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Application of Artificial Intelligence Software to Identify Emotions of Lung Cancer Patients in Preoperative Health Education: A Cross-Sectional Study

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ABSTRACT

Aim(s): To determine the correlation between preoperative health education and the emotions of lung cancer patients, artificial intelligence software was used.

Design: This was a cross-sectional study.

Methods: This study included 210 lung cancer patients from Sun Yat-sen University Cancer Center and examined the impact of health education on patient emotions using an AI-based emotion analysis tool.

Results: This study indicated a significant relationship between the tone and emotional content of health education materials and patient emotions. Specifically, educational materials with an explanatory tone and negative sentiment appeared to impact patients' emotional states.

Conclusion: Quality improvements in health education can potentially benefit lung cancer patients' emotional well-being by minimizing the use of both explanatory tone and negative sentiment in educational content.

Implications for the Profession and/or Patient Care: This research suggests that the careful crafting of health education materials, taking into consideration tone and emotional expressions, can have a tangible positive effect on the emotional state of lung cancer patients.

Reporting Method: The study was reported in accordance with the STROBE guidelines.

Patient or Public Contribution: No patients, service users, caregivers, or members of the public were involved in the design, conduct, collection, analysis, or interpretation of the data for this study, nor were they involved in writing the manuscript.

1 | Introduction

Lung cancer has become the second most commonly diagnosed cancer and the leading cause of cancer-associated mortalities. According to 2020 cancer statistics, there were 2.20 million new cases of lung cancer, accounting for approximately 11.4% of all new cancer cases. There are almost 1.8 million lung cancer deaths, representing 18.0% of deaths from other types of

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cancer (Sung et al. 2021). The morbidity and mortality of lung cancer are also the highest in China, posing grave threats to human health (Cao et al. 2020; He et al. 2021). Quality of life, as the most significant health issue for lung cancer patients, is closely correlated with emotional disorders (Clark et al. 2013; Koczywas et al. 2013). Emotional disorders appear as a reflection at diagnosis and persist throughout the treatment of lung cancer (Signorelli et al. 2020).

Health education, for the purpose of health promotion, improved quality of life, and elimination of emotional disorders, includes the dissemination of scientific and systematic educational content, the organization of educational activities, and outcome evaluation (Zodpey et al. 2018; Cetkin and Tuna 2019; Sun et al. 2021). With the annual increase in the incidence of lung cancer worldwide and the widespread application of minimally invasive surgery, health education has become the focus of preventing postoperative complications and improving patient prognosis (Nakamura et al. 2014; Cao et al. 2020). Currently, there are no uniform evidence-based guidelines for preoperative health education for lung cancer patients around the world. However, numerous studies have illustrated and compared the significance of different modes and forms involved in health education, ignoring health education content as the basis and lacking in-depth study (Huang et al. 2019; Green et al. 2020).

Based on a synthesis of prior experiences in Chinese hospitals, health education can be categorized into three dimensions: content, tone, and emotion. When examining the learning outcomes of lung cancer patients undergoing health education, it is imperative to consider situational factors. Health communication, viewed as a form of nurses' linguistic expression, is an important situational factor (Nantsupawat et al. 2020; Gerchow et al. 2021).

Currently, there is a widespread consensus regarding the importance of health education. Health education plays a crucial role in cancer prevention by enhancing public understanding of the risk factors associated with cancers and early screening methods, thereby facilitating the adoption of preventive actions (Poudel et al. 2021; Lobato-Delgado et al. 2022). Health education can also promote healthy behavior changes, such as assisting lung cancer patients in quitting smoking and guiding them through respiratory function training (Zeng et al. 2024). It can also contribute to health equity by providing health knowledge to a higher number of underserved cancer patients and mitigating health disparities (Ciria-Suarez et al. 2022). In addition, health education can strengthen the communication between nurses and patients, enabling patients to better understand their conditions and treatment plans. This fosters greater proactiveness in treatment adherence and collaboration with healthcare providers, ultimately improving medical experiences and health outcomes (Yang et al. 2022; Yusefi et al. 2022). However, the quality improvement of health education is still in the exploratory stage.

Studies have shown that the populations of students with different emotional states have different learning effects (Roberson and Davidoff 2000). Facial expression is a nonverbal format of expression and communication that can transmit the most emotionally relevant information (Egger et al. 2019; Küntzler et al. 2021). Understanding patients' emotional responses during health education sessions allows for more personalized and effective communication. By recognizing emotions, healthcare providers can adjust their educational strategies to better meet the emotional needs of their patients (Burgess et al. 2023).

Artificial intelligence (AI) serves as the core technology that enables automated emotion recognition (Vistorte et al. 2024). It processes visual data (facial expressions) and converts it into quantifiable emotional metrics. The FaceReader software, powered by AI, is responsible for this recognition. FaceReader is an AI software for facial expression recognition that accurately identifies not only six basic emotions (i.e., joy, anger, sadness, disgust, fear, and surprise) but also neutral emotions. It also analyzes facial expressions in real time or from recorded videos to determine the presence and intensity of specific emotions (Martin et al. 2024).

The primary advantage of FaceReader software over manual coding by humans is its reliance on consistent, algorithm-based rules. This ensures that the analysis is free from personal bias, as well as errors caused by fatigue or lapses in attention. Consequently, FaceReader can be regarded as relatively accurate (Yu and KO 2017). Currently, various datasets have been tested using FaceReader, achieving a success rate of facial expression between 80% and 90% (Skiendziel et al. 2019; Landmann 2023; Zhu et al. 2024).

Nowadays, FaceReader has been confirmed to be reliable and valid for both students at school and other populations of learners outside of school (Van Kuilenburg et al. 2005; Den Uyl and Van Kuilenburg 2005; Lewinski et al. 2014; Boonipat et al. 2021). At the same time, there is currently no evidence to suggest that facial expression in lung cancer patients significantly differs from that of nonpatients.

Based on clinical experience, the emotions of lung cancer patients when receiving health education may affect education outcomes. However, there is a notable absence of empirical evidence detailing the correlation between patients' emotions and health education. In light of this, we hypothesized that a positive relationship would be found between emotions and health education, such that the more positive the patient emotion state is, the more effective the health education will be. The purpose of this study was to investigate the correlation between health education and preoperative patients' emotions with the aid of the FaceReader.

2 | Materials and Methods

2.1 | Study Design

This was a cross-sectional study in which patients who underwent radical surgery for lung cancer were identified from a 3-A-class hospital located in Guangzhou, China.

2.2 | Ethical Approval

During the study design phase, research team members submitted a comprehensive research proposal to the Ethics Committee.

The proposal detailed the study objectives, methodology, participant recruitment strategies, data collection, and analysis plans, as well as measures to ensure participant privacy and confidentiality. The Ethics Committee conducted a thorough review to ensure that the study adhered to ethical standards, with particular emphasis on safeguarding participants' rights and privacy. All participants were informed of the study's purpose, procedures, potential risks, and benefits, and provided written informed consent. Throughout the study, research team members adhered to the Ethics Committee's guidelines to ensure ethical data collection and processing.

This study was approved by the Ethics Committee of the Sun Yat-sen University Cancer Center (Approval Number: B2021-151-01; Date of Approval: June 28, 2021). All participants participated voluntarily and signed consent forms in person. This study followed the STROBE statement guidelines for cross-sectional studies (https://www.equator-network.org/reporting-guidelines/strobe/).

2.3 | Participants

Eligible patients were aged 18–70 years, presented with a single peripherally shaped nodule or mass on one side lobe from imaging findings, did not receive previous chemotherapy or radiotherapy, were expected to undergo thoracoscopic lobectomy, and voluntarily signed informed consent.

Patients were not included if they were diagnosed with abnormal renal, hepatic, cardiac, or pulmonary functions; had facial palsy; or had language comprehension impairment.

2.4 | Sample Size

This study used the "pwr" package in R to conduct the power analysis. In this analysis, we set the significance level (sig.level) to 0.05 and the power to 0.8. The expected correlation coefficients (r) were set to 0.2, 0.3, and 0.5, respectively. The calculated required sample sizes were 193, 84, and 28. A total of 210 subjects were available for the final analyses.

2.5 | Data Collection

This study was conducted between July 2021 and December 2021.

2.5.1 | Patient Characteristics

Demographic, disease-associated, and disease-specific data, which consisted of age, sex, occupation, lifestyle habits such as exercising, eating, smoking and alcohol, educational status, past medical history such as hypertension and diabetes, household economic status, and staging of lung cancer, were collected by investigators.

2.5.2 | Health Education

The health education objectives were divided into six parts based on health education purposes, including preoperative preparation, cooperation on the day of surgery, postoperative attention to drainage tubes, postoperative pulmonary rehabilitation, postoperative exercise rehabilitation, and postoperative diet arrangement. The analytical framework of health education in this study was based on three dimensions specified in the codebook: content, tone, and emotion.

The tone of health education included questions, requests and explanations, whereas the content of health education in the codebook included informative and perceptual vocabulary, and the emotions of health education were divided into positive and negative emotions.

The scientific and objective codebook was compiled by educators and domain experts with rich experience in content, emotion, and tone analysis. Following the compilation of the codebook, this study segmented the content of health education into individual sentences and then applied the jieba package, a Python software package for word segmentation. Based on the codebook labels, the percentage of vocabulary in the content, tone, and emotion of each sentence could be calculated, from which the number of vocabularies in those three aspects from the six different parts of health education could be obtained.

2.5.3 | Emotion

In this study, patients were video recorded by a device-DJI Pocket 2 (DJI, China) throughout the entire health education session. FaceReader, an AI emotion recognition software based on a facial emotion recognition algorithm, can convert video content into the arousal probability of six basic emotions and neutral emotions and then output them in .txt format. Researchers uploaded txt format files using R software and conducted the statistical analysis. The reliability and validity of FaceReader were assessed, with 89% accuracy for facial emotion recognition (Van Kuilenburg et al. 2005; Den Uyl and Van Kuilenburg 2005; Lewinski et al. 2014).

2.6 | Research Methods

The trained educators were five senior nurses with extensive clinical experience from the Sun Yat-sen University Cancer Center. Investigators informed lung cancer patients of the purpose and significance of the study at admission and collected demographic, disease-associated, and disease-specific data from the patients after they signed the informed consent. Once the dates of surgery were determined, the educators provided perioperative health education for the lung cancer patients in the learning room. Then, the investigators calculated the percentage of vocabulary in content, tone and emotion aspects in every sentence and the number of vocabularies in each of the three aspects in the six parts based on the codebook. The recording of patients' facial emotions during health education by the DJI Pocket 2 device was returned to the Social Science Investigation Center of Sun Yat-sen University to analyze patients' emotions using FaceReader software. Data entry was completed within 2 weeks after data collection by two independent investigators.

2.7 | Statistics

Empower (R) software and R software were used for statistical analysis, and the comparison of measurement data is expressed as the mean ± standard deviation (SD). Missing data were handled by mean imputation. We construct a multilevel random intercept model. The first level consists of preoperative education sentences, whereas the second level includes random intercepts at the individual level. This approach allows us to account for variability at the individual level by incorporating random intercepts across multiple levels. The random intercept model can be represented by the following equation:

$$\text{Emotion}_{ij} = \beta_0 + \beta_1 X_{ij} + u_j + \epsilon_{ij}$$

where, Emotion_{ij} is the emotion level of patient j as influenced by sentence i, X_{ij} represents the attributes of the preoperative education sentences, β_0 is the fixed intercept, β_1 is the regression coefficient for the sentence attributes, u_j is the random intercept at the individual (patient) level, and ϵ_{ij} is the residual error at the sentence level.

3 | Results

Among the 210 patients with lung cancer, 46.4% were male and 53.1% were female (53.1%), with an average age of 54.78 ± 10.56 years. A total of 20.9% of patients had tertiary (university) qualifications, and the remaining 79.1% of patients had a junior college education or below. There was no significant difference in any of the patients' characteristics ($p > 0.05$).

Figure 1 illustrates the distribution of vocabulary content in health education. The proportion of informative vocabulary in preoperative health education content surpassed that of perceptual vocabulary, accounting for approximately 20% of the whole content. Among them, the content of informative vocabulary in the first part (preoperative preparation) reached the highest proportion, nearly 25%. In contrast, perceptual vocabulary consistently maintained the lowest percentage, registering at less than 1% across the overall content.

Across all parts of preoperative health education, the proportion of negative vocabulary exceeded that of positive vocabulary, especially in terms of postoperative attention to drainage tubes and postoperative exercise rehabilitation (approximately 4%). Conversely, for cooperation on the day of surgery, the proportion of positive vocabulary (approximately 1%) surpassed that of negative vocabulary. Figure 2 depicts the distribution of emotional vocabulary content in health education.

The proportion of patients with a questioning tone greater than 4% was the highest, especially in the preoperative preparation and postoperative diet arrangement groups (6.26% and 5.63%, respectively). Except for postoperative exercise rehabilitation, the proportion of explanatory tone vocabulary remained below 2%, trailing behind both questioning and requesting tone vocabulary. The proportion of questions about tone vocabulary in the preoperative preparation and postoperative attention of drainage tube parts was greater than that in any other part of health education, accounting for 2.99% and 1.99%, respectively. Figure 3 provides an overview of the distribution of vocabulary content according to the tone of health education.

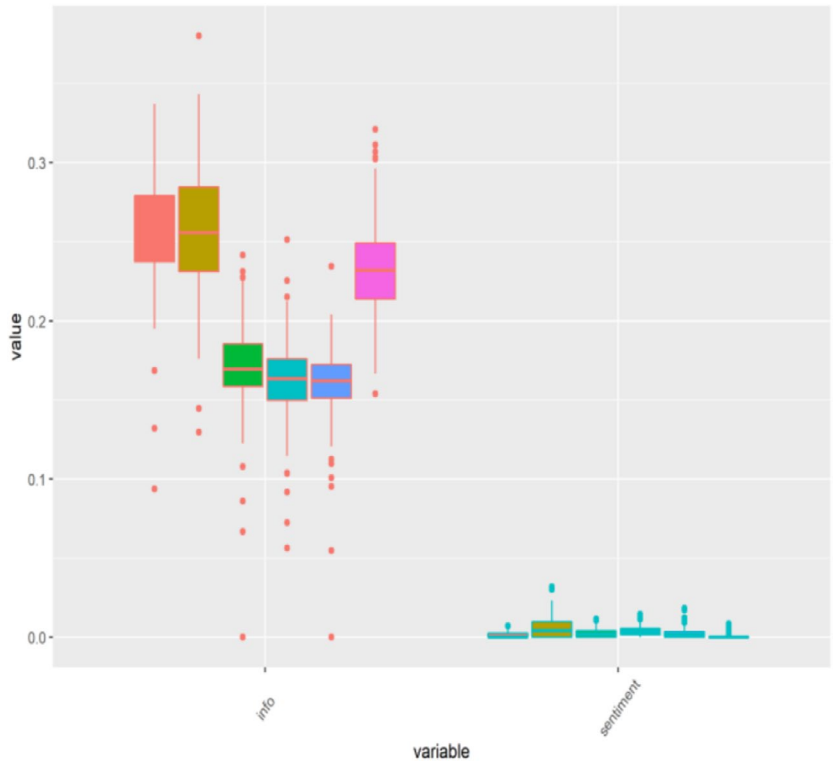

FIGURE 1 | Proportion of vocabulary content in the six parts of health education.

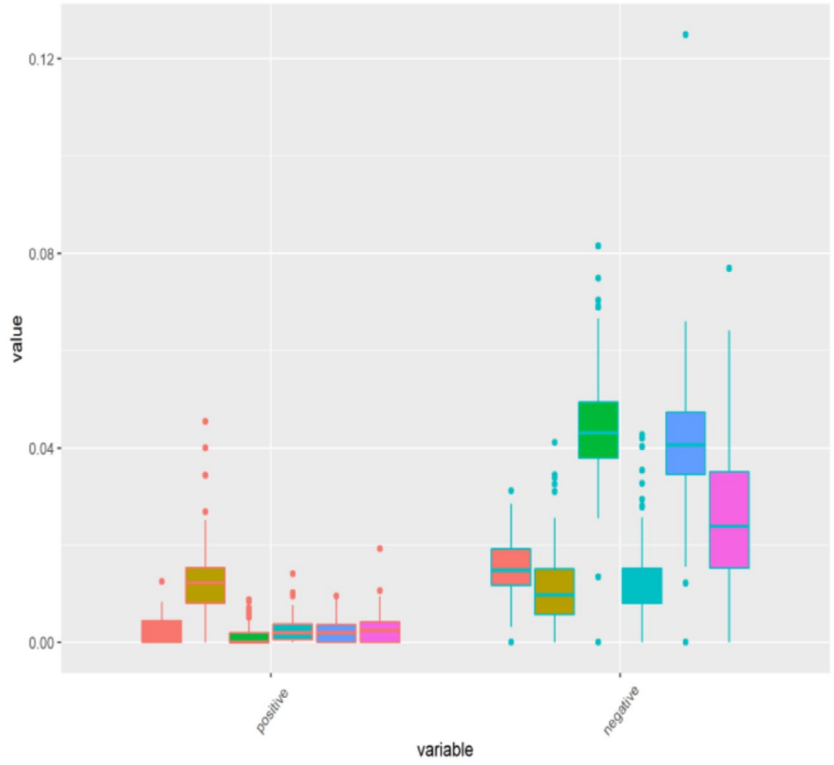

FIGURE 2 | Proportion of emotional vocabulary content in the six parts of health education.

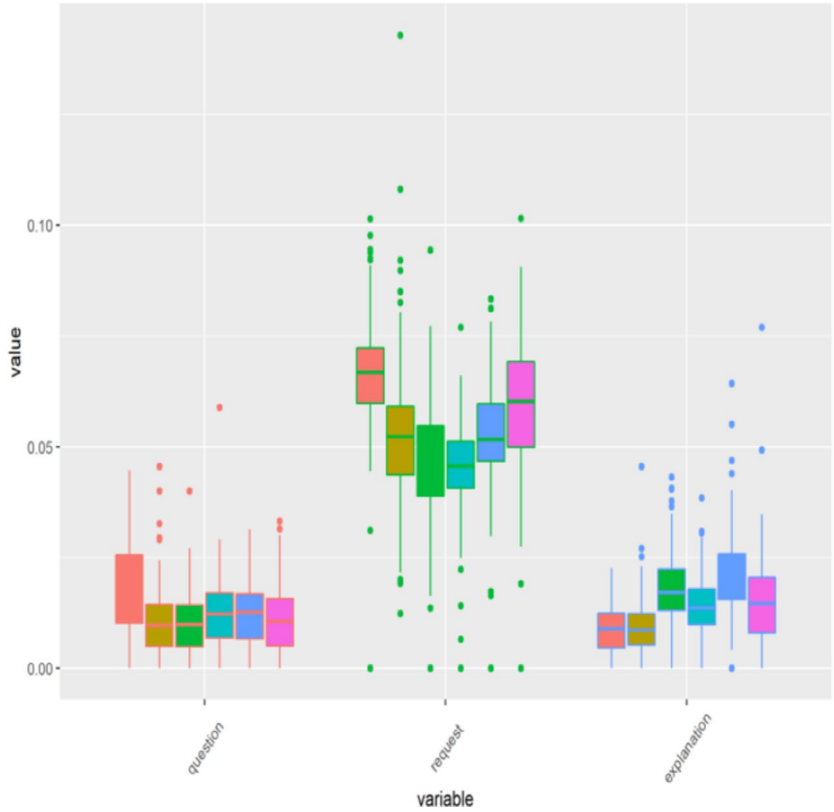

FIGURE 3 | Proportion of vocabulary in tone of the six parts of health education.

In this study, the recording durations of 210 patients who received preoperative health education were 56 h, 42 min, and 42 s, and the frame rate was 29.97 frames per second (fps), in which the number of effective identified frames (5,666,376 fps) accounted for 92.6% of the total number of video frames (6,118,735 fps). Emotional arousal may affect the memory of peripheral

TABLE 1 | Proportion of patients' emotions in the whole recording.

Emotions	Frames (fps)	Proportion (%)
Anger	118,389	2.09
Disgust	1221	0.02
Fear	100,031	1.77
Joy	78,233	1.38
Neutral	4,548,373	80.27
Sadness	635,159	11.21
Surprise	184,980	3.26
Total	5,666,376	100

Note: fps indicates frames per second.

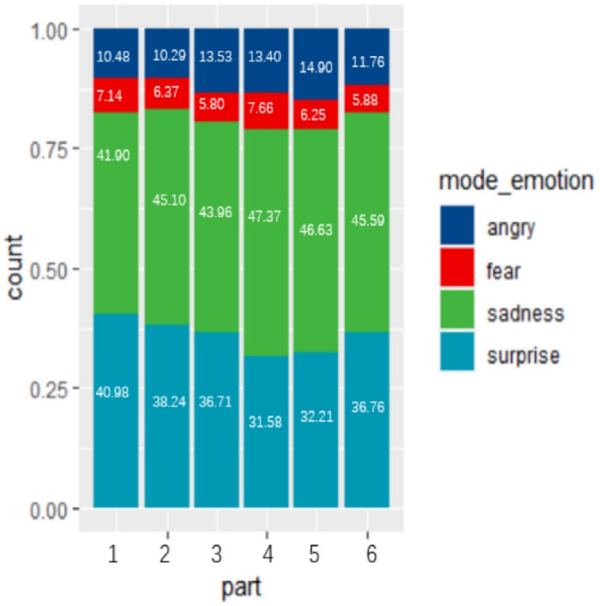

FIGURE 4 | Distribution of predominant emotion arousals in the six parts of health education. Part 1, preoperative preparation; part 2, cooperation on the day of surgery; part 3, postoperative attention to the drainage tube; part 4, postoperative pulmonary rehabilitation; part 5, postoperative exercise rehabilitation; and part 6, postoperative diet arrangement.

neutral information (Kensinger 2009). By calculating the maximum emotion arousal by each frame, the results presented in Table 1 indicate that neutral emotions predominated, constituting 79.51% of the total, followed by sadness, surprise, anger, and fear, which accounted for 11.21%, 3.26%, 2.09%, and 1.77%, respectively.

Learners' facial expression activities can evoke specific emotions (Yang et al. 2018). The distribution of the four predominant emotion arousals in each part is presented in Figure 4. In general, sadness emerged as the most predominant emotion of lung cancer patients, followed by anger, surprise, and fear. Overall, 14.90% of the patients in the postoperative exercise rehabilitation group expressed anger, and 41.90% of the patients in the preoperative exercise group were surprised. Fear was most prominently expressed in the preoperative preparations (7.14%) and postoperative pulmonary rehabilitation sections (7.66%).

Table 2 shows the influence of content, emotion, and tone vocabulary of health education on lung cancer patients' emotions by splitting the preoperative health education text into individual sentences, and the dependent variable was emotional arousal in each sentence. As shown in Table 2, the content of health education had no significant impact on overall emotional arousal, whereas the cause-in tone of health education had a significant negative impact on emotional arousal ($r = -0.038$, $p < 0.01$), which means that the questioning tone decreased the explanatory emotions of lung cancer patients. This suggests that lung cancer patients may experience less emotional arousal in response to a less directive or more uncertain communication style. Concerning the emotions conveyed by educators, positive emotion vocabulary had no significant effect, whereas negative emotion had a significant negative effect on emotional arousal ($r = -0.050$, $p < 0.001$), suggesting that the negative emotions of educators decreased patients' negative emotions. This result implies that negative emotions expressed by educators corresponded with a decrease in patients' negative emotional responses, possibly reflecting a form of emotional regulation or desensitization.

The random-effects parameters from the multilevel random intercept model indicate substantial variability at the individual level. The estimated variance for the intercept at the group level is 0.166, suggesting that individual differences account for a considerable portion of the variation in emotional arousal. The residual variance at the sentence level is 0.141, reflecting within-individual variability in response to different preoperative education sentences. The intraclass correlation coefficient (ICC) is 0.541, indicating that approximately 54.1% of the total variance in emotional arousal can be attributed to differences between individuals, whereas the remaining variance is because of sentence-level factors.

From the perspective of the specific emotions of lung cancer patients, we could see how the content, emotion and tone vocabulary of health education affect emotional arousal (Table 3). Informative vocabulary ($r = -0.014$, $p < 0.01$), perceptual vocabulary ($r = -0.071$, $p < 0.05$), questioning tone ($r = -0.030$, $p < 0.01$), explanatory tone ($r = 0.043$, $p < 0.01$), negative emotion ($r = 0.028$, $p < 0.05$), and positive emotion ($r = 0.084$, $p < 0.05$) all exhibited significant effects on sadness emotion arousal. These findings suggest that specific types of vocabulary and tone can meaningfully alter patients' emotional states, particularly in relation to sadness. Even subtle changes in communication style can influence emotional responses in a clinical setting. Among the influencing factors of anger emotion arousal, informative vocabulary ($r = -0.007$, $p < 0.01$), questioning tone ($r = -0.011$, $p < 0.05$), and negative emotion ($r = 0.016$, $p < 0.001$) exerted significant influences. These findings highlight the potential for certain types of vocabulary and tone to either alleviate or exacerbate patients' anger in response to health education. Factors influencing surprise emotion arousal included informative vocabulary ($r = -0.011$, $p < 0.001$), perceptual vocabulary ($r = 0.081$, $p < 0.01$), and negative emotion ($r = -0.027$, $p < 0.001$), further supporting the idea that vocabulary choice and emotional tone

TABLE 2 | Prediction of the emotional polarity of patients by a multilevel random intercept model.

Vocabulary	Contents	Tone	Emotion
Intercept	−0.183 (0.012)***	−0.182 (0.012)***	−0.181 (0.011)***
95% CI	[−0.206, −0.161]	[−0.204, −0.159]	[−0.203, −0.158]
Informative content	0.005 (0.004)		
95% CI	[−0.003, 0.014]		
Perceptual contents	0.012 (0.031)		
95% CI	[−0.049, 0.072]		
Questioning tone		0.010 (0.008)	
95% CI		[−0.007, 0.026]	
Request tone		0.002 (0.009)	
95% CI		[−0.016, 0.019]	
Explanatory tone		−0.038** (0.016)	
95% CI		[−0.068, −0.007]	
Positive emotion			−0.016 (0.032)
95% CI			[−0.079, 0.045]
Negative emotion			−0.050*** (0.012)
95% CI			[−0.073, −0.027]
Random-effects parameters			
Intercept (group level)	0.166	0.166	0.166
Residual	0.141	0.141	0.141
ICC	0.541	0.541	0.541
Log likelihood	20093.516	20090.666	20098.708
Number of sentence		38,124	
Number of patients		210	

Note: "**" indicates $p < 0.01$, and "***" indicates $p < 0.001$ for the correlation coefficient r of two variables.

play a crucial role in shaping patients' emotional reactions. Furthermore, both the questioning tone ($r = -0.013$, $p < 0.001$) and explanatory tone ($r = -0.015$, $p < 0.05$) were found to significantly reduce the arousal of fear, underscoring the importance of how information is presented in managing patients' emotional states.

The ICC values suggest that individual differences explain a substantial portion of the variance in emotional arousal, particularly in the sadness (51.9%), and anger (47.6%) models, where over 47% of the variation can be attributed to between-individual differences. The sentence-level factors, however, play a more prominent role in influencing surprise and fear arousal.

These findings suggest that even minor adjustments to the emotional tone and content of health education may have practical implications for improving patient care. Future studies should explore these relationships further to account for potential confounders and more fully understand the mechanisms by which communication affects patient emotions.

4 | Discussion

The analysis of the health education content focused on two primary types of vocabulary: informative vocabulary, which is objective and objectified information required for mastery, and perceptual vocabulary, which is the subjective information output of the educator and was not required to master. When integrated into discourse, perceptual vocabulary can evoke a specific emotional atmosphere in particular situations. In the hospital context of health education, nurses are tasked with conveying informative words to lung cancer patients before surgery.

Various educators have demonstrated distinct styles and emphasized different tones in health education, broadly classified as questioning, requesting, and explanatory tones. The requesting tone was most prominent in the health education process, especially in preoperative preparation and postoperative diet arrangement related to the safety of care. Patients were required to acquire knowledge on disease, diet, food, and personal hygiene during the stage of preoperative preparation. Due to the safety

TABLE 3 | Prediction of emotional arousal by a multilevel random intercept model.

Vocabulary	Sadness emotion arousal	Anger emotion arousal	Surprise emotion arousal	Fear emotion arousal
Intercept	0.130 (0.012)***	0.031 (0.006)***	0.042 (0.006)***	0.020 (0.004)***
95% CI	[0.105, 0.154]	[0.019, 0.042]	[0.031, 0.053]	[0.012, 0.028]
Contents				
Informative	−0.014 (0.005)**	−0.007 (0.003)**	−0.011 (0.004)***	−0.000 (0.002)
95% CI	[−0.024, −0.005]	[−0.013, −0.002]	[−0.018, −0.004]	[−0.005, 0.004]
Perceptual	−0.071 (0.036)*	−0.004 (0.020)	0.081 (0.026)**	−0.021 (0.018)
95% CI	[−0.141, 0.001]	[−0.043, 0.033]	[0.029, 0.133]	[−0.055, 0.004]
Tone				
Questioning	−0.030 (0.010)**	−0.011 (0.005)*	−0.003 (0.007)	−0.013 (0.005)***
95% CI	[−0.050, −0.011]	[−0.021, −0.000]	[−0.017, 0.011]	[−0.023, −0.004]
Request	−0.006 (0.011)	0.002 (0.006)	0.005 (0.008)	0.001 (0.005)
95% CI	[−0.027, 0.014]	[−0.010, 0.013]	[−0.010, 0.020]	[−0.009, 0.011]
Explanatory	0.043 (0.018)**	−0.013 (0.010)	−0.020 (0.013)	−0.015 (0.009)*
Emotion				
Positive	0.084 (0.037)*	−0.007 (0.020)	−0.039 (0.027)	0.002 (0.018)
95% CI	[0.012, 0.157]	[−0.047, 0.032]	[−0.092, 0.143]	[−0.033, 0.002]
Negative	0.028 (0.014)*	0.016 (0.007)*	−0.027 (0.010)***	−0.007 (0.007)
95% CI	[0.001, 0.056]	[0.004, 0.034]	[−0.047, −0.007]	[−0.020, 0.007]
Random-effects parameters				
Intercept (group level)	0.177	0.081	0.079	0.058
Residual	0.164	0.089	0.120	0.080
ICC	0.519	0.476	0.397	0.420
Log likelihood	14272.325	37701.421	26305.428	41761.144
Number of sentence	38,124			
Number of patients	210			

Note: "*" indicates $p < 0.05$, "**" indicates $p < 0.01$, and "***" indicates $p < 0.001$ for the correlation coefficient r of two variables.

of anesthesia recovery in patients and the timely recovery of gastrointestinal function and nutrition, patients also need accurate postoperative diet arrangements (Pilikidou et al. 2021).

The emotion of health education was divided according to the emotional-inducing vocabulary in daily life and clinical experience, with a generally low proportion of vocabulary compared to that of the informative vocabulary for mastery. It is generally assumed that positive emotion vocabulary could lead to positive emotions, while negative emotion vocabulary is generally believed to cause negative emotions (Gross and John 2003). More negative emotions than positive emotions were indicated, especially postoperative attention to drainage tubes and postoperative exercise rehabilitation, which are required for proficiency, mastery, and accurate implementation. For instance, if educators display serious expressions while addressing the risks associated with the dislodgement of chest drainage tubes, lung cancer patients might be particularly vigilant about the secure positioning of their drainage tubes. In particular, positive emotion outweighed negative emotion on the operation day, probably because nurses, surgeons, and anesthesiologists were more involved, and educators should encourage them to actively cooperate with multidisciplinary teams. This study revealed that the content of health education was characterized by a predominance of informative vocabulary, directive language for making requests, and negative expressions in specific contexts.

Perioperative health education has been widely recognized for improving postoperative emotional disorders in lung cancer patients, but the emotional status of patients in the health education process, which is difficult to capture, has often been disregarded (Cetkin and Tuna 2019). With the help of automatic emotion recognition software, this study revealed that neutral emotion accounted for the largest proportion, but neutral emotion belonged to emotion orientation but not emotion classification. Xu (2021) suggested that emotions continuously and gradually change in space and that patients have different emotional responses to different parts of health education, with differences in emphasis. Therefore, after the exclusion of neutral emotions, the remaining six emotions were generally negative, among which sadness was the most common, followed by surprise, anger and fear. Compared with the other five parts, anger accounted for the largest proportion of emotion in postoperative exercise rehabilitation. Overall, patients experienced negative emotions when receiving preoperative health education, and a follow-up study is suggested to further explore the relationship between negative emotions and concentration in the process of health education.

Researchers have found that there is an undeniable relationship between language and cognition and that health education is itself a professional form of language used in the hospital setting (Shan 2015). The study of emotion cognition should consider situational factors, and language is an important situational factor. Preoperative health education can cause changes in patients' emotions, and patients' emotions influence patients' acceptance and learning of health education to a certain extent. Within the health education framework, the use of an explanatory tone and negative emotions in health education had a negative impact on emotional arousal, which increased patients' negative emotions. An increase in informative vocabulary, perceptual vocabulary and questioning tone could increase the arousal of sadness, whereas an increase in explanatory tone and positive emotion could decrease sadness arousal. Informative vocabulary and questioning tone were found to enhance anger arousal, whereas the presence of negative emotions mitigated anger arousal. In addition to perceptual vocabulary, informative vocabulary and negative emotion played a role in elevating the arousal of surprise. Surprise, often indicative of heightened patient attention, suggests distraction. Overall, the explanatory tone significantly improved patients' negative emotions, especially fear; negative emotions generally significantly enhanced patients' negative emotions, especially surprise. Both the explanatory tone and negative emotions reduced the patient's arousal of surprise, indicating a greater level of attention distraction. In addition, although other aspects of health education did not exert a significant impact on overall patients' emotional arousal, they did significantly influence their individual emotions.

This study exhibits strengths in introducing an innovative research direction, departing from the conventional approach of combining various modes within existing health education content and structure. Most studies on the continuous enhancement of health education quality have overlooked the influence on patients' emotions during preoperative health education, potentially compromising the overall quality of health education. Moreover, AI emotion recognition software, which is typically implemented in school settings, was first introduced for lung cancer patients undergoing perioperative health education in this study. There is currently no evidence to suggest that facial expression in lung cancer patients significantly differs from that of nonpatients. This study is expected to provide a theoretical basis for guiding clinical nurses to carry out health education and improve the quality of care. Moreover, our finding may have a practical implication for clinical nurses as well in that it encourages the reduction of explanatory tone and negative emotion in the health education process to decrease the impact on lung cancer patients' emotions.

However, there are several limitations. Firstly, the main limitation of the present study resides in its cross-sectional design, by the lack of a deeper direct analysis of aspects such as the emotional states of the patients linked with health education. Our further studies should consider addressing a similar study question with a deeper analysis. Although the generalization of findings is limited because of the analytical depth, our results still possess a certain degree of validity. This is because the content of the health education is standardized, providing some consistency across different individuals. Therefore, we believe that the emotional responses of this sample are somewhat representative in this standardized context. Secondly, the sample size was mainly concerned with a 3-A-class hospital in Guangzhou instead of hospitals with different geographical locations and accreditation levels, possibly leading to a selection bias. Thus, large-scale and multicenter investigation is required in subsequent studies. Finally, this study focused mainly on lung cancer patients and lacked in-depth investigations of the health education of caregivers. Future studies that include caregivers of lung cancer patients will be carried out for the research team.

5 | Conclusion

In the context of lung cancer patients, there was a significant correlation between preoperative health education and patients' emotions, indicating that the manner in which information is presented in health education has a substantial impact on patients' emotional states. Our findings will enhance the understanding of the influence of emotions on preoperative health education in lung cancer patients, which would provide a basis to construct an effective intervention program. As nursing functions expand, nurses play an increasingly important role in health education. Accordingly, FaceReader-based health education programs for lung cancer patients, as well as their caregivers, may be a future direction worthy of consideration.

6 | Clinical Resources

1. Cancer Research UK: Lung Cancer. https://www.cancerresearchuk.org/about-cancer/lung-cancer
2. American Cancer Society: Lung Cancer Resources. https://www.cancer.gov/about-cancer/coping/feelings

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Ethics Statement

Ethical approval for the study was obtained from the Ethics Committee at Sun Yat-sen University Cancer Center (B2021-151-01; date of approval: June 28, 2021), and all patients enrolled in the study were volunteered to sign the consent in person.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data and materials sharing are available from the corresponding authors on the condition of the reasonable reason.

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