 participants from 4 countries. The focus group guide was revised based on feedback from this pilot session and finalized. The finalized guide was used for all focus groups (see **Supplemental Figure 3**). As participants were from hospitals all over Latin America, and the study occurred during the COVID pandemic, focus groups were conducted over WebEx, a secure online platform familiar to all participants and accessible from a computer or mobile device. Participants were asked to engage using their videos and microphones to approximate an in-person discussion. An experienced bilingual native Spanish speaker not otherwise involved in PEWS implementation facilitated all focus groups. Focus groups were recorded, then simultaneously translated to English and transcribed by a professional service. Transcripts were subsequently de-identified, and uploaded into MAXQDA qualitative software (VERBI GMBH, Berlin, Germany) for analysis. Each participant response was used as the unit of analysis. An a priori codebook was created by the research team to analyze data based on interpretation of the report, specific report components, and general feedback (negative and positive) about participants' experience with the CSAT (see **Supplemental Table 2**). A single coder (AA) coded all transcripts.

Patient and Public Involvement

Neither patients, parents, nor the public were involved in the design, conduct, or reporting of this research. We plan to consider the role of the patients and families in sustaining PEWS in future work.

Human Subjects Approval

This study was approved by the SJCRH IRB as exempt research.

Results

Descriptive Statistics

The CSAT survey achieved an 80% response rate (total n=169 responses from 29 centers, center median response rate 83.3%, see **Supplemental Table 1** for center details). Respondent and center demographics are described in **Table 1**. The overall mean CSAT result was 4.4 (out of 5; range per center 3.8-4.8) (**Table 2**).

Psychometrics and CSAT Structure

The Spanish version of the CSAT shows good reliability—an average Cronbach alpha of 0.77, ranging from 0.71 to 0.81 across the seven subscales (**Table 2**). Given the hypothesized structure of the seven CSAT domains, confirmatory factor analysis was used to assess how well the data fit this structural model. The results suggest excellent fit with a comparative fit index (CFI) of 0.825, RMSEA and SRMR scores of 0.067 (**Table 3**). Traditional guidelines suggest that CFI scores of > 0.80 indicate acceptable fit, and RMSEA and SRMR scores of < 0.08 also indicate acceptable fit.[39] Importantly, these results show that the seven-subscale model fits significantly better than the single factor model. More specifically, the smaller AIC value, the smaller relative chi-squared statistic, and the significant Vuong model fit test (LR = 424.5, p < .001) all show that the seven factor model fits the data better than the single factor model.[38] This reiterates the idea that the translated version of the CSAT retains an important subscale structure to measure clinical capacity.

Initial Validation Analyses

The survey included questions to assess the respondents' perception of PEWS, the PEWS implementation process and current use in their center, and general questions describing the institutional culture and implementation climate. Respondents who reported a higher strength of evidence supporting PEWS use, a stronger PEWS implementation leadership team, more frequent use of PEWS in the clinical setting, and generally collaborative hospital climate that is receptive to changes for quality improvement also scored higher on the CSAT assessment,

suggesting good construct validity. Of participants, 43.1% somewhat or strongly agreed that their center's resources were too tightly limited to improve quality of care, however, this was not associated with the total CSAT result (**Table 4**).

Individual and center characteristics were evaluated for associations with the CSAT result (**Table 5**). Front-line clinical staff rated sustainability lower than PEWS implementation leaders and other administrative staff (p = 0.006). We found no other significant differences by other individual demographics. Similarly, hospital characteristics, such as type and size of center, volume of pediatric cancer patients, or pediatric oncology unit structure, was not associated with the performance on the CSAT assessment. However, respondents at centers with a longer time since achieving PEWS implementation, rated sustainability of PEWS significantly higher (p<0.001). This relationship was significant across all domains except organizational readiness (**Supplemental Table 3**). Similar association was seen in center-level analysis, although not statistically significant (p=0.085, **Supplemental Tables 3 and 4**). The relationship between time from implementation of PEWS and mean CSAT total and domain results are further described in **Supplemental Figure 4**.

CSAT Report and Tool Usability

To evaluate the CSAT report, we conducted 3 focus groups (see **Supplemental Table 5** for focus group participant demographics), with a total of 22 participants (7-8 per group) from 10 countries. Participants generally found the CSAT and its report useful to assess the clinical capacity for sustainability of PEWS at their center; "*This tool provided a lot of information…we got a high score, however, we still have some items to improve. Yes, I love this tool because it tells us what items we need to pay attention to."* (Intensivist). Specifically, participants felt the tool allowed them to identify areas of strength and opportunity for improvement "*I consider that it is a valid tool, understandable in terms of this process that we can first see how we are numerically, but then it gives us an analysis to be able to say what we are doing well and what things we should improve*" (Nurse) and "*This is very positive because at the end they are giving*

me tips on the things that I should do within everything related to sustainability and all my weaknesses that it evaluates; it is telling me to focus on this and work on this." (Nurse). They also saw utility in using the tool to advocate for institutional support and resources to improve clinical capacity to sustain PEWS: "*Well, obviously this type of tool, CSAT report, is a tool to advocate; I mean, with this report I can talk to my foundation boss and tell her, we have a team that wants to work, a proper work flow, a very good score in monitoring and evaluation, but we lack organizational readiness, how easily can you through the foundation keep supporting us based on this report? That would be what I would do to advocate*." (Oncologist)

Participants recommended shortening the introductory text, reducing redundancy in reporting domain results, and including visual and descriptive cues to allow for easier interpretation of each center's strengths and weaknesses. They also suggested providing more guidance on how to use the report and next steps: "*I strongly agree to add a conclusion, or steps to follow in the last part of the second page, it would be a summary of what we have to do, actions to be taken*" (Nurse).

Discussion

The CSAT is the first reliable Spanish/English bilingual instrument to assess clinical capacity to sustain interventions and adding to the existing data of the CSAT's performance in high-resource settings.[26] The Spanish CSAT performed well across a heterogenous group of respondents from diverse hospitals in Latin America with variable resource-limitations, indicating good reliability. Our findings demonstrate that the respondents' perception of the clinical capacity to sustain PEWS at their center was associated with a positive perception of the intervention, its implementation process, and use, and the center's culture and implementation climate, suggesting initial validity in this setting. We also demonstrated the utility of the CSAT report for helping clinicians understand their capacity for sustaining interventions and

presented potential ways the report might be improved. These proposed changes will be integrated into the next version of the CSAT report.

Sustainability is the least-studied aspect of the implementation continuum for evidence-based interventions[25,40,41], and presents a challenge across a range of interventions and settings,[17] potentially limiting the long-term impact of effective interventions on patient outcomes. These problems are magnified in resource-limited settings, where investments for implementation and maintenance of interventions are more constrained.[22] Tools such as the CSAT are needed to aid clinicians and hospitals seeking to assess their organization's clinical capacity to sustain interventions. The translation of the CSAT to Spanish for this study further allows for the broad use of this measure, as lack of multi-lingual measure has been a notable scientific barrier for other instuments.[42,43] Now available in both English and Spanish, the CSAT and its associated center report provide an opportunity for clinicians and researchers to assess institutional factors contributing to intervention sustainability, thus improving the sustainment of evidence-based interventions and maximizing their benefits for patients. Additional research lending validity to the CSAT, including its application to different clinical settings and interventions, would be valuable to confirm or contradict the relationships demonstrated in this study.

This study leveraged an international collaborative to evaluate the clinical capacity to sustain one intervention, PEWS, across a variety of respondents and hospital settings. This allowed us to not only evaluate the CSAT, but also study these hospitals' capacity to sustain PEWS. The clinical capacity to sustain PEWS was rated higher by respondents directly involved in PEWS implementation than others (clinical staff and hospital administrators), suggesting that implementation leadership may feel more enthusiastic about the intervention than other hospital staff. The CSAT results did not vary, however, by other respondent demographics or center characteristics, indicating these factors did not influence a center's ability to sustain PEWS over time. A longer history of PEWS use (longer time from implementation) was associated with a higher clinical capacity for sustainment of PEWS as rated by the CSAT. Together, these findings suggest that centers build capacity to sustain improvement

interventions over time.[21,43] This outcome is promising, indicating hospitals are able to maintain the necessary infrastructure to sustain PEWS, regardless of hospital characteristics or resource-level. Such results are important for clinicians, hospital authorities, and funders as they indicate that investment in implementation of PEWS is likely to result in sustained improvements in patient outcomes over time. However, while these preliminary results are positive, more research prospectively tracking the relationship between PEWS sustainment and impact on clinical outcomes is needed to strengthen the evidence for this relationship. Lastly, the CSAT and the CSAT report helped hospitals identify specific limitations in clinical capacity for sustainment, creating an opportunity to grow capacity though targeted improvements. In the qualitative portion of our study, several participants noted the CSAT report could aid them to advocate for needed resources to hospital stakeholders, potentially giving clinicians a tool to actively build their institution's capacity over time.

This study has several limitations. Our respondents sample included primarily PEWS implementation leaders at participating centers, who generally rated the sustainability of PEWS higher than other participants. This may have introduced a source of bias to our study, resulting in over-estimates of the clinical capacity to sustain PEWS and contributing to the observed restriction of range. A more broad sample is needed in future work. This, however, should not have limited our ability to assess the reliability and validity of the CSAT instrument, which was our primary goal of this study. Similarly, while the current work evaluated the use of the CSAT to assess clinical capacity to sustain a single intervention (PEWS), prior diverse experience with the CSAT suggests it has a potential for broad utility to evaluate sustainability of clinical interventions globally.

Conclusion

The CSAT is a Spanish/English bilingual instrument to assess the clinical capacity to sustain evidence-based interventions in hospital settings of variable resource-levels. The CSAT report summarizes survey results to help clinical teams interpret their performance and identify areas of opportunity. This assessment of diverse hospitals in Latin America implementing PEWS

suggests that that clinical capacity for sustainment grows over time, a finding that should be explored in future work. To promote use of the CSAT, the English and Spanish version are currently available publicly at https://sustaintool.org/. Broader dissemination and adoption of this sustainability assessment tool for clinical interventions and quality improvement efforts in hospitals of all resource-levels will help ensure sustained improvements in patient outcomes from maintenance of critical evidence-based practices.

Tables and Figures:

Table 1: Center and respondent demographics and association with CSAT result

Category	Sub-Category	n (%) n=169	Mean CSAT	*p*
Individual Demographics				
Profession	Nurse	75 (44.4)	4.46	0.510
	Physician (Peds HO, Peds ICU, Other Physician)	86 (50.9)	4.40	
	Other (Management, Administration, Coordinators, Other)	8 (4.7)	4.56	
Role in PEWS	PEWS Implementation Leader	115 (68.0)	4.48	0.006
	Clinical Staff	40 (23.7)	4.25	
	Other (Hospital Admin, Data Admin, Other)	14 (8.3)	4.54	
Years Worked since Professional Degree	Less than 5 years	46 (27.7)	4.47	0.290
	From 6 to 10 years	32 (19.3)	4.33	
	More than 10 years	88 (53.0)	4.45	
	NA	3		
Gender	Male	37 (21.9)	4.47	0.576
	Female	132 (78.1)	4.42	
Age	Less than 30 years	12 (7.1)	4.54	0.382
	30 to 40	77 (45.6)	4.39	
	40 to 50	59 (34.9)	4.43	
	More than 50 years	21 (12.4)	4.54	
Center Characteristics				
Type of Hospital	General (adult and pediatric)	67 (39.6)	4.38	0.386
	Oncology (adult and pediatric)	44 (26.0)	4.49	
	Pediatric multidisciplinary	58 (34.3)	4.45	
Hospital Funding Structure	Public	117 (69.2)	4.47	0.087
	Private or public/private partnership	52 (30.8)	4.34	
Annual New Cancer Diagnoses	1-75	68 (40.2)	4.45	0.845
	76-150	49 (29.0)	4.43	
	>150	52 (30.8)	4.41	
Pediatric Oncology Unit Structure	No pediatric oncology unit (integrated with pediatrics or other unit)	19 (11.2)	4.39	0.602
	Separate pediatric	150 (88.8)	4.44	
Time since Implementation of PEWS	1-12 months	67 (39.6)	4.27	<0.001
	12-24 months	66 (39.1)	4.53	
	>24 months	36 (21.3)	4.55	
Number of staff working in center	0-249	24 (14.2)	4.51	0.398
	>249	145 (85.8)	4.42	

Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System, NA-not applicable

Table 2: CSAT subscale and overall descriptive statistics

Domain	Mean	Std. Dev.	Low	High	Cronbach's alpha
Engaged Staff & Leadership	4.55	0.48	2.80	5.00	0.77
Engaged Stakeholders	4.33	0.55	2.80	5.00	0.71
Organizational Readiness	4.08	0.66	2.00	5.00	0.80
Workflow Integration	4.49	0.52	2.50	5.00	0.76
Implementation & Training	4.37	0.56	2.40	5.00	0.79
Monitoring & Evaluation	4.48	0.53	2.20	5.00	0.81
Outcomes & Effectiveness	4.75	0.41	2.80	5.00	0.78
Overall	**4.43**	**0.42**	**2.74**	**5.00**	**0.77**

Abbreviations: CSAT-Clinical Sustainability Assessment Tool

Table 3: Confirmatory factor analysis (CFA) results of baseline and final Spanish CSAT instruments

Phase	Subscales	Items	Chi/df	CFI	RMSEA	SRMR	AIC
Baseline	1	35	2.31	0.685	0.088	0.080	10529.6
Final	7	35	1.76	0.825	0.067	0.067	10147.1

Note: Total n= 169; CFA model fit with robust maximum-likelihood. Vuong's test of model distinguishability demonstrated that the final seven domain model was a significantly better fit to the data than the baseline single domain model (Likelihood Ratio = 424.5, $p < .001$).

Abbreviations: CFA-Confirmatory factor analysis; CFI- comparative fit index; CSAT-Clinical Sustainability Assessment Tool; RMSEA-root mean square error of approximation; SRMR-standardized root mean square residual

Table 4: Validation questions influencing CSAT result

Validation Question	Response Category	n (%) n=169	CSAT mean	p-value
Perceptions of PEWS				
Please rate the strength of the scientific evidence supporting PEWS implementation.	Weak + Neither weak nor strong	7 (4.2)	4.05	<0.001
	Strong	56 (33.3)	4.31	
	Very strong	105 (62.5)	4.53	
	NA	1		
How important is PEWS to provide quality care to your patients?	Not very important (Neither important nor unimportant + Somewhat important)	17 (10.1)	3.95	<0.001
	Very important	152 (89.9)	4.49	
PEWS Implementation Process and Use				
How difficult was the implementation of PEWS in your hospital?	Very difficult	16 (9.6)	4.21	0.054
	Somewhat difficult	77 (46.1)	4.44	
	Neither easy nor difficult	41 (24.6)	4.40	
	Somewhat easy	24 (14.4)	4.54	
	Very easy	9 (5.4)	4.68	
	NA	2		
Our PEWS implementation team understands and uses quality improvement skills effectively.	Neither agree nor disagree	6 (3.6)	3.27	<0.001
	Somewhat agree	59 (34.9)	4.23	
	Strongly Agree	104 (61.5)	4.61	
Regarding patients under my care, how often is PEWS used in their care?	None of the time + Some of the time	7 (4.1)	4.17	0.002
	Most of the time	22 (13.0)	4.19	
	All the time	140 (82.8)	4.49	
Center Culture and Implementation Climate				
Our resources (personnel, time, financial) were too tightly limited to improve care quality.	Strongly Disagree	16 (9.8)	4.50	0.764
	Somewhat Disagree	41 (25.0)	4.38	
	Neither agree nor disagree	34 (20.7)	4.44	
	Somewhat agree	50 (30.5)	4.41	
	Strongly Agree	23 (14.0)	4.50	
	NA	5		
Our clinical team has changed or created systems in the hospital that make it easier to provide high quality care.	Neither agree nor disagree	20 (12.0)	4.14	<0.001
	Somewhat agree	79 (47.3)	4.29	
	Strongly Agree	68 (40.7)	4.68	
	NA	2		
We choose new processes of care that are more advantageous than the old to everyone involved (patients, clinicians, and our entire clinical team).	Strongly Disagree + Somewhat Disagree	3 (1.8)	3.98	<0.001
	Neither agree nor disagree	17 (10.1)	3.98	
	Somewhat agree	75 (44.6)	4.31	
	Strongly Agree	73 (43.5)	4.68	
	NA	1		
The working environment in our clinical team is collaborative and cohesive, with shared sense of purpose, cooperation, and willingness to contribute to the common good.	Strongly Disagree + Somewhat Disagree	8 (4.7)	4.16	<0.001
	Neither agree nor disagree	17 (10.1)	4.19	
	Somewhat agree	73 (43.2)	4.30	
	Strongly Agree	71 (42.0)	4.66	
Our clinical team has greatly improved quality of care in the past 12 months.	Somewhat Disagree + Neither agree nor disagree	14 (8.3)	4.03	<0.001
	Somewhat agree	66 (39.1)	4.26	
	Strongly Agree	89 (52.7)	4.63	

Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System, NA-not applicable

Figure Legends:

Figure 1. Participating Centers (n=29)
Map depicting 29 Proyecto EVAT collaborating pediatric oncology centers participating in the pilot of the Spanish-language CSAT (Clinical Sustainability Assessment Tool) with center characteristics.

Data Sharing Statement: Deidentified data from this study are available upon reasonable request to the corresponding author (asya.agulnik@stjude.org).

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References:

1. Chapman SM, Wray J, Oulton K, Peters MJ. Systematic review of paediatric track and trigger systems for hospitalised children. *Resuscitation.* 2016;109:87-109.
2. Agulnik A, Gossett J, Carrillo AK, Kang G, Morrison RR. Abnormal Vital Signs Predict Critical Deterioration in Hospitalized Pediatric Hematology-Oncology and Post-hematopoietic Cell Transplant Patients. *Frontiers in Oncology.* 2020;10(354).
3. Brown SR, Martinez Garcia D, Agulnik A. Scoping Review of Pediatric Early Warning Systems (PEWS) in Resource-Limited and Humanitarian Settings. *Frontiers in pediatrics.* 2018;6:410.
4. Olson D, Preidis GA, Milazi R, et al. Task shifting an inpatient triage, assessment and treatment programme improves the quality of care for hospitalised Malawian children. *Trop Med Int Health.* 2013;18(7):879-886.
5. Rosman SL, Karangwa V, Law M, Monuteaux MC, Briscoe CD, McCall N. Provisional Validation of a Pediatric Early Warning Score for Resource-Limited Settings. *Pediatrics.* 2019;143(5).
6. Agulnik A, Cárdenas A, Carrillo AK, et al. Clinical and organizational risk factors for mortality during deterioration events among pediatric oncology patients in Latin America: A multicenter prospective cohort. *Cancer.* 2021.
7. Agulnik A, Antillon-Klussmann F, Soberanis Vasquez DJ, et al. Cost-benefit analysis of implementing a pediatric early warning system at a pediatric oncology hospital in a low-middle income country. *Cancer.* 2019;125(22):4052-4058.
8. Graetz D, Kaye EC, Garza M, et al. Qualitative Study of Pediatric Early Warning Systems' Impact on Interdisciplinary Communication in Two Pediatric Oncology Hospitals With Varying Resources. *JCO global oncology.* 2020;6:1079-1086.
9. Agulnik A, Mendez Aceituno A, Mora Robles LN, et al. Validation of a pediatric early warning system for hospitalized pediatric oncology patients in a resource-limited setting. *Cancer.* 2017.
10. Agulnik A, Mora Robles LN, Forbes PW, et al. Improved outcomes after successful implementation of a pediatric early warning system (PEWS) in a resource-limited pediatric oncology hospital. *Cancer.* 2017;123(15):2965-2974.
11. Graetz DE, Giannars E, Kaye EC, et al. Clinician Emotions Surrounding Pediatric Oncology Patient Deterioration. *Front Oncol.* 2021;11:626457.
12. Agulnik A, Garza M, Gonzalez-Ruiz A, et al. Successful Implementation of a Pediatric Early Warning System (PEWS) in 10 Resource-LimitedPediatric Oncology Centers in Latin America and the Caribbean. *Pediatr Blood Cancer.* 2019;66 Suppl 4:s512-513.
13. Agulnik A, Garza M, Gonzalez-Ruiz A, et al. MODEL FOR REGIONAL COLLABORATION IN QUALITY IMPROVEMENT: IMPLEMENTATION OF A PEDIATRIC EARLY WARNING SYSTEM IN 17 PEDIATRIC ONCOLOGY CENTERS IN LATIN AMERICA AND THE CARIBBEAN. *Pediatric Critical Care Medicine.* 2020.
14. Moore JE, Mascarenhas A, Bain J, Straus SE. Developing a comprehensive definition of sustainability. *Implementation Science.* 2017;12(1):110.
15. Scheirer MA, Dearing JW. An agenda for research on the sustainability of public health programs. *Am J Public Health.* 2011;101(11):2059-2067.
16. Mortimer F, Isherwood J, Wilkinson A, Vaux E. Sustainability in quality improvement: redefining value. *Future Healthcare Journal.* 2018;5(2):88.
17. Shelton RC, Cooper BR, Stirman SW. The sustainability of evidence-based interventions and practices in public health and health care. *Annual Review of Public Health.* 2018;39:55-76.
18. Rabin BA, Brownson RC. Terminology for Dissemination and Implementation Research. In: Brownson RC, Colditz GA, Proctor EK, eds. *Dissemination and implementation research in health: translating science to practice.* Second ed.: Oxford University Press; 2017:19-46.
19. Hodge LM, Turner KM. Sustained Implementation of Evidence-based Programs in Disadvantaged Communities: A Conceptual Framework of Supporting Factors. *American Journal of Community Psychology.* 2016;58(1-2):192-210.

20. Schell S, Luke D, Schooley M, et al. Public health program capacity for sustainability: a new framework. *Implementation Science.* 2013;8(1):15.
21. Chambers DA, Glasgow RE, Stange KC. The dynamic sustainability framework: addressing the paradox of sustainment amid ongoing change. *Implementation Science.* 2013;8(1):117.
22. Gruen RL, Elliott JH, Nolan ML, et al. Sustainability science: an integrated approach for health-programme planning. *The Lancet.* 2008;372(9649):1579-1589.
23. Lennox L, Maher L, Reed J. Navigating the sustainability landscape: a systematic review of sustainability approaches in healthcare. *Implementation Science.* 2018;13(1):27.
24. McKay VR, Morshed AB, Brownson RC, Proctor EK, Prusaczyk B. Letting Go: Conceptualizing Intervention De-implementation in Public Health and Social Service Settings. *American Journal of Community Psychology.* 2018;62(1-2):189-202.
25. Proctor E, Luke D, Calhoun A, et al. Sustainability of evidence-based healthcare: research agenda, methodological advances, and infrastructure support. *Implementation Science.* 2015;10(1):88.
26. Malone S, Prewitt K, Luke D. Assessing clinical sustainability: a new, user-friendly tool for evaluating real-world practices. American Evaluation Association's annual conference; 2019; Minneapolis, MN.
27. Luke D. The Clinical Susatinability Assessment Tool (CSAT): Assessing sustainability in clinical medicine settings. . Paper presented at: 11th Annual Conference on the Science of Dissemination and Implementation in Health2018; Washington, D.C.
28. Clinical Sustainability Assessment Tool. https://sustaintool.org/csat/. Accessed August 17, 2020.
29. St. Jude Global. https://www.stjude.org/global.html. Accessed March 2, 2020.
30. Luke DA, Calhoun A, Robichaux CB, Elliott MB, Moreland-Russell S. The Program Sustainability Assessment Tool: a new instrument for public health programs. *Preventing chronic disease.* 2014;11:130184.
31. Helfrich CD, Li YF, Sharp ND, Sales AE. Organizational readiness to change assessment (ORCA): development of an instrument based on the Promoting Action on Research in Health Services (PARIHS) framework. *Implementation science : IS.* 2009;4:38.
32. Solberg LI, Asche SE, Margolis KL, Whitebird RR. Measuring an organization's ability to manage change: the change process capability questionnaire and its use for improving depression care. *American journal of medical quality : the official journal of the American College of Medical Quality.* 2008;23(3):193-200.
33. Marin G, Triandis HC, Betancourt H, Kashima Y. Ethnic Affirmation Versus Social Desirability:Explaining Discrepancies in Bilinguals' Responses to a Questionnaire. *Journal of Cross-Cultural Psychology.* 1983;14(2):173-186.
34. D'Alonzo KT. Evaluation and revision of questionnaires for use among low-literacy immigrant Latinos. *Revista latino-americana de enfermagem.* 2011;19(5):1255-1264.
35. *Qualtrics* [computer program]. Provo, Utah, USA2005.
36. Streiner DL. Starting at the beginning: an introduction to coefficient alpha and internal consistency. *Journal of personality assessment.* 2003;80(1):99-103.
37. Hu L, Bentler P. Evaluating model fit. In: Hoyle RH, ed. *Structural Equation Modeling: concepts, issues, and applications.* Thousand Oaks, CA: Sage Publications; 1995:76-99.
38. Vuong QH. Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses. *Econometrica.* 1989;57(2):307-333.
39. Kline RB. *Principles and practice of structural equation modeling.* Guilford publications; 2015.
40. Braithwaite J, Ludlow K, Testa L, et al. Built to last? The sustainability of healthcare system improvements, programmes and interventions: a systematic integrative review. *BMJ Open.* 2020;10(6):e036453.
41. Glasgow RE, Chambers D. Developing robust, sustainable, implementation systems using rigorous, rapid and relevant science. *Clinical and translational science.* 2012;5(1):48-55.

42. Wiltsey Stirman S, Kimberly J, Cook N, Calloway A, Castro F, Charns M. The sustainability of new programs and innovations: a review of the empirical literature and recommendations for future research. *Implementation science : IS.* 2012;7:17.

43. Moullin JC, Sklar M, Green A, et al. Advancing the pragmatic measurement of sustainment: a narrative review of measures. *Implementation Science Communications.* 2020;1(1):1-18.

Figure 1: Participating centers (n=29)

Center Characteristics	n(%)
Type of Hospital	
General (adult and pediatric)	11 (37.9%)
Oncology (adult and pediatric)	7 (24.1%)
Pediatric multidisciplinary	11 (37.9%)
Hospital Funding Structure	
Public	21 (72.4%)
Mix (Public/private partnership)	6 (20.7%)
Private	2 (6.9%)
Annual New Cancer Diagnoses	
1-75	12 (41.4%)
76-150	9 (31.0%)
>150	8 (27.6%)
Pediatric Oncology Unit Structure	
No pediatric oncology unit (integrated with pediatrics)	4 (13.8%)
Separate pediatric oncology unit	25 (86.2%)
Time since Implementation of PEWS	
1-12 months	10 (34.5%)
12-24 months	13 (44.8%)
>24 months	6 (20.7%)
Number of staff working in center	
0-249	5 (17.2%)
>249	24 (82.8%)

Figure 1. Participating Centers (n=29). Map depicting 29 Proyecto EVAT collaborating pediatric oncology centers participating in the pilot of the Spanish-language CSAT (Clinical Sustainability Assessment Tool) with center characteristics

338x190mm (600 x 600 DPI)

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2-3
Methods			
Study design	4	Present key elements of study design early in the paper	4-5, 6-7
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3-4, 5, 6-7
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	5-7
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*n/a*
Bias	9	Describe any efforts to address potential sources of bias	6-7
Study size	10	Explain how the study size was arrived at	5-6
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5-6
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	5-6
		(*b*) Describe any methods used to examine subgroups and interactions	5-6
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	5-7
		(*e*) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	7 and 9
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1, Fig 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 4

Outcome data	15*	Report numbers of outcome events or summary measures	Table 2 and 3, Pg 8-9
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	n/a
		(*b*) Report category boundaries when continuous variables were categorized	7
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	9-10
Discussion			
Key results	18	Summarise key results with reference to study objectives	10
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	12
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	10-12
Generalisability	21	Discuss the generalisability (external validity) of the study results	12
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Supplemental Tables and Figures

Measuring clinical capacity to sustain evidence-based interventions in resource-limited hospitals: A Spanish-language tool

Table of Contents:

Supplemental Table 1: Participating center relevant characteristics and response rates

Center	Country	Type of Hospital	Hospital Funding Structure	New Annual Cancer Diagnoses	Pediatric Oncology Unit Structure	Time since Implementation of PEWS (months)	Number of Staff Working in Center	Staff Surveyed	Responses	Response Rate (%)
1	Argentina	General (Adult and Peds)	Mix (Public/private partnership)	37	Separate pediatric	2.10	18	15	13	87%
2	Brazil	Pediatric Multidisciplinary	Public	140	Integrated with pediatrics	1.10	12	10	8	80%
3	Chile	Pediatric Multidisciplinary	Public	100	Separate pediatric	39.67	7	8	6	75%
4	Costa Rica	Pediatric Multidisciplinary	Public	168	Separate pediatric	6.13	4	5	3	60%
5	Dominican Republic	Pediatric Multidisciplinary	Public	99	Separate pediatric	19.33	8	7	7	100%
6	Dominican Republic	Pediatric Multidisciplinary	Public	59	Separate pediatric	22.40	43	9	6	67%
7	Ecuador	Oncology (Adult and Peds)	Mix (Public/private partnership)	94	Separate pediatric	24.43	40	6	5	83%
8	Ecuador	Oncology (Adult and Peds)	Mix (Public/private partnership)	75	Separate pediatric	12.27	48	6	6	100%
9	El Salvador	Pediatric Multidisciplinary	Public	185	Separate pediatric	22.40	42	4	4	100%
10	Guatemala	Pediatric Oncology	Mix (Public/private partnership)	513	Separate pediatric	69.07	250	6	6	100%
11	Haiti	Pediatric Multidisciplinary	Private	89	Separate pediatric	22.40	16	4	3	75%
12	Honduras	General (Adult and Peds)	Public	365	Integrated with pediatrics	38.63	35	5	5	100%
13	Mexico	General (Adult and Peds)	Public	19	Separate pediatric	19.33	49	4	4	100%
14	Mexico	Oncology (Adult and Peds)	Public	110	Separate pediatric	9.20	77	6	5	83%
15	Mexico	Oncology (Adult and Peds)	Mix (Public/private partnership)	27	Integrated with pediatrics	22.80	19	4	1	25%
16	Mexico	Pediatric Multidisciplinary	Public	143	Separate pediatric	7.17	55	6	6	100%

17	Mexico	General (Adult and Peds)	Public	42	Integrated with pediatrics	15.33	230	7	5	71%
18	Mexico	General (Adult and Peds)	Public	136	Separate pediatric	6.13	103	6	5	83%
19	Mexico	General (Adult and Peds)	Public	58	Separate pediatric	7.17	66	9	4	44%
20	Mexico	General (Adult and Peds)	Public	45	Separate pediatric	10.23	42	4	4	100%
21	Mexico	General (Adult and Peds)	Public	60	Separate pediatric	26.47	103	6	5	83%
22	Mexico	Pediatric Oncology	Private	60	Separate pediatric	51.83	103	9	9	100%
23	Mexico	Pediatric Multidisciplinary	Public	121	Separate pediatric	13.30	66	6	4	67%
24	Mexico	Pediatric Multidisciplinary	Public	49	Separate pediatric	21.37	22	5	4	80%
25	Nicaragua	Pediatric Multidisciplinary	Public	301	Separate pediatric	14.30	39	5	3	60%
26	Panama	Pediatric Multidisciplinary	Public	55	Separate pediatric	20.37	22	10	7	70%
27	Peru	General (Adult and Peds)	Mix (Public/private partnership)	200	Separate pediatric	5.17	22	13	9	69%
28	Peru	General (Adult and Peds)	Public	150	Separate pediatric	7.17	42	12	10	83%
29	Peru	Oncology (Adult and Peds)	Public	800	Separate pediatric	17.37	230	13	12	92%
TOTAL								**210**	**169**	**80%**

Supplemental Figure 1: English version of the Clinical Sustainability Assessment Tool (CSAT) final survey instrument

CSAT Questions

In the following questions, rate the EVAT program across a range of specific factors that affect sustainability. Please respond to as many items as possible. The more honest you can be with your answers, the more helpful the report will be in moving forward with your program's sustainability planning. If you truly feel you are not able to answer an item, you may select "NA."

For each statement, select the number that best indicates the extent to which you agree. The scale has a range from 1 to 5. Selecting 1 indicates "strongly disagree" and selecting 5 indicates "strongly agree."

NA		1	2	3	4	5
Not able to answer		Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree

Engaged Staff & Leadership: Having supportive frontline staff and management within the organization

1. EVAT engages leadership and staff throughout the process.
2. Clinical champions of EVAT are recognized and respected.
3. EVAT has engaged, ongoing champions.
4. EVAT has a leadership team made of multiprofessional partnerships.
5. EVAT has team-based collaboration and infrastructure.

Engaged Stakeholders: Having external support and engagement for EVAT

Stakeholders: individuals, groups, or organizations that positively or negatively influence the results of a project/initiative, which has authority and power.

1. EVAT engages the patient and family members as stakeholders.
2. There is respect for all stakeholders involved in EVAT.
3. The EVAT importance is valued by a diverse set of stakeholders.
4. EVAT engages other medical teams and community partnerships as appropriate.
5. The EVAT leadership team has the ability to respond to stakeholder feedback about EVAT.

Organizational Readiness: Having the internal support and resources needed to effectively manage EVAT

1. Organizational systems are in place to support the various needs of EVAT.
2. EVAT fits in well with the culture of the team.
3. EVAT has feasible and sufficient resources (e.g., time, space, funding) to achieve its goals.
4. EVAT has adequate staff to achieve its goals.
5. EVAT is well integrated into the operations of the hospital.

Workflow Integration: Designing EVAT to fit into existing practices and technologies

1. EVAT is built into the clinical workflow.
2. EVAT is easy for clinicians to use.
3. EVAT integrates well with established clinical practices.
4. EVAT aligns well with other clinical systems (e.g., EMR).
5. EVAT is designed to be used consistently.

Implementation & Training: Using processes that guide the direction, goals, and strategies of EVAT

1. EVAT clearly outlines roles and responsibilities for all staff.
2. The reason for EVAT is clearly communicated to and understood by all staff.
3. Staff receive ongoing coaching, feedback, and training.
4. EVAT implementation is guided by feedback from stakeholders.
5. EVAT has ongoing education across professions.

Monitoring & Evaluation: Assessing EVAT to inform planning and document results

1. EVAT has measurable process components, outcomes, and metrics.
2. Evaluation and monitoring of EVAT are reviewed on a consistent basis.
3. EVAT has clear documentation to guide process and outcome evaluation.
4. EVAT monitoring, evaluation, and outcomes data are routinely reported to the clinical care team.
5. EVAT process components, outcomes, and metrics are easily assessed and audited.

Outcomes & Effectiveness: Understanding and measuring EVAT outcomes and impact

1. EVAT has evidence of beneficial outcomes.
2. EVAT is associated with improvement in patient outcomes that are clinically meaningful.
3. EVAT is clearly linked to positive health or clinical outcomes.
4. EVAT is cost-effective.
5. EVAT has clear advantages over alternatives (including not implementing EVAT)

Intervention

The following questions will ask about EVAT. Please answer considering the time BEFORE COVID at your institution.

6. Please rate the strength of the scientific evidence supporting EVAT implementation.
    a. Very weak
    b. Weak
    c. Neither weak nor strong
    d. Strong
    e. Very strong
    f. Don't know/NA
7. How important is EVAT to provide quality care to your patients?
    a. Not at all important
    b. Somewhat unimportant
    c. Neither important nor unimportant
    d. Somewhat important
    e. Very important

8. How difficult was the implementation of EVAT, or do you expect the implementation of EVAT to be, in your hospital?
    a. Very difficult
    b. Somewhat difficult
    c. Neither easy nor difficult
    d. Somewhat easy
    e. Very easy
    f. Don't know/NA

9. Regarding patients under my care, how often is EVAT used in their care?
    a. EVAT is not yet implemented in my hospital
    b. None of the time
    c. Some of the time
    d. Most of the time
    e. All of the time

Organization

Please indicate how much you agree or disagree with each of the following statements.

	Not aplicable	Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat agree	Strongly Agree
10. Our resources (personnel, time, financial) are too tightly limited to improve care quality.		1	2	3	4	5
11. Our EVAT implementation team understands and uses quality improvement skills effectively.		1	2	3	4	5
12. Our clinical team has changed or created systems in the hospital that make it easier to provide high quality care.		1	2	3	4	5
13. We choose new processes of care that are more advantageous than the old to everyone involved (patients, clinicians, and our entire clinical team).		1	2	3	4	5
14. The working environment in our clinical team is collaborative and cohesive, with shared sense of purpose, cooperation, and willingness to contribute to the common good.		1	2	3	4	5
15. Our clinical team has greatly improved quality of care in the past 12 months.		1	2	3	4	5

Participant

The following questions will ask about your work. Please indicate your response for each question or statement.

16. What is your primary profession?
    a. Nurse
    b. Physician
    c. Healthcare Administration
    d. Other (please list): _____

17. Where is your primary area of work?
    e. Pediatric or Pediatric Hematology-Oncology floor
    f. Intensive Care Unit
    g. Non-clinical work
    h. Other (please list): _____

18. In relation to EVAT, what is your primary role in the implementation team?
    a. EVAT leader
    b. Clinical staff
    c. Hospital administrator
    d. Data manager (responsible to collect/send EVAT data)
    e. Other _____

19. How many years have you worked **since completing medical or nursing training**?
    a. 0-5 years
    b. 6-10 years
    c. 11-15 years
    d. 16-20 years
    e. Greater than 20 years
    f. N/A

20. How many years have you worked **at this hospital**?
    g. 0-5 years
    h. 6-10 years
    i. 11-15 years
    j. 16-20 years
    k. Greater than 20 years

21. What is your gender?
    a. Male
    b. Female
    c. Other

22. What is your age?
    a. <30 years old
    b. 30-40
    c. 40-50
    d. >50 years old

Supplemental Figure 2: Sample CSAT Report

EVAT Sustainability Report

Date: August 05, 2020

Incorporating new and effective practices into standard care begins with implementation, but requires intentional sustainment over time. Many factors can affect sustainability in clinical or healthcare settings, such as financial and political climates, organizational and regulatory characteristics, and elements of evaluation and training. The **Clinical Sustainability Assessment Tool (CSAT)** allows healthcare organizations and clinical programs, as well as their stakeholders, to evaluate programs such as EVAT to the extent that it is supported by processes and structures that will increase the likelihood of sustainability. Assessment results can be used to identify next steps in building EVAT's sustainability capacity in order to position efforts for long-term success.

Overall Sustainability score: 4.4

Domain	Domain Score
Engaged Staff & Leadership	4.5
Engaged Stakeholders	4.3
Organizational Readiness	4.1
Workflow Integration	4.5
Implementation & Training	4.4
Monitoring & Evaluation	4.5
Outcomes & Effectiveness	4.8

1 = Strongly Disagree
5 = Strongly Agree
NA = Not Applicable

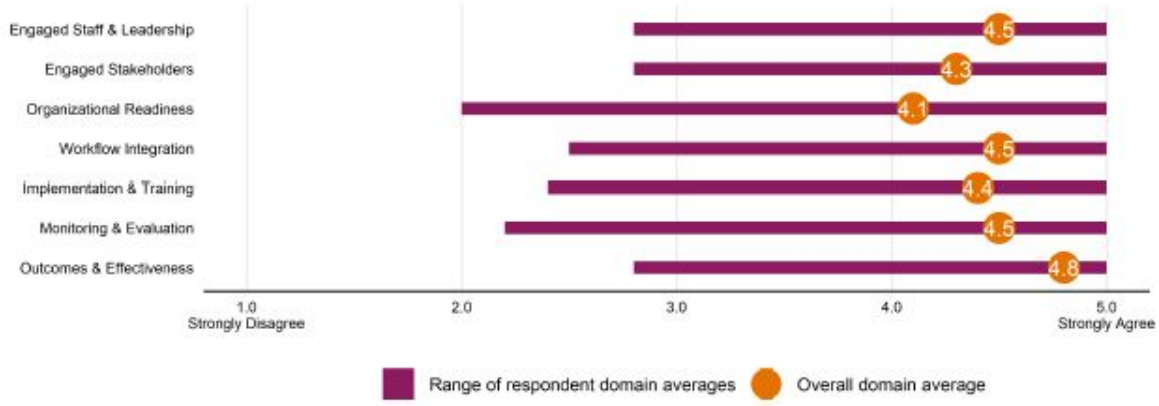
Interpreting the Results

The table presents the average score for each sustainability domain based on the responses provided by the surveyed participants **(169 participants)**. The remainder of the document presents the ratings for indicators within each domain. There is no minimum rating that guarantees sustainability of a program like EVAT. However, lower scores do indicate opportunities for improvement that you may want to focus on when developing a plan for sustainability.

Next Steps

- These results can be used to guide sustainability planning for the EVAT program.
- Areas with lower scores indicate that there is room for improvement.
- Address domains that are modifiable and have data available to support the necessary changes.
- Develop long-term strategies to address the domains that may be more difficult to modify.
- Make plans to assess sustainability of the EVAT on an ongoing basis to monitor changes as you strive for achieving continuous impact.

Average Sustainability by Domain



Results based on responses to the Clinical Sustainability Assessment Tool (CSAT), ©2020, Washington University in St. Louis, translated by St, Jude Children's Research Hospital. For more information about the CSAT visit https://sustaintool.org/ ; for information regarding Proyecto EVAT email ProyectoEVAT@stjude.org

EVAT Sustainability Report:

Date: August 05, 2020

Engaged Staff & Leadership

	Score
1. EVAT engages leadership and staff throughout the process.	4.7
2. EVAT leaders are recognized and respected.	4.3
3. EVAT has engaged, ongoing champions.	4.7
4. EVAT has a multidisciplinary leadership team.	4.6
5. EVAT has team-based collaboration and infrastructure.	4.4

Engaged Stakeholders

	Score
1. EVAT engages the patient and family members as stakeholders.	4.4
2. There is respect for all stakeholders involved in EVAT.	4.4
3. The importance of EVAT is valued by a diverse set of stakeholders.	4.3
4. EVAT engages other medical teams and community partnerships as appropriate.	3.9
5. The EVAT leadership team has the ability to respond to stakeholder feedback about EVAT.	4.6

Organizational Readiness

	Score
1. Organizational systems are in place to support the various needs of EVAT.	3.8
2. EVAT fits in well with the culture of the team.	4.4
3. EVAT has feasible and sufficient resources (e.g., time, space, funding) to achieve its goals.	3.6
4. EVAT has adequate staff to achieve its goals.	4.2
5. EVAT is well integrated into the operations of the hospital.	4.2

Workflow Integration

	Score
1. EVAT is built into the clinical workflow.	4.6
2. EVAT is easy for clinicians to use.	4.5
3. EVAT integrates well with established clinical practices.	4.6
4. EVAT aligns well with other clinical systems (e.g., EMR).	4.1
5. EVAT is designed to be used consistently.	4.7

Implementation & Training

	Score
1. EVAT clearly outlines roles and responsibilities for all staff.	4.6
2. The reason for EVAT is clearly communicated to and understood by all staff.	4.4
3. Staff receive ongoing coaching, feedback, and training.	4.3
4. EVAT implementation is guided by feedback from stakeholders.	4.3
5. EVAT has ongoing education across professions.	4.1

Monitoring & Evaluation

	Score
1. EVAT has measurable process components, outcomes, and metrics.	4.7
2. Evaluation and monitoring of EVAT are reviewed on a consistent basis.	4.5
3. EVAT has clear documentation to guide process and outcome evaluation.	4.7
4. EVAT monitoring, evaluation, and outcomes data are routinely reported to the clinical care team.	4.2
5. EVAT process components, outcomes, and metrics are easily assessed and audited.	4.4

Outcomes & Effectiveness

	Score
1. EVAT has evidence of beneficial outcomes.	4.8
2. EVAT is associated with significant improvement in clinical patient outcomes.	4.8
3. EVAT is clearly linked to positive health or clinical outcomes.	4.8
4. EVAT is cost-effective.	4.8
5. EVAT has clear advantages over alternatives (including not implementing EVAT).	4.6

Results based on responses to the Clinical Sustainability Assessment Tool (CSAT), ©2020, Washington University in St. Louis, translated by St, Jude Children's Research Hospital. For more information about the CSAT visit https://sustaintool.org/ ; for information regarding Proyecto EVAT email ProyectoEVAT@stjude.org.

Supplemental Figure 3: Focus group facilitator guide

Welcome:	Welcome to this focus group that aims to discuss the EVAT Sustainability Report based on the Clinical Sustainability Assessment Tool (CSAT), that you received. Thank you again for accepting our invitation and for giving us some of your valuable time to chat with us.
Description:	This session is part of a series of focus groups that we will be conducting with people who completed the Clinical Sustainability Assessment Tool (CSAT) in different institutions and countries. Our goal today is to ensure that everyone has the opportunity to share their comments and feedback with the group in order to evaluate and improve the CSAT assessment tool.
Description of rules to follow: Before we begin, I would like to go over some basic rules to follow during this focus group.	• Make sure you have the EVAT Sustainability Report (based on the CSAT) that was provided to you. • This session will be recorded, which will allow me to focus my attention on you rather than trying to take notes about the conversation. • It is important that only one person speaks at a time in order to facilitate later transcription of the recording. • The audio obtained from the recording will be transcribed and de-identified for later analysis. We will not use video for the purposes of this analysis. • For the purposes of this session, we will identify ourselves and refer to each participant using only their first names to avoid hierarchies and facilitate communication. We remind you that your comments will be subsequently de-identified. • What is shared in the session stays in the session. As facilitators, we are committed to maintaining the confidentiality of what is discussed here and, in the same way, we appreciate that what is said here is not discussed with other people once the session is over. • There are no right or wrong answers to the questions we will ask today, we just want to know about your ideas, experiences and opinions, all of which are of great value to us. Listening to each other's points of view is imperative, both positive and negative. It is important for us to listen to everyone's ideas and opinions. We want the ideas of each participant in the focus group to be equally represented; so, do not hesitate to share your opinions. • You do not have to agree with others, but you must listen to and respect the opinions expressed by other participants. • You do not have to wait to be called to intervene in the question round. It is an open discussion so you can comment at any time.
Technical considerations:	○ We appreciate that each participant keeps their camera active throughout the session. If you have any problem activating your camera, remember that you can ask (co-facilitator) for help via chat. ○ It is recommended to use the grid view so you can see all the participants on one screen. This will help give the feel of an in-person meeting. The grid view can be selected from the menu in the upper right corner of your screen. ○ Remember to keep your microphone muted, and to activate it whenever you want to comment or say something. ○ We understand that you may need to answer a phone call or a pager message. If you can turn off those devices, please do so. If that is not possible, please mute your microphone while you are on the call and return to the group as soon as possible. ○ Please use the “chat” function only to communicate technical problems as we want you to express your comments out loud on the subject at hand today.

Doubts before proceeding	**Do you have any questions regarding the rules or a technical matter before we start the question round?**
Introduction of the facilitators and participants:	Now we will introduce ourselves, briefly and in turns. In this section I will call you so that each one of you can tell what your name is, your place of origin, your role as part of your work team and how many months or years of experience each one has providing medical care to children with cancer. (*The facilitator will lead this part of the session using the list of participants*). My name is <state your name, origin, role, and length of service>, and I will serve as a facilitator for our conversation today *[if a co-facilitator is present]* Today we are joined by <Name of the co-facilitator> who will serve as co-facilitator, take notes, and help us to ensure that everything runs smoothly from a technical standpoint. <Co- facilitator> will be waiting for your comments in the chat to attend to any technical problem (audio, difficulties to see the video, etc.) Remember to keep your camera turned on as much as possible. **Introduction of the participants:** Now the moderator will call each participant to introduce themselves. (*The facilitator will lead this part of the session using the list of participants*)
Introduction to Question Round:	In the previous section I have called you to introduce yourself. However, I would like to clarify that in the question section you do not have to wait to be called. Please give your opinion or comment when you consider it appropriate.
Understandability and utility of the report: The CSAT Sustainability Report provides you with a score to help you understand how prepared your hospital is to maintain EVAT.	1. Do you feel that the score is easy to understand? a. What does the score mean to you? How do you interpret the score? b. Can you tell what are the strengths and weakness of your center based on the report? (Pause after the question to await additional comments. Follow new routes according to comments and opinions) c. Is there anything in the report that surprised you? Or something that you disagree with? 2. How does the written information in the report help you understand how to use your score? 3. If you were able, do you feel like you could take action to improve sustainability of [name of intervention] based on this report? How? Please give an example based on your report. (Keep the focus more on the report, rather than EVAT) 4. What other information you would need that would help you take action based on this report? 5. Do you find the second page useful? Informative?
Overall look and feel: We're also interested in your opinion about the best way to present the information in the report so that people would like to read it. We've broken it up into these sections: - score - written text - domain graphs, and - details on the 2nd page (**Request that the co-facilitator share his/her**	1. In your opinion, does the way in which the information is organized make sense? a. What would you do to improve it? b. Is there something missing from the report? c. Does the report appear to you to be coherently organized? 2. Is there any aspects of the report that you find confusing? Or that you would recommend changing? (tell them: there might be something we would like to change that we think would make it easier to read or understand or just aesthetics) What would you suggest? For example, a. Score review box? b. Written text? (ask them: Do you think it has a lot of text? Or if they could communicate the same idea with fewer words, or perhaps explain more specifically offering more details or more descriptive? Maybe make the report a little more concise?) c. The domain averages graph? d. Detailed info on 2nd page?

screen with the report image)	3. Any feedback overall design? (If they offer a negative opinion, offer them **positive feedback.** For example, "how interesting what you say, we would like to know more about it ...") 4. The report offers a snapshot at a certain moment. Would you find it useful to complete the survey periodically to follow up on those aspects that pose an opportunity for improvement? And, if so, how often would you consider it appropriate to carry out the evaluation? [The principal investigator recommends not addressing this point unless the participants speak about it spontaneously].
Conclusion:	Before closing, we would like to know if there is anything else that, in your opinion, we have not covered. Is there anything else about conducting this assessment and receiving the report that you would like us to know? Do you have any additional recommendations about something that you consider important?
Closing:	Thank you for participating and for spending your valuable time with us. We will work in coordination with you to offer you information about the analysis of the results of this project. If you have additional questions, you can contact Dr. Asya Agulnik directly or any of the EVAT team members at St. Jude who will always be happy to assist you.

Supplemental Table 2: Focus group code book

Domain	Code	Definition
Interpreting Report	Ease of Interpretation	Comments on how easy or hard it is to interpret the report, including to use it to identify the center's strengths/weaknesses, both for the participant or members of their team
	Report Interpretation	The participants actual interpretation of their report, including their center's strengths and weaknesses as described by the report (this shows us we need to work on x, or we do a good job with y), anything they were surprised by from their report and if they agree with it. General comments about ease of interpretation or how one could understand the strengths and weaknesses, without specific mentions of them, coded as "ease of interpretation".
	Report Use	Mentions of how the respondents or their team plans to use the report to improve their EVAT program or its sustainability
	Additional Information	Additional information that should be provided in the report to improve usability or anything that is missing that should be provided
Report Components	Written Material	Comments about the quality of the written text in the report and how it does/does not help with interpretation
	Second Page	Comments about the utility of the second page of the report
	Score Review Box	Comments about the score review box
	Domain Graph	Comments about the domain averages graphs
	Other individual components	Comments about an individual component of the report not mentioned in the other "report components' codes. General comments about the report should be coded as 'overall report'
Overall Look and Feel	Overall Report	Comments about the overall organization and design of the report, including things that should be adjusted or changed in the report in general, or things that are confusing. Do not code comments about individual components (code one of the 'report components')
CSAT	CSAT Components	Comments about clarity of specific CSAT domains or questions, including the Likert scale, not related to the report itself
	CSAT Use	Comments about how the CSAT was administered at the center (how many people, how often, etc.) or how it should be used in the future
Negative	Negative comment	Double code with any comment of something that is negative or needs improvement in the report or the CSAT tool itself

Supplemental Table 3: CSAT domains and time from PEWS implementation

		Individual-Level			Center-Level		
Domain	Time since Implementation of PEWS (Months)	n (%) n=169	Mean CSAT	p-value	n (%) n=29	Mean CSAT	p-value
Engaged Staff & Leadership	1-12 months	67 (39.6)	4.37		10 (34.5)	4.43	
	12-24 months	66 (39.1)	4.68	<0.001	13 (44.8)	4.66	0.040
	>24 months	36 (21.3)	4.64		6 (20.7)	4.65	
Engaged Stakeholders	1-12 months	67 (39.6)	4.13		10 (34.5)	4.18	
	12-24 months	66 (39.1)	4.50	<0.001	13 (44.8)	4.50	0.122
	>24 months	36 (21.3)	4.38		6 (20.7)	4.40	
Organizational Readiness	1-12 months	67 (39.6)	3.95		10 (34.5)	4.00	
	12-24 months	66 (39.1)	4.15	0.141	13 (44.8)	4.15	0.393
	>24 months	36 (21.3)	4.18		6 (20.7)	4.19	
Workflow Integration	1-12 months	67 (39.6)	4.26		10 (34.5)	4.33	
	12-24 months	66 (39.1)	4.61	<0.001	13 (44.8)	4.60	0.011
	>24 months	36 (21.3)	4.68		6 (20.7)	4.69	
Implementation & Training	1-12 months	67 (39.6)	4.19		10 (34.5)	4.20	
	12-24 months	66 (39.1)	4.47	0.004	13 (44.8)	4.41	0.224
	>24 months	36 (21.3)	4.51		6 (20.7)	4.51	
Monitoring & Evaluation	1-12 months	67 (39.6)	4.36		10 (34.5)	4.40	
	12-24 months	66 (39.1)	4.53	0.039	13 (44.8)	4.46	0.438
	>24 months	36 (21.3)	4.61		6 (20.7)	4.61	
Outcomes & Effectiveness	1-12 months	67 (39.6)	4.65		10 (34.5)	4.71	
	12-24 months	66 (39.1)	4.80	0.022	13 (44.8)	4.75	0.410
	>24 months	36 (21.3)	4.86		6 (20.7)	4.86	

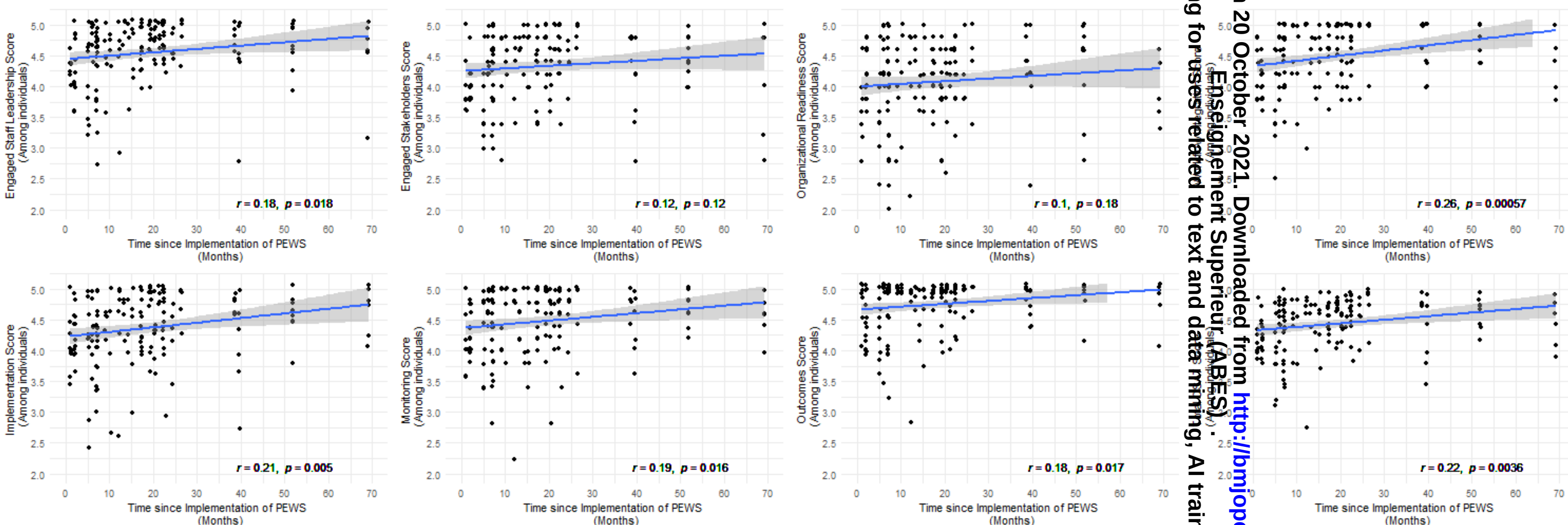
Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System

Supplemental Table 4: Center demographics influencing CSAT results (among centers)

Category	Sub-Category	n (29)	mean	p-value
Hospital Characteristics (Among sites)				
Type of Hospital	General (adult and pediatric)	11	4.46	0.811
	Oncology (adult and pediatric)	7	4.4	
	Pediatric multidisciplinary	11	4.48	
Hospital Funding	Public	21	4.49	0.245
	Private or public/private partnership)	8	4.34	
Annual New Cancer Diagnoses	1-75	12	4.44	0.96
	76-150	9	4.47	
	>150	8	4.46	
Pediatric Oncology Structure	No pediatric oncology unit (integrated with pediatrics or other unit)	4	4.31	0.463
	Separate pediatric	25	4.48	
Time since Implementation of PEWS	1-12 months	10	4.32	0.085
	12-24 months	13	4.51	
	>24 months	6	4.56	
Number of staff working in center	0-249	5	4.41	0.74
	>249	24	4.46	

Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System

Supplemental Figure 4: CSAT result trends with time from PEWS implementation. Scatter plot between time since implementation of PEWS (months) vs each domain scores and total CSAT result (using jitter method, added smooth line and correlation coefficient) using individual level (1. n=169) and center-level (2. n=29) analysis.



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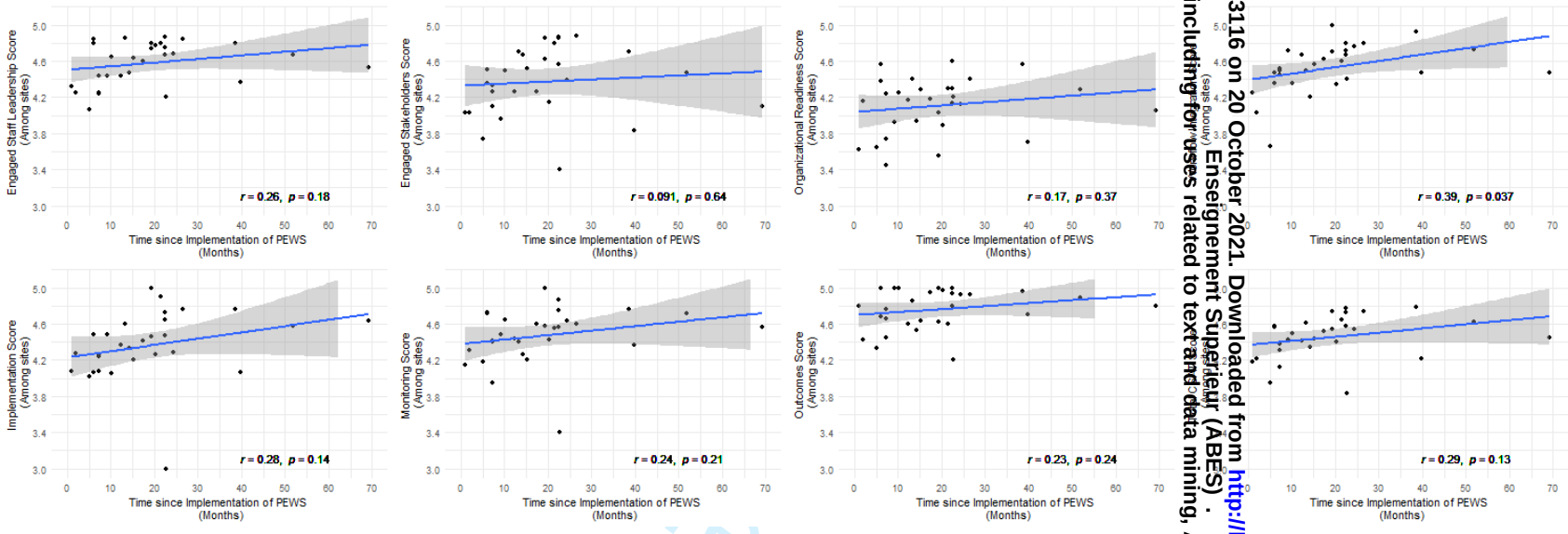

2.

Supplemental Table 5: Focus group participant demographics

Focus Group	Characteristics		n (%)
ICU Physicians	Total		8
	Gender	Male	4 (50%)
		Female	4 (50%)
	Countries Represented		6
Floor Physicians	Total		7
	Gender	Male	2 (29%)
		Female	5 (71%)
	Countries Represented		6
Nurses	Total		7
	Gender	Male	0 (0%)
		Female	7 (100%)
	Countries Represented		6
Overall	Total		22
	Gender	Male	6 (27%)
		Female	16 (72%)
	Countries Represented*		10

*Counties Represented: Argentina, Chile, Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru

Abbreviations: ICU-Intensive Care Unit

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Reliability and validity of a Spanish-language measure assessing clinical capacity to sustain Pediatric Early Warning Systems (PEWS) in resource-limited hospitals

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Abstract

Background: Pediatric Early Warning Systems (PEWS) improve identification of deterioration, however, their sustainability has not been studied. Sustainability is critical to maximize impact of interventions like PEWS, particularly in low-resource settings. This study establishes the reliability and validity of a Spanish-language Clinical Sustainability Assessment Tool (CSAT) to assess clinical capacity to sustain interventions in resource-limited hospitals.

Methods: Participants included PEWS implementation leadership teams of 29 pediatric cancer centers in Latin America involved in a collaborative to implement PEWS. The CSAT, a sustainability assessment tool validated in high-resource settings, was translated into Spanish and distributed to participants as an anonymous electronic survey. Psychometric, confirmatory factor analysis (CFA), and multivariate analyses were preformed to assess reliability, structure, and initial validity. Focus groups were conducted after participants reviewed CSAT reports to assess their interpretation and utility.

Results: The CSAT survey achieved an 80% response rate (n=169) with a mean score of 4.4 (of 5; 3.8-4.8 among centers). The CSAT had good reliability with an average internal consistency of 0.77 (0.71 to 0.81); and confirmatory factor analyses supported the seven-domain structure. CSAT results were associated with respondents' perceptions of the evidence for PEWS, its implementation and use in their center, and their assessment of the hospital culture and implementation climate. The mean CSAT score was higher among respondents at centers with longer time using PEWS ($p<0.001$). Focus group participants noted the CSAT report helped assess their center's clinical capacity to sustain PEWS and provided constructive feedback for improvement.

Conclusions: We present information supporting the reliability and validity of the CSAT tool, the first Spanish-language instrument to assess clinical capacity to sustain evidence-based interventions in hospitals of variable resource-levels. This assessment demonstrates a high capacity to sustain PEWS in these resource-limited centers with improvement over time from PEWS implementation.

Strengths and Limitations of this Study

- The Clinical Sustainability Assessment Tool (CSAT) was translated to Spanish and edited for clarity and syntax by regional group of experts, ensuring cultural appropriateness.
- The CSAT was administered to the multidisciplinary Pediatric Early Warning System (PEWS) implementation leadership teams of 29 diverse pediatric cancer centers in Latin America implementing PEWS, adding to generalizability of results.
- Analysis focused on establishing reliability (psychometric, confirmatory factor analysis) and initial validity of the CSAT, as well as describing the clinical capacity to sustain PEWS in participating centers.
- Study strengths include the mixed method design, large sample size, high response rate, and diversity of participants and centers across multiple countries, allowing for evaluation of individual and hospital characteristics associated with clinical capacity for sustainability and feedback on the CSAT report.
- Limitations include the risk of bias to the study, including from the predominant inclusion of PEWS implementation leaders and the use of the CSAT to assess a single intervention (PEWS).

Background

Pediatric Early Warning Systems (PEWS) are evidence-based bedside assessment tools to identify early clinical deterioration in hospitalized children.[1] PEWS are particularly useful for hospitalized children with cancer, who frequently experience clinical deterioration resulting in preventable mortality,[2] especially in resource-limited hospitals.[3-6] PEWS implementation improves patient outcomes through promoting interdisciplinary communication between nurses and physicians, leading to quicker identification of clinical deterioration and prompt intervention to address complications.[6-11] In 2017 Proyecto EVAT, a quality improvement collaborative of Latin American pediatric oncology centers, was formed to improve survival of hospitalized children with cancer through PEWS implementation.[6,12] Currently, Proyecto EVAT has 60 centers in 19 countries; to-date 37 have successfully implemented PEWS.[13] Despite the potential benefit of PEWS over time, the long-term sustainability of PEWS is not yet established.

Many clinical interventions like PEWS lack evidence demonstrating their sustainability. Sustainment, or the maintenance of an intervention over time, is critical to maximize benefits of evidence-based interventions,[14-17] particularly in low-resource settings.[18,19] Theoretically, sustainment is associated with greater hospital clinical capacity to maintain an intervention, including skilled staff, adequate finances, and engaged leadership.[20,21] Implementing new interventions is costly, and if they are not sustained, then initial investments are lost.[22,23] Premature abandonment of effective interventions may lead to staff frustration, damaged relationships with patients, and a loss of general capacity to provide services.[24] For these reasons, understanding sustainment of evidence-based interventions is extremely important, particularly in low-resource settings where resources available for intervention implementation are constrained.[22] Unfortunately, there is little empirical evidence about factors that contribute to intervention sustainment in hospital settings, in part due to a lack of measurement tools.[25]

In this study, we describe the development and testing of a Spanish-language version of the Clinical Sustainability Assessment Tool (CSAT), a theoretically-informed, reliable measure of

clinical capacity for intervention sustainment.[26,27] Currently available in English, the CSAT can be completed either individually or as a group in 15 minutes or less. Upon completion, a complementary CSAT report is generated that summarizes the responses to the tool and helps identify areas for improving clinical capacity.[28] The CSAT is being used increasingly in a variety of clinical settings and used to evaluate diverse interventions, indicating it is a useful measure of sustainability for researchers, evaluators, and clinicians. The goal of this study was to evaluate the usability, reliability, and validity of a Spanish-language CSAT and demonstrate its use to evaluate capacity for sustaining PEWS in resource-limited hospitals participating in Proyecto EVAT.

Methods

Proyecto EVAT

Escala de Valoración de Alerta Temprana (EVAT) is a Spanish-language PEWS composed of a five-component scoring tool (Neurologic, Cardiovascular, Respiratory, Staff concern, and Family concern) associated with an escalation algorithm that guides the clinical team in the treatment of a deteriorating patient.[9] Through collaboration between St. Jude Global at St. Jude Children's Research Hospital (SJCRH) and local stakeholders, Proyecto EVAT was formed in 2017 with the goal to improve survival in hospitalized pediatric oncology patients through implementation of PEWS.[12,29] As part of Proyecto EVAT, each hospital assembles a local PEWS implementation leadership team, adjusting the size to account for local needs. In collaboration with the EVAT Steering Committee, a 26-member multidisciplinary team of nurses and physicians from 11 hospitals in 8 countries in Latin America, Proyecto EVAT provides hospital-to-hospital mentorship through a 3-phase implementation process, including planning, piloting, and outcome assessment, to help establish the resources and processes necessary to implement and maintain PEWS. A center is considered to have completed PEWS implementation when they achieved an error rate, as indicated by incorrect calculation of PEWS or algorithm use, of less than 15% for at least 2 months.[13]

In the first 3 years of the program, we successfully supported PEWS implementation in 37 hospitals of varying resources.[13] Of these, 29 centers from 14 countries completed implementation prior to June 2020, when this study was conducted (see **Figure 1** for center characteristics). These centers represent diverse hospital organization, including pediatric multidisciplinary, dedicated oncology, and general (adult and pediatric) hospitals with private, public, and mixed (public-private) funding structures, including hospitals with or without dedicated pediatric oncology units. Together, these hospitals manage approximately 4,300 annual new diagnoses of childhood cancer annually (**Supplemental Table 1**). While all hospitals are mentored through the same 3-step phase implementation process, our previous experience suggests that centers face a variety of sustainability challenges, including turnover of PEWS leadership teams, variable hospital leadership support for the program, and human and material resource limitations. No formal assessment of PEWS sustainability, however, has been conducted.

CSAT Adaptation

We adapted the CSAT, a brief and reliable instrument consisting of 35 items within seven domains to assess an institution's capacity for sustaining a clinical practice.[10, 12] These domains include Engaged Staff & Leadership, Engaged Stakeholders, Organizational Readiness, Workflow Integration, Implementation & Training, Monitoring & Evaluation, and Outcomes & Effectiveness.[26,27,30] Each domain includes 5 items that are scored on a Likert scale from 1 to 7 (35 questions total), where 7 indicates an individual believes their institution has that domain to a great extent. CSAT development and testing demonstrated excellent internal consistency and several trends towards discriminant validity.[27] For this survey, we also include several validating questions taken from existing measures including the organizational readiness to change assessment (ORCA)[31] and the Change Process Capability Questionnaire,[32] which bear conceptual overlap with the CSAT and include indications of intervention implementation as well as quality improvement. The survey was translated to Spanish by bilingual staff at SJCRH,

iteratively edited for clarity and syntax, and back-translated to confirm accuracy. Based on feedback from the EVAT Steering Committee and the research teams' experience with prior surveys in Latin America, the Likert scale was adjusted from the 7-point original scale to a 5-point scale. This is modification is consistent with literature demonstrating that reduction of Likert anchors resolved ambiguities and improved validity, reliability, and response rates among Latino populations within the United States.[33,34] An electronic version of the Spanish tool was reviewed by 19 members of the EVAT Steering Committee, representing countries in Mexico, Central and South America, to establish baseline acceptability within the context of Proyecto EVAT. During testing, survey completion took 10-15 minutes. Feedback was integrated into the final version of the Spanish CSAT tool. The Spanish CSAT is available at https://sustaintool.org; the English version used in this study is included in **Supplement Figure 1**.

CSAT Pilot Testing and Data Collection

After initial translation and testing, the adapted Spanish CSAT was distributed through an anonymous electronic survey on Qualtrics[35] to PEWS implementation leadership teams of 29 centers completing implementation by July 2020 (**Supplemental Table 1**). The PEWS implementation leadership team consists of the core individuals (physicians, nurses, and administrators) responsible for implementing and maintaining PEWS at their center, as identified by each site leader working with our program. This included an average of 7 (range 4-15) individuals per center, with a total 210 participants surveyed. The assessment consisted of the CSAT (35 questions) as well as demographic questions about the individual, intervention, and organization (**Supplemental Figure 1**). The survey remained open for 1 month following distribution and weekly reminders were sent to participants. Center-specific data were collected from PEWS implementation site leader at each participating center. Time since implementation of PEWS was calculated from the date of implementation completion (as defined above) to when the survey was completed (August 1st, 2020). After completing the assessment, each participant was provided a Spanish-language center-specific CSAT report summarizing results from their hospital (see **Supplemental Figure 2** for English example).

Data Management and Analyses

The survey data were analyzed using R (Version 4.0.4). Initially, descriptive analyses were used to explore the responses. Psychometric and multivariate analyses using R package Lavaan were conducted to assess CSAT reliability and validity characteristics. Reliability analyses focused on the internal consistency (i.e., Cronbach's alpha) for each of the seven CSAT domains. Internal consistency measures the extent to which individual items in a subscale measure the same underlying construct.[36] Confirmatory factor analysis was conducted to confirm the subscale structure and assess the fit of the items within their hypothesized latent domains. In the confirmatory factor analyses, we used traditional fit indices to assess the adequacy of the CSAT structural model, including the comparative fit index (CFI), the root mean square error of approximation (RMSEA), and the standardized root mean square residual (SRMR),[37] as well as the Vuong model fit test.[38] Analysis of Variance (ANOVA) was used to assess initial validity of the measure. This was conducted using demographic characteristics of the setting, PEWS intervention, and participants. ANOVA was used to study the association between center and respondent characteristics and CSAT results.

Focus Groups

Following survey administration and distribution of center CSAT reports, all participants were invited to participate in focus groups to discuss the CSAT tool and report, focusing on usability. From those volunteering to participate, three focus groups were organized to be homogenous by discipline: nursing, pediatric floor physicians, and intensivists. This focus group structure encouraged open and honest discussions. The focus groups were semi-structured using a facilitator guide to assess participants' ability to interpret the CSAT report and to elicit constructive feedback to improve its usability. The facilitator guide was developed based on the components of the CSAT report along with questions regarding the participant's report use. This guide was translated into Spanish by bilingual members of the research team (CV, AA,

MPT). A pilot focus group was conducted including 7 participants from 4 countries. The focus group guide was revised based on feedback from this pilot session and finalized. The finalized guide was used for all focus groups (see **Supplemental Figure 3**).

As participants were from hospitals all over Latin America, and the study occurred during the COVID pandemic, focus groups were conducted over WebEx, a secure online platform familiar to all participants and accessible from a computer or mobile device. Participants were asked to engage using their videos and microphones to approximate an in-person discussion. An experienced bilingual native Spanish speaker not otherwise involved in PEWS implementation facilitated all focus groups (CV).

Focus groups were audio recorded, then simultaneously translated to English and transcribed by a professional service. Transcripts were subsequently de-identified, and uploaded into MAXQDA qualitative software (VERBI GMBH, Berlin, Germany) for analysis. Each participant response was used as the unit of analysis. As the focus group aimed to address specific questions regarding the report, an a priori codebook was deductively developed by the research team based on the facilitator guide to analyze data regarding the interpretation of the report, specific report components, and general feedback (negative and positive) about participants' experience with the CSAT (see **Supplemental Table 2**). A single coder (AA) coded all transcripts. Thematic analysis was conducted on coded data to describe the participants overall perspectives on the report, its usability, as well as specific recommendations for improvement.

Patient and Public Involvement

Neither patients, parents, nor the public were involved in the design, conduct, or reporting of this research. We plan to consider the role of the patients and families in sustaining PEWS in future work.

Human Subjects Approval

This study was approved by the SJCRH Institutional Review Board (IRB) as exempt research under category 2 (research that includes interactions involving survey procedures and minimal risk) as study number 20-0501. Per this determination, no written informed consent was required from participants; consent was inferred from their agreement to complete the anonymous survey or participate in the focus group.

Results

Descriptive Statistics

The CSAT survey achieved an 80% response rate (total n=169 responses from 29 centers, center median response rate 83.3%, see **Supplemental Table 1** for center details). Respondent demographics are described in **Table 1**. The overall mean CSAT result was 4.4 (out of 5; range per center 3.8-4.8) (**Table 2**).

Psychometrics and CSAT Structure

The Spanish version of the CSAT shows acceptable to excellent reliability—an average Cronbach alpha of 0.77, ranging from 0.71 to 0.81 across the seven subscales (**Table 2**). Given the hypothesized structure of the seven CSAT domains, confirmatory factor analysis was used to assess how well the data fit this structural model. The results suggest acceptable fit with a comparative fit index (CFI) of 0.825, RMSEA and SRMR scores of 0.067 (**Table 3**). Traditional guidelines suggest that CFI scores of > 0.80 indicate acceptable fit, and RMSEA and SRMR scores of < 0.08 also indicate acceptable fit.[39] Importantly, these results show that the seven-subscale model fits significantly better than the single factor model. More specifically, the smaller AIC value, the smaller relative chi-squared statistic, and the significant Vuong model fit test (LR = 424.5, p < .001) all show that the seven factor model fits the data better than the single factor

model.[38] This reiterates the idea that the translated version of the CSAT retains an important subscale structure to measure clinical capacity.

Initial Validation Analyses

The survey included questions to assess the respondents' perception of PEWS, the PEWS implementation process and current use in their center, and general questions describing the institutional culture and implementation climate. Respondents who reported a higher strength of evidence supporting PEWS use, a stronger PEWS implementation leadership team, more frequent use of PEWS in the clinical setting, and generally collaborative hospital climate that is receptive to changes for quality improvement also scored higher on the CSAT assessment, suggesting good construct validity. Of participants, 43.1% somewhat or strongly agreed that their center's resources were too tightly limited to improve quality of care, however, this was not associated with the total CSAT result (**Table 4**).

Individual and center characteristics were evaluated for associations with the CSAT result (**Table 1**). Front-line clinical staff rated sustainability lower than PEWS implementation leaders and other administrative staff ($p = 0.006$). We found no other significant differences by other individual demographics. Similarly, hospital characteristics, such as type and size of center, volume of pediatric cancer patients, or pediatric oncology unit structure, was not associated with the performance on the CSAT assessment. However, respondents at centers with a longer time since achieving PEWS implementation, rated sustainability of PEWS significantly higher ($p<0.001$). This relationship was significant across all domains except organizational readiness (**Supplemental Table 3**). Similar association was seen in center-level analysis, although not statistically significant ($p=0.085$, **Supplemental Tables 3 and 4**). The relationship between time from implementation of PEWS and mean CSAT total and domain results are further described in **Supplemental Figures 4 and 5**.

CSAT Report and Tool Usability

To evaluate the CSAT report, we conducted 3 focus groups (see **Supplemental Table 5** for focus group participant demographics), with a total of 22 participants (7-8 per group) from 10 countries. Participants generally found the CSAT and its report useful to assess the clinical capacity for sustainability of PEWS at their center; "*This tool provided a lot of information…we got a high score, however, we still have some items to improve. Yes, I love this tool because it tells us what items we need to pay attention to."* (Intensivist). Specifically, participants felt the tool allowed them to identify areas of strength and opportunity for improvement "*I consider that it is a valid tool, understandable in terms of this process that we can first see how we are numerically, but then it gives us an analysis to be able to say what we are doing well and what things we should improve*" (Nurse) and "*This is very positive because at the end they are giving me tips on the things that I should do within everything related to sustainability and all my weaknesses that it evaluates; it is telling me to focus on this and work on this.*" (Nurse). They also saw utility in using the tool to advocate for institutional support and resources to improve clinical capacity to sustain PEWS: "*Well, obviously this type of tool, CSAT report, is a tool to advocate; I mean, with this report I can talk to my foundation boss and tell her, we have a team that wants to work, a proper work flow, a very good score in monitoring and evaluation, but we lack organizational readiness, how easily can you through the foundation keep supporting us based on this report? That would be what I would do to advocate*." (Oncologist)

Participants recommended shortening the introductory text, reducing redundancy in reporting domain results, and including visual and descriptive cues to allow for easier interpretation of each center's strengths and weaknesses. They also suggested providing more guidance on how to use the report and next steps: "*I strongly agree to add a conclusion, or steps to follow in the last part of the second page, it would be a summary of what we have to do, actions to be taken*" (Nurse).

Discussion

The CSAT is the first reliable Spanish/English bilingual instrument to assess clinical capacity to sustain interventions and adding to the existing data of the CSAT's performance in high-resource settings.[26] The Spanish CSAT performed well across a heterogenous group of respondents from diverse hospitals in Latin America with variable resource-limitations, indicating good reliability. Our findings demonstrate that the respondents' perception of the clinical capacity to sustain PEWS at their center was associated with a positive perception of the intervention, its implementation process, and use, and the center's culture and implementation climate, suggesting initial validity in this setting. We also demonstrated the utility of the CSAT report for helping clinicians understand their capacity for sustaining interventions and presented potential ways the report might be improved. These proposed changes will be integrated into the next version of the CSAT report.

Sustainability is the least-studied aspect of the implementation continuum for evidence-based interventions[25,40,41], and presents a challenge across a range of interventions and settings,[17] potentially limiting the long-term impact of effective interventions on patient outcomes. These problems are magnified in resource-limited settings, where investments for implementation and maintenance of interventions are more constrained.[22] Tools such as the CSAT are needed to aid clinicians and hospitals seeking to assess their organization's clinical capacity to sustain interventions. The translation of the CSAT to Spanish for this study further allows for the broad use of this measure, as lack of multi-lingual measure has been a notable scientific barrier for other instuments.[42,43] Now available in both English and Spanish, the CSAT and its associated center report provide an opportunity for clinicians and researchers to assess institutional factors contributing to intervention sustainability, thus improving the sustainment of evidence-based interventions and maximizing their benefits for patients. Additional research lending validity to the CSAT, including its application to different clinical settings and interventions, would be valuable to confirm or contradict the relationships demonstrated in this study.

This study leveraged an international collaborative to evaluate the clinical capacity to sustain one intervention, PEWS, across a variety of respondents and hospital settings. This allowed us to not only evaluate the CSAT, but also study these hospitals' capacity to sustain PEWS. The clinical capacity to sustain PEWS was rated higher by respondents directly involved in PEWS implementation than others (clinical staff and hospital administrators), suggesting that implementation leadership may feel more enthusiastic about the intervention than other hospital staff. The CSAT results did not vary, however, by other respondent demographics or center characteristics, indicating these factors did not influence a center's ability to sustain PEWS over time. A longer history of PEWS use (longer time from implementation) was associated with a higher clinical capacity for sustainment of PEWS as rated by the CSAT. Together, these findings suggest that centers build capacity to sustain improvement interventions over time.[21,43] This outcome is promising, indicating hospitals are able to maintain the necessary infrastructure to sustain PEWS, regardless of hospital characteristics or resource-level. Such results are important for clinicians, hospital authorities, and funders as they indicate that investment in implementation of PEWS is likely to result in sustained improvements in patient outcomes over time. However, while these preliminary results are positive, future research to prospectively evaluate the relationship between hospital clinical capacity, assessed by a broader group of hospital staff, PEWS sustainment, and impact on clinical outcomes is needed to strengthen the evidence for this relationship. Lastly, the CSAT and the CSAT report helped hospitals identify specific limitations in clinical capacity for sustainment, creating an opportunity to grow capacity though targeted improvements. In the qualitative portion of our study, several participants noted the CSAT report could aid them to advocate for needed resources to hospital stakeholders, potentially giving clinicians a tool to actively build their institution's capacity over time.

This study has several limitations. Our respondents sample included primarily PEWS implementation leaders, who generally rated the sustainability of PEWS higher than other participants and are likely more invested in maintaining PEWS use at their centers. This may have introduced bias to our study, resulting in over-estimates of the clinical capacity to sustain

PEWS and contributing to the observed restriction of range. A more broad sample of participants, including clinical staff using PEWS, is needed in future work. Similarly, there is a potential risk of non-response bias, as we do not have demographic details for the 20% non-responders to compare with study participants. However, these limitations should not impact our ability to assess the reliability and validity of the CSAT instrument, which was our primary goal of this study. Similarly, while the current work evaluated the use of the CSAT to assess clinical capacity to sustain a single intervention (PEWS), prior diverse experience with the CSAT suggests it has a potential for broad utility to evaluate sustainability of clinical interventions globally.

Conclusion

The CSAT is a Spanish/English bilingual instrument to assess the clinical capacity to sustain evidence-based interventions in hospital settings of variable resource-levels. The CSAT report summarizes survey results to help clinical teams interpret their performance and identify areas of opportunity. This assessment of diverse hospitals in Latin America implementing PEWS suggests that that clinical capacity for sustainment grows over time. Future work should explore this finding to further evaluate how centers build clinical capacity to sustain PEWS during initial implementation and how maintenance of capacity relates to sustainability of PEWS use and its impact on patient care over time. To promote use of the CSAT, the English and Spanish version are currently available publicly at https://sustaintool.org/. Broader dissemination and adoption of this sustainability assessment tool for clinical interventions and quality improvement efforts in hospitals of all resource-levels will help ensure sustained improvements in patient outcomes from maintenance of critical evidence-based practices.

Tables and Figures:

Table 1: Respondent demographics and association with CSAT result

Category	Sub-Category	n (%) n=169	Mean CSAT	*p*
Individual Demographics				
Profession	Nurse	75 (44.4)	4.46	0.510
	Physician (Peds HO, Peds ICU, Other Physician)	86 (50.9)	4.40	
	Other (Management, Administration, Coordinators, Other)	8 (4.7)	4.56	
Role in PEWS	PEWS Implementation Leader	115 (68.0)	4.48	0.006
	Clinical Staff	40 (23.7)	4.25	
	Other (Hospital Admin, Data Admin, Other)	14 (8.3)	4.54	
Years Worked since Professional Degree	Less than 5 years	46 (27.7)	4.47	0.290
	From 6 to 10 years	32 (19.3)	4.33	
	More than 10 years	88 (53.0)	4.45	
	NA	3		
Gender	Male	37 (21.9)	4.47	0.576
	Female	132 (78.1)	4.42	
Age	Less than 30 years	12 (7.1)	4.54	0.382
	30 to 40	77 (45.6)	4.39	
	40 to 50	59 (34.9)	4.43	
	More than 50 years	21 (12.4)	4.54	
Center Characteristics				
Type of Hospital	General (adult and pediatric)	67 (39.6)	4.38	0.386
	Oncology (adult and pediatric)	44 (26.0)	4.49	
	Pediatric multidisciplinary	58 (34.3)	4.45	
Hospital Funding Structure	Public	117 (69.2)	4.47	0.087
	Private or public/private partnership	52 (30.8)	4.34	
Annual New Cancer Diagnoses	1-75	68 (40.2)	4.45	0.845
	76-150	49 (29.0)	4.43	
	>150	52 (30.8)	4.41	
Pediatric Oncology Unit Structure	No pediatric oncology unit (integrated with pediatrics or other unit)	19 (11.2)	4.39	0.602
	Separate pediatric	150 (88.8)	4.44	
Time since Implementation of PEWS	1-12 months	67 (39.6)	4.27	<0.001
	12-24 months	66 (39.1)	4.53	
	>24 months	36 (21.3)	4.55	
Number of staff working in center	0-249	24 (14.2)	4.51	0.398
	>249	145 (85.8)	4.42	

Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System, NA-not applicable

Table 2: CSAT subscale and overall descriptive statistics

Domain	Mean	Std. Dev.	Low	High	Cronbach's alpha
Engaged Staff & Leadership	4.55	0.48	2.80	5.00	0.77
Engaged Stakeholders	4.33	0.55	2.80	5.00	0.71
Organizational Readiness	4.08	0.66	2.00	5.00	0.80
Workflow Integration	4.49	0.52	2.50	5.00	0.76
Implementation & Training	4.37	0.56	2.40	5.00	0.79
Monitoring & Evaluation	4.48	0.53	2.20	5.00	0.81
Outcomes & Effectiveness	4.75	0.41	2.80	5.00	0.78
Overall	**4.43**	**0.42**	**2.74**	**5.00**	**0.77**

Abbreviations: CSAT-Clinical Sustainability Assessment Tool

Table 3: Confirmatory factor analysis (CFA) results of baseline and final Spanish CSAT instruments

Phase	Subscales	Items	Chi/df	CFI	RMSEA	SRMR	AIC
Baseline	1	35	2.31	0.685	0.088	0.080	10529.6
Final	7	35	1.76	0.825	0.067	0.067	10147.1

Note: Total n= 169; CFA model fit with robust maximum-likelihood. Vuong's test of model distinguishability demonstrated that the final seven domain model was a significantly better fit to the data than the baseline single domain model (Likelihood Ratio = 424.5, $p < .001$).

Abbreviations: CFA-Confirmatory factor analysis; CFI- comparative fit index; CSAT-Clinical Sustainability Assessment Tool; RMSEA-root mean square error of approximation; SRMR-standardized root mean square residual

Table 4: Validation questions influencing CSAT result

Validation Question	Response Category	n (%) n=169	CSAT mean	p-value
Perceptions of PEWS				
Please rate the strength of the scientific evidence supporting PEWS implementation.	Weak + Neither weak nor strong	7 (4.2)	4.05	<0.001
	Strong	56 (33.3)	4.31	
	Very strong	105 (62.5)	4.53	
	NA	1		
How important is PEWS to provide quality care to your patients?	Not very important (Neither important nor unimportant + Somewhat important)	17 (10.1)	3.95	<0.001
	Very important	152 (89.9)	4.49	
PEWS Implementation Process and Use				
How difficult was the implementation of PEWS in your hospital?	Very difficult	16 (9.6)	4.21	0.054
	Somewhat difficult	77 (46.1)	4.44	
	Neither easy nor difficult	41 (24.6)	4.40	
	Somewhat easy	24 (14.4)	4.54	
	Very easy	9 (5.4)	4.68	
	NA	2		
Our PEWS implementation team understands and uses quality improvement skills effectively.	Neither agree nor disagree	6 (3.6)	3.27	<0.001
	Somewhat agree	59 (34.9)	4.23	
	Strongly Agree	104 (61.5)	4.61	
Regarding patients under my care, how often is PEWS used in their care?	None of the time + Some of the time	7 (4.1)	4.17	0.002
	Most of the time	22 (13.0)	4.19	
	All the time	140 (82.8)	4.49	
Center Culture and Implementation Climate				
Our resources (personnel, time, financial) were too tightly limited to improve care quality.	Strongly Disagree	16 (9.8)	4.50	0.764
	Somewhat Disagree	41 (25.0)	4.38	
	Neither agree nor disagree	34 (20.7)	4.44	
	Somewhat agree	50 (30.5)	4.41	
	Strongly Agree	23 (14.0)	4.50	
	NA	5		
Our clinical team has changed or created systems in the hospital that make it easier to provide high quality care.	Neither agree nor disagree	20 (12.0)	4.14	<0.001
	Somewhat agree	79 (47.3)	4.29	
	Strongly Agree	68 (40.7)	4.68	
	NA	2		
We choose new processes of care that are more advantageous than the old to everyone involved (patients, clinicians, and our entire clinical team).	Strongly Disagree + Somewhat Disagree	3 (1.8)	3.98	<0.001
	Neither agree nor disagree	17 (10.1)	3.98	
	Somewhat agree	75 (44.6)	4.31	
	Strongly Agree	73 (43.5)	4.68	
	NA	1		
The working environment in our clinical team is collaborative and cohesive, with shared sense of purpose, cooperation, and willingness to contribute to the common good.	Strongly Disagree + Somewhat Disagree	8 (4.7)	4.16	<0.001
	Neither agree nor disagree	17 (10.1)	4.19	
	Somewhat agree	73 (43.2)	4.30	
	Strongly Agree	71 (42.0)	4.66	
Our clinical team has greatly improved quality of care in the past 12 months.	Somewhat Disagree + Neither agree nor disagree	14 (8.3)	4.03	<0.001
	Somewhat agree	66 (39.1)	4.26	
	Strongly Agree	89 (52.7)	4.63	

Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System, NA-not applicable

Figure Legends:

Figure 1. Participating Centers (n=29)
Map depicting 29 Proyecto EVAT collaborating pediatric oncology centers participating in the pilot of the Spanish-language CSAT (Clinical Sustainability Assessment Tool) with center characteristics.

Data Sharing Statement: Deidentified data from this study are available upon reasonable request to the corresponding author (asya.agulnik@stjude.org).

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References:

1. Chapman SM, Wray J, Oulton K, Peters MJ. Systematic review of paediatric track and trigger systems for hospitalised children. *Resuscitation.* 2016;109:87-109.
2. Agulnik A, Gossett J, Carrillo AK, Kang G, Morrison RR. Abnormal Vital Signs Predict Critical Deterioration in Hospitalized Pediatric Hematology-Oncology and Post-hematopoietic Cell Transplant Patients. *Frontiers in Oncology.* 2020;10(354).
3. Brown SR, Martinez Garcia D, Agulnik A. Scoping Review of Pediatric Early Warning Systems (PEWS) in Resource-Limited and Humanitarian Settings. *Frontiers in pediatrics.* 2018;6:410.
4. Olson D, Preidis GA, Milazi R, et al. Task shifting an inpatient triage, assessment and treatment programme improves the quality of care for hospitalised Malawian children. *Trop Med Int Health.* 2013;18(7):879-886.
5. Rosman SL, Karangwa V, Law M, Monuteaux MC, Briscoe CD, McCall N. Provisional Validation of a Pediatric Early Warning Score for Resource-Limited Settings. *Pediatrics.* 2019;143(5).
6. Agulnik A, Cárdenas A, Carrillo AK, et al. Clinical and organizational risk factors for mortality during deterioration events among pediatric oncology patients in Latin America: A multicenter prospective cohort. *Cancer.* 2021.
7. Agulnik A, Antillon-Klussmann F, Soberanis Vasquez DJ, et al. Cost-benefit analysis of implementing a pediatric early warning system at a pediatric oncology hospital in a low-middle income country. *Cancer.* 2019;125(22):4052-4058.
8. Graetz D, Kaye EC, Garza M, et al. Qualitative Study of Pediatric Early Warning Systems' Impact on Interdisciplinary Communication in Two Pediatric Oncology Hospitals With Varying Resources. *JCO global oncology.* 2020;6:1079-1086.
9. Agulnik A, Mendez Aceituno A, Mora Robles LN, et al. Validation of a pediatric early warning system for hospitalized pediatric oncology patients in a resource-limited setting. *Cancer.* 2017.
10. Agulnik A, Mora Robles LN, Forbes PW, et al. Improved outcomes after successful implementation of a pediatric early warning system (PEWS) in a resource-limited pediatric oncology hospital. *Cancer.* 2017;123(15):2965-2974.
11. Graetz DE, Giannars E, Kaye EC, et al. Clinician Emotions Surrounding Pediatric Oncology Patient Deterioration. *Front Oncol.* 2021;11:626457.
12. Agulnik A, Garza M, Gonzalez-Ruiz A, et al. Successful Implementation of a Pediatric Early Warning System (PEWS) in 10 Resource-LimitedPediatric Oncology Centers in Latin America and the Caribbean. *Pediatr Blood Cancer.* 2019;66 Suppl 4:s512-513.
13. Agulnik A, Garza M, Gonzalez-Ruiz A, et al. MODEL FOR REGIONAL COLLABORATION IN QUALITY IMPROVEMENT: IMPLEMENTATION OF A PEDIATRIC EARLY WARNING SYSTEM IN 17 PEDIATRIC ONCOLOGY CENTERS IN LATIN AMERICA AND THE CARIBBEAN. *Pediatric Critical Care Medicine.* 2020.
14. Moore JE, Mascarenhas A, Bain J, Straus SE. Developing a comprehensive definition of sustainability. *Implementation Science.* 2017;12(1):110.
15. Scheirer MA, Dearing JW. An agenda for research on the sustainability of public health programs. *Am J Public Health.* 2011;101(11):2059-2067.
16. Mortimer F, Isherwood J, Wilkinson A, Vaux E. Sustainability in quality improvement: redefining value. *Future Healthcare Journal.* 2018;5(2):88.
17. Shelton RC, Cooper BR, Stirman SW. The sustainability of evidence-based interventions and practices in public health and health care. *Annual Review of Public Health.* 2018;39:55-76.
18. Rabin BA, Brownson RC. Terminology for Dissemination and Implementation Research. In: Brownson RC, Colditz GA, Proctor EK, eds. *Dissemination and implementation research in health: translating science to practice.* Second ed.: Oxford University Press; 2017:19-46.
19. Hodge LM, Turner KM. Sustained Implementation of Evidence-based Programs in Disadvantaged Communities: A Conceptual Framework of Supporting Factors. *American Journal of Community Psychology.* 2016;58(1-2):192-210.

20. Schell S, Luke D, Schooley M, et al. Public health program capacity for sustainability: a new framework. *Implementation Science.* 2013;8(1):15.
21. Chambers DA, Glasgow RE, Stange KC. The dynamic sustainability framework: addressing the paradox of sustainment amid ongoing change. *Implementation Science.* 2013;8(1):117.
22. Gruen RL, Elliott JH, Nolan ML, et al. Sustainability science: an integrated approach for health-programme planning. *The Lancet.* 2008;372(9649):1579-1589.
23. Lennox L, Maher L, Reed J. Navigating the sustainability landscape: a systematic review of sustainability approaches in healthcare. *Implementation Science.* 2018;13(1):27.
24. McKay VR, Morshed AB, Brownson RC, Proctor EK, Prusaczyk B. Letting Go: Conceptualizing Intervention De-implementation in Public Health and Social Service Settings. *American Journal of Community Psychology.* 2018;62(1-2):189-202.
25. Proctor E, Luke D, Calhoun A, et al. Sustainability of evidence-based healthcare: research agenda, methodological advances, and infrastructure support. *Implementation Science.* 2015;10(1):88.
26. Malone S, Prewitt K, Luke D. Assessing clinical sustainability: a new, user-friendly tool for evaluating real-world practices. American Evaluation Association's annual conference; 2019; Minneapolis, MN.
27. Luke D. The Clinical Susatinability Assessment Tool (CSAT): Assessing sustainability in clinical medicine settings. . Paper presented at: 11th Annual Conference on the Science of Dissemination and Implementation in Health2018; Washington, D.C.
28. Clinical Sustainability Assessment Tool. https://sustaintool.org/csat/. Accessed August 17, 2020.
29. St. Jude Global. https://www.stjude.org/global.html. Accessed March 2, 2020.
30. Luke DA, Calhoun A, Robichaux CB, Elliott MB, Moreland-Russell S. The Program Sustainability Assessment Tool: a new instrument for public health programs. *Preventing chronic disease.* 2014;11:130184.
31. Helfrich CD, Li YF, Sharp ND, Sales AE. Organizational readiness to change assessment (ORCA): development of an instrument based on the Promoting Action on Research in Health Services (PARIHS) framework. *Implementation science : IS.* 2009;4:38.
32. Solberg LI, Asche SE, Margolis KL, Whitebird RR. Measuring an organization's ability to manage change: the change process capability questionnaire and its use for improving depression care. *American journal of medical quality : the official journal of the American College of Medical Quality.* 2008;23(3):193-200.
33. Marin G, Triandis HC, Betancourt H, Kashima Y. Ethnic Affirmation Versus Social Desirability:Explaining Discrepancies in Bilinguals' Responses to a Questionnaire. *Journal of Cross-Cultural Psychology.* 1983;14(2):173-186.
34. D'Alonzo KT. Evaluation and revision of questionnaires for use among low-literacy immigrant Latinos. *Revista latino-americana de enfermagem.* 2011;19(5):1255-1264.
35. *Qualtrics* [computer program]. Provo, Utah, USA2005.
36. Streiner DL. Starting at the beginning: an introduction to coefficient alpha and internal consistency. *Journal of personality assessment.* 2003;80(1):99-103.
37. Hu L, Bentler P. Evaluating model fit. In: Hoyle RH, ed. *Structural Equation Modeling: concepts, issues, and applications.* Thousand Oaks, CA: Sage Publications; 1995:76-99.
38. Vuong QH. Likelihood Ratio Tests for Model Selection and Non-Nested Hypotheses. *Econometrica.* 1989;57(2):307-333.
39. Kline RB. *Principles and practice of structural equation modeling.* Guilford publications; 2015.
40. Braithwaite J, Ludlow K, Testa L, et al. Built to last? The sustainability of healthcare system improvements, programmes and interventions: a systematic integrative review. *BMJ Open.* 2020;10(6):e036453.
41. Glasgow RE, Chambers D. Developing robust, sustainable, implementation systems using rigorous, rapid and relevant science. *Clinical and translational science.* 2012;5(1):48-55.

42. Wiltsey Stirman S, Kimberly J, Cook N, Calloway A, Castro F, Charns M. The sustainability of new programs and innovations: a review of the empirical literature and recommendations for future research. *Implementation science : IS.* 2012;7:17.

43. Moullin JC, Sklar M, Green A, et al. Advancing the pragmatic measurement of sustainment: a narrative review of measures. *Implementation Science Communications.* 2020;1(1):1-18.

Figure 1: Participating centers (n=29)

Center Characteristics	n(%)
Type of Hospital	
General (adult and pediatric)	11 (37.9%)
Oncology (adult and pediatric)	7 (24.1%)
Pediatric multidisciplinary	11 (37.9%)
Hospital Funding Structure	
Public	21 (72.4%)
Mix (Public/private partnership)	6 (20.7%)
Private	2 (6.9%)
Annual New Cancer Diagnoses	
1-75	12 (41.4%)
76-150	9 (31.0%)
>150	8 (27.6%)
Pediatric Oncology Unit Structure	
No pediatric oncology unit (integrated with pediatrics)	4 (13.8%)
Separate pediatric oncology unit	25 (86.2%)
Time since Implementation of PEWS	
1-12 months	10 (34.5%)
12-24 months	13 (44.8%)
>24 months	6 (20.7%)
Number of staff working in center	
0-249	5 (17.2%)
>249	24 (82.8%)

Figure 1. Participating Centers (n=29). Map depicting 29 Proyecto EVAT collaborating pediatric oncology centers participating in the pilot of the Spanish-language CSAT (Clinical Sustainability Assessment Tool) with center characteristics

338x190mm (600 x 600 DPI)

Supplemental Tables and Figures

Reliability and validity of a Spanish-language measure assessing clinical capacity to sustain Pediatric Early Warning Systems (PEWS) in resource-limited hospitals

Table of Contents:

Supplemental Table 1: Participating center relevant characteristics and response rates

Center	Country	Type of Hospital	Hospital Funding Structure	New Annual Cancer Diagnoses	Pediatric Oncology Unit Structure	Time since Implementation of PEWS (months)	Number of Staff Working in Center	Staff Surveyed	Responses	Response Rate (%)
1	Argentina	General (Adult and Peds)	Mix (Public/private partnership)	37	Separate pediatric	2.10	18	15	13	87%
2	Brazil	Pediatric Multidisciplinary	Public	140	Integrated with pediatrics	1.10	12	10	8	80%
3	Chile	Pediatric Multidisciplinary	Public	100	Separate pediatric	39.67	7	8	6	75%
4	Costa Rica	Pediatric Multidisciplinary	Public	168	Separate pediatric	6.13	4	5	3	60%
5	Dominican Republic	Pediatric Multidisciplinary	Public	99	Separate pediatric	19.33	8	7	7	100%
6	Dominican Republic	Pediatric Multidisciplinary	Public	59	Separate pediatric	22.40	43	9	6	67%
7	Ecuador	Oncology (Adult and Peds)	Mix (Public/private partnership)	94	Separate pediatric	24.43	40	6	5	83%
8	Ecuador	Oncology (Adult and Peds)	Mix (Public/private partnership)	75	Separate pediatric	12.27	48	6	6	100%
9	El Salvador	Pediatric Multidisciplinary	Public	185	Separate pediatric	22.40	42	4	4	100%
10	Guatemala	Pediatric Oncology	Mix (Public/private partnership)	513	Separate pediatric	69.07	250	6	6	100%
11	Haiti	Pediatric Multidisciplinary	Private	89	Separate pediatric	22.40	16	4	3	75%
12	Honduras	General (Adult and Peds)	Public	365	Integrated with pediatrics	38.63	35	5	5	100%
13	Mexico	General (Adult and Peds)	Public	19	Separate pediatric	19.33	49	4	4	100%
14	Mexico	Oncology (Adult and Peds)	Public	110	Separate pediatric	9.20	77	6	5	83%
15	Mexico	Oncology (Adult and Peds)	Mix (Public/private partnership)	27	Integrated with pediatrics	22.80	19	4	1	25%
16	Mexico	Pediatric Multidisciplinary	Public	143	Separate pediatric	7.17	55	6	6	100%

17	Mexico	General (Adult and Peds)	Public	42	Integrated with pediatrics	15.33	230	7	5	71%
18	Mexico	General (Adult and Peds)	Public	136	Separate pediatric	6.13	103	6	5	83%
19	Mexico	General (Adult and Peds)	Public	58	Separate pediatric	7.17	66	9	4	44%
20	Mexico	General (Adult and Peds)	Public	45	Separate pediatric	10.23	42	4	4	100%
21	Mexico	General (Adult and Peds)	Public	60	Separate pediatric	26.47	103	6	5	83%
22	Mexico	Pediatric Oncology	Private	60	Separate pediatric	51.83	103	9	9	100%
23	Mexico	Pediatric Multidisciplinary	Public	121	Separate pediatric	13.30	66	6	4	67%
24	Mexico	Pediatric Multidisciplinary	Public	49	Separate pediatric	21.37	22	5	4	80%
25	Nicaragua	Pediatric Multidisciplinary	Public	301	Separate pediatric	14.30	39	5	3	60%
26	Panama	Pediatric Multidisciplinary	Public	55	Separate pediatric	20.37	22	10	7	70%
27	Peru	General (Adult and Peds)	Mix (Public/private partnership)	200	Separate pediatric	5.17	22	13	9	69%
28	Peru	General (Adult and Peds)	Public	150	Separate pediatric	7.17	42	12	10	83%
29	Peru	Oncology (Adult and Peds)	Public	800	Separate pediatric	17.37	230	13	12	92%
TOTAL								**210**	**169**	**80%**

Supplemental Figure 1: English version of the Clinical Sustainability Assessment Tool (CSAT) final survey instrument

CSAT Questions

In the following questions, rate the EVAT program across a range of specific factors that affect sustainability. Please respond to as many items as possible. The more honest you can be with your answers, the more helpful the report will be in moving forward with your program's sustainability planning. If you truly feel you are not able to answer an item, you may select "NA."

For each statement, select the number that best indicates the extent to which you agree. The scale has a range from 1 to 5. Selecting 1 indicates "strongly disagree" and selecting 5 indicates "strongly agree."

NA		1	2	3	4	5
Not able to answer		Strongly Disagree	Disagree	Neither Disagree nor Agree	Agree	Strongly Agree

Engaged Staff & Leadership: Having supportive frontline staff and management within the organization

1. EVAT engages leadership and staff throughout the process.
2. Clinical champions of EVAT are recognized and respected.
3. EVAT has engaged, ongoing champions.
4. EVAT has a leadership team made of multiprofessional partnerships.
5. EVAT has team-based collaboration and infrastructure.

Engaged Stakeholders: Having external support and engagement for EVAT

Stakeholders: individuals, groups, or organizations that positively or negatively influence the results of a project/initiative, which has authority and power.

1. EVAT engages the patient and family members as stakeholders.
2. There is respect for all stakeholders involved in EVAT.
3. The EVAT importance is valued by a diverse set of stakeholders.
4. EVAT engages other medical teams and community partnerships as appropriate.
5. The EVAT leadership team has the ability to respond to stakeholder feedback about EVAT.

Organizational Readiness: Having the internal support and resources needed to effectively manage EVAT

1. Organizational systems are in place to support the various needs of EVAT.
2. EVAT fits in well with the culture of the team.
3. EVAT has feasible and sufficient resources (e.g., time, space, funding) to achieve its goals.
4. EVAT has adequate staff to achieve its goals.
5. EVAT is well integrated into the operations of the hospital.

Workflow Integration: Designing EVAT to fit into existing practices and technologies

1. EVAT is built into the clinical workflow.
2. EVAT is easy for clinicians to use.
3. EVAT integrates well with established clinical practices.
4. EVAT aligns well with other clinical systems (e.g., EMR).
5. EVAT is designed to be used consistently.

Implementation & Training: Using processes that guide the direction, goals, and strategies of EVAT

1. EVAT clearly outlines roles and responsibilities for all staff.
2. The reason for EVAT is clearly communicated to and understood by all staff.
3. Staff receive ongoing coaching, feedback, and training.
4. EVAT implementation is guided by feedback from stakeholders.
5. EVAT has ongoing education across professions.

Monitoring & Evaluation: Assessing EVAT to inform planning and document results

1. EVAT has measurable process components, outcomes, and metrics.
2. Evaluation and monitoring of EVAT are reviewed on a consistent basis.
3. EVAT has clear documentation to guide process and outcome evaluation.
4. EVAT monitoring, evaluation, and outcomes data are routinely reported to the clinical care team.
5. EVAT process components, outcomes, and metrics are easily assessed and audited.

Outcomes & Effectiveness: Understanding and measuring EVAT outcomes and impact

1. EVAT has evidence of beneficial outcomes.
2. EVAT is associated with improvement in patient outcomes that are clinically meaningful.
3. EVAT is clearly linked to positive health or clinical outcomes.
4. EVAT is cost-effective.
5. EVAT has clear advantages over alternatives (including not implementing EVAT)

Intervention

The following questions will ask about EVAT. Please answer considering the time BEFORE COVID at your institution.

6. Please rate the strength of the scientific evidence supporting EVAT implementation.
    a. Very weak
    b. Weak
    c. Neither weak nor strong
    d. Strong
    e. Very strong
    f. Don't know/NA
7. How important is EVAT to provide quality care to your patients?
    a. Not at all important
    b. Somewhat unimportant
    c. Neither important nor unimportant
    d. Somewhat important
    e. Very important

8. How difficult was the implementation of EVAT, or do you expect the implementation of EVAT to be, in your hospital?
    a. Very difficult
    b. Somewhat difficult
    c. Neither easy nor difficult
    d. Somewhat easy
    e. Very easy
    f. Don't know/NA

9. Regarding patients under my care, how often is EVAT used in their care?
    a. EVAT is not yet implemented in my hospital
    b. None of the time
    c. Some of the time
    d. Most of the time
    e. All of the time

Organization

Please indicate how much you agree or disagree with each of the following statements.

	Not aplicable	Strongly Disagree	Somewhat Disagree	Neither agree nor disagree	Somewhat agree	Strongly Agree
10. Our resources (personnel, time, financial) are too tightly limited to improve care quality.		1	2	3	4	5
11. Our EVAT implementation team understands and uses quality improvement skills effectively.		1	2	3	4	5
12. Our clinical team has changed or created systems in the hospital that make it easier to provide high quality care.		1	2	3	4	5
13. We choose new processes of care that are more advantageous than the old to everyone involved (patients, clinicians, and our entire clinical team).		1	2	3	4	5
14. The working environment in our clinical team is collaborative and cohesive, with shared sense of purpose, cooperation, and willingness to contribute to the common good.		1	2	3	4	5
15. Our clinical team has greatly improved quality of care in the past 12 months.		1	2	3	4	5

Participant

The following questions will ask about your work. Please indicate your response for each question or statement.

16. What is your primary profession?
    a. Nurse
    b. Physician
    c. Healthcare Administration
    d. Other (please list): _____

17. Where is your primary area of work?
    e. Pediatric or Pediatric Hematology-Oncology floor
    f. Intensive Care Unit
    g. Non-clinical work
    h. Other (please list): _____

18. In relation to EVAT, what is your primary role in the implementation team?
    a. EVAT leader
    b. Clinical staff
    c. Hospital administrator
    d. Data manager (responsible to collect/send EVAT data)
    e. Other _____

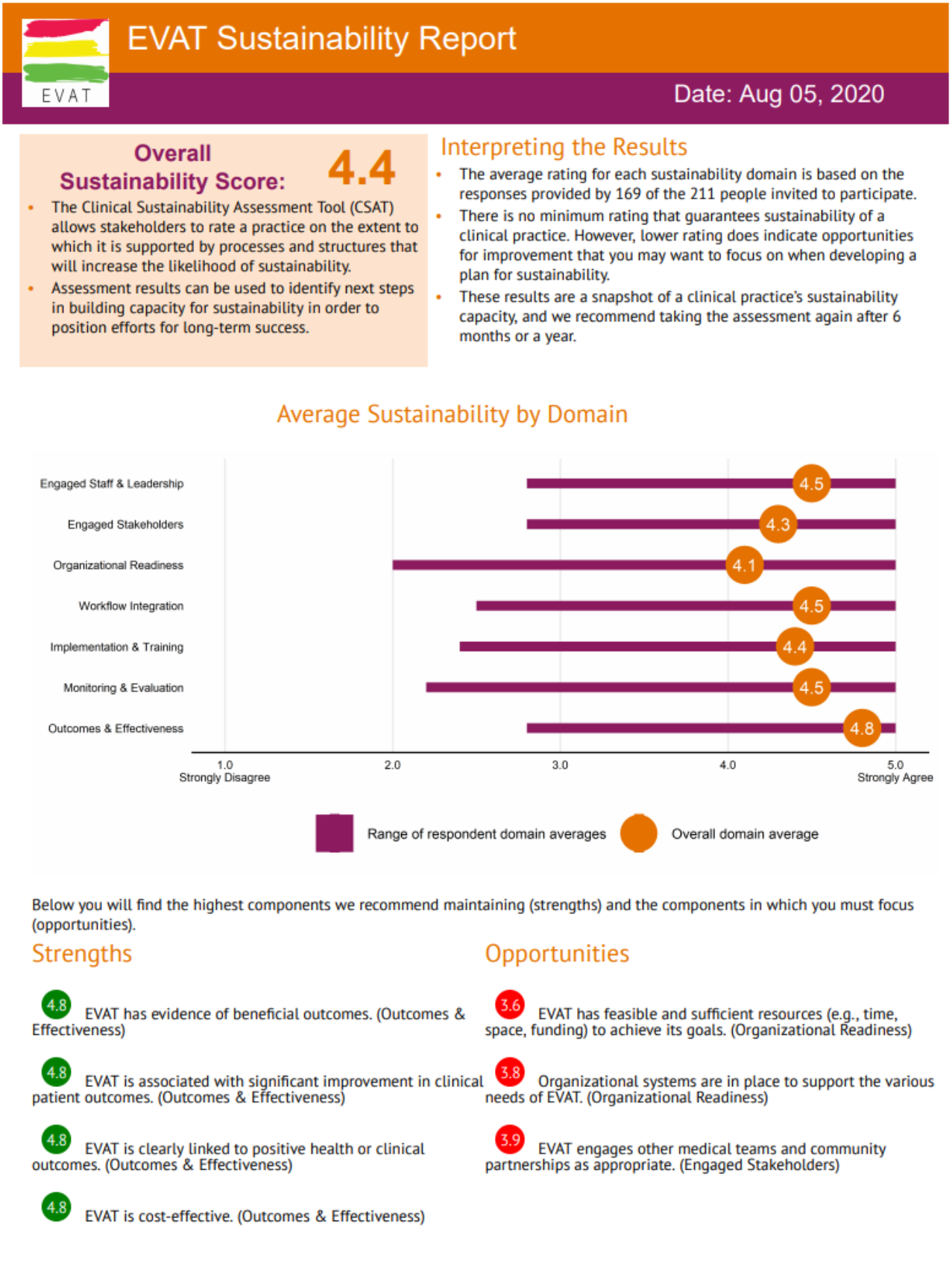
19. How many years have you worked **since completing medical or nursing training**?
    a. 0-5 years
    b. 6-10 years
    c. 11-15 years
    d. 16-20 years
    e. Greater than 20 years
    f. N/A

20. How many years have you worked **at this hospital**?
    g. 0-5 years
    h. 6-10 years
    i. 11-15 years
    j. 16-20 years
    k. Greater than 20 years

21. What is your gender?
    a. Male
    b. Female
    c. Other

22. What is your age?
    a. <30 years old
    b. 30-40
    c. 40-50
    d. >50 years old

Supplemental Figure 2: Sample CSAT Report



EVAT Sustainability Report:

Date: Aug 05, 2020

Engaged Staff & Leadership

Score 4.5

		Score
1.	EVAT engages leadership and staff throughout the process.	4.7
2.	EVAT leaders are recognized and respected.	4.3
3.	EVAT has engaged, ongoing champions.	4.7
4.	EVAT has a multidisciplinary leadership team.	4.6
5.	EVAT has team-based collaboration and infrastructure.	4.4

Engaged Stakeholders

Score 4.3

		Score
1.	EVAT engages the patient and family members as stakeholders.	4.4
2.	There is respect for all stakeholders involved in EVAT.	4.4
3.	The importance of EVAT is valued by a diverse set of stakeholders.	4.3
4.	EVAT engages other medical teams and community partnerships as appropriate.	3.9
5.	The EVAT leadership team has the ability to respond to stakeholder feedback about EVAT.	4.6

Organizational Readiness

Score 4

		Score
1.	Organizational systems are in place to support the various needs of EVAT.	3.8
2.	EVAT fits in well with the culture of the team.	4.4
3.	EVAT has feasible and sufficient resources (e.g., time, space, funding) to achieve its goals.	3.6
4.	EVAT has adequate staff to achieve its goals.	4.2
5.	EVAT is well integrated into the operations of the hospital.	4.2

Workflow Integration

Score 4.5

		Score
1.	EVAT is built into the clinical workflow.	4.6
2.	EVAT is easy for clinicians to use.	4.5
3.	EVAT integrates well with established clinical practices.	4.6
4.	EVAT aligns well with other clinical systems (e.g., EMR).	4.1
5.	EVAT is designed to be used consistently.	4.7

Implementation & Training

Score 4.3

		Score
1.	EVAT clearly outlines roles and responsibilities for all staff.	4.6
2.	The reason for EVAT is clearly communicated to and understood by all staff.	4.4
3.	Staff receive ongoing coaching, feedback, and training.	4.3
4.	EVAT implementation is guided by feedback from stakeholders.	4.3
5.	EVAT has ongoing education across professions.	4.1

Monitoring & Evaluation

Score 4.5

		Score
1.	EVAT has measurable process components, outcomes, and metrics.	4.7
2.	Evaluation and monitoring of EVAT are reviewed on a consistent basis.	4.5
3.	EVAT has clear documentation to guide process and outcome evaluation.	4.7
4.	EVAT monitoring, evaluation, and outcomes data are routinely reported to the clinical care team.	4.2
5.	EVAT process components, outcomes, and metrics are easily assessed and audited.	4.4

Outcomes & Effectiveness

Score 4.8

		Score
1.	EVAT has evidence of beneficial outcomes.	4.8
2.	EVAT is associated with significant improvement in clinical patient outcomes.	4.8
3.	EVAT is clearly linked to positive health or clinical outcomes.	4.8
4.	EVAT is cost-effective.	4.8
5.	EVAT has clear advantages over alternatives (including not implementing EVAT).	4.6

Next Steps

- These results can be used to guide sustainability planning for your clinical practice.
- Areas with lower ratings indicate that there is room for improvement.
- Address domains that are modifiable and have data available to support the needed changes.
- Develop long-term strategies to tackle the domains that may be more difficult to modify.
- Make plans to assess your practice's sustainability on an ongoing basis to monitor changes as you strive for an ongoing impact.

Supplemental Figure 3: Focus group facilitator guide

Welcome:	Welcome to this focus group that aims to discuss the EVAT Sustainability Report based on the Clinical Sustainability Assessment Tool (CSAT), that you received. Thank you again for accepting our invitation and for giving us some of your valuable time to chat with us.
Description:	This session is part of a series of focus groups that we will be conducting with people who completed the Clinical Sustainability Assessment Tool (CSAT) in different institutions and countries. Our goal today is to ensure that everyone has the opportunity to share their comments and feedback with the group in order to evaluate and improve the CSAT assessment tool.
Description of rules to follow: Before we begin, I would like to go over some basic rules to follow during this focus group.	• Make sure you have the EVAT Sustainability Report (based on the CSAT) that was provided to you. • This session will be recorded, which will allow me to focus my attention on you rather than trying to take notes about the conversation. • It is important that only one person speaks at a time in order to facilitate later transcription of the recording. • The audio obtained from the recording will be transcribed and de-identified for later analysis. We will not use video for the purposes of this analysis. • For the purposes of this session, we will identify ourselves and refer to each participant using only their first names to avoid hierarchies and facilitate communication. We remind you that your comments will be subsequently de-identified. • What is shared in the session stays in the session. As facilitators, we are committed to maintaining the confidentiality of what is discussed here and, in the same way, we appreciate that what is said here is not discussed with other people once the session is over. • There are no right or wrong answers to the questions we will ask today, we just want to know about your ideas, experiences and opinions, all of which are of great value to us. Listening to each other's points of view is imperative, both positive and negative. It is important for us to listen to everyone's ideas and opinions. We want the ideas of each participant in the focus group to be equally represented; so, do not hesitate to share your opinions. • You do not have to agree with others, but you must listen to and respect the opinions expressed by other participants. • You do not have to wait to be called to intervene in the question round. It is an open discussion so you can comment at any time.
Technical considerations:	○ We appreciate that each participant keeps their camera active throughout the session. If you have any problem activating your camera, remember that you can ask (co-facilitator) for help via chat. ○ It is recommended to use the grid view so you can see all the participants on one screen. This will help give the feel of an in-person meeting. The grid view can be selected from the menu in the upper right corner of your screen. ○ Remember to keep your microphone muted, and to activate it whenever you want to comment or say something. ○ We understand that you may need to answer a phone call or a pager message. If you can turn off those devices, please do so. If that is not possible, please mute your microphone while you are on the call and return to the group as soon as possible. ○ Please use the “chat” function only to communicate technical problems as we want you to express your comments out loud on the subject at hand today.

Doubts before proceeding	**Do you have any questions regarding the rules or a technical matter before we start the question round?**
Introduction of the facilitators and participants:	Now we will introduce ourselves, briefly and in turns. In this section I will call you so that each one of you can tell what your name is, your place of origin, your role as part of your work team and how many months or years of experience each one has providing medical care to children with cancer. (*The facilitator will lead this part of the session using the list of participants*). My name is <state your name, origin, role, and length of service>, and I will serve as a facilitator for our conversation today *[if a co-facilitator is present]* Today we are joined by <Name of the co-facilitator> who will serve as co-facilitator, take notes, and help us to ensure that everything runs smoothly from a technical standpoint. <Co- facilitator> will be waiting for your comments in the chat to attend to any technical problem (audio, difficulties to see the video, etc.) Remember to keep your camera turned on as much as possible. **Introduction of the participants:** Now the moderator will call each participant to introduce themselves. (*The facilitator will lead this part of the session using the list of participants*)
Introduction to Question Round:	In the previous section I have called you to introduce yourself. However, I would like to clarify that in the question section you do not have to wait to be called. Please give your opinion or comment when you consider it appropriate.
Understandability and utility of the report: The CSAT Sustainability Report provides you with a score to help you understand how prepared your hospital is to maintain EVAT.	1. Do you feel that the score is easy to understand? a. What does the score mean to you? How do you interpret the score? b. Can you tell what are the strengths and weakness of your center based on the report? (Pause after the question to await additional comments. Follow new routes according to comments and opinions) c. Is there anything in the report that surprised you? Or something that you disagree with? 2. How does the written information in the report help you understand how to use your score? 3. If you were able, do you feel like you could take action to improve sustainability of [name of intervention] based on this report? How? Please give an example based on your report. (Keep the focus more on the report, rather than EVAT) 4. What other information you would need that would help you take action based on this report? 5. Do you find the second page useful? Informative?
Overall look and feel: We're also interested in your opinion about the best way to present the information in the report so that people would like to read it. We've broken it up into these sections: - score - written text - domain graphs, and - details on the 2nd page (**Request that the co-facilitator share his/her**	1. In your opinion, does the way in which the information is organized make sense? a. What would you do to improve it? b. Is there something missing from the report? c. Does the report appear to you to be coherently organized? 2. Is there any aspects of the report that you find confusing? Or that you would recommend changing? (tell them: there might be something we would like to change that we think would make it easier to read or understand or just aesthetics) What would you suggest? For example, a. Score review box? b. Written text? (ask them: Do you think it has a lot of text? Or if they could communicate the same idea with fewer words, or perhaps explain more specifically offering more details or more descriptive? Maybe make the report a little more concise?) c. The domain averages graph? d. Detailed info on 2nd page?

screen with the report image)	3. Any feedback overall design? (If they offer a negative opinion, offer them **positive feedback.** For example, "how interesting what you say, we would like to know more about it ...") 4. The report offers a snapshot at a certain moment. Would you find it useful to complete the survey periodically to follow up on those aspects that pose an opportunity for improvement? And, if so, how often would you consider it appropriate to carry out the evaluation? [The principal investigator recommends not addressing this point unless the participants speak about it spontaneously].
Conclusion:	Before closing, we would like to know if there is anything else that, in your opinion, we have not covered. Is there anything else about conducting this assessment and receiving the report that you would like us to know? Do you have any additional recommendations about something that you consider important?
Closing:	Thank you for participating and for spending your valuable time with us. We will work in coordination with you to offer you information about the analysis of the results of this project. If you have additional questions, you can contact Dr. Asya Agulnik directly or any of the EVAT team members at St. Jude who will always be happy to assist you.

Supplemental Table 2: Focus group code book

Domain	Code	Definition
Interpreting Report	Ease of Interpretation	Comments on how easy or hard it is to interpret the report, including to use it to identify the center's strengths/weaknesses, both for the participant or members of their team
	Report Interpretation	The participants actual interpretation of their report, including their center's strengths and weaknesses as described by the report (this shows us we need to work on x, or we do a good job with y), anything they were surprised by from their report and if they agree with it. General comments about ease of interpretation or how one could understand the strengths and weaknesses, without specific mentions of them, coded as "ease of interpretation".
	Report Use	Mentions of how the respondents or their team plans to use the report to improve their EVAT program or its sustainability
	Additional Information	Additional information that should be provided in the report to improve usability or anything that is missing that should be provided
Report Components	Written Material	Comments about the quality of the written text in the report and how it does/does not help with interpretation
	Second Page	Comments about the utility of the second page of the report
	Score Review Box	Comments about the score review box
	Domain Graph	Comments about the domain averages graphs
	Other individual components	Comments about an individual component of the report not mentioned in the other "report components' codes. General comments about the report should be coded as 'overall report'
Overall Look and Feel	Overall Report	Comments about the overall organization and design of the report, including things that should be adjusted or changed in the report in general, or things that are confusing. Do not code comments about individual components (code one of the 'report components')
CSAT	CSAT Components	Comments about clarity of specific CSAT domains or questions, including the Likert scale, not related to the report itself
	CSAT Use	Comments about how the CSAT was administered at the center (how many people, how often, etc.) or how it should be used in the future
Negative	Negative comment	Double code with any comment of something that is negative or needs improvement in the report or the CSAT tool itself

Supplemental Table 3: CSAT domains and time from PEWS implementation

		Individual-Level			Center-Level		
Domain	Time since Implementation of PEWS (Months)	n (%) n=169	Mean CSAT	p-value	n (%) n=29	Mean CSAT	p-value
Engaged Staff & Leadership	1-12 months	67 (39.6)	4.37	<0.001	10 (34.5)	4.43	0.040
	12-24 months	66 (39.1)	4.68		13 (44.8)	4.66	
	>24 months	36 (21.3)	4.64		6 (20.7)	4.65	
Engaged Stakeholders	1-12 months	67 (39.6)	4.13	<0.001	10 (34.5)	4.18	0.122
	12-24 months	66 (39.1)	4.50		13 (44.8)	4.50	
	>24 months	36 (21.3)	4.38		6 (20.7)	4.40	
Organizational Readiness	1-12 months	67 (39.6)	3.95	0.141	10 (34.5)	4.00	0.393
	12-24 months	66 (39.1)	4.15		13 (44.8)	4.15	
	>24 months	36 (21.3)	4.18		6 (20.7)	4.19	
Workflow Integration	1-12 months	67 (39.6)	4.26	<0.001	10 (34.5)	4.33	0.011
	12-24 months	66 (39.1)	4.61		13 (44.8)	4.60	
	>24 months	36 (21.3)	4.68		6 (20.7)	4.69	
Implementation & Training	1-12 months	67 (39.6)	4.19	0.004	10 (34.5)	4.20	0.224
	12-24 months	66 (39.1)	4.47		13 (44.8)	4.41	
	>24 months	36 (21.3)	4.51		6 (20.7)	4.51	
Monitoring & Evaluation	1-12 months	67 (39.6)	4.36	0.039	10 (34.5)	4.40	0.438
	12-24 months	66 (39.1)	4.53		13 (44.8)	4.46	
	>24 months	36 (21.3)	4.61		6 (20.7)	4.61	
Outcomes & Effectiveness	1-12 months	67 (39.6)	4.65	0.022	10 (34.5)	4.71	0.410
	12-24 months	66 (39.1)	4.80		13 (44.8)	4.75	
	>24 months	36 (21.3)	4.86		6 (20.7)	4.86	

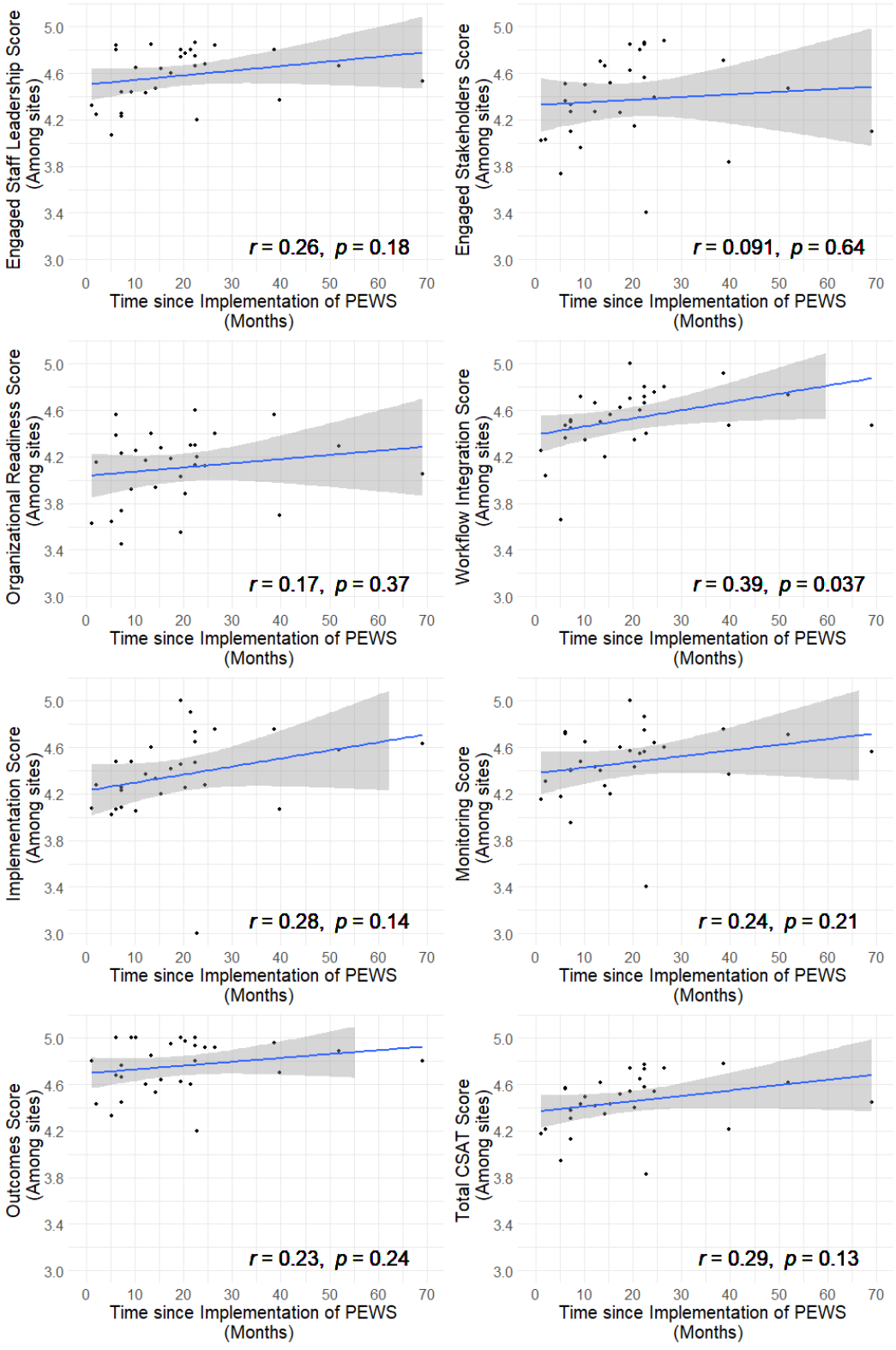
Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System

Supplemental Table 4: Center demographics influencing CSAT results (among centers)

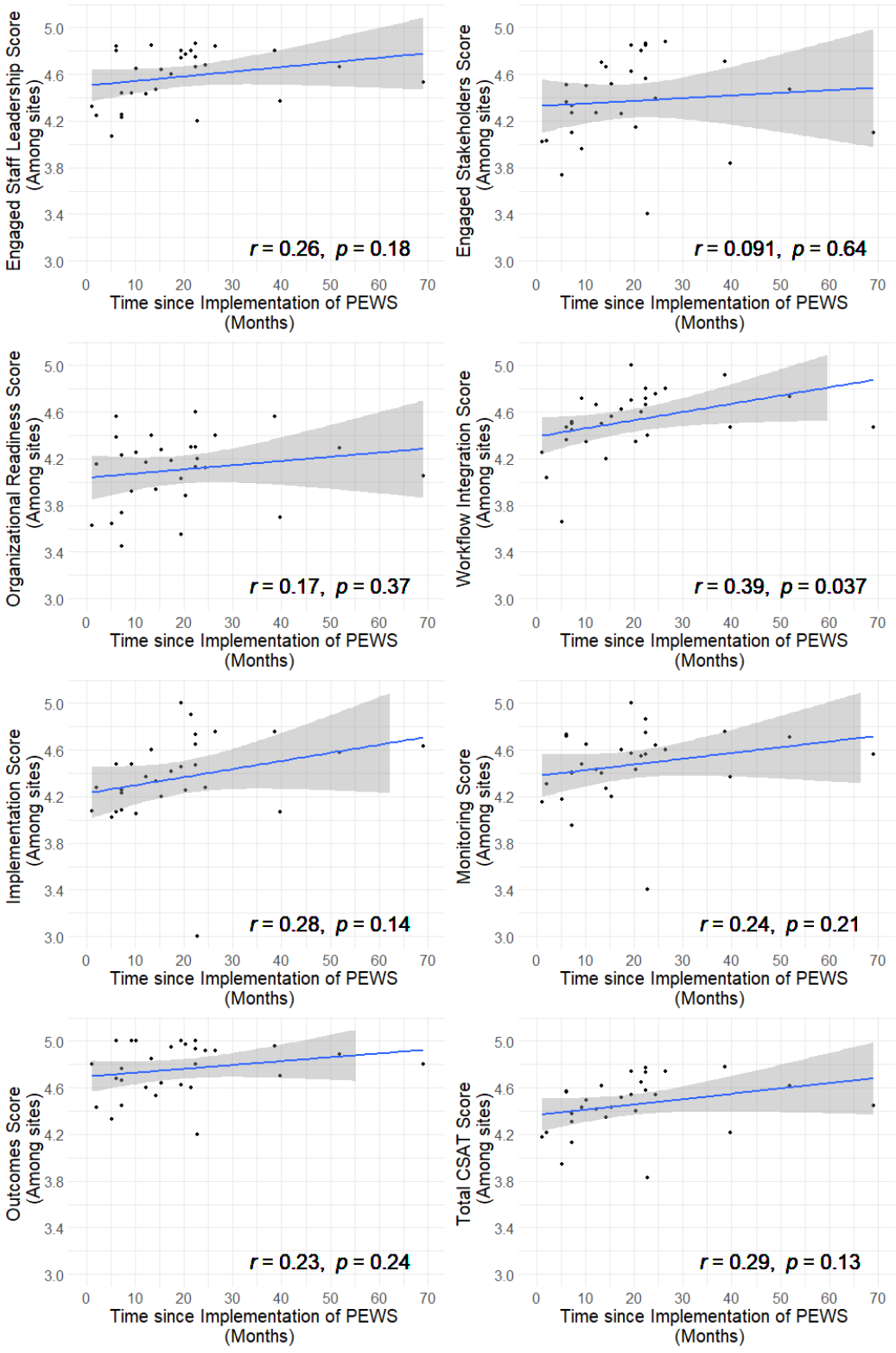
Category	Sub-Category	n (29)	mean	p-value
Hospital Characteristics (Among sites)				
Type of Hospital	General (adult and pediatric)	11	4.46	0.811
	Oncology (adult and pediatric)	7	4.4	
	Pediatric multidisciplinary	11	4.48	
Hospital Funding	Public	21	4.49	0.245
	Private or public/private partnership)	8	4.34	
Annual New Cancer Diagnoses	1-75	12	4.44	0.96
	76-150	9	4.47	
	>150	8	4.46	
Pediatric Oncology Structure	No pediatric oncology unit (integrated with pediatrics or other unit)	4	4.31	0.463
	Separate pediatric	25	4.48	
Time since Implementation of PEWS	1-12 months	10	4.32	0.085
	12-24 months	13	4.51	
	>24 months	6	4.56	
Number of staff working in center	0-249	5	4.41	0.74
	>249	24	4.46	

Abbreviations: CSAT-Clinical Sustainability Assessment Tool, PEWS-Pediatric Early Warning System

Supplemental Figure 4: CSAT result trends with time from PEWS implementation (center-level, n=29). Center-level scatter plot between time since implementation of PEWS (months) vs domain scores and total CSAT result (using jitter method, added smooth line and correlation coefficient), demonstrating consistency of relationship between time since implementation and sustainability of PEWS.



Supplemental Figure 5: CSAT result trends with time from PEWS implementation (individual, n=169). Individual-level scatter plot between time since implementation of PEWS (months) vs domain scores and total CSAT result (using jitter method, added smooth line and correlation coefficient), demonstrating consistency of relationship between time since implementation and sustainability of PEWS.



Supplemental Table 5: Focus group participant demographics

Focus Group	Characteristics		n (%)
ICU Physicians	Total		8
	Gender	Male	4 (50%)
		Female	4 (50%)
	Countries Represented		6
Floor Physicians	Total		7
	Gender	Male	2 (29%)
		Female	5 (71%)
	Countries Represented		6
Nurses	Total		7
	Gender	Male	0 (0%)
		Female	7 (100%)
	Countries Represented		6
Overall	Total		22
	Gender	Male	6 (27%)
		Female	16 (72%)
	Countries Represented*		10

*Counties Represented: Argentina, Chile, Dominican Republic, Ecuador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Peru

Abbreviations: ICU-Intensive Care Unit

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,2
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1,2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4
Objectives	3	State specific objectives, including any prespecified hypotheses	4-5
Methods			
Study design	4	Present key elements of study design early in the paper	6-9
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	5-6, 7, 8-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	7-10
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	*n/a*
Bias	9	Describe any efforts to address potential sources of bias	8-9
Study size	10	Explain how the study size was arrived at	7-8
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	7-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	8
		(*b*) Describe any methods used to examine subgroups and interactions	8
		(*c*) Explain how missing data were addressed	n/a
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	7-8
		(*e*) Describe any sensitivity analyses	n/a
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	10
		(b) Give reasons for non-participation at each stage	n/a
		(c) Consider use of a flow diagram	n/a
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Table 1, Fig 1
		(b) Indicate number of participants with missing data for each variable of interest	Table 4

Outcome data	15*	Report numbers of outcome events or summary measures	Table 2 and 3, Pg 10-11
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-11
		(*b*) Report category boundaries when continuous variables were categorized	n/a
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	n/a
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	11-12
Discussion			
Key results	18	Summarise key results with reference to study objectives	13
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	14-15
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	13-14
Generalisability	21	Discuss the generalisability (external validity) of the study results	14
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	1

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.