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Auditory perception of lay judges about gender identification of women with Reinke's edema

Percepção auditiva de juízes leigos quanto ao gênero de mulheres com edema de Reinke

Amanda Maria Pereira[1]
Ana Paula Dassie-Leite[1]
Eliane Cristina Pereira[2]
Juliana Benthien Cavichiolo[3]
Marcelo de Oliveira Rosa[4]
Elmar Allen Fugmann[3]

Keywords

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ABSTRACT

Purpose: To investigate the auditory perception of lay judges of the voice gender identification of women with Reinke's edema and to associate it with its severity and fundamental frequency (F_0). **Methods**: This is an observational, analytical and cross-sectional study. A total of 46 lay judges analyzed 48 samples (counting numbers 1 to 10) of 24 women with Reinke's edema – the Reinke's Edema Group (REG) and 24 individuals, men and women, with other types of voice disorders – Control Group (CG). The judges had to classify the voices as being of a man or a woman. Additionally, they needed to indicate their certainty or not about their choice. Results were associated with the severity of the Reinke's edema (Type 1, 2 or 3) and the F_0 (extracted from the vowel /ɛ/). **Results**: Misidentification of gender was higher in the REG and certainty about the choice was higher in the CG. Type 1 cases caused fewer misidentifications compared to type 2 and 3. The women's voices that were identified as male voices had a lower F_0 (141Hz) when compared to voices that were correctly identified (149Hz). **Conclusion:** Women with Reinke's edema are frequently identified as men. Lower F_0 was related with more misidentification and less certainty when assessing the speaker's gender.

Descritores

Edema Laríngeo
Percepção-auditiva
Avaliação
Qualidade da Voz
Voz

RESUMO

Objetivo: Investigar a percepção auditiva de juízes leigos quanto ao gênero de mulheres com edema de *Reinke*, relacionada com o grau do edema e a frequência fundamental da voz. **Método**: Estudo observacional, analítico e transversal. Participaram 46 juízes leigos que analisaram 48 vozes disfônicas - 24 vozes de mulheres com Edema de *Reinke* (Grupo Edema de *Reinke* - GER) e 24 vozes de mulheres e homens com outros tipos de disfonias (Grupo Controle - GC). Os juízes analisaram a contagem de números de 1 a 10 e julgaram as vozes como pertencentes a homem ou mulher, além de descreverem também se tinham certeza ou dúvida quanto à resposta. Os resultados do GER foram associados ao Grau do Edema (1, 2 ou 3) e à frequência fundamental média (F_0), analisada por meio da vogal /ɛ/. **Resultados**: Observou-se que a porcentagem de erros em relação ao gênero foi maior no GER quando comparada à do GC, o percentual de certezas quanto ao gênero foi maior no GC. No GER, edemas de grau 1 ocasionaram menos erros quando comparados aos graus 2 e 3. A média da F_0 das mulheres cujas vozes foram julgadas como masculinas (141 Hz) foi menor do que as identificadas corretamente (149 Hz). **Conclusão**: Por meio da avaliação de juízes leigos, as vozes das mulheres com edema de *Reinke* são identificadas como vozes masculinas. O aumento do grau do edema e a redução da F_0 estão relacionados à maior quantidade de erros e/ou dúvidas em relação à identificação do gênero de mulheres com edema de *Reinke*.

Correspondence address:
Ana Paula Dassie-Leite
Departamento de Fonoaudiologia, Universidade Estadual do Centro-Oeste – UNICENTRO
Rodovia PR 156, Km 07, Riozinho, Irati (PR), Brasil, CEP: 83500-000.
E-mail: pauladassie@hotmail.com

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[1] Departamento de Fonoaudiologia, Universidade Estadual do Centro-Oeste – UNICENTRO - Irati (PR), Brasil.

[2] Prefeitura Municipal de Prudentópolis - Prudentópolis (PR), Brasil.

[3] Serviço de Endoscopia PerOral, Hospital de Clínicas, Universidade Federal do Paraná – UFPR - Curitiba (PR), Brasil.

[4] Departamento de Eletrotécnica, Universidade Tecnológica Federal do Paraná – UTFPR - Curitiba (PR), Brasil.

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INTRODUCTION

The voice plays a fundamental role in human communication and social interaction. Characteristics such as the speaker's age, gender, race, sexual orientation, personality and emotions are identified through the voice[1]. Therefore, changes to vocal characteristics may lead to an incorrect listener impression of the speaker's real identity and misidentification of these characteristics[2].

Reinke's edema is a benign diffuse laryngeal lesion with extravasation of fluid in the superficial layer of the lamina propria. Its severity varies and it is usually bilateral[3]. It is commonly preceded by long-term smoking associated with vocal abuse[4,5]. Smoking and chronic tobacco use are the dominant etiological factors, although other factors may be involved, such as hormonal issues and the aging process[6,7]. Tobacco modifies the layers of the vocal fold, which changes the vocal fold's vibratory cycles and vocal quality[7].

The perceived vocal characteristics of individuals with Reinke's edema are: roughness, low pitch, fluid voice, creaky voice and monoloudness[2,8,9]. The acoustic data usually presents: lower fundamental frequency (F_0), changes in jitter, shimmer, harmonic-to-noise ratio and reduction in the maximum phonation time[10-13].

Usually, individuals seek professional help only when they have respiratory difficulties and/or when the vocal changes generate identity confusion. For example, women are commonly mistaken for men in phone calls. The low pitch resulting from the Reinke's edema does not seem to cause significant discomfort in men. Thus, this may probably be the reason why women more frequently seek medical and speech language therapist assistance. However, treatment is quite rare for women under 45 years of age[2].

Women with Reinke's edema commonly complain about being addressed as men, especially in phone calls. However, there are only a few studies regarding this condition[9,14]. Recently, a study showed that women with Reinke's edema self-assess their voices as masculine. The same study also concluded that these women's voices were perceived as belonging to a male speaker and that this perception is mainly related to the low F_0. Other voice acoustic parameters, such as lower cepstral peaks, were also identified as related factors[14].

A better understanding of the gender identification ambiguity reported by women with Reinke's edema, as well as the relationship of this ambiguity with laryngological and vocal data, may contribute to clinical and/or preventive discussions about these cases.

Therefore, the aim of the present study was to investigate the auditory perception of lay judges regarding the voice gender identification of women with Reinke's edema and to associate it with its severity and F_0.

METHODS

This is an observational, analytical, cross-sectional study, approved by the Ethics Committee of the of the Clinical Hospital Complex (*Complexo do Hospital de Clínicas*) of the *Universidade Federal do Paraná* under the protocol number 221.401/2012. The research was divided in two phases: first, voice recording; second, voice analysis by lay judges.

Phase 1: voice recording

A total of 48 individuals participated in the voice recordings: 36 women and 12 men, divided into two groups: the Reinke's Edema Group (REG), with 24 women with laryngeal diagnosis of Reinke's edema; and the Control Group (CG), with 12 men and 12 women with diverse laryngeal diagnoses.

The participants were patients from the Larynx and Voice Clinic of the Clinical Hospital Complex (*Ambulatório de Laringe e Voz do Complexo do Hospital de Clínicas*) of the *Universidade Federal do Paraná.* The patients were invited to participate in this study during their regular follow-up and appointments with an ear, neck and throat (ENT) physician.

After explaining the study objectives, the patients who agreed to participate signed an Informed Consent Form. Next, the data was collected.

The inclusion criteria for the REG were: woman, laryngeal diagnosis of unilateral or bilateral Reinke's edema, with classification of severity in Type 1, 2 or 3 and age above 18 years. The inclusion criteria for the CG were: age above 18 years and any laryngeal diagnoses, expect Reinke's edema.

The exclusion criteria for the REG and the CG were: history of anabolic steroid use, due to the possibility of developing a lower pitch voice and neurological problems that could lead to misunderstandings about the tasks. Additionally, any man in the CG who presented a diagnosis for incomplete vocal mutation, and therefore could be misidentified as a woman, was also excluded.

The data collection procedures for both REG and CG were:

- Identification and clinical history: a questionnaire developed by the researchers to collect identification data, general health information, and voice care habits were applied;
- Laryngoscopy or Nasofibrolaryngoscopy: with an 8.0 mm laryngoscope - autoclavable 70º Storz® or the Pentax® Fiber Nasolaryngoscope - FNL-10RP3 (for individuals unable to undergo the examination orally). The following information was collected: presence or absence of vocal fold lesion and type of lesion. The medical diagnoses were given by consensus of a medical team: two resident physicians, the chief physician of the clinic and the head teacher. Participants of the REG were classified according to the severity of the disease as determined by laryngeal appearance based on indirect laryngoscopic findings: Type 1, edematous swelling is observed on the upper surface of the vocal folds, while patency of the glottis is adequately preserved; Type 2, edematous swelling extends from the upper to the lower surface beyond the margins of both vocal folds, which are partly in contact with each other; Type 3, edematous swelling is further advanced so that an opening can be seen only at the posterior portion of the glottis, or the swelling is so bulged in a sack-like shape that it hangs down to the subglottic space during inspiration[15];

- Voice recording: sustained vowel /ɛ/ and counting numbers 1 to 10, in Brazilian Portuguese. Samples were recorded directly on a notebook with Andrea Pure Audio® and a Karsect® unidirectional head microphone positioned at 45° from the mouth. The recordings were performed in a quiet room, with noise level below 50 dB. The noise level was measured using the Voxmetria® acoustic analysis program (CTS *Informática*, version 2.5) which has a feature that evaluates room noise. An omnidirectional microphone was used to capture ambient sounds;
- Voice acoustic analysis: the Voxmetria® program (CTS *Informática*, version 2.5) was used to evaluate the mean fundamental frequency of the vowel /ɛ/. The beginning and end of the emission were cutoff to avoid raise and decay moments, known to be more unstable.

The participants of the REG were between 44 and 77 years old (mean of 56.5 years old) and the CG participants were between 18 and 78 years old (mean of 54 years old). No difference between the groups was observed in terms of the participant's age (p-value > 0.05). The REG had 9 individuals (all women) and the CG had 8 individuals (six women and two men) with or above 60 years of age. No difference was observed between the groups (p-value = 1.00). If there was a confounding factor related to gender identification in terms of age, both groups would have the same chances of this occurring.

The Chart 1 presents the CG laryngeal diagnostics.

Chart 1. Laryngeal diagnostics of the CG

Men (n = 12)		Women (n = 12)	
n	Diagnosis	n	Diagnosis
3	Functional dysphonia without laryngeal findings	3	Epidermoid cyst
2	Reinke's edema	3	Presbyphonia
1	Cerebellar ataxia without laryngeal findings	2	Unilateral vocal fold paralysis
1	Epidermoid cyst	2	Psychogenic dysphonia
1	Stiffness of vocal fold after radiotherapy	1	Vocal Fold Scarring
1	After surgery of human papillomavirus located at the supraglottic	1	Midposterior triangular chink
1	Unilateral vocal fold paralysis		
1	Presbyphonia		
1	Psychogenic dysphonia		

Caption: CG = control group; n= number

Phase 2: voice analysis by lay judges

A total of 50 lay judges (16 men and 34 women; between 18 and 52 years old) were invited to participate in this study. They were not informed about the study population. However, after concluding the Phase 2 task, they were informed about the study objectives.

The judges who agreed to participate, evaluated the previously recorded voices, as described in Phase 1. They signed the Informed Consent Form only after completing the task.

All judges had to be 18 years or older to participate. Other inclusion criteria were: to have no relationship with speech language pathology or work in fields related to the voice or communication. Any judge with a hearing complaint or with difficulties understanding the requested task was excluded.

Individually, the judges had to analyze the numbers counted from 1 to 10 of the 48 recorded individuals (24 from REG and 24 from the CG). The voice samples were presented randomly.

The judges marked their responses for each voice in a specific protocol which had the following guidelines:

1) Identify the gender of the individual by hearing the presented voice. The answer options were: man or woman;
2) Regarding your previous answer: are you certain or not about your choice?

Each voice was played three times. To evaluate the intra-rater reliability, 20% of the voice samples were repeated, five voices of the REG and five of the CG.

The Kappa Coefficient Test was applied to analyze the intra-rater reliability of all 50 judges. Taking into account that the judges were not specialist and/or not used to performing perceptual-auditory analysis, a Kappa Coefficient of 0.6 or above was considered acceptable. The Kappa Coefficient varied from 0.33 to 1.00. 4 judges presented Kappa values below 0.6 and were excluded. The mean Kappa values for the 46 remaining judges was 0.7; the results ranged from 0.66 to 1.00.

The responses of the 46 judges were computed in an Excel spreadsheet; 46 judges analyzed the 48 voices, producing a total of 2,208 analyses.

In all the statistical tests, the level of significance was set at 5%. The Pearson's chi-squared test (association between categorical variables) was used to analyze the gender identification, certainty or not, relationship with the Reinke's edema severity and comparison between ages (elderly and non-elderly).

The Student's t-test (for comparison of the means of the continuous variables with normal distribution) was used to analyze the relationship between gender identification, certainty or not, and the voice F_0 and its relationship with elderly and non-elderly individuals.

RESULTS

Table 1 shows the judges' analysis for voice gender identification of the REG and CG. More misidentifications were observed in the REG, 24.6%, than in the CG, 2.4%, (p-value = 0.000). Similar results were observed for the judges' certainty or not (p-value = 0.000).

Table 2 shows the relationship between the severity of the edema and the voice gender identification of the REG (Table 2). Women with cases of type 2 or 3 were misidentified more often than women with type 2 (p-value = 0.000). The same occurred for the certainty or uncertainty of the answer (p-value = 0.000). No difference was observed between type 2 and 3 (p-value = 0.65).

Table 3 shows the relationship between F_0 and the voice gender identification and certainty of the answers for the REG. The voices with more misidentifications had a lower F_0 than the correctly identified voices, 141Hz and 149Hz, respectively (p-value = 0.000). Similarly, the voices with more uncertain answers had a lower F_0 than the voices with more certain answers, 144Hz and 148Hz, respectively (p-value = 0.000).

Since both groups included elderly individuals above 60 years old (9 in the REG and 8 in the CG), additional analysis to investigate any relationship between age and the distribution of correct identification and misidentifications related to the gender was performed (Table 4). No difference was found between the elderly and non-elderly groups, for either correct identifications or misidentifications (p-value = 0.239) or for certainty or uncertainty in the answers (p-value = 0.183). Therefore, age does not seem to influence the voice gender identification of the lay judges.

Additionally, a comparison was performed between elderly and non-elderly individuals considering the F_0 (Table 5). The non-elderly women of the REG presented lower F_0 values than the elderly women of the CG (p-value = 0.018). In the CG, this difference was observed only for men. Elderly men presented higher F_0 values than non-elderly ones (p -values = 0.01).

Table 1. Judge's analysis regarding the voice gender in the CG and the REG

Answer	Group				p-value
	CG		REG		
	n	%	n	%	
Correct Identification	1078	97.6	832	75.4	0.000
Misidentification	26	2.4	272	24.6	
Certain	983	89.0	67.9	75.0	0.000
Not certain	121	11.0	354	32.1	

Pearson's chi-squared test with Yates; p-value < 0.05
Caption: CG = control group; REG = Reinke's edema group; n = number

Table 2. Relationship between the severity of the edema and gender identification in REG

Answer	Edema Severity						p-value
	1		2		3		
	n	%	n	%	n	%	
Correct Identification	544	84.5	118	64.1	170	61.6	0.000
Misidentification	100	15.5	66	35.9	106	38.4	
Certain	487	75.6	117	63.6	146	52.9	0.000
Not certain	157	24.4	67	36.4	130	47.1	

Pearson's chi-squared test with Yates; p-value < 0.05. P-values for Correct identification: type 1 Vs. type 2 = 0.000; type 2 Vs. type 3 = 0.65. P-values for Certain and Not certain: type 1 Vs. type 2 = 0.01; type 2 Vs. type 3 = 0.02
REG = Reinke's edema group; n = number

Table 3. Relationship between the F_0 and the voice gender identification and certainty for the REG

Correct Identification			Misidentification			p-value
n	Mean F0	SD	n	Mean F0	SD	
832	149	20.11	272	141	14.65	0.000

Certain			Not Certain			p-value
n	Mean F0	SD	n	Mean F0	SD	
750	148	20.25	354	144	16.47	0.000

Student's t-test: p-value < 0.05
Caption: F_0 = fundamental frequency; SD = Standard Deviation; REG = Reinke's edema group; n = number

Table 4. Relationship between age and gender identification and certainty

Answer	Elderly				p-value
	Yes		No		
	n	%	n	%	
Correct Identification	686	87.72%	1224	85.83	0.239
Misidentifications	96	12.28%	202	14.17	
Certain	601	76.85%	1132	79.38	0.183
Not certain	181	23.15%	294	20.62	

Pearson's chi-squared test with Yates; p-value < 0.05
Caption: n = number

Table 5. Relationship between elderly and non-elderly considering the F_0 and the REG and the CG

Group	Fundamental Frequency						p-value
	Elderly			Non-elderly			
	Mean	SD	n	Mean	SD	n	
REG	159.25	21.53	9	140.27	15.01	15	*0.018
CG women	185.04	31.63	6	174.78	14.92	6	0.51
CG men	154.35	24.64	2	115.5244	17.12	10	*0.01

Student's t-test; *p-value < 0.05
Caption: SD = Standard Deviation; CG = control group; REG = Reinke's edema group; n = number

DISCUSSION

Gender is historically defined by physical, psychological and social characteristics with voice also contributing to the distinction between men and women[14]. Thus, laryngeal pathologies and vocal alterations may be a confusing factor when identifying the speaker's gender, especially when such a judgment is made exclusively from hearing the voice.

There was more gender misidentification in the REG than in the CG (Table 1). Therefore, women with Reinke's edema are more frequently misidentified as men than women with other laryngeal pathologies. Additionally, women with Reinke's edema often report being mistaken for a man on the telephone[2].

Women with Reinke's edema self-rate their voices as masculine[14]. This finding was observed in a recent study where a group of women with the disease self-assessed their voices as masculine or feminine using a scale from 0 to 9, were 0 = totally masculine and 9 = totally feminine. The mean score was 3.6 (standard deviation = 1.9); the control group, with vocally healthy women, presented a mean score of 6.9 (standard deviation = 1.8).

This type of vocal self-perception may be due to the excessive edema in the vocal folds that changes the F_0 and generates a lower pitch[8]. The intensity of the deviations in the vocal parameters influences the self-perception of the voice gender.

Considering healthy voices, the distinction between male and female voices is quite clear. Depending on the speaker's gender, the larynx develops with specific characteristics, producing different F_0 values for men and women[16]. The male larynx and vocal tract are larger and the vocal folds are longer, which produces lower vocal frequencies and therefore, lower pitch[17]. In addition, men have more vocal fold mass, which makes the vocal fold vibrations slower resulting in less glottic cycles per second[2]. In severe Reinke's edema cases, the F_0 is lower due to the excessive edema, which may result in masculine-sounding voices[14].

To our knowledge, there in only one study that verified the perception that lay judges had of women with Reinke's edema. The study included 10 women with Reinke's edema, 10 vocally healthy women, 10 vocally healthy men and 24 judges. Voices of women with Reinke's edema were found to be perceived as male voices, especially by the female judges[14]. Regarding the acoustic analysis, besides the lower F_0, women with Reinke's edema presented lower cepstral peak values, deviations in the formant values and in the harmonic-to-noise ratio[14]. However, no analysis between the judge's perception about male/female voices and the acoustic analysis was performed.

The F_0 is widely understood to be the main parameter to differentiate male and female voices[2,18]. However, it is also known that it is not the only vocal feature that allows people to differentiate the voice gender, with other communication aspects being considered essential. Studies with transgender women highlight the important role that resonance balance and the improvement of communicative competence have to increase the F_0[19]. Features such as intonation, voice modulation, resonance, grammar and vocabulary are also important to differentiate male and female voices[18].

The CG presented more certain answers regarding voice gender identification, which highlights that voice gender identification for other laryngeal diagnoses were different than for Reinke's edema diagnosis. However, the F_0 alone is not enough for the listener to have more certainty while identifying the speaker's gender. Thus, it is possible to have a low F_0 that is still identified as a female voice, and vice-versa.

It is noteworthy that when the aim of this study was explained to the judges after they completed the Phase 2 task, they were surprised that they had been identifying female voices. Some judges believed that the voices of the REG belonged to homosexuals and/or elderly individuals, rather than to women smokers.

Regarding the elderly individuals' voices, changes in the F_0 are fairly common, for both men and women. For men, the F_0 increases due to vocal fold muscles and tissue atrophy. For women, the F_0 decreases and a lower pitch is perceived; this occurs due to an edema in the vocal fold, caused by hormonal changes after menopause[2]. However, no misidentification or uncertain answers were observed for male or female voices in the elderly[20]. Additionally, the present study found no influence of age on voice gender identification. Thus, it may be inferred that the vocal characteristics of the Reinke's edema are quite peculiar and much more susceptible to generating doubts about the speaker's real gender than other vocal deviations, such as presbyphonia in women, which also reduces F_0.

Further research with a larger cohort of elderly individuals should be undertaken both for Reinke's edema patients and for patients with other types of dysphonia. Thus, a detailed analysis could be performed considering the effects that age has on the listener's judgement of male and female voices. Also, a homogeneous distribution of men and women should be considered given that they present opposite vocal alterations with aging. The present study was able to analyze vocal aging effects for women; the REG was composed of only female

(8 elderly, 6 non-elderly), homogeneous groups. Unfortunately, we could not analyze elderly men nor consider a group of adults and a group of elderly individuals due to the small sample size.

Considering the Reinke's edema severity, women with type 1 were less misidentified than women with type 2 or 3 (Table 2). It is believed that women with Reinke's edema present specific characteristics that make their vocal emission easily confused with a male vocal emission, especially when more severe. Therefore, types 2 and 3 of Reinke's edema are more likely to cause doubts and gender misidentification. To our knowledge, no research has been performed to address this topic.

The perception that people have regarding the voice of women with Reinke's edema may explain the reason why they only seek professional help at advanced stages of the disease. Moreover, in mild cases, the edema is usually associated with a low pitch, fluid voice, considered to be charming and sexy[21]. Therefore, it is possible that women only seek assistance when they are mistaken for a man, producing negative outcomes on vocal psychodynamics, or when there are respiratory difficulties.

Voices with lower F_0, 141Hz were more misidentified than voices with higher F_0, 149Hz, (Table 3). Hence, lower F_0 for women with Reinke's edema is associated with more voice gender misidentification. The same was observed for the answers' certainty or not, 144Hz and 148 Hz, respectively.

As already mentioned, F_0 is one of the main parameters to differentiate male and female voices. The mean F_0 for men with a normal larynx is 127Hz[22,23]; for women, it is within a range from 200 to 240 Hz[22,23]. Hence, it is notable that the female voices that were more often mistakenly identified as male ones, had an F_0 closer to the man's range. Thus, the present study data may explain the gender misidentification of women with Reinke's edema. The non-elderly women of the REG had lower F_0 than the elderly women. On the other hand, the elderly men of the CG had higher F_0 than the non-elderly ones.

The vocal psychodynamics information observed in these research outcomes may assist the speech language therapist to deal with Reinke's edema patients; especially those with difficulties to stop smoking. The professional may explain that quitting this habit as soon as possible may also avoid communication problems. Additionally, this knowledge can be shared in preventive actions, thus, as well as highlighting the already known harms of cigarette smoking, important losses related to quality of life and interpersonal relationships can be shared.

It is important to highlight this study's limitations: 1. small sample size; more individuals, especially with severe edema stages, could guarantee a more robust analysis; 2. no perceptual-auditory or acoustic analysis was performed; these analyses could have helped to understand which parameters have more impact when identifying a voice as male or female.

Although the results of the present study did not indicate any relationship between age (non-elderly Vs. elderly) and gender identification, it is important to undertake further research with a larger sample size (men, women, non-elderly and elderly) with Reinke's edema diagnosis.

CONCLUSION

Women with Reinke's edema are frequently identified as men when assessed by lay judges. Severe stages of the disease and a lower F_0 play an important role in voice gender identification and on the certainty of identifying the speaker's gender from hearing their voice.

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Author contributions

AMP was responsible for the data collection and analysis and the writing of the manuscript; APDL was the advisor, responsible for the study design, data analysis and discussion and the final revision of the manuscript; ECP was responsible for the data analysis and discussion and writing of the manuscript; JBC, MOR and EAF were responsible for the data collection and analysis.