

# Long-term outcomes of standardized training for caregivers of children with tracheostomies: The Istanbul PAediatric Tracheostomy (ISPAT) project

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## Abstract

**Background and Objectives:** Children with tracheostomies are at increased risk of tracheostomy-related complications and require extra care. Standardized training programs for caregivers can improve tracheostomy care and reduce complications. In this study, we compared caregiver knowledge and skill scores after a standardized theoretical and practical training program on tracheostomy care (Istanbul PAediatric Tracheostomy (ISPAT) project) immediately and 1 year post-training and evaluated how this training affected the children's clinical outcomes.

**Materials and Methods:** We included 32 caregivers (31 children) who had received standardized training a year ago and administered the same theoretical and practical tests 1 year after training completion. We recorded tracheostomy-related complications and the number and reasons for admission to the healthcare centers. All data just before the training and 1 year after training completion were compared.

**Results:** After 1 year of training completion, the median number of correct answers on the theoretical test increased to 16.5 from 12 at pretest ( $p < 0.001$ ). Compared with pretest, at 1-year post-training practical skills assessment scores, including cannula exchange and aspiration, were significantly higher (both  $p < 0.001$ ) and mucus plug, bleeding, and stoma infection reduced significantly ( $p = 0.002$ ,  $0.022$ , and  $0.004$ , respectively). Hands-on-training scores were better than pretest but declined slightly at 1 year compared to testing immediately after training. Emergency

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admission decreased from 64.5% to 32.3% ( $p = 0.013$ ). Hospitalization decreased from 61.3% to 35.5% ( $p = 0.039$ ).

**Conclusion:** Our findings indicate that caregiver training can lead to a persistent increase in knowledge and skill for as long as 1 year, as well as improvements in several measurable outcomes, although a slight decrease in scores warrants annual repetitions of the training program.

**KEYWORDS**

caregiver, long-term outcome, tracheostomy, training

## 1 | INTRODUCTION

Over the last few decades, pediatric tracheostomy has been performed mainly in children with neuromuscular disease (NMD); central nervous system, cardiac, genetic, and metabolic disorders, and chronic lung diseases. Due to underlying medical conditions, this patient group has higher morbidity and mortality rate relative to other tracheostomized children.<sup>1-6</sup>

In children with many complex health problems, tracheostomy affords them time until the discovery of new molecular treatments for the primary disease or corrective surgery. It allows discharge from the intensive care unit (ICU) or hospital, increases patients' quality of life, reduces hospital/intensive care admissions, prolongs patients' life span, and decreases healthcare costs.<sup>4,7-9</sup>

On the other hand, children with tracheostomies require extra care and may develop some tracheostomy-related complications like mucus plug, spontaneous decannulation, and stoma infection. Particularly, stoma infection, tracheitis, and pneumonia are major infectious complications in children with tracheostomies, and the tracheostomy cannula serves as a potential route for spread of pathogens.<sup>3</sup> To prevent complications, minimize spread of pathogens, and provide adequate tracheostomy care (TC), caregivers should be educated and skilled in basic TC which includes guidelines for hygiene such as handwashing and use of sterile materials. Unplanned hospital/emergency admissions related to tracheostomy can occur in up to 66% of children within 6 months after discharge.<sup>10</sup> Acute life-threatening tracheostomy-related complications include tracheostomy occlusion (29%) and accidental decannulation (15%), which are not uncommon.<sup>11</sup> Follow-up of children with tracheostomies who have complex problems is a dynamic process and essentially includes caregiver education. The theoretical knowledge and practical skills of caregivers can be improved with regular training programs. If the outcomes of these trainings on children with tracheostomies and the duration of the effects are known, whereby the frequency of standardized training and which topics should be emphasized in the training content can be revealed more clearly.

A 2020 United Kingdom study implemented a quality improvement program consisting of a multidisciplinary team setup, interventions aimed at improving TC, and caregivers' training program.<sup>12</sup>

During the program period, all tracheostomy-related events as a severity score and hospitalizations were investigated, and a significant reduction in the severity scores and the length of hospital stay was reported.<sup>12</sup> However, the frequency of tracheostomy-related events in the periods before and after the implementation of the program was not investigated, nor were the persistence of TC knowledge and skills. In this study, we explored the long-term outcomes of this caregiver training program. Our primary aim was to measure the persistence of the standardized theoretical and practical training of caregivers that was applied a year ago and to evaluate their TC knowledge and skills 1 year post-training. Our secondary aim was to show how caregiver education is reflected in the patient clinical outcome.

## 2 | MATERIALS AND METHODS

### 2.1 | Study design

The current research was a follow-up study of a quasi-experimental multicenter study called the Istanbul PAediatric Tracheostomy (ISPAT) study group. In the first step of the project, a multidisciplinary team comprising specialists from diverse departments involved in the pediatric TC was established (pediatric otolaryngology, pulmonology, gastroenterology, critical care, neonatology, pediatric surgery, dentistry, nursing, physical therapy, speech therapy, and family representatives), and standardized simulation-based training for healthcare providers was performed.<sup>13</sup> In the second step, standardized theoretical and practical training of caregivers was performed by the trained healthcare providers, and the caregiver knowledge and skill scores immediately post-training were evaluated.<sup>14</sup> In the third step, we investigated the overall outcomes of the training and examined the level of knowledge and skill retained 1 year later (Figure 1).

### 2.2 | Settings

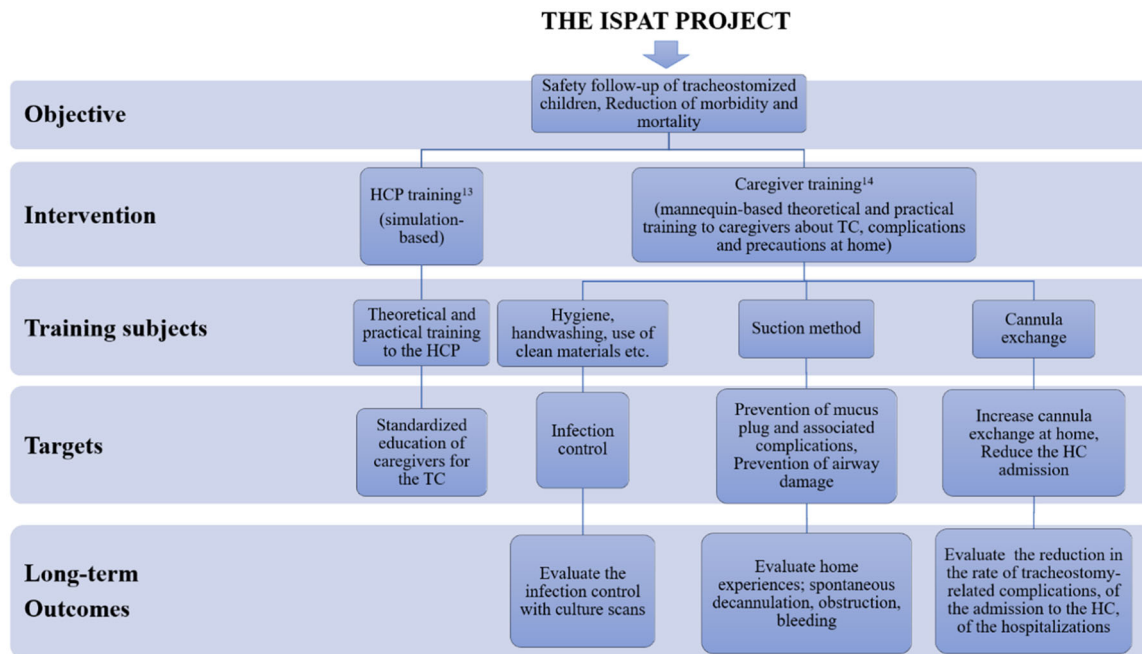
This follow-up study was conducted in six tertiary pediatric pulmonology centers in Istanbul between September and November

2021 as a continuation of the ISPAT project,<sup>13,14</sup> which was implemented between September and November 2020. The pre-training period was defined as a 1-year period from September 2019 to training commencement (September–November 2020). The post-training period covers a 1-year period from training completion (September–November 2020) to September–November 2021. Between September and November 2021, a secondary evaluation of training was performed, and the medical data of children with tracheostomies were collected (Figure 2).

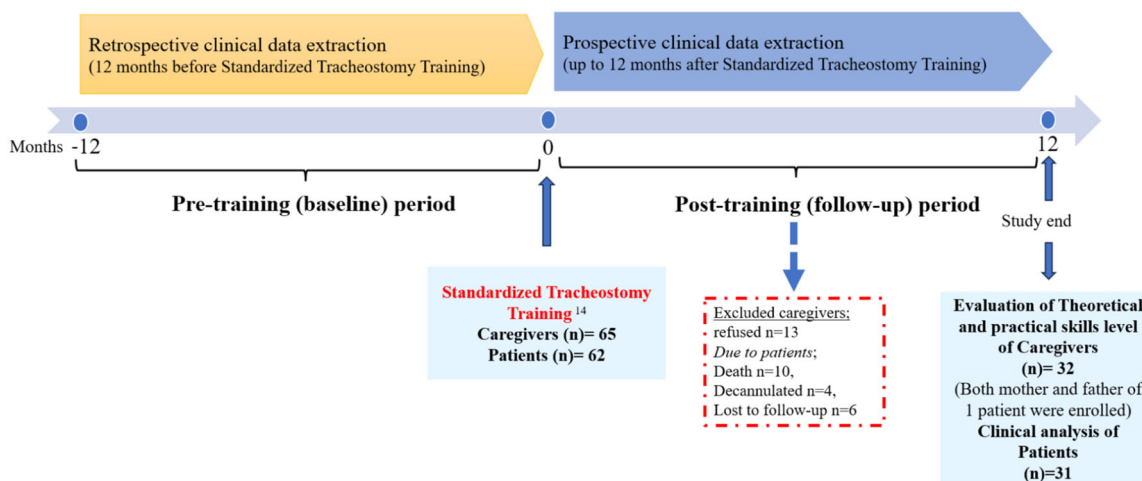
## 2.3 | Study population

Sixty-two children with tracheostomies and 65 caregivers who were included in the ISPAT project in 2020 were invited to participate in the study. Children who were decannulated, died, or lost follow-up and children/caregivers who did not wish to participate in the study were excluded.

This study was approved by the Research Ethics Committee of the Medeniyet University School of Medicine (approval number:



**FIGURE 1** ISPAT project algorithm. ED, emergency department; HC, health center; HCP, healthcare provider, TC, tracheostomy care. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]



**FIGURE 2** Timeline of the study. [Color figure can be viewed at [wileyonlinelibrary.com](https://onlinelibrary.wiley.com)]

2021/0453). Participants were informed about the study and written informed consent was obtained from all participants.

## 2.4 | Study protocol

### 2.4.1 | Stage 1: Evaluation of consistency of theoretical and practical skills of caregivers

As in the first part of the ISPAT project, the same theoretical and practical tests were administered 1 year after training completion.<sup>14</sup>

For theoretical assessment, the caregivers completed a written test comprising 23 multiple-choice questions about TC, such as suctioning the cannula, managing tracheostomy complications, and emergencies, such as cannula obstruction or accidental decannulation.

For practical assessment, the caregivers were asked to change the cannula on a mannequin and demonstrate the cannula suctioning and exchanging processes, which involved 16 steps (preparation: 6 steps, process: 10 steps) and 18 steps (preparation: 7 steps, process: 11 steps), respectively.

In this study, two posttest evaluations were performed: one immediately after training completion and another at 1 year post-training.

### 2.4.2 | Stage 2: Evaluating long-term outcomes of patients after training completion by caregivers

The medical data reflecting the children's clinical outcomes were obtained from the online national health registry system (<https://enabiz.gov.tr>), the testimonials of patients/caregivers, and the patients' files. Children with tracheostomies routinely visited the centers every 3 months; all the visits, including any other unexpected visits, were recorded in each patient's electronic medical record. The number and causes of health center (HC) admissions, including family HC, emergency department (ED), any part of the hospital, and the ICU were obtained from the national health registry system and patient files. The frequency of cannula exchange, mucus plug, spontaneous decannulation, bleeding, and stoma infection was recorded in the patient files by asking relevant questions to the patient/caregiver at all planned and unplanned clinical visits. The presence of mucus plugs, bleeding, spontaneous decannulation, stoma infection, and the need for HC admission related to these conditions were evaluated as subjective outcomes, which were assessed through family interviews and verified through medical records. Information about ED admission, length of hospitalization, ICU admission, and length of ICU stay was obtained directly from medical records and the national registry system, and these parameters were evaluated as objective outcomes.

Additionally, the caregivers were asked whether TC training made them feel more confident. The caregivers were also questioned about their practices of changing the cannula at home and any difficulties encountered during the process. If a knowledge gap or

incorrect information was identified, it was addressed immediately after the completion of both the theoretical and practical tests.

Quarterly tracheal aspirate culture results were retrieved from patients' records for 1 year before and after the training period. The data of children whose samples were cultured for at least two-quarters were included in the evaluation of respiratory cultures as part of the study. Four children without culture were excluded, leaving 27 of the 31 children. All the data from the year before the training (pretraining period) were compared with those from the year after training completion (post-training period).

## 2.5 | Statistical analysis

Statistical analysis was performed using the Number Cruncher Statistical System 2007 statistical software package (NCSS, LLC). Variables are presented as mean  $\pm$  standard deviation or median and interquartile range (IQR), as appropriate. Categorical variables are presented as proportions. Theoretical test scores were calculated as the total number of correct answers. Practical test scores were calculated as the total number of steps performed correctly. The distribution of the variables was examined using the Shapiro-Wilk normality test. The Friedman test was used for time comparisons of nonnormally distributed variables, Dunn's multiple comparison test was used for subgroup comparisons, the Wilcoxon test was used for binary time groups, the Stuart-Maxwell test was used for time comparisons of qualitative data, and the McNemar test was used for binary time comparisons of qualitative data. In addition, the Related Cochran's Q test was employed to compare more than two related proportions and to assess the homogeneity of training effects on the qualitative data. The results were evaluated at the significance level of  $p < 0.05$ .

## 3 | RESULTS

Of the 65 caregivers who participated in the original study, 32 consented to participate in this 1-year follow-up study; 13 refused to participate due to concerns related to the COVID-19 pandemic. Among the children with tracheostomies, 10 died (mortality rate: 16.1%), 4 were decannulated, and 6 could not be reached. Severe comorbid conditions were detected in 10 patients who died; 5 had NMD (complicated by status epilepticus and acute respiratory distress syndrome), 3 had genetic syndromes (complicated by underlying congenital cardiovascular diseases leading to cardiac failure and multiple organ failure), and 2 had metabolic syndromes (complicated by acute kidney failure and sepsis). No death was caused by tracheostomy-related complications. Among the 32 caregivers, 20 were mothers and 12 were fathers (mean age:  $36.56 \pm 8.35$  years). Both the mother and father of one patient were enrolled.

Among the 31 children, 18 were girls and 13 were boys. The mean age was  $91.4 \pm 51.5$  months. The most common underlying etiology was NMD (74.2%,  $n = 23$ ), and the others were respiratory (12.9%,  $n = 4$ ), genetic (9.7%,  $n = 3$ ), and cardiovascular (3.2%,  $n = 1$ ) diseases. The median age at tracheostomy insertion was 26 months

(IQR = 6–66), and the median duration of tracheostomy was 31 months (IQR = 18–63). The most common respiratory status before tracheostomy was invasive mechanical ventilation (45.2%,  $n = 14$ ), followed by both oxygen and noninvasive mechanical ventilation (35.5%,  $n = 11$ ), and only supplementary oxygen (3.2%,  $n = 1$ ); 5 (16.1%) did not require any respiratory support.

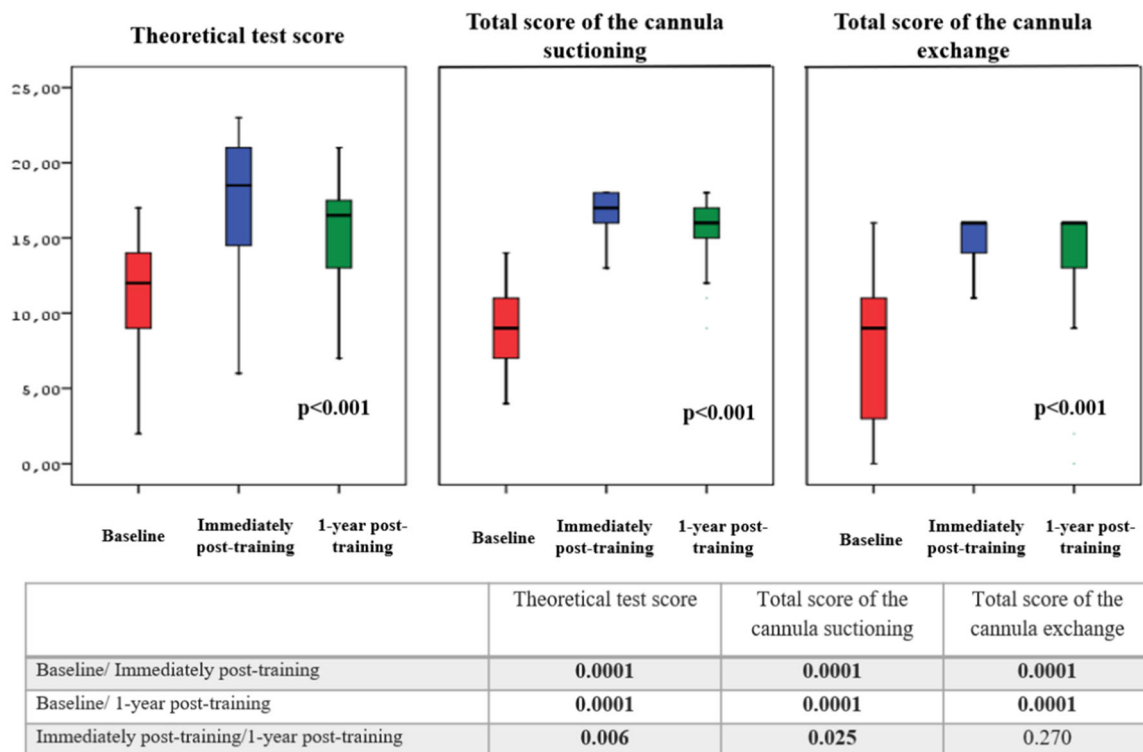
### 3.1 | Evaluation of training

The median (IQR) scores on theoretical tests increased from 12.0 (9.0–14.0) to 16.5 (13.0–17.8) at 1-year post-training compared with the pretest ( $p < 0.001$ ). The median (IQR) theoretical test score immediately post-training was significantly higher than that at 1-year post-training [18.5 (14.3–21.0) versus 16.5 (13.0–17.8),  $p = 0.006$ ].

In the practical skills evaluation, scores for cannula exchange and suctioning significantly increased from 9.0 (7.0–11.0) and 9.0 (3.0–11.0), respectively, in the pretest to 16.0 (13.0–16.0) and 16.0 (15.0–17.0, respectively, immediately post-training (both  $p < 0.001$ ). Comparison between immediately and 1-year post-training revealed no significant difference in the median scores for the cannula exchange [16.0 (14.0–16.0) to 16.0 (13.0–16.0),  $p = 0.270$ ] but a significant decrease for the cannula suctioning [17.0 (16.0–18.0) to 16.0 (15.0–17.0),  $p = 0.025$ ] (Figure 3, Supplementary Table 1).

The ratio of hand washing before cannula exchange was 59.4% ( $n = 19$ ) in the pretest, 93.8% ( $n = 30$ ) immediately post-training,

and 84.4% ( $n = 27$ ) at 1-year post-training ( $p = 0.003$ , 0.052, and 1.000, respectively). The ratio of hand washing before the suctioning of the cannula was 53.1% ( $n = 17$ ) in the pretest, 96.9% ( $n = 31$ ) immediately post-training, and 93.8% ( $n = 30$ ) at 1-year post-training ( $p < 0.001$ , 0.001, and  $P = 1.000$ , respectively). Following the replacement of the cannula, only 50.0% ( $n = 16$ ) of caregivers removed the obturator quickly in the pretest and caregivers did this with the ratio of 100% ( $n = 32$ ) immediately post-training. At 1-year post-training, that ratio was 87.5% ( $n = 28$ ) ( $p < 0.001$ ,  $p = 0.001$ , and 0.662, respectively). The caregivers who assessed the child's breathing and oxygenation after cannula exchange were 56.3% ( $n = 18$ ) in the pretest and 100% ( $n = 32$ ) immediately post-training, and it decreased to 84.4% ( $n = 27$ ) at 1-year post-training ( $p < 0.001$ ,  $p = 0.018$ , and 0.377, respectively). The caregivers who assessed the child's breathing and oxygen saturation level after suctioning of the cannula were 78.1% ( $n = 25$ ) in the pretest, 100% ( $n = 32$ ) immediately post-training, and 93.8% ( $n = 30$ ) at 1-year post-training ( $p = 0.007$ , 0.091, and 1.000, respectively) (Figure 4, Supplementary Table 2). The ratio of caregivers who were able to change the cannula was 46.9% ( $n = 15$ ) in the pre-training period, compared with 80.7% ( $n = 27$ ) after 1 year of the post-training period ( $p < 0.001$ ). While the ratio of the tracheostomy change interval was 64.5% ( $n = 20$ ) monthly and 22.6% ( $n = 7$ ) when needed in the pre-training period, it changed to 83.9% monthly and 6.5% ( $n = 2$ ) when needed during the year after training ( $p = 0.010$ ).

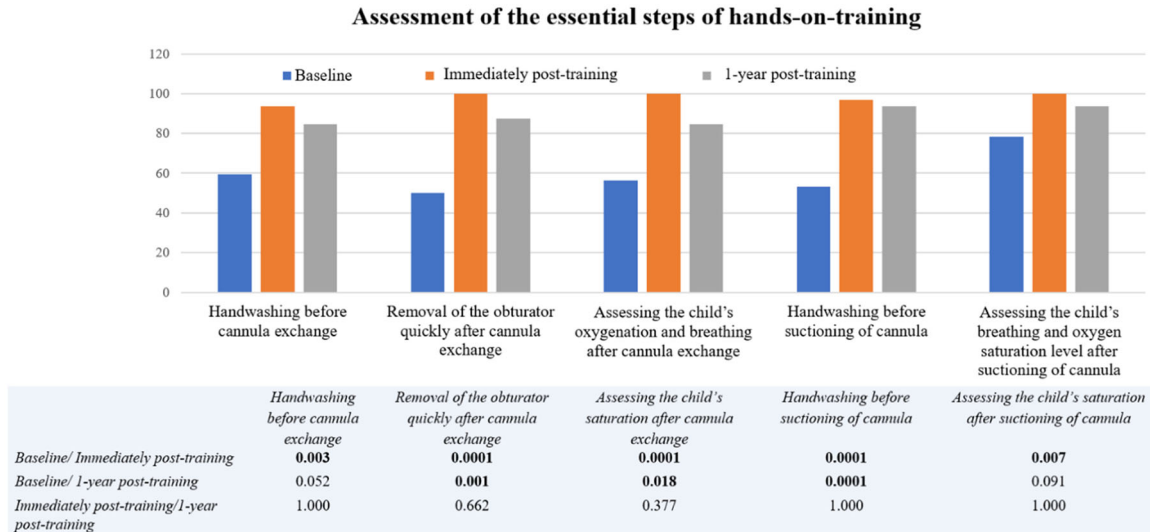


**FIGURE 3** Comparison of the theoretical and the practical training scores between the pretraining (baseline), immediately post-training, and 1-year post-training. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

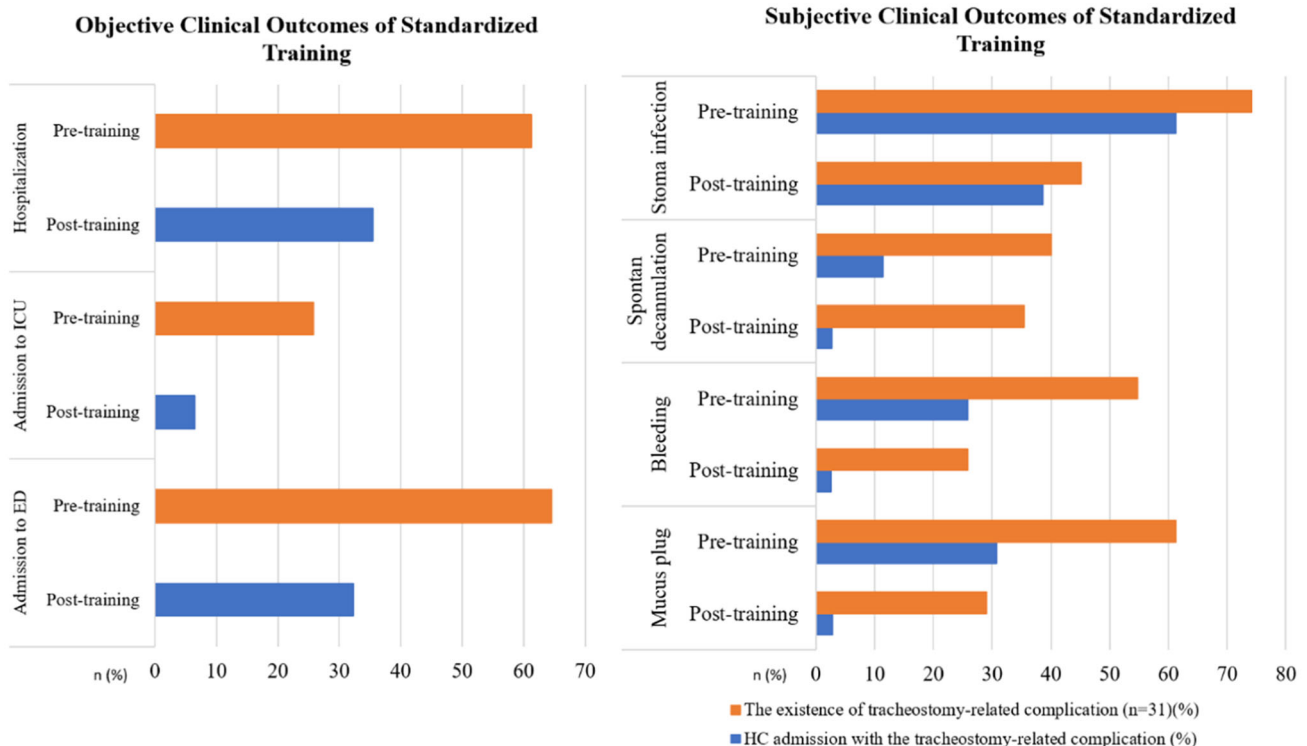
### 3.2 | Tracheostomy-related complications and health center admissions

The rate of mucus plug decreased from 61.3% ( $n = 19$ ) to 29.0% ( $n = 9$ ) ( $p = 0.002$ ) in the 1-year post-training period. The rate of bleeding from the cannula also reduced from 54.8% ( $n = 17$ ) to 25.8% ( $n = 8$ ) in the 1-year post-training period ( $p = 0.022$ ). The rate of admission to the HC caused by bleeding was 25.9% ( $n = 9$ ) and 2.6%

( $n = 1$ ) in the pretraining and the 1-year post-training periods, respectively ( $p = 0.25$ ). The rate of spontaneous decannulation was similar between periods [40.0% ( $n = 12$ ) and 35.5% ( $n = 11$ ), respectively ( $p = 0.998$ )]. The rate of stoma infection significantly decreased from 74.2% ( $n = 23$ ) to 45.2% ( $n = 14$ ) in the 1-year post-training period ( $p = 0.004$ ). Among these, admission rate to the HC caused by stoma infection did not change between the two periods (61.3% ( $n = 19$ ), 38.7% ( $n = 12$ ), respectively ( $p = 0.998$ ) (Figure 5).



**FIGURE 4** Assessment of the essential and critical steps during hands-on-training. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]



**FIGURE 5** Tracheostomy-related complications and the usage of the health center. ED, emergency department; HC, health center; ICU, intensive care unit. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

The admission rate of ED decreased from 64.5% ( $n = 20$ ) to 32.3% ( $n = 10$ ) ( $p = 0.013$ ). The main causes of ED admission were an increase and/or color change of secretions (70%,  $n = 14$ ) and mucus plug (30%,  $n = 6$ ) in the pretraining period. In the 1-year post-training period, an increase and/or color change in secretions was detected in 80% ( $n = 8$ ) of the ED admissions. Admission to the ED caused by mucus plugs was not seen in this period.

Hospitalization decreased from 61.3% ( $n = 19$ ) to 35.5% ( $n = 11$ ) ( $p = 0.039$ ). The tracheostomy-related admission to the ICU was 25.8% ( $n = 8$ ) in the pretraining period and 6.5% ( $n = 2$ ) over the 1-year post-training period ( $p = 0.07$ ) (Figure 5). The median (IQR) length of stay in the hospital was similar between the two periods [13 days (7–25) and 10 days (3–25), respectively,  $p = 0.866$ ] and there was no significant change in the length of ICU stay [median (IQR): 19 days (6–66.75) and 37 days (10.5–48), respectively  $p = 0.317$ ].

### 3.3 | Evaluation of respiratory cultures

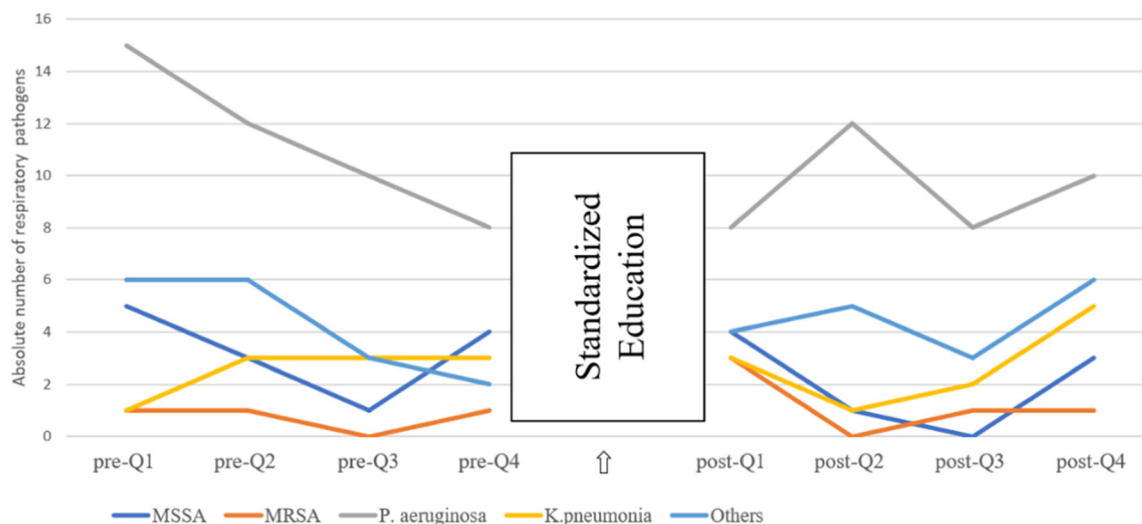
In the tracheal aspirate cultures between pre- and post-training periods, no significant difference was found between the overall colonization and isolation rates of all microorganisms ( $p = 0.58$ ). The tracheal aspirate culture results and the distribution of isolated microorganisms according to quarterly periods are presented in Figure 6.

## 4 | DISCUSSION

We have observed the long-term impact of caregiver training about TC on their knowledge and skills and the effect on the improvement of the clinical outcomes of children with tracheostomy. Both

theoretical and practical training were generally still effective 1 year after training completion. Furthermore, HC admission and tracheostomy-related complications, such as mucus plugs, stoma infections, and bleeding, were markedly reduced.

Several studies have provided simulation or mannequin-based training on standardized TC and scenarios that may be challenging for caregivers and have found training to significantly increase caregiver knowledge.<sup>14–19</sup> Woodbridge et al. designed a simulation-based training program for 20 caregivers of neonatal and pediatric patients with new tracheostomy and found that caregivers' competence and comfort with skill and scenario increased after training.<sup>17</sup> Prickett et al. offered a standardized simulation-based training program consisting of desaturation, mucus plug, and decannulation scenarios to 39 caregivers. They reported a significant increase in caregiver confidence levels and scores for all three scenarios; however, they did not examine long-term follow-up.<sup>18</sup> No study has compared the 1-year period before and after such standardized training of caregivers. Ours is the first study on this aspect. Our data indicated that although the caregivers' theoretical knowledge and practical skills, particularly cannula aspiration, increased immediately after training completion, a decline was observed 1-year later. This implies that the standardized theoretical and practical training should be repeated leastways annually for enhanced effectiveness. These retraining programs should be conducted, considering caregivers' questions, on a mannequin (if possible, simulation-based), and should include emergency scenarios. To ensure competency, caregivers should, whenever feasible, have the opportunity to practice on children with tracheostomies under supervision. Thus, these retraining programs can significantly contribute to the development and sustainability of fundamental skills among caregivers.



**FIGURE 6** The distribution of the respiratory pathogens between the pretraining and post-training periods with quarterly examination. MSSA: methicillin-susceptible *Staphylococcus Aureus*; MRSA: methicillin-resistant *Staphylococcus Aureus*, *P. aeruginosa*: *Pseudomonas Aeruginosa*, *K. pneumoniae*: *Klebsiella Pneumoniae*. Q1: first quarter of the year; Q2: second quarter of the year; Q3: third quarter of the year; Q4: fourth quarter of the year; others: *Streptococcus pneumoniae*, *Stenotrophomonas maltophilia*, *Acinetobacter* species, and other most commonly seen bacteria in the respiratory cultures of tracheostomized children. [Color figure can be viewed at [wileyonlinelibrary.com](http://wileyonlinelibrary.com)]

In the literature, the overall mortality rate of children with tracheostomies ranges from 2.9% to 59.0%, whereas tracheostomy-related mortality rates range from 0% to 5.9%.<sup>3,4,20</sup> In our study, the mortality rate was 16%, likely because most children in our cohort had NMD. None of the deaths in our study were directly related to tracheostomy, but we can say that the sample size was too small to draw a definitive conclusion on this issue.

Many studies have emphasized that the higher mortality and morbidity rate of children with tracheostomy may be reduced with a multidisciplinary TC program, with an improvement in the quality of TC.<sup>21–30</sup> McKeon et al.<sup>24</sup> reported that a multidisciplinary TC program may improve patient safety and quality of care. They also reported that 65.2% of the complications associated with tracheostomy were preventable and therefore suggested investigating measurable pediatric tracheostomy outcome metrics and assessing long-term outcomes.<sup>24</sup> Caloway et al.<sup>30</sup> implemented a family education program on a limited number of neonates' caregivers and observed significantly decreased tracheostomy-related complication scores. In comparison, our study had a larger number of patients and a more homogeneous structure, and we compared the caregiver knowledge levels before, immediately after, and 1 year after the program. Moreover, we demonstrated the effects of standardized education on both subjective and objective outcomes over a 1-year period.

In the United Kingdom, a recent multicentric quality improvement program demonstrated that the most common tracheostomy-related complications were mucus plug (45.1%) and spontaneous decannulation (29.3%) in the pediatric population. They observed significant reductions in severity scores and length of hospital stay.<sup>12</sup> Another study implemented the 'Trach Me Home' protocol for standardized postoperative education of caregivers of children with tracheostomies; the researchers found no difference in 30-day readmissions but tracheostomy-related wound complications significantly decreased.<sup>31</sup> In our study, the most common tracheostomy-related complications were stoma infection (74.2%) and mucus plug (61.3%), the frequencies of which decreased dramatically after the ISPAT project. Consistent with previous studies, we observed a reduction in hospitalizations (from 61.3% to 35.5%), whereas the length of hospital stay was comparable between the pre- and post-training periods.

The most frequently isolated respiratory pathogens in children with tracheostomies were reported to be *Pseudomonas aeruginosa*, *Methicillin-Resistant Staphylococcus Aureus* (MRSA), and *Stenotrophomonas maltophilia*.<sup>32,33</sup> In our study, the most frequently isolated pathogen was *P. aeruginosa*, while MRSA was the least. Another study investigating the impact of hygiene guidelines on MRSA isolation rates during the COVID-19 pandemic, published in 2022, reported a reduction in MRSA infection rates.<sup>34</sup> Although there was an improvement in handwashing before the procedures, there was no change in microorganism diversity in the study.

This study demonstrates the impact of the ISPAT project on clinical outcomes and long-term effects. This is the first study to directly compare caregiver knowledge and clinical outcomes in the year preceding and following a standardized tracheotomy education

program. Our study is also the first to demonstrate objective and measurable long-term clinical outcomes after standardized training with more homogeneous structure. These findings can provide valuable insights into the effectiveness of standardized training programs.

Despite its several strengths, our research has also several limitations. First, the timing of our study was unfortunately influenced by the COVID-19 pandemic. It has been reported that healthcare utilization decreased by about half during the pandemic, especially in the early stages of the pandemic, with a slight increase observed in the mid-pandemic period.<sup>35,36</sup> Therefore, the pandemic reduced the number of hospital admissions and limited caregiver participation, resulting in a smaller study population. Besides reducing the frequency of infections through preventive measures, the pandemic may have influenced the hospitalization rates in our cohort. Second, the duration of tracheostomy in children may vary, and the expected tracheostomy-related complications before and after training may differ because more complications are reported subsequent to tracheostomy insertion, which is why the pre-training complication ratio was high. Additionally, the presence of the COVID-19 pandemic could have reduced this effect and increased post-training complication rates. Third, there is a possibility of recall bias, as some information on tracheostomy-related complications relied on the caregivers' statements. Fourth, the data from the pre-training period were accessed retrospectively, which may have resulted in data loss. Moreover, the absence of mortality rates in the pre-training period limited our ability to establish a relationship with post-training mortality rates. Finally, we did not have an untrained control group. Moreover, the caregivers in our cohort were experienced in TC and may have gained knowledge and skills with each passing day. Despite a full year of experience, however, the 1-year post-training TC knowledge scores were significantly lower than those immediately after training completion, highlighting the necessity of repeating the training at regular intervals—at least annually. Nevertheless, these data will shed light on future larger-scale and longer-term prospective studies, including an untrained control group, are warranted.

## 5 | CONCLUSION

Our findings underscore the importance and applicability of training caregivers through a standardized education program, especially given the reduction in many measurable outcomes of tracheostomy-related complications. Because of the complexity of children with tracheostomies, it is not possible to completely eradicate complications. However, the complication rate can be minimized by the hands-on training of caregivers for children with tracheostomy by specialized healthcare providers. This enables families to solve many problems related to tracheostomy at home, thus decreasing their HC and ED admission rates. Although some scores decreased 1 year after completion of training, the fact that their knowledge and skill levels remained high compared with pretest results indicates the

importance of standardized education to caregivers of children with tracheostomies.

## AUTHOR CONTRIBUTIONS

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All authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

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The author's have nothing to report.

## CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

## DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

## DECLARATION OF INFORMED CONSENT

Written consent was obtained from parents.

This study was presented as an oral presentation at Turkish Thoracic Society 25th Annual Congress in 2022 and was deemed worthy of the 'Pediatric Pulmonary Diseases Study Group Oral Presentation First Award'.

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## SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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