

SIG 3**Research Article**

Patient Education Experience: Adherence to Prescribed Heat and Moisture Exchanger

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ABSTRACT

Purpose: After total laryngectomy, patients lose their natural humidification and heating capacity of the upper airway. Using heat and moisture exchangers (HMEs) with the highest possible humidification has been shown to improve the negative impact of this loss. However, many patients are not adhering to an optimal routine. This pilot aimed to determine whether personalized support and education can support these patients in establishing an optimal HME routine.

Method: Forty-nine patients who currently did not utilize two HMEs per day (hereinafter, “HMEs/day”) enrolled and completed a 30-day pilot program, in which patients utilized two HMEs/day while tracking key respiratory symptoms. Pre- and post-pilot questionnaires, a daily tracking tool, and a wrap-up questionnaire were completed by patients. Information was collected via telephone, e-mail, and/or postal service. One-on-one support was provided by the Atos Medical case management team.

Results: Eighty-eight percent (43) of the patients in the pilot reported a positive change in at least one of the measurable domains. Overall, patients experienced positive changes in the measured domains, which included coughing, ease of breathing, mucus production, hours of sleep, and hours of uninterrupted sleep.

Conclusions: This pilot reinforced the research-based evidence noting that consistent HME use (with highest humidification tolerated) improves respiratory symptoms. Further research is needed in a larger population base; however, this pilot showed promising results for future projects. Additionally, the tailored support provided to patients proved beneficial for patients utilizing two HMEs/day.

Total laryngectomy surgery permanently alters the anatomy and physiology of a person’s upper aerodigestive tract (Andaloro & Widrich, 2025). After surgery, the respiratory and digestive tracts are surgically separated from the upper airway. The trachea is repositioned, and a permanent tracheostoma is created. This causes the person to be a neck breather through the stoma, which eliminates the previous humidification, resistance, warming, and filtering effects provided by the upper airway, leading to unconditioned air reaching the lungs (Scheenstra, Muller, Vincent, Ackerstaff, et al., 2011; Scheenstra, Muller, Vincent, & Hilgers, 2011;

van den Boer et al., 2015). Air that is not properly humidified and warmed has detrimental effects on pulmonary function (Hilgers et al., 1990). Without these protective functions of the upper airway, unconditioned air places patients at high risk for increased mucus production, reduced mucus clearance, and excessive coughing (Hilgers et al., 1990). This could increase the risk of airway infections (van den Boer et al., 2014). To counteract these effects, heat and moisture should be reintroduced to the inhaled air. Heat and moisture exchangers (HMEs) capture warmth and moisture from the patient’s exhaled breath and transfer it into the inhaled air, thereby restoring warmth and moisture to air breathed by total laryngectomy patients (Scheenstra, Muller, Vincent, Ackerstaff, et al., 2011; Scheenstra, Muller, Vincent, & Hilgers, 2011; Zuur et al., 2006). HMEs attach to the stoma using either an intraluminal or a peristomal attachment method. HMEs provide pulmonary benefits by replicating

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the functions of the upper airway/nose—humidifying and warming the air inhaled through the tracheostoma while also providing essential airway resistance. Consistent, daily, 24/7 HME use has been shown to significantly reduce coughing, forced expectoration, and stoma-clearing frequency (Bień et al., 2010; Parrilla et al., 2015). Research indicates that patients should use HMEs continuously, day and night, with the highest level of humidification that they can tolerate (Ward et al., 2023). However, maintaining 24/7 usage can be difficult for various reasons, contributing to poor compliance, a complex and difficult to understand problem in health care (Thummak et al., 2023). Having HMEs with different breathing resistances and access to more than one type of HME helps with increasing adherence (Ward et al., 2023).

Reportedly, there is a wide variation in adherence to utilization of HMEs in the laryngectomy population, with rates ranging from 35% to 77% (Bień et al., 2010; Herranz et al., 2013; Hilgers et al., 1991). In a recent study, 62% of laryngectomy patients do not follow an optimal day and night HME routine, despite evidence supporting the benefits (Ward et al., 2023). HMEs with higher humidification levels can further enhance pulmonary health, even for patients already using HMEs consistently (Ward et al., 2023). However, increased humidification comes with greater breathing resistance (Leemans et al., 2023). Therefore, it is important to have access to multiple HME options, ideally at least two types: to support patient adherence and encourage use of HMEs with highest tolerable humidification levels throughout the day and night (Longobardi et al., 2022; Ward et al., 2023).

The case management (CM) team at Atos Medical provides comprehensive support for laryngectomy patients through advocacy, access, awareness, and adherence. The CM team aimed to determine the barriers to utilization of two HMEs per day (hereinafter, “HMEs/day”) and if one-on-one support and education would assist in the consistent utilization and establishment of a day/night routine. Utilization of two HMEs/day, one during the day and one at night, is a commonly noted routine (Longobardi et al., 2022; Ward et al., 2023). HMEs with a higher degree of humidification are typically well tolerated at night. The “HME Awareness Pilot” described in this article was an educational experience focused on patients who utilized fewer than their prescribed number of HMEs daily (1.9 HMEs or fewer). Therefore, these patients were not meeting the prescribed goal of two HMEs/day to achieve optimal pulmonary health (Ward et al., 2023).

Method

Criteria

Eligibility criteria for the pilot were that patients had to be current clients of Atos Medical who had placed

at least three orders in the past 12 months, Provox Life (PL) users, and patients ordering fewer than 60 HMEs a month despite having an Rx for 60 HMEs per month. PL is a line of HMEs available through Atos Medical. There are six different HMEs in the PL line with differences in levels of breathability/resistance and humidification, along with specialized HMEs for hands-free speaking and HMEs with additional filtering for protection from airborne particles. Only English-speaking patients were included in the pilot. The team estimates that approximately 1,400 Atos Medical patients meet these criteria. We aimed to enroll 50–100 patients. Over 600 patients were contacted, of whom 88 enrolled and 49 completed the program in its entirety. This was designed as an educational activity rather than a research study.

Setup

Atos Medical’s patient database was reviewed to determine who met the inclusion criteria. A minimum of three attempts were made to connect with patients to offer enrollment, which could be completed via phone, e-mail, or both. To begin the pilot, patients signed an agreement form and answered questions that were asked again at the end of the pilot. During discussions with the patient, the CM team provided education on the different HMEs, focusing on optimal humidification and breathability. CM guidance allowed patients to make educated decisions on which HME(s) to utilize during the day based on their lifestyle and activities and which higher humidification HME to utilize at night. Once this educational introduction was complete, the patients were encouraged to start the 30-day tracking period.

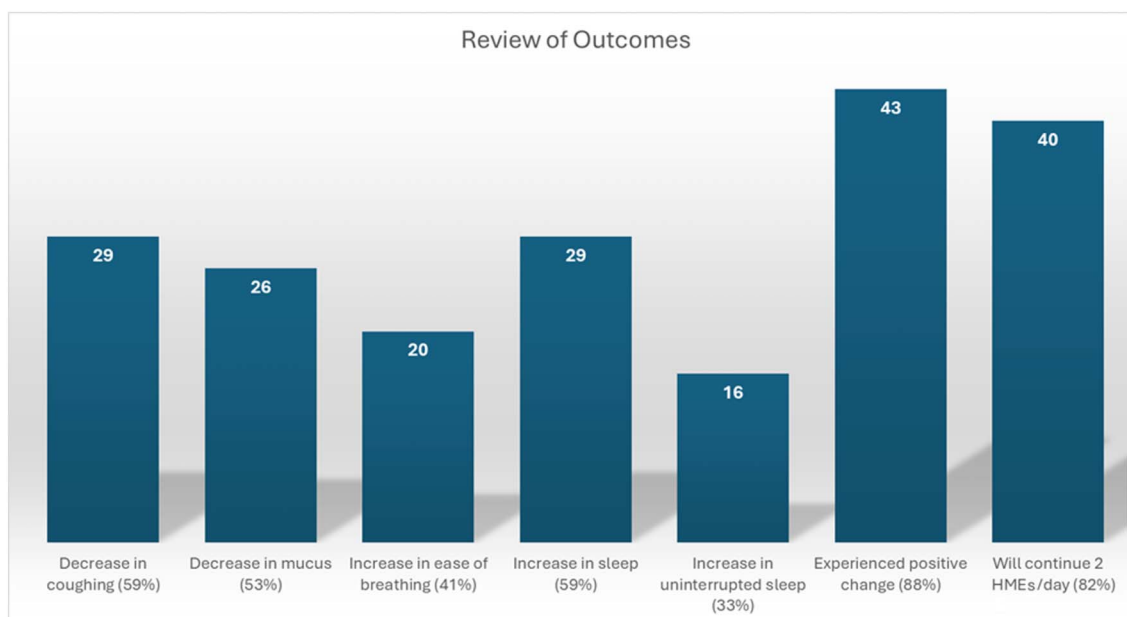
Data Collected

The tracking tool included daytime HME type; coughs; forced expectoration; the number of times the HME was removed to take a deep breath; the number of times the stoma was cleaned; nighttime HME type; hours of sleep at night; hours of sleep without waking up; episodes of nighttime coughing; and the number of times the patient woke up due to shortness of breath, difficulty breathing, mucus, or coughing. When recording the number of coughs, the CM team helped the patients determine the best way to count their coughs. One patient utilized a counter that they slept with under their pillow to count coughs overnight. The CM team called patients to follow up weekly during this period. The phone calls allowed the team to connect one-on-one with patients.

Analysis of Data

Many of the patient calls were a reflection on the previous week and reviewing data. While reflecting on the

Figure 1. This figure reviews the key outcomes measured by the pilot program. The percentages are the percentage of patients who experienced the listed change, whereas the numbers in the blue bars are the actual number of patients who experienced the listed change. Only patients who completed the entire pilot program were included in this figure. HMEs = heat and moisture exchangers.



week, new habits that the patients were creating were discussed, such as getting into a routine of changing their HME. The calls also involved active listening by the CM team, with reflections on previous patient comments in comparison to more recent comments. Building personal connections helped the CM team to tailor education to each patient, incorporating their individual goals while emphasizing the importance of using two HMEs/day with them. Some patients preferred not to fill out the tracking tool and simply complete the pre- and post-pilot questionnaires but still communicated with the CM team weekly. After the 30-day tracking period, patients completed a post-pilot questionnaire that had identical questions as the pre-pilot or baseline questionnaire for direct comparison. An additional questionnaire consisted of a 5-point Likert scale to measure patients' opinions about changes in their respiratory health after the pilot. The scale ranged from *much more coughing* (or other more appropriate variable, e.g., mucus, shortness of breath) to *much less coughing*. Some patients requested to continue the personalized education after the pilot. Through discussions and a review of tracking data, the CM team was able to pinpoint specific areas where additional education may have benefited the patient.

Results

A total of 605 patients were contacted for enrollment in the pilot. Of these, 331 did not respond to outreach

efforts. Ultimately, 274 patients were successfully reached via phone and e-mail. Among those, 88 enrolled in the pilot, and 49 completed the pilot. Participants were located across the United States. The pilot ran from July 2, 2024, to January 10, 2025.

Patients reported many reasons for not utilizing two HMEs/day during initial calls. Reasons included lack of knowledge of HMEs, not having an established routine of use, and financial concerns (both insurance and out-of-pocket costs).

After the pilot was completed, 82% (40) of patients reported that they would continue to utilize two HMEs/day as routine. Patients shared that the reason for continuing was largely due to reduction in troublesome symptoms, such as less coughing and less mucus production. The most frequently mentioned reason for continuing 24/7 HME use was the reduction in coughing both on the wrap-up questionnaire and through their tracking data. Fifty-nine percent (29) of patients reported an improvement in coughing. Fifty-three percent (26) of patients reported decreased mucus production (measured by forcible coughs, patient reports, and the wrap-up questionnaire). Forty-one percent (20) of patients reported improvement in ease of breathing through the HME. Patients' experience with ease of breathing was extracted from the post-pilot questionnaire. Hours of sleep at night increased in 59% (29) of patients. Thirty-three percent (16)

Table 1. Data review.

Variable	Total "Yes"	<i>M</i>	<i>SD</i>	Sample size	Lower bound of 95% confidence interval for the mean	Upper bound of 95% confidence interval for the mean
Coughing	29	59%	50%	49	45%	73%
Mucus	26	53%	50%	49	39%	67%
Ease of breathing	20	41%	50%	49	27%	55%
Sleep	29	59%	50%	49	45%	73%
Uninterrupted sleep	16	33%	47%	49	20%	46%
Continue two HMEs/day	40	82%	39%	49	71%	92%
Any positive change	43	88%	33%	49	79%	97%

Note. Confidence intervals were calculated using the Wald approximation and a two-sided critical value of 1.96 (assumes a normal distribution). HMEs = heat and moisture exchangers.

reported improvement in the length of time spent asleep, specifically how long patients were able to sleep without waking up. Sleep was not only largely measured by hours of sleep on the patient tracker but also directly asked on the post-pilot questionnaire. Whereas some patients recorded the exact number of hours they slept, others provided generalizations on their tracking sheets, for example, noting “only a couple” or “many” nighttime awakenings. Through follow-up discussions, the team was able to clarify these responses and determine whether meaningful improvements had occurred. Overall, 88% (43) of patients reported improvement in at least one domain (cough, mucus, sleep) during the pilot (see Figure 1).

Discussion

The benefits of humidifying, warming, and filtering the air we breathe are vast and variable. Laryngectomy patients lose this natural function of the upper airway after surgery. Utilization of HMEs restores humidification and warms the air laryngectomy patients breathe. Despite HME availability and well-established benefits, some patients do not utilize HMEs after a laryngectomy. Research indicates that utilizing an optimal day and night HME regimen offers numerous benefits for laryngectomy patients (Longobardi et al., 2022; Ward et al., 2023). This pilot is an example of the benefits of personalized education and support that can help patients adopt an optimal day and night regimen and result in improved patient outcomes.

Working with patients in creating a day/night routine was a large part of the pilot. The connection made between the patients and the team was mutually beneficial not only for the patient but also for the team. Learning the common concerns and questions made it easier for the team to anticipate these concerns and address them as early as possible. Through these interactions, the team gained valuable insights into common patient concerns

and frequently asked questions, enabling more proactive and tailored support throughout the pilot. Many patients often struggle to correctly retain all the information provided during medical visits, as reflected in their comments and understanding of HMEs. This highlights the importance of reinforcing education through repetition. Patients shared that they were unaware they needed to replace the HME within a 24-hr period. Whereas some patients were using a single HME for an entire day, others were extending the use of a single HME over multiple days by saving and reusing for a total of 24 hr of use. This practice is inconsistent with the PL HME’s “Instruction for Use.” Specifically, patients shared that “I was told to change my HME 1×/day ...” and “(my parent) was told she could wear an HME for multiple days.” Some patients had never tried a higher humidification HME at night and were unaware of the potential benefits (as shown in the literature) in pulmonary symptoms (Longobardi et al., 2022; Ward et al., 2023). Patients shared that they did not choose to wear a different HME because “I get lazy,” “Doesn’t make a difference” or cited the expense of two HMEs/day. Insurance concerns were a large barrier in patients being able to utilize two HMEs/day, often related to co-pays or lack of coverage of supplies. In these cases, the patients were referred to Atos Medical client navigators for help working directly with their insurance to appeal for additional HME coverage.

The clinical navigators who conducted the surveys and provided weekly support have direct patient care experience as a nurse/nurse practitioner and speech pathologist. Conversations at the onset included general information on HMEs, including how they function, how long they are to be worn, and that they are not to be saved and reused after a 24-hr period. Education was provided on the differences in the various HMEs and the rationale for wearing a higher humidification HME at night. Participants were asked what they wanted to achieve by participating so future discussion could be tailored toward this goal.

During the tracking period, individual concerns were addressed. For example, if a person reported struggles at the onset of the pilot, their difficulties adjusting to a new routine were acknowledged, and discussions were had up front about the fact that some people will initially note increased mucus, which can make the new routine difficult. The adaptation period when HMEs are introduced are described in the literature. Mérol et al. (2012) demonstrated significant improvements in pulmonary symptoms and quality of life with HME use following total laryngectomy, and subsequent studies emphasize that pulmonary rehabilitation with HMEs is a gradual adaptive process. During the initial period of HME use, patients may experience variable respiratory symptoms reflecting physiologic adjustment to airway humidification. This early transition phase to HME use highlights the importance of timely follow-up, individualized counseling, and expectation setting to support adherence and the successful integration of HME use into daily routines (Ackerstaff et al., 2003; Parrilla et al., 2015). Tracking data were obtained, and changes in the numbers they recorded from week to week were discussed (see Figure 2 for a blank weekly tracker). Open-ended questions were utilized to encourage free flow of information: “How are you adjusting to the new routine?” “What if any changes have you noticed over the past week?” or “Is there anything else you want to discuss?” As people adjusted to their new routine and became comfortable, they often led the conversations and provided information without being asked formal questions.

The results seen in this pilot were in line with results in current literature. Patients who shared that they would continue to utilize two HMEs/day noted they would do so because of improvements in their troublesome respiratory symptoms. Almost 90% of those who completed the pilot saw at least one of the following improvements: reduction in coughing, reduction in mucus production, and improvement in sleep (see Table 1). These findings have previously been noted in the literature (Bieñ et al., 2010; Longobardi et al., 2022; Parrilla et al., 2015; Ward et al., 2023). Prior to the pilot, patients identified coughing and mucus production as major concerns. Over half of the patients in the pilot experienced improvement in at least one of these areas. This aligns with recent studies showing that switching to a higher humidification HME and implementing a day/night routine have been reported to significantly improve pulmonary outcomes (Longobardi et al., 2022; Ward et al., 2023). These pilot results aligned with decreased coughing episodes after 30 days of adhering to using two HMEs/day, consistent with these studies. It is known from the literature that patients have trouble sleeping after a laryngectomy and that using an HME has been shown to be associated with better sleep (Parrilla et al., 2015). Our results showed that sleep was troublesome for

patients as well, in terms of both the total time spent asleep and uninterrupted sleep. Sleep disturbances were reported as well, including reduced total sleep duration and sleep interruptions throughout the night. The improvement seen in both total time and uninterrupted length of time was a big benefit for patients. An additional study has shown that using a day and night regimen of the highest humidification HME improved sleep significantly (Ward et al., 2023). Ward et al. (2023) demonstrated that transitioning to PL HMEs resulted in improvements in sleep quality and a reduction of cough symptoms among patients who had previously been using two HMEs/day but not PL HMEs. Ease of breathing through the HME was also measured, as reported in patient narratives. Some patients reported an increase in ease of breathing, which is likely attributed to acclimation to wearing an HME, decreased mucus, and decreased coughing. As many patients experienced improvements with a consistent HME routine, the majority expressed their intention to continue the regimen to maintain those benefits. After the pilot was completed, the Atos Medical CM team remained in contact with many patients per their request, who then continued to share their positive results and noted their continued utilization of two HMEs/day.

Consistent themes were revealed across the measured domains. A sampling of patient quotes can be found in Table 2. One domain was not directly measured; however, improvement in quality of life was reported by many patients. One patient shared her goal with the team at the beginning of the pilot: taking a walk. She felt uncomfortable walking due to her need for frequent suctioning. After taking part in the HME Awareness Pilot, using two HMEs/day, she reported feeling comfortable taking a walk without her portable suction. At the beginning of the pilot, 42 participants set a personal goal. Thirty-eight (90%) of those who set a goal reported achieving their goal at the end of the pilot. These stories of success reinforced the value of routine for the team and improvements in the patient's quality of life—an additional benefit.

Personalization of the education provided was also a benefit for patients. By understanding the patients on a deeper level, the team was able to tailor information about routines and available options, incorporating patient input to ensure relevance and effectiveness. This close connection between the team and the patient encouraged patients to ask about other facets of their care and inquire about other options available to them. The team shared information with the patient and collaborated with the patient's health care provider as able. The benefits of providing patient-centered care cannot be overstated.

There were some limitations in discussing the outcomes of the pilot. Because this initiative was designed as an educational activity rather than a research study, data

Figure 2. Blank biweekly planner. Copyright © 2024 Atos Medical, Inc. Reprinted with permission. HME = heat and moisture exchanger.

HME Awareness Pilot

Monthly Tracking Form

DAYTIME						NIGHTTIME				
DATE	Type of HME: _____					Type of HME: _____				
	RECORD NUMBER OF EACH					RECORD NUMBER OF EACH				
	Hours wearing an HME during the day	Coughs per day	Forced coughs to clear mucus	Times removed HME to take a deep breath or breathe easier	Times cleaned your stoma	Hours wearing an HME at night	Hours of sleep at night	Hours of sleep without waking up at night	Coughs at night	Times woke up due to shortness of breath, difficulty breathing, mucus, or coughing
WEEK 1										
WEEK 2										
WEEK 3										
WEEK 4										

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Table 2. Patient comments.

Theme	Comment
Sleep	"It is a major difference when you use the nighttime HME every night."
Coughing	"(After utilizing two HMEs/day) For the first time I was able to go to a family event with confidence I wouldn't be coughing constantly and having to clean my stoma."
Mucus	"It reduced the amount of coughing up mucus and not having to constantly clean my TEP."
Quality of life	"Yes (improved my quality of life), because it really does make a difference using the different HMEs at the appropriate times."
Education	"It (the pilot) encouraged me to use appropriate HMEs and change them regularly. It (the pilot) also made me aware of the number of times per day that I clear mucus. It has created the habit of proper use."

Note. These patient experiences may not be representative of all patient outcomes. Each person's situation is unique, and risks, outcomes, experiences, and results may vary. HME(s) = heat and moisture exchanger(s).

collected were intended to inform quality improvement rather than to support formal statistical analysis. Additionally, the inability to reach 1,400 patients who would have qualified for inclusion in the pilot proved challenging. Despite multiple attempts with various methods of communication, being able to connect proved difficult. With future efforts, we aim to inform patients about the opportunity to receive education prior to direct outreach from our team.

A total laryngectomy has an incredible impact on a patient's life. It not only alters their breathing anatomy and physiology but also impacts their swallowing, sense of smell and taste, appearance, and method of communication (Bickford et al., 2018). While patients have a strong multidisciplinary team, particularly prior to surgery, ongoing support has not been well analyzed (Bickford et al., 2018). Patients have reported that they feel more supported when the care they receive is flexible and responsive (Bickford et al., 2018). These are two advantages provided by this pilot. Being knowledgeable about what the patient has and continues to go through as well as being able to demonstrate an understanding of this patient need were key to this pilot. As members of the team have a clinical background, being able to understand the patient's experience is of utmost importance in building trust.

Conclusions

The pilot demonstrated positive outcomes from providing tailored patient education and the effects of patient use 24/7 of two HMEs/day, particularly with reduced coughing, less mucus production, and improved sleep quality. Additionally, the individualized support provided by the CM team was well received by patients, reinforcing the value of establishing a routine through personalized support and education. In the future, additional opportunities are available for research into the benefits of using two HMEs/day.

This pilot demonstrates the need for ongoing, personalized patient education. As a result, Atos Medical plans to transition the pilot into a permanent offering, namely, the HME Awareness Program. We will receive direct referrals to the program from clinicians and offer patients the opportunity to self-enroll. We will continue the educational and tracking components of the program moving forward, focusing on helping patients establish and maintain a day/night routine of situational HME use to optimize their pulmonary health. The goal of the program remains to educate and support laryngectomy patients.

Ethics Statement

Atos Medical Inc's HME Pilot Program ("Pilot Program") does not constitute a research project that meets the regulatory definition of human subjects research and, therefore, is not subject to the requirement of review and approval by an institutional review board (IRB). The Pilot Program qualifies for an IRB exemption because its design and implementation are solely for educational purposes.

Data Availability Statement

The data sets generated and/or analyzed during the current pilot are not publicly available due to private client data from Atos Medical Inc.

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