Working voices

An epidemiological study of occupational voice demands and their impact on the call centre industry

Report submitted to the IOSH Research Committee

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This report is printed on chlorine-free, acid-free stock produced from woodpulp originating from managed, sustainable plantations. The paper is recyclable and biodegradable.

Printed in England by Paradigmprint (UK) Ltd

Published by IOSH
The Grange
Highfield Drive
Wigston
Leicestershire
LE18 1NN
UK
t +44 (0)116 257 3100
f +44 (0)116 257 3101
www.iosh.co.uk

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Acknowledgments

The authors would like to thank Dr Gary Adamson of the School of Psychology, University of Ulster, for assistance with statistics, particularly structural equation modelling.

The authors appreciate the co-operation and enthusiasm of call centre management and call agents in participating in this study.

They also acknowledge and appreciate the funding from IOSH, which made this much-needed research possible and has led to a significant contribution to the literature on occupational vocal health research.

Abstract

Call centre workers use their voice for prolonged periods, thus increasing their risk of occupational voice disorders. The lack of robust investigation into voice use and its impact on vocal performance represents a gap in occupational health and safety research. The objectives of this study were to:

- investigate the work context and vocal communication demands for call agents
- evaluate call agents' vocal health, awareness and performance
- identify key risks and training needs for employees and employers in call centres.

This was an occupational epidemiological study consisting of qualitative and quantitative approaches. It had three stages: interviews with senior call centre managers; a large-scale epidemiological online survey; and acoustic measurements in the actual work environment.

The interviews with the managers revealed that the vast majority of call centres do not provide vocal training. The acoustic data indicated that at the end of a telephone call the call agent's voice may have become hoarse with fatigue and pitch variation compared to the start of the call. The structural equation modelling based on survey data showed that physiological voice production is significantly associated with psychosocial and medical health. A high risk group of call agents, identified as women who have recently started work in a call centre, who have received no vocal training and are off work on sick leave, is at significant risk of developing physiological voice problems. Those who reported having received vocal training in the workplace were at significantly lower risk of developing physiological voice problems.

This study has identified the factors predisposing call centre workers to physiological and musculoskeletal voice problems, and has demonstrated a significant relationship between vocal health and medical and psychosocial health in these workers. The research has highlighted implications for vocal health and occupational safety, with recommendations for preventive care and further research.

Executive summary

Introduction

The call centre industry depends on the effective vocal performance of its employees. Because of the nature of the industry, call agents speak for prolonged periods, which places a greater than usual demand on their voice. This increases the risk of occupational voice disorders, which are musculoskeletal problems due to laryngeal muscle tension. The failure to investigate voice use and the impact of overuse on vocal performance has resulted in a significant gap in the evidence base of occupational health and safety research. Furthermore, the vast majority of the published studies investigating the vocal demands of call agents include small participant numbers. Moreover, there have been no studies investigating voice use and performance or the impact of vocal and communication demands in the call centre industry in the UK and Ireland.

Objectives

The objectives of the study were to:

- investigate the work context and vocal communication demands for call agents
- evaluate call agents' vocal health, awareness and performance
- identify key risks and training needs for employees and employers in call centres in the UK and Ireland.

Null hypotheses

The overall null hypothesis is that there is no relationship between physiological voice production and psychosocial and medical health among workers in call centres.

The sub-hypotheses are that there is no relationship between:

- the mechanical, sensation and acoustic factors and physiological voice production among workers in call centres
- medical conditions and medical advice factors and medical health among call agents within call centres
- functional and emotional factors and psychosocial health among workers in call centres
- vocal training and physiological voice production.

Methods

This research is an occupational epidemiological study with a mixed methods design, comprising both qualitative and quantitative approaches. In total, 14 call centres in the UK and Ireland participated. There were three stages to the study:

- interviews with senior managers (eg call centre manager or human resources (HR) manager) in the call centres ($n = 13$; one call centre did not participate in the interviews as the manager was on sick leave at the time of data collection)
- a large-scale epidemiological online survey ($n = 598$)
- acoustic measurements in the actual work environment ($n = 70$).

The research participants were employees from call centres in the UK and Ireland. A strategic recruitment approach was employed. A list of call centres throughout the UK and Ireland was compiled and their HR departments were contacted via email with an invitation to participate in the study. Some of these contacts were followed up by a telephone call. In addition, an advertisement was placed in the Customer Contact Association's monthly members' bulletin.

The measurement tools were a semi-structured telephone questionnaire, a biopsychosocial online questionnaire (the main measurement tool), and call recordings. A semi-structured questionnaire was developed for telephone interviews with a senior manager from the call centres. These interviews were intended to assess the organisation's communication and training needs. A biopsychosocial questionnaire was developed for the online survey to investigate the work environment and vocal demands and health of call agents. Quality teams in call centres routinely monitor recorded calls between the call agents and customers. Natural conversation in a sample of these calls was selected and analysed across a range of acoustic parameters to determine the volume, pitch and quality of the call agent's voice.

In the first stage of this research, telephone interviews were conducted with a senior manager (eg call centre manager or HR manager) in each participating call centre. These interviews were about 10 minutes long, and the information collected from them informed the development of the main measurement tool.

Secondly, a large-scale epidemiological study was conducted using an online biopsychosocial questionnaire, which was sent to call agents in the participating call centres. This was published on a secure website and call agents accessed and completed it at a convenient time, with the agreement of the call centres' management teams. Participants received information on the study, including the time required for completion (around 10 minutes) and an assurance that all responses were anonymous.

The third and final stage involved acoustic measurement from a monitored telephone call sample of a random sample of participants in one participating call centre. A sample of natural conversation was selected by a call centre staff member and given to the research team in digital format for analysis.

The data from the telephone interviews were transcribed and analysed thematically to determine context and process characteristics of the organisations. Qualitative content analysis identified underlying themes and issues.

Acoustic analysis was conducted on voices in a sample of recorded calls using the Multi-Dimensional Voice Program (MDVP), which is a software program that provides a robust, multi-dimensional analysis of voice with graphic and numerical presentation of the analysis. From the recordings, three sections were selected, each consisting of three seconds of the call agent's continuous voice uninterrupted by the customer, during 10 seconds of the first, middle and end stages of the call. The voice sample recordings were analysed for 14 acoustic parameters.

All numerical data were analysed using SPSS version 15. The data from the biopsychosocial questionnaire were analysed using a multivariate analysis approach, ie structural equation modelling (SEM). This analysis explored potential effects across a wide range of variables. The research design and associated analysis attempted to overcome the traditional complications of multiple indicators, indirect effects and measurement error by using SEM with latent variables and LISREL (Linear Structural Relations) estimation.

The researchers obtained ethical approval from the School of Communication Risk and Ethics Filter Committee, University of Ulster.

Results

Overall, 25 per cent of the call agents reported voice misuse (the average call agent reported six types of voice misuse), 25 per cent presented voice strain symptoms (an average of four sensation, mechanical and acoustic symptoms per call agent), 11 per cent said that they had been diagnosed with a voice disorder, and 10 per cent reported that voice problems had had an impact on their functioning in the work environment (the average call agent reported one vocal impact).

The call agents reported various kinds of vocal symptoms, including:

- difficulty talking against background noise (60 per cent)
- coughing or clearing the throat (43 per cent)
- voice sounding creaky and dry (43 per cent)
- failing to be heard by an interlocutor while talking on the telephone (41 per cent)
- finding speaking on the telephone an effort or tiring (38 per cent).

These issues reflect the demands of the work environment in the call centre setting, such as background noise and room acoustics.

The interviews with the managers indicated that although training for call agents is regular (involving induction and ongoing refreshers) and comprehensive, the majority of call centres do not include vocal training. Nevertheless, most of the managers reported that they understood the need and benefits of voice training for their employees.

The acoustic data indicated that at the end of a telephone call the call agent's voice can be hoarse and fatigued and pitch can become inconsistent, compared to the start of the call.

The SEM based on the online survey clearly showed that psychosocial and medical health are both associated with physiological voice production among call agents in call centres. Therefore, an increase in psychosocial and medical health problems leads to an increase in physiological voice problems. Mechanical, sensation and acoustic factors significantly contributed to physiological voice production among call agents within call centres. Where a call agent reported associated medical conditions and sought advice, this was found to have a significant effect on their medical health. Functional and emotional factors significantly contribute to psychosocial health among call agents. It was interesting that a high risk group of call agents was identified, who are at significant risk of developing physiological voice problems. These are women who have recently started work in a call centre, who have received no vocal training and are off work on sick leave. It was shown that vocal training delivered in the workplace significantly reduces the risk of developing physiological voice problems.

Conclusions

This study identified the factors that predispose the call centre workers in this sample to physiological voice problems and found a significant relationship between vocal health and medical and psychosocial health in this population. Through a systematic mixed methods approach, the construct of 'physiological voice problems' was tested and deemed to be a significant measure of the mechanical, sensation and acoustic parameters of musculoskeletal voice disorders. In addition, a physiological voice problem was found to be a predictor of medical and psychosocial health. The characteristics and presenting symptoms of call agents reporting voice problems are consistent with indicators in the literature of vocal strain and musculoskeletal voice problems.

The research has implications for occupational safety and health, and a high-risk group was identified along with recommendations and preventive strategies for the call centre industry. The study has occupational safety and health implications for employers and employees in the communications industry as it was found that vocal training delivered in the workplace significantly reduces the risk of developing physiological voice problems. There is a need for further robust research and recommendations were provided.

This study has provided the following additions to the current literature and evidence base for vocal occupational safety and health:

- Psychosocial health and medical problems are both significantly associated with physiological voice production among call agents. Therefore, an increase in psychosocial and medical health problems leads to increase in physiological voice problems.
- Mechanical, sensation and acoustic factors significantly contribute to physiological voice production among call agents.
- Medical conditions and medical advice factors significantly contribute to voice-related medical health among call agents.
- The functional and emotional latent factors significantly explained homogeneity in answers to the questionnaire items designed to measure the emotional aspects contributing to psychosocial health among call agents.
- A high-risk group of call agents was identified who are significantly at risk of developing physiological voice problems. These are women who have recently started work in a call centre, who have received no vocal training and are off work on sick leave.
- It was shown that vocal training delivered in the workplace significantly reduces the risk of developing physiological voice problems.

The SEMs identified significant risks relating to vocal health and key voice training needs and goals for call agents and call centre management, as shown in Table 1. Table 2 shows a summary of the key voice training needs and goals for call agents and call centre management.

Table 1
Risks relating to vocal health

Risk factors relating to vocal health for call agents* and call centre management†	
Physiological voice problems	New starters
Psychosocial health problems	Vocal training
Medical health problems	Days off on sick leave
Female	

* Direct impact
† Indirect impact

Table 2
Summary of the key voice training needs and goals

Call agents	Call centre management
Voice training needs	
Awareness Vocal warm-up Pitch variation Preventing fatigue Tone of voice Volume of voice Listening skills Voice projection and handling Cognitive issues Sources of advice	Awareness Update health and safety policy
Overall key benefits of voice training	
Good vocal health Effective communication and interaction Good communication between all staff in the call centre Satisfied customers	Reduction in absenteeism and sick leave Workforce consists of effective communicators Good communication between all staff in the call centre Satisfied customers

Implications and recommendations for occupational safety and health

The findings from this study give rise to several implications and recommendations for occupational safety and health (OSH), as listed below.

- implications:
  - it is necessary to prevent rather than treat voice problems among call agents
  - the levels of risk of voice disorders among call agents need to be identified
  - OSH policies on voice care should be established and reviewed regularly
- recommendations:
  - vocal training should be provided for all call agents, especially new starters
  - initiatives or strategies should be developed to reduce absenteeism among call agents in call centres
  - vocal health should be included in call centres' OSH policy.

Recommendations for further research

Recommendations for further research among call agents include:

- determining universally accepted definitions of voice disorders, assessment and methodologies, which should be used consistently
- determining standardised measurement tools (a battery of tests) that can be used universally
- determining whether professional voice users' occupations cause or exacerbate voice disorders
- conducting a large-scale risk assessment to identify the prevalence of precipitating and perpetuating factors contributing to occupational voice disorders and to classify the levels of risk of occupational voice disorders
- identifying the levels of risk for call agents of developing voice problems and the optimum levels of intervention to aid assessment and prevention
- further developing the biopsychosocial questionnaire (used in the present online survey) as a screening tool
- confirming that voice training improves the vocal quality of professional voice users by conducting a randomised controlled trial with two groups of call agents, one receiving the vocal training programme and another receiving no training, to compare and establish the effect of voice training among call agents
- investigating the efficacy of different types of voice training programme in order to develop an optimally effective programme for call centre workers
- investigating cost-effective methods of providing voice training to call agents
- verifying physiological change to vocal function using medical visualisation techniques.

1 Introduction

1.1 Background to the human voice

The human voice is the central and most important tool for the communication industry but is often underestimated and neglected. However, the voice is not simply the tool for communication transmission; it is directly related to effective verbal communication and interaction.

The voice can be described using the following parameters: vocal note quality, pitch, loudness and resonance.[1] An individual's ordinary voice is said to be normal if it has the following characteristics:

- it has a clear vocal note
- it is audible
- it is appropriate to the person's age and sex
- it carries linguistic and emotional information
- it is stable and flexible
- it has reaonable stamina
- normal phonation (the production of speech sounds) is comfortable.[1]

A voice problem reflects a change in the features of the individual's normal voice. Prolonged voice misuse may put additional strain and tension on the laryngeal musculature that can result in musculoskeletal disorders.[1,2] Muscular tension of the larynx and surrounding areas can affect the function and effectiveness of the voice for communication clarity, audibility and efficiency, in a process often referred to as vocal attrition. Voice problems can range from loss of voice, known as aphonia, to varying levels of vocal impairment, or dysphonia.[1] Dysphonia is defined as a voice disorder characterised by abnormalities in pitch, loudness and/or quality of the voice.[3]

However, in the current literature there are inconsistencies in the use of definitions of voice disorders. For the purpose of this report, the above definition of dysphonia will be used and referred to as a voice disorder. Voice disorders are multi-factorial and can manifest themselves in a number of ways, such as voice loss, vocal strain and acoustic deterioration. A voice disorder due to work-related overuse or abuse that may threaten working ability is also known as an occupational voice disorder.[3,4] A professional voice user is an individual who depends on a consistent and appealing voice quality as a main tool in their employment. Those who have regular or chronic episodes of voice loss would generally be disadvantaged in their jobs and may need to seek alternative employment.[5]

1.2 Risk factors for the voice among the workforce

Many occupations require their practitioners to have an effective working voice. It is estimated that around 25 per cent of the workforce in the US[5] and 30 per cent in Finland[4] are employed in professions that place demands on the voice. There is substantial epidemiological and physiological evidence that teachers, singers, actors, lawyers and call centre workers are at risk of work-related voice problems.[7] The literature has reported that voice disorders tend to be multi-factorial, with no single cause identified.[8] The risk factors for voice disorders for professional voice users include:

- background noise
- vocal loading
- poor air quality (dryness, dust)
- poor posture.[9,10]

It is also suggested in the literature that women are at greater risk of voice problems than men.[11] The reasons for this difference are partly anatomical and physiological, as women have smaller larynges and have more vocal fold vibrations, thus needing greater vocal effort to phonate and project their voices compared to men. It has been indicated that these risk factors are cumulative but preventable.[9,12] Voice disorders among the workforce can affect the communicative, interactive and economic efficiency of the organisation or industry.[3,7,13] Thus both vocal and communicative effectiveness are important in a working environment.

1.3 Occupational health and safety issues in the call centre industry

The call centre or contact centre industry is particularly dependent on its workers' effective vocal performance. ('Call centre' and 'contact centre' are used interchangeably in the context of this report. Although contact centres use forms of communication other than the telephone, such as email and text messaging, while call centres use only the telephone to interact with customers, this study focuses

only on telephone communication.) A report by the UK Department of Trade and Industry (DTI) in 2004[14] provided one of the most comprehensive reviews of the contact centre industry across the country. In the UK in 2003, there were 5,320 contact centres and almost 500,000 agent positions. The industry has grown by almost 250 per cent since 1995 and continues to add tens of thousands of positions each year. This industry is predicted to continue to grow in the UK and worldwide.[14]

The DTI report stated that 95 per cent of employers considered verbal communication as an essential skill when recruiting staff. However, it also reported that, in general, communication and interpersonal skills appear to be slipping. In addition, a range of OSH issues were identified as potential risks or current stressors in this work environment, raising the importance of regular appraisal and review of the impact of these issues on the health and economic wellbeing of the industry.

The Health and Safety Executive conducted an in-depth investigation of stress and psychosocial stressors in the call centre industry in 2003.[15] The potential hazards highlighted related to vocal, optical, auditory and musculoskeletal health. Furthermore, literature has indicated that the environment and posture of the call agent influences the effectiveness of voice production. Poor environments and postures may contribute to musculoskeletal problems through laryngeal muscle tension – in other words, poor posture modifies the tension and dimensions of the vocal tract, affecting the quality of the voice.[1]

Vocal health was evaluated by self-reported frequency of symptoms, with 39 per cent reporting hoarseness, 32 per cent pitch change and 42 per cent discomfort in the throat. The report suggests that existing risks can be controlled through good work design and the provision of information and training. However, the contributory physiological demands have not been fully evaluated in relation to the various elements, including the physical work environment.

It has been suggested that occupational voice problems result from repetitive strain injury but are not generally defined and viewed as such. However, voice disorders are indisputably musculoskeletal disorders, as they involve damage to the larynx and the surrounding areas.[1] Furthermore, there is controversy over the definition and diagnosis of repetitive strain injury, which is demonstrated by the difficulty individuals can have in proving that they have suffered a workplace injury.

The Industrial Injuries Advisory Council[16] report published in 2006 considered the risk of voice loss in those employed in occupations with high levels of noise and concluded that the lack of good quality data indicating occupational voice disorders meant that it was impossible to prescribe any remedial action. This indicates that evidence of physiological change is required. Furthermore, the prevention and treatment of occupational voice disorders requires improved OSH arrangements.[3]

1.4 Importance of the voice for call agents

In the call centre and contact centre industry, agents communicate with customers by telephone, email and text message. However, the vast majority of communications are by telephone. Although organisations encourage customers to use online or email-based contact points, the proportion of communication carried out by email or text message is small, with most customers preferring traditional telephone interaction.[17] Thus call agents have to use their voice for long periods, which places a high demand on their voice and increases the risk of occupational voice disorders. A study investigating the prevalence of voice problems among telemarketers compared to the general population concluded that they were twice as likely to report one or more symptoms of vocal strain compared with the control group.[18] This study also reported that impaired work productivity due to voice problems occurred among 31 per cent of the telemarketers.[18] A recent study found that voice disorders were reported among 46 per cent of call centre operators in Italy.[19]

Call centre agents are particularly reliant on a well-functioning voice. Risks to vocal performance and efficiency are not simply physiological; telephone interaction also demands co-ordination of optimum psychological, behavioural and environmental settings to maintain an efficient balance for the interaction. The demands of this work environment have been described as emotional, cognitive and vocal.[20] When the call agent's voice becomes strained, hoarse or effortful, this in turn may add emotional and cognitive stress, which could have an affect on the customer and result in less efficient interaction, particularly when following a protocol for calls.[21]

1.5 Rationale for the project

Voice disorders are a global health problem1 that have been identified as a research and/or clinical priority in recent publications.[1,16] Large resources have already been spent without fully

understanding or appreciating the interactional dimensions of telephone communication, ie the physical, environmental, behavioural and psychosocial aspects of vocal communication. The failure to investigate the use of the voice and the impact of vocal performance has resulted in a significant gap in the evidence base of OSH research.[14] Furthermore, most of the published studies investigating the vocal demands of call agents involve small numbers of participants (between 24 and 373).[10,18,21–23] There have also been no studies investigating voice use and the impact of vocal and communication demands and performance in the call centre industry in the UK and Ireland.

1.6 Aim and objectives of the project

This study aimed to address this significant gap in the evidence base of OSH research in call centres. It will therefore provide the missing element of voice-based evidence by investigating and appraising the interactional dimensions of vocal health and communicative performance.

The objectives of the study were to:

- investigate the work context and vocal communication demands for call agents
- evaluate call agents' vocal health, awareness and performance
- identify key risks and training needs for employees and employers in call centres.

1.7 Significance of the project

This study investigated the work context and vocal communication demands for call agents, evaluated their vocal health, awareness and performance, and identified key risks and training needs for employees and employers in call centres. It therefore provides the missing element of voice-based evidence by investigating and appraising the interactional dimensions of vocal health and communicative performance in a UK and Ireland perspective. It will have benefits for employees and employers in call centres and for policy makers, and will ultimately enhance customer service.

2 Literature review: vocal demands and health of call agents in call centres

2.1 Background

Voice disorders are a global health problem[7] and have been identified as a research and/or clinical priority in recent publications.[7,16] Although it is difficult to determine the prevalence of voice problems in the general population, Ramig & Verdolini[24] estimated that between 3 and 9 per cent of workers in the US have complained of voice disorders at one time or another. A wide range of occupations depend on the voice as a professional tool, such as teaching, singing, acting and working in call centres.[7] The heavy vocal demands associated with these professions increases the risk of occupational voice disorder.[3,22]

Within the range of professional voice users deemed to be at higher risk, the largest body of evidence has resulted from epidemiological studies of voice disorders in teachers. Prevalence rates have been estimated at between 12 and 26 per cent, depending on the sample and methodology.[25,26] In a study of Dutch teachers, De Jong *et al*.[27] found that more than half of teachers (in a sample of 1,878) reported voice problems during their career and approximately a fifth had a history of sick leave due to voice problems. A recent French study of 3,646 teachers found that 50 per cent of female teachers reported suffering always or often from at least one type of voice symptom, compared to 26 per cent of males.[28]

There is a large body of literature investigating the prevalence and symptomatology of vocal attrition in teachers, who may be affected in many ways, with mechanical, sensation and acoustic symptoms developing on a continuum.[29] Vocal endurance is considered to be one of the main demands on the voice.[30] Studies have investigated the effect of vocal loading on the acoustics of the voice,[31–33] using acoustic parameters such as fundamental frequency, sound pressure level, jitter and shimmer. There is a relationship between self-reported symptoms of vocal fatigue and increases in fundamental frequency and sound pressure level (SPL).[31] Sapir *et al*.[32] described vocal attrition in teachers and reported a steady decline in vocal function over time, which presents as abnormal throat sensations, abnormal voice quality and pitch, inadequate vocal strength and endurance. In addition to vocal endurance, the raised volume required to speak over background noise causes strained or hyperfunctional vocal behaviour.[33] They found that day care centre teachers used a louder voice throughout the day, 9.1 dB higher than their baseline sound pressure levels taken in a quiet room. They also used a higher fundamental frequency (247 Hz compared to their baseline of 202 Hz), with few opportunities for voice rest.

In a study of voice disorders among a random sample of teachers, there was a prevalence rate of 57 per cent, including 20.2 per cent for organic dysphonia, 28.8 per cent for functional dysphonia and 8.1 per cent for chronic laryngitis, diagnosed using videolaryngostroboscopy.[11] In the same study vocal symptomatology was self-reported, with 44 per cent complaining of momentary voice disruptions while speaking and 79 per cent reporting pharyngeal paraesthesia and needing to clear their throat. The authors in this reported study discussed laryngeal overexertion as the reason for vocal symptoms such as pink or red vocal chords and excessive tension in laryngeal muscles. There are similar findings from previous studies.[34,35]

The reported prevalence of voice disorders is high among other occupations, such as 46 per cent among call centre operators.[19] Thus voice disorders are an important vocal health issue that needs to be addressed, especially among occupations such as call centre workers. Therefore, the objective is to review the published available research studies investigating the vocal demands and health of call centre workers.

2.2 Methods

A systematic search of the literature was conducted on 15 July 2009, using the following electronic databases:

- CSA Illumina
- Cochrane Library
- EBSCO Host CINAHL
- ISI Web of Knowledge: Web of Science
- OvidSP Embase
- OvidSP Medline
- OvidSP PsychINFO
- PubMed Central.

These searches were performed using the following defined search terms: 'occupational voice' OR 'occupational dysphonia' OR 'voice' AND 'call centre' OR 'call agents' OR 'customer-service advisors' OR 'telemarketers'. From these searches, studies were identified and then screened for inclusion in this review. The inclusion criterion was investigating the vocal demands and health of call centre workers. To obtain the comprehensive relevant literature, no studies were excluded on the basis of study design, study quality, outcome measures, type of intervention or profession/occupation. References from the articles were also reviewed. In total, five studies investigating the vocal demands and health of call centre workers were selected for this review.

2.3 Results

Five studies were identified that investigated the vocal demands and health of employees in the call centre industry.[10,18,21-23] The description (design, participants, intervention groups, measurements and measurement collection time points) of these five studies is displayed in Table 3.

Of the five published studies investigating the voice health of employees in the call centre industry, four were conducted by Lehto and colleagues in Finland. These studies were conducted in call centres with relatively small numbers of customer service advisers (between 24 and 48). Two studies considered the effect of a vocal training course in the short term[22] or longer term,[10] while the other two studies investigated changes in[23] and correlations between[21] subjective voice complaints and objective acoustic measurements. All four studies investigated self-reported voice symptoms by the customer service advisers recorded during the morning shift[22] or at four different times during a working day (in the morning, before lunch, after lunch and at the end of the working day).[10,21,23] A summary of the key findings from these studies is shown in Table 4. Lehto and colleagues found that self-reported voice symptoms, such as an increase in the feeling of mucus and the consequent need to clear the throat increased significantly during the working day,[10,21–23] which was endorsed by acoustic analysis, in particular by the fundamental frequency.[21,23] There were no correlations between subjective voice complaints and objective acoustic measurements.[21,23]

Jones *et al.*[18] compared the prevalence of voice problems among telemarketers ($n = 304$) with the general population ($n = 187$) in the US and investigated whether these voice problems affected productivity or were associated with risk factors (Table 1). The findings showed that telemarketers were twice as likely to report one or more symptoms of vocal strain compared with non-telemarketers (the control group). In addition, these voice problems affected productivity and were associated with modifiable risk factors (Table 4).

Of the five studies, two considered the effect of a vocal training course in the short term[22] or longer term.[23] The training programme in these studies included both indirect and direct methods, which were delivered in the call centres during a two-day training course plus a one-day seminar, and, in one study,[10] an additional one-day refresher course six months later. A description of the training programmes is outlined in Table 5.

The findings reported that vocal training significantly improved some voice-related symptoms such as vocal quality, vocal strain, vocal fatigue, hoarseness and voice impairment; see Table 6. It was concluded that a short vocal training course may be beneficial to self-reported wellbeing for call centre employees both in the short term (three weeks after baseline measurement[22]) and longer term (18 months after training[10]).

2.4 Discussion

This concise review of the published available research studies investigating the vocal demands and health of call centre workers shows that all of the five included studies indicated that vocal health is an important issue for the call centre industry. These studies collectively reported that call centre employees are at increased risk of developing voice symptoms, and these workers reported voice symptoms themselves, which increased during the working day. This observation was backed up by subjective, self-reported symptoms and objective, acoustic parameters. Voice training may be beneficial to self-reported wellbeing for call centre employees. However, the details of vocal communication demands and vocal health status among call agents are unknown. Furthermore, the published studies investigating the voices of call agents were conducted in Finland and the US, and there is no published research carried out in the UK or Ireland in this area.

Preventive strategies are recommended to reduce the risk of voice disorders among the working population.[12] One suggested method of primary prevention for professional voice users is voice training.[13] Although professional singers and actors often receive training in voice care and

Table 3
Description of studies investigating vocal demands and health of call centre employees (information as reported in each publication)

Study	Design	Participants	Intervention groups	Measurements	Measurement collection time points
Jones *et al.* (2002)[18]	Cross-sectional survey	373 participants	Two groups: • call centre employees (*n* = 304) • community college students (control group; *n* = 187)	Questionnaire including the following information • demographic • vocational • personality • biological risk factors for voice problems • symptoms of vocal attrition • effects of symptoms at work	Once
Lehto *et al.* (2003)[22]	Observational	48 call centre customer service advisers (38 women, 10 men)	One group	Two questionnaires: • subjective voice problems and symptoms • impact of training (completed after training) Clinical examination: perceptual voice analysis and laryngeal examination with a mirror by a phoniatrician (one occasion)	1 Baseline 2 After training (three weeks later)
Lehto *et al.* (2005)[10]	Observational	45 call centre customer service advisers (35 women, 10 men)	One group	Two questionnaires: • subjective voice problems and symptoms • impact of training (completed after training) Clinical examination: perceptual voice analysis and laryngeal examination with a mirror by a phoniatrician (one occasion)	1 Baseline 2 Two weeks after training (five weeks later) 3 Follow-up (18 months after training)
Lehto *et al.* (2006)[21]	Observational (field study)	24 female customer service advisers	One group	• Speech sample (five minutes) • Questionnaire on vocal symptoms • Clinical examination: perceptual voice analysis and laryngeal examination with a mirror by a phoniatrician (one occasion)	Four times during a working day (morning, before lunch break, after lunch break, end of working day)
Lehto *et al.* (2008)[23]	Observational (field study)	30 customer service advisers (24 women, 8 men)	One group	• Speech sample (five minutes) • Questionnaire on vocal symptoms • Clinical examination: perceptual voice analysis and laryngeal examination with a mirror by a phoniatrician (one occasion)	Four times during a working day (morning, before lunch break, after lunch break, end of working day)

Study	Key findings
Jones *et al.* 2002[15]	Telemarketers were twice as likely to report one or more symptoms of vocal attrition compared with controls. Of those surveyed, 31% reported that their work was affected by an average of five symptoms
Lehto *et al.* 2003[19]	After the voice training, more than 50% of women and men reported a decrease in the feeling of mucus and a consequent need to clear the throat, as well as diminished worsening of their voice. Over 60% thought that voice training had improved their vocal habits
Lehto *et al.* 2005[8]	Short vocal training course significantly reduced some of the vocal symptoms
Lehto *et al.* 2006[18]	Fundamental frequency (F_0) and self-reported voice symptoms increased significantly during the working day for females. Correlations between vocal symptoms and acoustic measures were not found
Lehto *et al.* 2008[20]	Fundamental frequency (F_0) underwent a statistically significant increase during the working day for both genders. No correlations between the changes in objective and subjective parameters

Table 4
Summary of results from studies investigating vocal demands and health of call centre employees (information as reported in each publication)

Study	Training		Format and duration of training
	Indirect	Direct	
Lehto *et al.* 2003[22]*	Education: theory of voice production, resonance and articulation; vocal hygiene; balanced breathing patterns; body posture as a tool to reduce tension when speaking; dietary habits	Practice vocal exercises, eg producing voice more economically; warm-up and cool-down voice exercises	Two-day training course plus one-day seminar
Lehto *et al.* 2005[10]*	Education: theory of voice production, resonance and articulation; vocal hygiene; balanced breathing patterns; body posture as a tool to reduce tension when speaking; dietary habits	Practice vocal exercises, eg producing voice more economically; warm-up and cool-down voice exercises; relaxation of jaw and pharynx while producing nasal, vowel and humming sounds	Two-day training course, one-day seminar and a further one-day refresher course six months later

* The training was delivered as indirect and direct methods combined

Table 5
Studies including voice training programmes in call centres (information as reported in each publication)

Study	Effect of training
Lehto *et al.* 2003[22]	Significant reduction in vocal fatigue, hoarseness and worsening of the voice, and also improved vocal quality. These effects were greater in women
Lehto *et al.* 2005[10]	Significant reduction in reported feeling of vocal strain, hoarseness and voice impairment during the working day

Table 6
Summary of findings from studies showing the effect of voice training among call centre employees (information as reported in each publication)

preservation, the vast majority of professional voice users, including call agents, are unaware of how to maintain or improve their voice, which is their greatest professional asset and communication tool.

The systematic literature review included studies related to the prevention of voice disorders and concluded that there is no evidence that voice training prevents voice disorders.[6] Furthermore, as this was a systematic review, only randomised controlled trials (RCTs) were considered, and RCTs published after 15 July 2009 were not included. As there was no review focusing solely on the impact of voice training for professional voice users, including various study designs, the present authors addressed this issue in a recent review paper.[36] The objective was to review the current published available research into the impact of voice training on the vocal quality of professional voice users, in order to demonstrate the implications for vocal health and offer recommendations for further research. From the 10 studies selected for the earlier review, two included call centre workers, which were included in the present review.[10,22] The findings from the 10 studies indicated that there was no conclusive evidence that voice training improves the vocal effectiveness of the professional voice users studied (ie teachers, call centre workers, singers and audiovisual communication graduate students),

due to a range of methodological limitations of the included studies (eg low participant numbers: $n = 11–60$). However, all the studies in the review concluded that voice training may be beneficial for professional voice users. Some studies did show that voice training significantly improved the professional voice user's knowledge and awareness and their quality of voice. This indicates that vocal training may be beneficial for professional voice users such as call agents. However, it is not confirmed that voice training improves the vocal quality of professional voice users, including call agents, or prevents occupational voice disorders. Furthermore, the precise vocal training needs of call agents have not been identified. There is therefore a need for robust research with powered sample sizes to confirm whether voice training improves the vocal quality and efficiency of professional voice users.

2.4.1 OSH issues

The risk factors for occupational voice disorders – such as background noise, unsatisfactory room acoustics, poor air quality (dryness, dust), poor posture and vocal loading[9,37] – can be considered as an OSH issue. Current UK health and safety law,[38] backed up by guidance and research from the Health and Safety Executive,[15] requires employers to provide resources to prevent occupational risks. On this basis, professional voice users such as call agents should be provided with a safe working environment and/or information on vocal care.

In the UK, the Industrial Injuries Advisory Council[16] published a position paper on occupational voice loss, which considered the risk of voice loss in those employed in occupations with high levels of noise. The report concluded that although several research studies have been published, there is insufficient current evidence for occupational voice loss to meet the requirements for prescription by the Council. Therefore, it is suggested that OSH policies on occupational voice disorders should be established and reviewed regularly, according to emerging evidence.

2.4.2 Gaps in the voice research literature

In reviewing the published literature on voice research among call agents, the present research raises more research questions that need to be addressed. In general, the current voice research literature displays inconsistencies in definitions of terminology, assessment and methodology. Thus there is a need for the development of more validated standardised measurement tools for voice research and also for studies to use these validated tools more consistently, to allow comparison of findings across studies.

Further research is required to address the following issues:

- a universally accepted definition of voice disorders
- definitions of assessment and methodologies, which should be used consistently
- the development of a screening tool
- the development of standardised measurement tools that can be used universally
- a determination of whether occupation causes or exacerbates voice disorders among professional voice users
- a large-scale risk assessment to identify the prevalence of precipitating and perpetuating factors contributing to occupational voice disorders and to classify the levels of risk
- the training needs of call agents
- confirmation using a well-designed, controlled and powered study (preferably a randomised controlled trial) that voice training improves the vocal quality of professional voice users
- investigation of the most effective forms of voice training programmes in terms of format, method of delivery and duration, and assessment of cost-effectiveness.

From reviewing studies investigating the vocal demands and health of call centre workers, it is clear that the research areas that need to be addressed first are detailed vocal communication demands and vocal health, and voice training needs of call agents in the UK and Ireland.

2.5 Conclusion

This review of the published research into the vocal demands and health of call centre workers showed that there are limited studies in this area. To date, there are only five studies[10,18,21–23] that investigated the voices of call centre workers, of which two considered the effect of vocal training.[10,22] The studies showed that call centre employees report voice symptoms themselves and also indicate that voice training may improve their vocal quality. This has OSH implications for the call centre industry.

All five studies were published recently (within the last decade), indicating that voice use by call agents is a relatively new and growing research area. Further research is required to provide the missing element of voice-based evidence, by investigating and appraising vocal health and communicative performance among call agents. The present study aims to address this significant gap in the evidence base of OSH research.

3 Study design and methodology

3.1 Research design

The literature review outlined in Section 2 showed that previous studies investigating the vocal health of call centre workers have small sample sizes and are experimental in nature; further investigation is therefore required. This research is an occupational epidemiological study with a mixed methods design, consisting of both qualitative and quantitative approaches. There were three stages to this research study:

1 interviews with a senior manager (eg call centre manager or HR manager) at each call centre
2 a large-scale online epidemiological survey
3 acoustic measurements in the real work environment.

3.2 Participants and recruitment

The research participants were employees from call centres in the UK and Ireland. A strategic recruitment approach was adopted. A list of call centres throughout the UK and Ireland was compiled using the Contact Centre Association (CCA) UK membership list and internet searches such as yell.com and GoldenPages.ie. Using this list, each centre's HR department was contacted via email, inviting participation in the study. Some of these contacts were followed up by a telephone call. In addition, an article was placed in the CCA's monthly members' bulletin. The CCA has over 820 member organisations, so over 820 call centres received information about this study. The recruitment process continued for six months. Interested managers from call centres contacted the research team and received full details of the study. In total, 14 call centres participated. The management team in each participating call centres told their call agents about the study (via email, posters on notice boards or at staff meetings) and invited them to complete the online survey. A senior manager from each participating organisation provided written informed consent on behalf of their call centre. The first question on the questionnaire for the online survey asked the call agents to indicate consent, and the managers participating in the interviews provided written consent via email.

3.3 Sample size

As this is a relatively new area of research, the main measurement tool was a biopsychosocial questionnaire for the online survey, which was developed to collect the relevant information to meet the aims and objectives of this study; thus power calculations (to determine the sample size of participants required to provide a significant difference) were not made. The convenient sample sizes of the participants (nonprobability sampling which involves the sample being drawn from that part of the population which is accessible) in each stage of this study were:

- interviews with one manager from each participating call centre ($n = 13$; although 14 call centres participated in the survey, one call centre did not complete the interviews as the manager was on sick leave at the time of data collection)
- the online survey, which was completed by 600 call agents (598 were analysed – see the results section) from the participating call centres
- acoustic measurements conducted by 12 per cent of participants from stage 2 ($n = 70$).

The researchers considered that these sample sizes were sufficient for the measurement tools to collect information on the vocal demands and communication, vocal health and training needs of call agents in call centres in the UK and Ireland. The findings from this study will be used for a power calculation in the follow-up randomised controlled trial in call centres.

3.4 Measurement tools

3.4.1 Semi-structured questionnaire

A semi-structured questionnaire was developed for telephone interviews with a senior manager from the call centres. These interviews aimed to assess the organisation's communication and training needs. This questionnaire included a mixture of open and closed questions on the demographics of the company and the current training provision and needs for call agents. Example questions are: 'What is your organisation's format of training?' and 'Does this training include vocal care?' The findings from these interviews were used to further refine and inform the design of the biopsychosocial questionnaire.

3.4.2 Biopsychosocial questionnaire (main measurement tool)

The aim of the online survey was to investigate the work environment and vocal demands and health of call agents. A biopsychosocial questionnaire was developed for the online survey, which was based on self-report tools, tested for reliability and validity. This questionnaire included the Voice Symptom Scale (VoiSS),[39] the Voice Handicap Index (VHI),[40] and the Vocology Screening Profile (VSP).[29] The VoiSS was developed from 800 participants and is psychometrically the most robust and extensively validated self-report voice measure available.[39] This scale includes three domains of impairment, physiological and emotional aspects of voice symptoms and is assessed using a five-item scale (where 0 = never and 4 = frequently). Example items are 'Do you feel you have to strain to produce voice?' and 'Does your voice make you feel incompetent?' The VHI was devised by Jacobson *et al.*[40] and uses a similar five-item scale. Example items are 'My voice difficulties restrict my personal and social life' and 'My voice problem upsets me'. The VSP assesses vocal symptomatology.[29] This uses the same measurement scale and example items include 'Increased effort to talk' and 'Feeling thirsty', relating to physiological, acoustic and vocal function symptoms.

This comprehensive biopsychosocial questionnaire contained questions divided into the following sections:

- personal information such as age
- work-related environment, eg working full or part-time
- social activities such as singing
- voice use, eg difficulty talking against background noise
- voice symptoms such as hoarseness
- vocal impact, eg straining needed to produce voice
- other information such as requests for further information or training to improve vocal performance at work.

The questionnaire used a quantitative approach with drop-down menus and options to select or tick boxes. Several of the managers from call centres asked to see the questionnaire before giving permission for the survey to be carried out in their call centre, and to ensure that the maximum number of call centres could be involved in the survey, all questions were optional. The researchers were aware that this would lead to a different number of responses for each question. The questionnaire was piloted among a sample of call agents, different from those participating in the main survey, with a successful outcome.

3.4.3 Telephone recordings

Telephone conversations between call agents and customers are routinely recorded and monitored in call centres. A sample of this natural conversation was selected and analysed for acoustic parameters. This was conducted to determine the acoustic quality of the call agents' voice.

3.5 Procedures

For the first stage of this research, telephone interviews were conducted with a senior manager (eg the manager of the call centre or the HR manager) in the participating call centres. These interviews lasted approximately 10 minutes and the information collated from them informed the development of the measurement tool, the biopsychosocial questionnaire. Secondly, a large-scale epidemiology study was conducted using an online biopsychosocial questionnaire, which was given to call agents in the participating call centres. This was published on a secure website and accessed by the participants at a convenient time, in agreement with their management teams. Participants received information on the study, including the time required for completion and an assurance that all responses were anonymous. The questionnaire took approximately 10 minutes to complete. The third and final stage involved acoustic measurement from a random sample of monitored telephone calls involving call agents at one call centre participating in the online survey. A sample of the natural conversation was selected by a call centre staff member and given to the research team in digital format for analysis.

3.6 Data analysis

The data from the telephone interviews were transcribed and analysed thematically to determine the context and process characteristics of the organisations. Qualitative content analysis identified underlying themes and issues.

Acoustic analysis was conducted on a sample of the voice of call agents from the telephone recordings using the Multi-Dimensional Voice Program (MDVP) (Kay Elemetrics Corporation, New Jersey; model 5105), which is a software program that provides a robust multi-dimensional analysis of voice

with graphic and numerical presentation of analysis.[41] This tool provides information about the voice and whether or how it differs from the norm. MDVP is the gold standard measurement tool for quantitative analysis of voice. The analysis calculates 34 parameters of voice and includes:

- voice break and subharmonic parameters, eg degree of subharmonics (DSH)
- short and long term frequency perturbations, eg jitter
- short and long term amplitude perturbations, eg shimmer (shim)
- noise-related parameters, eg sound pressure level (SPL)
- tremor parameters, eg amplitude tremor intensity index (ATRI).[41]

The full descriptions of all the parameters are in Appendix 1.

From the telephone recordings, three sections each consisting of three seconds of the call agent's continuous voice uninterrupted by the customer were selected during 10 seconds at the start, middle and end of the telephone call. Three seconds of recording is within the recommended range for acoustic analysis by the manufacturer of the voice analysis software.[41] The voices of the call agents in these recordings were analysed for the following 14 acoustic parameters:

- mean fundamental frequency (MF_0)
- highest fundamental frequency (Fhi)
- lowest fundamental frequency (Flo)
- standard deviation of F0 (STD)
- amplitude tremor frequency (Fatr)
- absolute jitter (Jita)
- jitter percentage (Jitt)
- shimmer in dB (ShdB)
- shimmer percentage (Shim)
- peak-to-peak amplitude variation (vAm)
- noise to harmonic ratio (NHR)
- degree of voice breaks (DVB)
- degree of subharmonics (DSH)
- degree of voiceless (DUV).

These parameters were selected as being clinically relevant to this population and context. The measurement tool was used to measure the acoustic dimensions of the call agents' voices from the sample calls. These measurements provided more objective data for the identification of voice and communication parameters, related to the perception and evaluation of effective telephone communication with customers.

All numerical data were analysed using SPSS version 15. The data were normally distributed, so parametric tests were completed. Descriptive statistics were conducted including means, standard deviations and ranges or frequencies as appropriate for each of 94 variables in the biopsychosocial questionnaire and the 14 acoustic parameters. Pearson correlations were completed to compare the acoustic parameters at the start, middle and end of the call, and also to determine correlations between the variables in the biopsychosocial questionnaire.

Given the complexity of the biopsychosocial questionnaire and the array of variables affecting vocal strain, there was a need to employ sophisticated forms of analysis, with the capacity to explore potential directional effects across a wide range of variables. While multiple regression analysis is frequently used to analyse social science data, the main problem is handling measurement error and indirect or mediating effects. Since most multivariate procedures cannot deal with multiple variables, particularly multiple dependent or criterion variables, hypothesis testing is difficult.

Therefore, the study adopted a multivariate analysis approach using structural equation modelling (SEM) to develop vocal health measurement models in determining the construct validity of potential factors contributing to voice problems.[42] The research design and associated analysis attempted to overcome the traditional complications of multiple indicators, indirect effects and measurement error by using SEM with latent variables and LISREL (Linear Structural Relations) estimation. SEM is a statistical methodology that takes a confirmatory (ie hypothesis-testing) approach to the multivariate analysis of a structural theory bearing on some phenomenon, representing causal processes which generate assumptions on multiple variables.[29]

3.6.1 Null hypotheses

The overall null hypothesis is that there is no relationship between physiological voice production and psychosocial and medical health among call agents within call centres. The sub-hypotheses are that there is no relationship:

- between mechanical, sensation and acoustic factors and call agents' physiological voice production
- between the medical conditions and medical advice factors and call agents' medical health
- between functional and emotional factors and call agents' psychosocial health
- between vocal training and physiological voice production.

LISREL provides indices of goodness of fit, which reflect the appropriateness of the statistical model relative to the population variance covariance matrix. LISREL provides a number of indices of goodness-of-fit. Two commonly used fit indices in SEM are the chi-square and the RMSEA (root mean square error of approximation). A non-significant chi-square ($p > 0.05$) is indicative of acceptable model fit. However, for models with relatively large sample sizes ($n > 200$) the chi-square is often found to be significant (ie it rejects acceptable statistical models). The RMSEA is known to perform well for larger sample sizes,[30] where a value of < 0.05 indicates a close fit and values of < 0.08 indicate reasonable errors of approximation in the population.[31]

3.7 Ethical issues

This study obtained ethical approval from the School of Communication Risk and Ethics Filter Committee at the University of Ulster. The biopsychosocial questionnaire and the telephone call recordings were anonymous. These were only identified by code and not by individual call agent's or customer's name.

All data were stored securely. Electronic data, including telephone recordings, were stored on password-protected computers and hard copies were stored in a locked filing cabinet only accessible by the research team. All information was treated as confidential under the Data Protection Act.[44]

This methodology was published by the team as a study protocol paper.[45]

4 Findings and results

4.1 Telephone interviews with senior managers from call centres

One manager from 13 of the 14 call centres that took part in the study agreed to participate in a telephone interview on one occasion. In one call centre, no one was available to complete the interview as the contact person was on sick leave at the time of the interviews. Qualitative content analysis identified 10 underlying themes from these interviews, described below.

4.1.1 Demographics of participating call centres

The 13 managers were from call centres located across the UK and Ireland:

- England ($n = 5$)
- Northern Ireland ($n = 5$)
- Republic of Ireland ($n = 2$)
- Wales ($n = 1$).

The call centres handled a variety of business, as follows:

- customer service ($n = 7$)
- sales ($n = 4$)
- information gathering ($n = 1$)
- other (all of the above three functions) ($n = 1$).

The number of call agents in the call centres ranged from 12 to 1,800. Among the 13 call centres:

- eight (61 per cent) had fewer than 50 call agents
- one (8 per cent) had between 101 and 250
- one (8 per cent) had between 251 and 500
- one (8 per cent) between 501 and 1,000
- two (15 per cent) had over 1,000.

It was reported that 11 call centres dealt with both inbound and outbound calls but their work was mainly inbound. Two call centres did only outbound work.

4.1.2 Call centres' health and safety policy

All the call centres reported having a health and safety policy, covering areas such as breaks, access to water, availability of headphones and monitoring of calls. The duration of breaks differed among call centres, varying from 10 minutes on a six-hour shift to five minutes each hour (for smoking, tea and so on) plus 30 minutes for lunch. One call centre reported that in addition to two 15-minute and one 30-minute lunch breaks, call agents have comfort breaks including massages, and have access to health advice as part of the company's health and wellbeing policy. All the call centres provide access to water, with the majority having water coolers throughout the buildings. Calls are monitored in all call centres and the majority of centres record some or all the calls.

4.1.3 Quality and quantity targets

Of the 13 call centres, nine reported having targets for quality and quantity. All the managers reported that they placed more emphasis on quality rather than quantity. The quality measures and target criteria differed among call centres. Example targets include: 'customers' requests are satisfied in at least 95 per cent of cases', 'at least 85 per cent of calls are dealt with by an adviser' (call handling), and 'in at least 50 per cent of calls regarding contracts, the contracts remain in place' (contract retention). Call duration varied from 2 to 4½ minutes.

4.1.4 Monitoring the calls of call agents

Depending on the management structure of the call centres, calls were monitored by the following personnel:

- quality team
- trainers
- team leaders
- senior team leaders
- call centre manager

- quality development team
- managing director
- operations manager
- quality coaching manager
- quality assurance team managers
- quality executives
- quality control reporting team
- verification team
- validation team
- various other managers.

The most common role responsible for monitoring calls was the team leader ($n = 5$). In some call centres, more than one person was responsible for monitoring calls.

4.1.5 Training for call agents

All managers in the call centres reported that they offer training to call agents. Most (95–100 per cent) of this training is organised in house, with the remainder covered by the following means:

- contracted in as consultancy (for customer service)
- through National Vocational Qualifications (NVQs)
- using external trainers
- at one call centre, using clients to deliver training.

The personnel responsible for training included team managers or leaders and training managers, supported by:

- training development manager
- client and operations manager
- training co-ordinator
- training officer
- training team
- operations team
- learning and development training manager
- learning and development training team
- operations team
- champions
- quality executives
- validation team
- call centre manager
- managing director
- clients
- other managers.

The training in all call centres included induction and then ongoing support as required. Induction training usually included classroom-based learning, PowerPoint presentations, mock-ups and seminars. The majority of call centres included the following in their induction training on:

- business-specific issues
- products
- services
- systems
- customer services
- the organisation.

Trainees were then monitored before going live on telephones, and back-up support was available for the first few weeks. The duration of formal induction training ranged from three hours to four weeks, with monitoring for up to four months. Ongoing training included refresher training as required, customer service training once a year for all staff, and updates on customers. The frequency of ongoing training ranged from daily to once a year.

The reported training needs of call agents were many and varied. Their responses indicated a need for training on:

- products
- systems
- customer knowledge
- customer interaction (how to react to customers)
- tools to deal with all types of call
- dealing with problematic calls
- customer service.

For many respondents this was their first job, and these call agents needed:

- knowledge and understanding of call centre systems
- guidance on following scripts
- encouragement to have faith in the script (according to one managing director)
- guidance on using their workstation properly,
- product knowledge
- training on dealing appropriately with clients
- help in improving their attitude and work ethic poor
- advice on tone and volume of voice, enthusiasm, listening skills, voice projection and handling
- help to develop their career path
- confidence (the knowledge that what they say is correct).

In addition, two managers reported that they conducted focus groups with call agents on the use of headphones or to provide opportunity for them to express their concerns, which were successful for both call agents and management.

4.1.6 Vocal care training

The majority of the managers interviewed reported that their call centres do not include vocal care in their training; only three reported that they do, and these were small companies. One call centre reported that at the recruitment stage they monitor the voice of applicants for clarity. At the call centres that included vocal care training, this involved the following:

- communication
- rate of speech
- tone of voice
- behaviour of voice
- highlighting important words in the script
- not shouting
- drinking water regularly
- seating position
- advice to see your GP if you have a voice problem
- vocal warm-ups.

One manager reported the following: 'I don't know how to deliver vocal care training. If I knew how, I would deliver it'. Several other managers echoed this statement.

All but one of the call centre managers interviewed stated that call agents should receive training on vocal care and they reported numerous perceived benefits for both the organisation and the call agent. The reported benefits for the organisation were:

- improved customer service
- fulfilment of the organisation's health, safety and wellbeing strategies
- more effective call handling
- more sales
- less absenteeism
- improved communication between customer and agent
- improved business opportunities
- clear voice
- reduced sickness levels
- fulfilment of the duty of care
- slower staff turnover
- improved relationships in the workplace
- more standardised customer service.

The reported benefits for the call agents were:

- clear voice
- more effective communication
- improved quality
- fewer complaints about calls
- lower likelihood of burnout
- reduced risk of throat and voice problems
- more effective call handling
- increased awareness of vocal health
- more sales
- less absenteeism
- improved customer experience
- better protection for the voice and vocal cords
- enhanced speed of calls
- improved general health awareness
- more standardised procedures.

4.1.7 Sickness in call centres

The overall reported sickness level of call agents was low; the stated levels ranged from less than 1 per cent to 10 per cent, with an average of 5.0 per cent. This level was reported to vary among contracts, call agents and seasons (with the months January–March registering the highest level). One manager stated that throat problems are usually reported in winter months (January–March) but are not regular. Another manager reported that one call agent had a sore throat and subsequently lost her voice a few months ago. In another call centre, a call agent had throat problems at the time of the interview.

The majority of call centres did not have a formal procedure if call agents complained of voice or throat problems. When these issues occurred, the call agents were advised to contact their GP and/or were given administrative tasks instead of using the telephones. In total, five managers (39 per cent) reported that they had experience of call agents complaining of voice or throat problems.

4.1.8 Differences in size of company

In general, the size of company had a bearing on differences in policies and supervision. Managers in large call centres (with more than 100 employees) tended to have more detailed health and safety policies than small ones (with fewer than 50 employees). The larger companies also tended to have staff specifically assigned to monitoring calls, training and quality. In smaller companies the call centre manager or managing director was solely responsible for these issues. In one very large call centre, approximately 5 per cent of training was consultancy-based.

4.1.9 Differences in the type of call centre and calls

From the four call centres that dealt mainly with sales, three managers reported setting targets for both the quality and quantity of calls. Two call centres dealt with outbound calls only and both of these centres had quality and quantity call targets.

4.1.10 Additional comments

One manager made an additional comment that managers need to look after their staff to reduce the likelihood of sickness and thus reduce absenteeism.

4.2 Online survey – biopsychosocial questionnaire

In total 600 call agents completed the biopsychosocial questionnaire, but two of these questionnaires contained unusual values and after seeking statistical advice these two were removed from the analysis as they would influence the overall results. Therefore, 598 questionnaires were included in the analysis. Because the questions were not compulsory, there were a different number of responses for each question (see methods section for rationale). Overall, the response level for the questions was high (ie $n = 540–598$) except for three questions:

- Have you partaken in any of the following today – smoking (number of cigarettes)? ($n = 347$)
- Have you partaken in any of the following today – eating food? If yes, give details including amount of your last food consumed, eg one packet of crisps, Mars bar – average size ($n = 410$)
- Have you partaken in any of the following today – chatting to friends during breaks? If yes, approximate number of minutes ($n = 434$).

4.2.1 Demographics and sample characteristics

The 598 call agents represented 14 call centres throughout the UK and Ireland. The mean age of the call agents ($n = 586$) was 26.5 years (SD 8.84 years; range 16–65 years). Of the 578 call agents that answered the gender question, there were slightly more males ($n = 306$; 53 per cent) than females ($n = 272$; 47 per cent). Of all the 598 call agents, 43 per cent completed the questionnaire in the morning (ie before 12.00), 44 per cent between 12.00 and 17.00, and 13 per cent between 17.00 and 22.58 (time generated by the server receiving completed questionnaires).

4.2.2 Work-related environment issues

The mean reported time that respondents had worked in a call centre was 2 years 5 months (SD 2 years 10 months; range 3 weeks–19 years). The majority (78 per cent) were employed full time with 22 per cent working part time ($n = 570$). The call agents ($n = 573$) reported that the category that best described their current contract was as follows:

- sales: 12 per cent
- customer service: 75 per cent
- information gathering: 2 per cent
- all of the above categories: 2 per cent
- other: 9 per cent.

The duration of the shift during which the call agents ($n = 550$) completed the questionnaire ranged from 2 hours 30 minutes to 16 hours, with an average shift of 7½–8 hours. The mean time already spent on the shift at the time of completing the questionnaire was 3 hours 35 minutes, and the range was from 0 minutes (start of shift) to 10 hours 30 minutes ($n = 540$). The call agents ($n = 568$) reported expecting to take or have taken between zero to six or more breaks during the current shift (0: 5 per cent; 1: 13 per cent; 2: 7 per cent; 3: 64 per cent; 4: 5 per cent; 5: 3 per cent; 6 or more: 3 per cent). The vast majority, 99.1 per cent ($n = 344$), of the call agents reported that they didn't smoke any cigarettes on the day of completing the survey, while 0.6 per cent smoked between 16 and 20 cigarettes, and 0.3 per cent more than 20 cigarettes.

The call agents drank between none and four or more drinks (of water, coffee/tea, carbonated sugar mineral drink (eg cola) or alcohol) during the day on which they completed the survey; see Table 7. Of these drinks, water was the most frequently consumed.

Table 7
Fluid consumption on the day the survey was completed

		Number of drinks consumed on the day of the survey				
		0	1	2	3	4+
Water (n = 561)	no.	200	131	107	59	64
	%	35.7	23.4	19.1	10.5	11.4
Coffee or tea (n = 562)	no.	246	153	98	46	19
	%	43.8	27.2	17.4	8.2	3.4
Carbonated sugar mineral drinks (eg cola) (n = 567)	no.	376	127	47	11	6
	%	66.3	22.4	8.3	1.9	1.1
Alcohol (n = 563)	no.	549	1	5	1	7
	%	97.5	0.2	0.9	0.2	1.2

Of the 598 call agents, 414 (69 per cent) had eaten food before completing the questionnaire and 184 (31 per cent) had not. In total, 410 call agents answered the question regarding type of last meal, and the main kinds of food consumed were classified under the following categories:

- chocolate, sweets, nuts (9 per cent)
- crisps (12 per cent)
- fruit or vegetables (7 per cent)
- bread meal (34 per cent)
- main meal (12 per cent)

- soup-type food (3 per cent)
- take-away meal (10 per cent)
- cereal products (9 per cent)
- dairy products (1 per cent)
- nothing to eat (3 per cent).

The mean time since last consuming fluids ($n = 543$) was 58 minutes (range 0 minutes–16 hours) and food ($n = 541$) was 3 hours 22 minutes (range 0 minutes–24 hours).

A majority of the call agents (77 per cent) reported that they chatted to their friends during the day of the survey ($n = 598$). Of these, 434 call agents reported that they chatted on average 32 minutes with a range from 1 minute to 8 hours. Over half of the call agents reported that their current sitting posture was upright, other responses were legs-crossed, slumped, or other; see Figure 1.

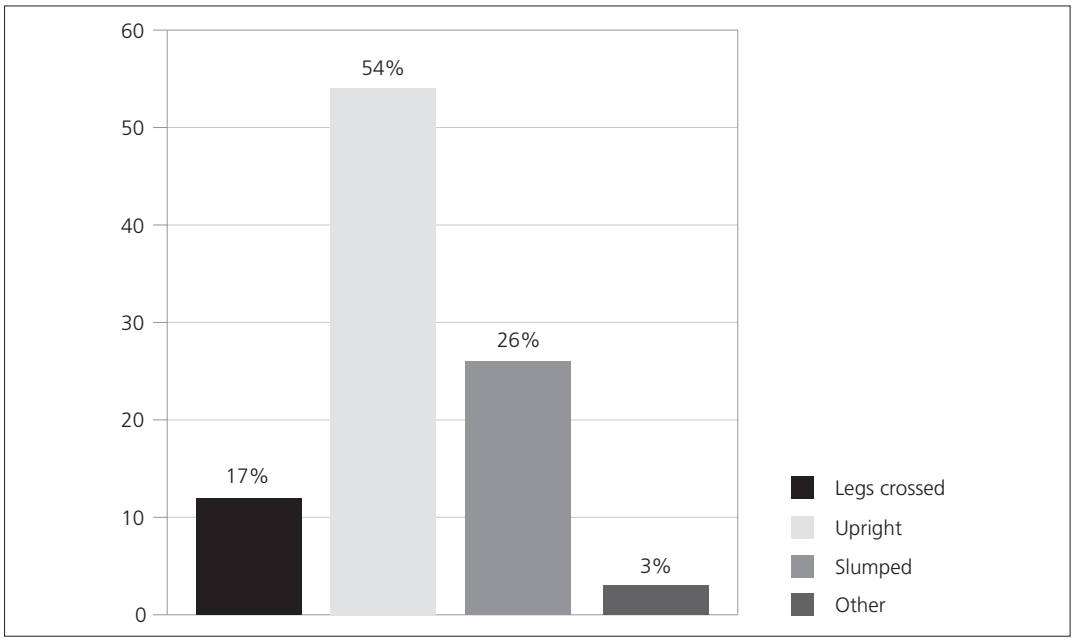


Figure 1
Sitting posture of the call agents ($n = 558$)

4.2.3 Sickness

The number of times the call agents reported having been off work on sick leave in the last six months varied from none to five or more times; see Figure 2.

The average numbers of days off work on sick leave during this time were ($n = 543$):

- not applicable: 32 per cent
- 1–2 days: 44 per cent
- 3–7 days: 18 per cent
- 8–31 days: 4 per cent
- 32 days or more: 2 per cent.

The number of times this sick leave was related to colds, throat infections or voice problems were ($n = 545$):

- not applicable: 35 per cent
- none: 1 per cent
- once: 25 per cent
- twice: 14 per cent
- three or more times: 5 per cent.

Of the 598 call agents, 153 (26 per cent) reported currently having a cold or throat infection.

4.2.4 Training

The call agents rated the amount of training provision in their current workplace ($n = 560$) as:

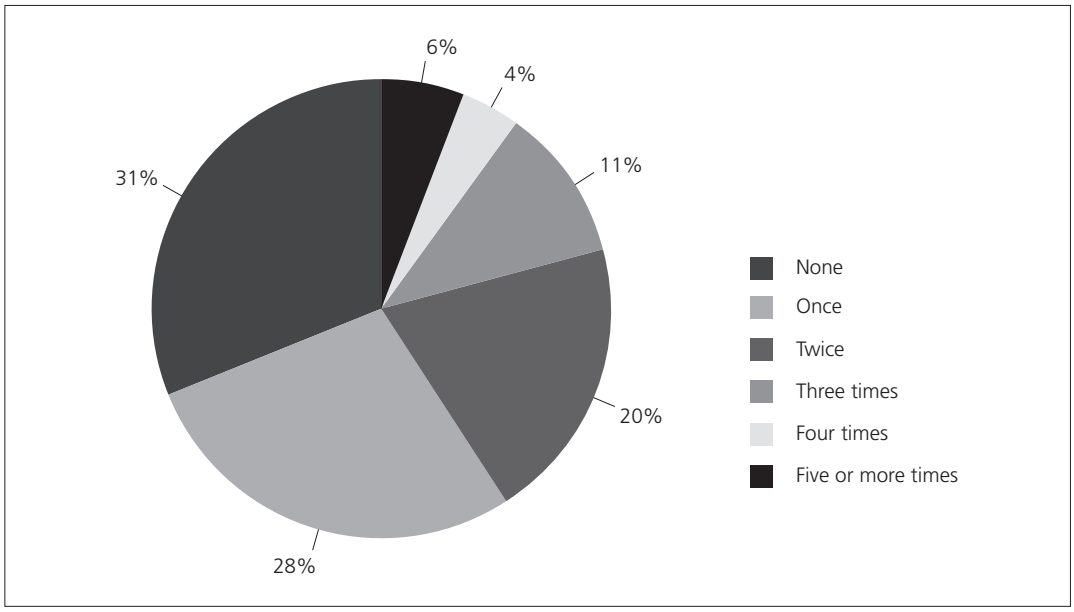


Figure 2
Number of occasions call agents have been on sick leave in the last six months ($n = 558$)

- very poor: 3 per cent
- poor: 9 per cent
- average: 33 per cent
- good: 39 per cent
- excellent: 16 per cent

and the quality of training provision ($n = 557$) as:

- very poor: 3 per cent
- poor: 9 per cent
- average: 30 per cent
- good: 39 per cent
- excellent: 19 per cent.

In total, 90 (15 per cent) call agents reported that they had received vocal training at work. In addition, 51 (9 per cent) call agents reported that they had received vocal training outside work, eg personal voice coaching.

4.2.5 Social activities

The call agents reported that they participated in a range of social activities outside work that could affect their voice during the previous week, eg singing, shouting, smoking, drinking a lot of caffeine (more than six cups per day), socialising in bars, weightlifting and drinking alcohol. The reported frequencies of participation in these social activities are shown in Table 8. The activities the call agents reported participating in the most were singing (58 per cent), smoking (54 per cent), socialising in bars (47 per cent), weight-lifting (45 per cent), and drinking alcohol (40 per cent). Of the seven social activities listed in the question, the call agents reported participating in a mean of three each.

4.2.6 Voice use and characteristics

The call agents' reported voice use is shown in Table 9. The call agents reported experiencing a wide range of the vocal uses listed in the question. The most reported kinds of voice misuse were:

- having difficulty talking against background noise (60 per cent)
- coughing or clearing the throat (43 per cent)
- voice sounding creaky and dry (43 per cent)
- when talking on the telephone, people fail to hear me (41 per cent)
- speaking on the telephone is an effort or tiring (38 per cent).

Overall, 25 per cent of the call agents reported voice misuse characteristics. The average number of reported voice misuse characteristics by the call agents was six. The epidemiological data showed that the prevalence rate was 25 per cent for voice misuse.

Table 8
Frequency with which respondents participated in social activities outside work in the previous week

Social activity		Frequency				
		Never	Rarely	Sometimes	Often	Very often
Singing (*n* = 557)	no.	121	114	165	101	56
	%	22	20	30	18	10
Shouting (*n* = 549)	no.	349	72	67	38	23
	%	64	13	12	7	4
Smoking (*n* = 555)	no.	142	115	137	92	69
	%	25	21	25	17	12
Excessive caffeine (more than six cups per day) (*n* = 553)	no.	317	98	54	32	52
	%	57	18	10	6	9
Socialising in bars (*n* = 557)	no.	246	48	71	56	136
	%	44	9	13	10	24
Weightlifting (*n* = 554)	no.	184	123	150	54	43
	%	33	22	27	10	8
Drinking alcohol (*n* = 553)	no.	231	99	112	54	57
	%	42	18	20	10	10

Table 9
Voice use and characteristics

Voice-related question		Frequency				
		Never	Rarely	Sometimes	Often	Very often
Have you received any training on vocal expression and effectiveness in telephone communication? (*n* = 548)	no.	457	49	31	7	4
	%	83	9	6	1	1
Have you received information on voice care for telephone communication? (*n* = 549)	no.	400	89	44	13	3
	%	73	16	8	2	1
Have you ever sought medical help for your voice? (*n* = 549)	no.	404	75	40	22	8
	%	73	14	7	4	2
Have you ever been diagnosed with a voice disorder? (*n* = 549)	no.	436	55	43	8	7
	%	79	10	8	2	1
Is it difficult to keep your voice going at the end of a shift? (*n* = 548)	no.	408	59	54	20	7
	%	74	11	10	4	1
Do you have difficulty attracting attention? (*n* = 547)	no.	400	74	51	14	8
	%	73	13	9	3	2
Do you have throat problems while singing? (*n* = 550)	no.	219	160	112	36	23
	%	40	29	20	7	4
When you're talking on the telephone, do people fail to hear you? (*n* = 552)	no.	197	127	147	58	23
	%	36	23	27	10	4

Table 9
continued

Voice-related question		Frequency				
		Never	Rarely	Sometimes	Often	Very often
Do you lose your voice? (*n* = 551)	no.	219	145	123	37	27
	%	40	26	22	7	5
Do you have a weak voice? (*n* = 551)	no.	316	126	73	24	12
	%	57	23	13	5	2
Do you find speaking on the telephone an effort or tiring? (*n* = 551)	no.	223	116	142	41	29
	%	41	21	26	7	5
Do you have difficulty talking against background noise? (*n* = 551)	no.	120	102	180	100	49
	%	22	18	33	18	9
Are you unable to shout or raise your voice? (*n* = 548)	no.	313	111	95	19	10
	%	57	20	17	4	2
Does the sound of your voice vary throughout the day? (*n* = 551)	no.	286	114	115	21	15
	%	52	20	21	4	3
Does your voice sound creaky and dry? (*n* = 547)	no.	185	124	152	56	30
	%	34	23	28	10	5
Does your voice 'give out' in the middle of speaking? (*n* = 550)	no.	382	83	59	15	11
	%	69	15	11	3	2
Do you cough or clear your throat? (*n* = 552)	no.	204	109	135	61	43
	%	37	20	24	11	8
Does it feel as if there is something stuck in your throat? (*n* = 550)	no.	252	106	122	46	24
	%	46	19	22	8	5
Do you have swollen glands? (*n* = 551)	no.	357	107	58	20	9
	%	65	19	10	4	2
Do you have a lot of phlegm in your throat? (*n* = 553)	no.	291	137	92	22	11
	%	52	25	17	4	2
Do you have a blocked nose? (*n* = 551)	no.	245	140	117	34	15
	%	45	25	21	6	3
Do you often get throat infections? (*n* = 552)	no.	375	79	63	24	11
	%	68	14	12	4	2
Do you feel miserable or depressed with your voice? (*n* = 554)	no.	329	112	87	18	8
	%	59	20	16	3	2
Are you embarrassed by your voice? (*n* = 553)	no.	282	82	115	50	24
	%	51	15	21	9	4

Table 9
continued

Voice-related question		Frequency				
		Never	Rarely	Sometimes	Often	Very often
Does your voice make you feel stressed or nervous? (*n* = 552)	no.	483	30	22	9	8
	%	88	5	4	2	1
Does your voice put a strain on communicating on the telephone? (*n* = 553)	no.	426	47	59	11	10
	%	77	8	11	2	2
Do people seem irritated by your voice? (*n* = 556)	no.	378	62	62	35	19
	%	68	11	11	6	4
Does your voice make you feel incompetent? (*n* = 557)	no.	301	97	99	41	19
	%	54	17	18	7	4

4.2.7 Voice symptoms

The call agents reported experiencing a range of voice symptoms, as outlined in Table 10. The most reported voice symptom was hoarseness (66 per cent), followed by loss of pitch range (45 per cent), and a lowering of voice pitch (38 per cent). In total, 25 per cent of the call agents reported voice symptoms. The average number of symptoms reported by the call agents was four. Thus the prevalence rate was 25 per cent for reported voice symptoms by call agents.

The call agents that reported the highest voice misuse also reported the most voice symptoms.

Table 10
Voice symptoms

Voice symptom		Frequency				
		Never	Rarely	Sometimes	Often	Very often
Hoarseness (*n* = 548)	no.	89	101	182	103	73
	%	16	18	33	19	14
Volume disturbance (trouble speaking loudly) (*n* = 550)	no.	373	81	65	21	10
	%	68	14	12	4	2
Voice is lower in pitch (*n* = 548)	no.	197	142	142	45	22
	%	36	26	26	8	4
Loss of pitch range (highest to lowest note) (*n* = 550)	no.	170	131	158	61	30
	%	31	24	29	11	5
Loss of volume (*n* = 549)	no.	314	107	77	35	16
	%	57	20	14	6	3
Breathiness (air escaping as you talk) (*n* = 548)	no.	338	117	62	21	10
	%	62	21	11	4	2
Increased effort to talk (*n* = 546)	no.	350	100	63	22	11
	%	64	18	12	4	2
Tendency to lose voice at the end of a sentence (*n* = 545)	no.	318	123	76	16	12
	%	58	23	14	3	2
Tendency to lose voice in the middle of a sentence (*n* = 550)	no.	368	110	50	14	8
	%	67	20	9	2	2

Table 10
continued

Voice symptom		Frequency				
		Never	Rarely	Sometimes	Often	Very often
Voice 'breaks' during speaking (*n* = 550)	no.	332	118	69	22	9
	%	60	21	13	4	2
Vocal fatigue (voice tires or changes quality afte speaking for a short time) (*n* = 547)	no.	314	104	93	26	10
	%	57	19	17	5	2
Shortness of breath while speaking (*n* = 548)	no.	323	115	84	21	5
	%	59	21	15	4	1
Pain in the throat or neck (*n* = 550)	no.	324	123	86	11	6
	%	59	22	16	2	1
Dryness in the throat (*n* = 550)	no.	323	129	74	13	11
	%	59	23	14	2	2
Sore throat (*n* = 548)	no.	297	150	68	21	12
	%	54	27	13	4	2
Burning sensation in throat (*n* = 548)	no.	250	148	108	29	13
	%	46	27	20	5	2
Feeling thirsty (*n* = 549)	no.	308	138	77	13	13
	%	56	26	14	2	2

4.2.8 Vocal impact

The reported vocal impact on the call agents is summarised in Table 11. The most reported statement was 'My voice problem upsets me' (31 per cent). The next most reported statement was 'My voice makes me feel less able to do my job' (14 per cent). Overall, 10 per cent of the call agents reported that their voice had an impact on them. On average, each call agent reported agreeing with one vocal impact statement. The epidemiological study showed that the prevalence rate was 10 per cent for vocal impact as reported by call agents.

Overall, 28 per cent of the call agents reported voice misuse, voice-related symptoms and vocal impact.

Of the 598 call agents, 20 per cent indicated that they would like further information or training to improve their vocal performance at work. An information leaflet was sent to those call agents who asked for one and provided contact details.

4.2.9 Correlations

Demographics

A number of Pearson correlations were found between age, gender, organisation, length of tenure working in a call centre, whether working full or part time, type of contract, time already spent in current shift, and whether diagnosed with a voice disorder, and the questions (items) in the biopsychosocial questionnaire – see Tables 12–19.

Table 11
Vocal impact

Vocal impact		Frequency				
		Never	Rarely	Sometimes	Often	Very often
My voice makes it difficult for people to hear me (*n* = 544)	no.	474	32	25	9	4
	%	87	6	4	2	1
People have difficulty understanding me in a noisy room (*n* = 543)	no.	485	34	14	4	6
	%	89	6	3	1	1
People ask 'What's wrong with your voice?' (*n* = 545)	no.	500	24	16	3	2
	%	91	4	3	1	1
I feel as though I have to strain to produce voice (*n* = 546)	no.	480	35	15	10	6
	%	88	6	3	2	1
My voice difficulties restrict my personal and social life (*n* = 546)	no.	403	78	48	10	7
	%	74	14	9	2	1
The clarity of my voice is unpredictable (*n* = 541)	no.	473	42	17	3	6
	%	87	8	3	1	1
I feel left out of conversation because of my voice (*n* = 547)	no.	419	77	36	8	7
	%	76	14	7	2	1
My voice problem causes me to lose income (*n* = 546)	no.	467	54	17	4	4
	%	85	10	3	1	1
My voice problem upsets me (*n* = 546)	no.	251	128	113	38	16
	%	46	23	21	7	3
My voice makes me feel less able to do my job (*n* = 546)	no.	345	125	55	13	8
	%	63	23	10	2	2

Table 12
Correlations: age

	p value	Direction
Gender	0.022	+
Approximately how long have you been doing call centre work?	0.000	+
Select one of the following categories that best describes your current contract: sales; customer service; information gathering; other	0.041	+
Have you partaken in any of the following today: drinking coffee/tea?	0.000	+
Have you partaken in any of the following today: drinking carbonated sugar mineral drinks, eg cola?	0.003	–
Have you partaken in any of the following today: chatting to friends?	0.003	–
Have you partaken in any of the following today: chatting to friends, if yes, approximate number of minutes?	0.000	–
What is your current sitting posture?	0.002	–
How many times have you been off work on sick leave in the last six months?	0.000	–
Has this sick leave been related to colds, throat infections or voice problems?	0.001	–
Please rate the amount of training provision in your current workplace	0.019	+
Does the training provided in your current work include vocal training?	0.019	–
Singing	0.000	–
Shouting	0.000	–
Smoking	0.000	–
Socialising in bars	0.018	–
Weightlifting	0.000	–
Drinking alcohol	0.000	–
Do you have a weak voice?	0.024	–
Do you have difficulty talking against background noise?	0.041	–
Are you unable to shout or raise your voice?	0.049	+
Does it feel as if there is something stuck in your throat?	0.031	–
Do you often get throat infections?	0.049	–
Hoarseness	0.000	–
Voice is lower in pitch	0.008	–
Loss of pitch range (highest to lowest note)	0.032	–
Loss of volume	0.015	–
I feel as though I have to strain to produce voice	0.042	+
My voice problem upsets me	0.020	–

Table 13
Correlations: gender

	p value	Direction
Age	0.022	+
Which organisation do you work for?	0.000	–
Do you work full-time or part-time?	0.000	–
Duration of shift	0.000	–
How many total breaks are you expecting to take or have taken during this shift?	0.008	–
Have you partaken in any of the following today: drinking water?	0.005	–
Have you partaken in any of the following today: drinking coffee/tea?	0.025	+
Have you partaken in any of the following today: drinking carbonated sugar mineral drinks, eg cola?	0.000	–
Have you partaken in any of the following today: eating food? If yes, give details including amount of your last food consumed	0.025	–
What is your current sitting posture?	0.000	–
Do you currently have a cold or throat infection?	0.030	+
Please rate the amount of training provision in your current workplace	0.021	+
Please rate the quality of training provision in your current workplace	0.004	+
Shouting	0.000	–
Weight-lifting	0.001	–
Do you have throat problems while singing?	0.000	+
Do you have a weak voice?	0.000	+
Are you unable to shout or raise your voice?	0.006	+
Do you cough or clear your throat?	0.027	+
Do you have swollen glands?	0.001	+
Do you have a lot of phlegm in your throat?	0.000	+
Are you embarrassed by your voice?	0.023	+
Does your voice put a strain on communicating on the phone?	0.005	+
Volume disturbance (trouble speaking loudly)	0.001	+
Voice is lower in pitch	0.000	+
Loss of pitch range (highest to lowest note)	0.000	+
Loss of volume	0.001	+
Breathiness (air escaping as you talk)	0.000	+
Increased effort to talk	0.024	+
Tendency to lose voice in the middle of a sentence	0.001	+
Voice ‘breaks’ during speaking	0.001	+
Pain in the throat or neck	0.015	+
Burning sensation in throat	0.000	+
Feeling thirsty	0.019	+
My voice problem causes me to lose income	0.040	+

Table 14
Correlations: organisation

	p value	Direction
Gender	0.000	–
How many total breaks are you expecting to take or have taken during this shift?	0.003	+
Have you partaken in any of the following today: drinking carbonated sugar mineral drinks, eg cola?	0.024	+
How many times have you been off work on sick leave in the last six months?	0.000	+
What was the average number of days off work on sick leave during this time?	0.000	+
Has this sick leave been related to colds, throat infections or voice problems?	0.000	+
Please rate the amount of training provision in your current workplace	0.000	–
Please rate the quality of training provision in your current workplace	0.000	–
Singing	0.023	+
Weightlifting	0.000	+
Drinking alcohol	0.002	–
Do you find speaking on the telephone an effort or tiring?	0.011	+
Do you have difficulty talking against background noise?	0.000	+
Are you unable to shout or raise your voice?	0.015	+
Does the sound of your voice vary throughout the day?	0.012	+
Do you cough or clear your throat?	0.001	+
Do you have a blocked nose?	0.021	–
Do you often get throat infections?	0.000	–
Does your voice make you feel stressed or nervous?	0.000	–
Does your voice put a strain on communicating on the phone?	0.032	–
Do people seem irritated by your voice?	0.000	–
Does your voice make you feel incompetent?	0.001	–
Feeling thirsty	0.007	–

Table 15
Correlations: duration of working in a call centre

	p value	Direction
Age	0.000	+
Do you work full-time or part-time?	0.034	+
Select one of the following categories that best describes your current contract: sales; customer service; information gathering; other	0.000	+
Have you partaken in any of the following today: drinking coffee/tea?	0.000	+
Have you partaken in any of the following today: eating food? If yes, give details including amount of your last food consumed	0.009	+
What is your current sitting posture?	0.006	–
How many times have you been off work on sick leave in the last six months?	0.000	–
Shouting	0.031	–
Smoking	0.000	–
Weight-lifting	0.001	–
Drinking alcohol	0.013	–
Have you received any training on vocal expression and effectiveness in telephone communication?	0.040	–
Is it difficult to keep your voice going near the end of your shift?	0.020	–
Do you cough or clear your throat?	0.025	–
Does it feel as if there is something stuck in your throat?	0.004	–
Do you have a blocked nose?	0.001	–
Do you often get throat infections?	0.009	–
Are you embarrassed by your voice?	0.008	–
Hoarseness	0.000	–
Voice is lower in pitch	0.043	–
Loss of pitch range	0.018	–
Vocal fatigue (voice tires or changes quality after speaking for a short time)	0.043	–
Feeling thirsty	0.025	–
My voice problem upsets me	0.000	–
My voice makes me feel less able to do the job	0.006	–

Table 16
Correlations: working full- or part-time

	p value	Direction
Gender	0.000	–
Approximately how long have you been doing call centre work?	0.034	+
Duration of shift	0.000	+
Time already spent in current shift	0.000	+
How many total breaks are you expecting to take or have taken during this shift?	0.000	+
Smoking	0.013	+
Socialising in bars	0.009	+
Drinking alcohol	0.003	–

Table 17
Correlations: type of contract (eg sales, customer service, information gathering)

	p value	Direction
Approximately how long have you been doing call centre work?	0.000	+
Time already spent in current shift	0.013	+
Have you partaken in any of the following today: drinking coffee/tea?	0.046	+
Do you have throat problems while singing?	0.026	+

Table 18
Correlations: time already spent in current shift

	p value	Direction
Do you work full-time or part-time?	0.000	+
Select one of the following categories that best describes your current contract: sales; customer service; information gathering; other	0.013	+
Duration of shift	0.000	+
How many total breaks are you expecting to take or have taken during this shift?	0.003	+
Have you partaken in any of the following today: smoking? If yes, how many?	0.022	+
Have you partaken in any of the following today: water? If yes, amount?	0.000	+
Have you partaken in any of the following today: drinking coffee/tea? If yes, amount?	0.002	+
Have you partaken in any of the following today: drinking carbonated sugar mineral drinks, eg cola? If yes, amount?	0.000	+
Have you partaken in any of the following today: eating food?	0.000	+
Have you partaken in any of the following today: eating food? If yes, give details including amount of your last food consumed	0.001	+
Have you partaken in any of the following today: chatting to friends?	0.005	+
Have you partaken in any of the following today: chatting to friends? If yes, approximate number of minutes	0.001	+
How long ago did you last drink something (minutes)?	0.013	–
How long ago did you last eat something (minutes)?	0.000	–
Shouting	0.024	–
Do you lose your voice?	0.022	–
Do you find speaking on the telephone an effort or tiring?	0.019	–
Do you have difficulty talking against background noise?	0.014	–
Does the sound of your voice vary throughout the day?	0.022	–
Do you have a blocked nose?	0.015	–
I feel left out of conversation because of my voice	0.011	–

Table 19
Correlations: diagnosed with a voice problem

	p value	Direction
What was the average number of days off work on sick leave during this time?	0.014	+
How many times has this sick leave been related to colds, throat infections or voice problems?	0.000	+
Do you currently have a cold or throat infection?	0.000	+
Please rate the quality of training provision in your current workplace	0.001	–
Singing	0.030	+
Excessive caffeine (more than six cups per day)	0.048	+
Socialising in bars	0.035	+
Have you received any training on vocal expression and effectiveness in telephone communication?	0.000	+
Have you received information on voice care for telephone communication?	0.000	+
Have you ever sought medical help for your voice?	0.000	+
Is it difficult to keep your voice going near the end of your shift?	0.000	+
Do you have difficulty attracting attention?	0.000	+
Do you have throat problems while singing?	0.000	+
When talking on the telephone, do people fail to hear you?	0.000	+
Do you lose your voice?	0.000	+
Do you have a weak voice?	0.000	+
Do you find speaking on the telephone an effort or tiring?	0.000	+
Do you have difficulty talking against background noise?	0.000	+
Are you unable to shout or raise your voice?	0.000	+
Does the sound of your voice vary throughout the day?	0.000	+
Does your voice sound creaky and dry?	0.000	+
Does your voice ‘give out’ in the middle of speaking?	0.000	+
Do you cough or clear your throat?	0.000	+
Does it feel as if there is something stuck in your throat?	0.000	+
Do you have swollen glands?	0.000	+
Do you have a lot of phlegm in your throat?	0.000	+
Do you have a blocked nose?	0.000	+
Do you often get throat infections?	0.000	+
Do you feel miserable or depressed with your voice?	0.000	+
Are you embarrassed by your voice?	0.000	+
Does your voice make you feel stressed or nervous?	0.000	+
Does your voice put a strain on communicating on the telephone?	0.000	+
Hoarseness	0.000	+
Volume disturbance (trouble speaking loudly)	0.000	+

Table 19
continued

	p value	Direction
Voice is lower in pitch	0.000	+
Loss of pitch range (highest to lowest note)	0.000	+
Loss of volume	0.000	+
Breathiness (air escaping as you talk)	0.000	+
Increased effort to talk	0.000	+
Tendency to lose voice at the end of a sentence	0.000	+
Tendency to lose voice in the middle of a sentence	0.000	+
Voice 'breaks' during speaking	0.000	+
Vocal fatigue (voice tires or changes quality after speaking for a short time)	0.000	+
Shortness of breath while speaking	0.000	+
Pain in the throat or neck	0.000	+
Dryness in throat	0.000	+
Sore throat	0.000	+
Burning sensation in throat	0.000	+
Feeling thirsty	0.000	+
My voice makes it difficult for people to hear me	0.000	+
People have difficulty understanding me in a noisy room	0.000	+
People ask 'What's wrong with your voice?'	0.000	+
I feel as though I have to strain to produce voice	0.000	+
My voice difficulties restrict my personal and social life	0.000	+
The clarity of my voice is unpredictable	0.000	+
I feel left out of conversation because of my voice	0.000	+
My voice problem causes me to lose income	0.000	+
My voice problem upsets me	0.000	+
My voice makes me feel less able to do my job	0.000	+

Items for constructs

Pearson correlations were conducted on the items in the questionnaire. The correlations between the following items are shown in Table 20:

- feels as if there is something stuck in your throat (Stuck)
- pain in the throat or neck (Pain)
- dryness in throat (Dryness)
- sore throat (Sore)
- burning sensation in throat (Burning)
- feeling thirsty (Thirst).

All the correlations between these items were significant ($p = 0.000$).

Table 20
Pearson correlations

	Struck	Pain	Dryness	Sore	Burning	Thirst
Struck	1	0.489*	0.435*	0.449*	0.408*	0.415*
Pain	0.489*	1	0.712*	0.634*	0.560*	0.562*
Dryness	0.435*	0.712*	1	0.625*	0.473*	0.562*
Sore	0.449*	0.634*	0.625*	1	0.482*	0.593*
Burning	0.408*	0.560*	0.473*	0.482*	1	0.450*
Thirst	0.415*	0.562*	0.562*	0.593*	0.450*	1

* Correlation is significant at the 0.01 level (two-tailed)

The correlations were all significant between the following eight items:

- do you have a weak voice? (Weak)
- does your voice sound creaky and dry? (Dry)
- hoarseness (Hoarse)
- volume disturbance – trouble speaking loudly (Disturb)
- voice is lower in pitch (Pitch low)
- loss of pitch range – highest to lowest note (Pitch range)
- loss of volume (Volume)
- breathiness – air escaping as you talk (Breath).

These correlations are displayed in Table 21.

Table 21
Pearson correlations

	Weak	Dry	Hoarse	Disturb	Pitch low	Pitch range	Volume	Breath
Weak	1	0.315*	0.290*	0.500*	0.554*	0.425*	0.494*	0.321*
Dry	0.315*	1	0.365*	0.349*	0.397*	0.441*	0.414*	0.431*
Hoarse	0.290*	0.365*	1	0.404*	0.528*	0.641*	0.455*	0.361*
Disturb	0.500*	0.349*	0.404*	1	0.679*	0.552*	0.667*	0.480*
Pitch low	0.554*	0.397*	0.528*	0.679*	1	0.717*	0.672*	0.453*
Pitch range	0.425*	0.441*	0.641*	0.552*	0.717*	1	0.646*	0.519*
Volume	0.494*	0.414*	0.455*	0.667*	0.672*	0.646*	1	0.573*
Breath	0.321*	0.431*	0.361*	0.480*	0.453*	0.519*	0.573*	1

* Correlation is significant at the 0.01 level (two-tailed)

Correlations for the following six items were all significant:

- have you ever sought medical help for your voice? (Help)
- have you ever been diagnosed with a voice disorder? (Diagnosed)
- do you have swollen glands? (Glands)
- do you have a lot of phlegm in your throat? (Phlegm)
- do you have a blocked nose? (Nose)
- do you often get throat infections? (Infections).

For more detail, see Table 22.

	Help	Diagnosed	Glands	Phlegm	Nose	Infections
Help	1	0.710*	0.420*	0.423*	0.399*	0.290*
Diagnosed	0.710*	1	0.360*	0.349*	0.332*	0.217*
Glands	0.420*	0.360*	1	0.460*	0.438*	0.386*
Phlegm	0.423*	0.349*	0.460*	1	0.382*	0.276*
Nose	0.399*	0.332*	0.438*	0.382*	1	0.369*
Infections	0.290*	0.217*	0.386*	0.276*	0.369*	1

Table 22
Pearson correlations

* Correlation is significant at the 0.01 level (two-tailed)

Correlations were calculated for the following 17 items:

- is it difficult to keep your voice going near the end of your shift? (Voice going)
- do you have difficulty attracting attention? (Attention)
- do you have throat problems while singing? (Singing)
- when talking on the phone, do people fail to hear you? (Phone)
- do you lose your voice? (Lose voice)
- do you find speaking on the telephone an effort or tiring? (Tiring)
- do you have difficulty talking against background noise? (Back noise)
- are you unable to shout or raise your voice? (Shout)
- does the sound of your voice vary throughout the day? (Sound)
- does your voice 'give out' in the middle of speaking? (Give out)
- do you cough or clear your throat? (Cough)
- increased effort to talk (Effort)
- tendency to lose voice at the end of a sentence (Lose end)
- tendency to lose voice in the middle of a sentence (Lose middle)
- voice 'breaks' during speaking (Voice breaks)
- vocal fatigue – voice tires or changes quality after speaking for a short time (Fatigue)
- shortness of breath while speaking (Shortness).

Table 23 shows that all of these correlations were significant.

Table 23
Pearson correlations

	Voice going	Attention	Singing	Phone	Lose voice	Tiring	Back noise	Shout
Voice going	1	0.616*	0.247*	0.173*	0.118*	0.260*	0.141*	0.319*
Attention	0.616*	1	0.403*	0.271*	0.228*	0.404*	0.278*	0.470*
Singing	0.247*	0.403*	1	0.465*	0.380*	0.398*	0.285*	0.413*
Phone	0.173*	0.271*	0.465*	1	0.567*	0.399*	0.348*	0.301*
Lose voice	0.118*	0.223*	0.380*	0.567*	1	0.418*	0.350*	0.280*
Tiring	0.260*	0.404*	0.398*	0.399*	0.148*	1	0.612*	0.481*
Back noise	0.141*	0.278*	0.285*	0.348*	0.350*	0.612*	1	0.435*
Shout	0.319*	0.470*	0.413*	0.301*	0.280*	0.481*	0.435*	1
Sound	0.280*	0.469*	0.373*	0.359*	0.363*	0.554*	0.498*	0.698*
Give out	0.265*	0.334*	0.328*	0.222*	0.193*	0.251*	0.140*	0.418*
Cough	0.216*	0.356*	0.336*	0.289*	0.228*	0.446*	0.415*	0.539*
Effort	0.275*	0.466*	0.407*	0.334*	0.311*	0.374*	0.267*	0.518*
Lose end	0.352*	0.544*	0.378*	0.348*	0.322	0.394*	0.292*	0.620*
Lose middle	0.307*	0.559*	0.396*	0.313*	0.337*	0.433*	0.302*	0.627*
Voice breaks	0.293*	0.528*	0.406*	0.336*	0.345*	0.381*	0.255*	0.589*
Fatigue	0.345*	0.488*	0.381*	0.325*	0.311*	0.365*	0.250*	0.509*
Shortness	0.301*	0.484*	0.325*	0.290*	0.274*	0.395*	0.241*	0.513*

* Correlation is significant at the 0.01 level (two-tailed)

Table 24 shows significant correlations for the following five items:

- my voice makes it difficult for people to hear me (Hear)
- people have difficulty understanding me in a noisy room (Noisy)
- my voice difficulties restrict my personal and social life (Social)
- my voice problem causes me to lose income (Income)
- my voice makes me feel less able to do the job (Job).

Table 24
Pearson correlations

	Hear	Noisy	Social	Income	Job
Hear	1	0.770*	0.610*	0.611*	0.505*
Noisy	0.770*	1	0.571*	0.593*	0.427*
Social	0.610*	0.571*	1	0.576*	0.618*
Income	0.611*	0.593*	0.576*	1	0.455*
Job	0.505*	0.427*	0.618*	0.455*	1

* Correlation is significant at the 0.01 level (two-tailed)

Table 23
continued

Sound	Give out	Cough	Effort	Lose end	Lose middle	Voice breaks	Fatigue	Shortness
0.280*	0.265*	0.216*	0.275*	0.352*	0.307*	0.293*	0.345*	0.301*
0. 469*	0.334*	0.356*	0.466*	0.544*	0.559*	0.528*	0.488*	0.484*
0.373*	0.328*	0.336*	0.407*	0.378*	0.396*	0.406*	0.381*	0.325*
0.359*	0.222*	0.289*	0.334*	0.348*	0.313*	0.336*	0.325*	0.290*
0.363*	0.193*	0.228*	0.311*	0.322*	0.337*	0.345*	0.311*	0.274*
0.554*	0.251*	0.446*	0.374*	0.394*	0.433*	0.381*	0.365*	0.395*
0.498*	0.140*	0.415*	0.267*	0.292*	0.302*	0.255*	0.250*	0.241*
0.698*	0.418*	0.539*	0.518*	0.620*	0.627*	0.589*	0.509*	0.513*
1	0.346*	0.553*	0.510*	0.540*	0.555*	0.520*	0.492*	0.490*
0.346*	1	0.420*	0.394*	0.401*	0.376*	0.420*	0.434*	0.328*
0.553*	0.420*	1	0.442*	0.423*	0.418*	0.406*	0.403*	0.386*
0.510*	0.394*	0.442*	1	0.590*	0.640*	0.623*	0.657*	0.535*
0.540*	0.401*	0.423*	0.590*	1	0.747*	0.710*	0.561*	0.552*
0.555*	0.376*	0.418*	0.640*	0.747*	1	0.858*	0.619*	0.616*
0.520*	0.420*	0.406*	0.623*	0.710*	0.858*	1	0.682*	0.653*
0.492*	0.434*	0.403*	0.657*	0.561*	0.619*	0.682*	1	0.646*
0.490*	0.328*	0.386*	0535*	0.552*	0.616*	0.653*	0.646*	1

Correlations for the following four items were calculated:

- do you feel miserable or depressed with your voice? (Depressed)
- are you embarrassed by your voice? (Embarrassed)
- I feel left out of conversation because of my voice (Conversation)
- my voice problem upsets me (Upsets).

All of these correlations were significant – see Table 25.

Table 25
Pearson correlations

	Depressed	Embarrassed	Conversation	Upsets
Depressed	1	0.398*	0.413*	0.442*
Embarrassed	0.398*	1	0.408*	0.360*
Conversation	0.413*	0.408*	1	0.531*
Upsets	0.442*	0.360*	0.531*	1

* Correlation is significant at the 0.01 level (two-tailed)

4.2.10 Measurement models

Before investigating the structural relationships, six measurement models were developed:

- sensation
- acoustics
- medical advice and medical conditions
- mechanical
- functional
- emotional.

The measurement model for the 'sensation' latent construct is displayed in Figure 3. This measurement model has six observed items with factor loadings (0.78–0.86) from the latent construct 'sensation' to these six items:

- does it feel as if there is something stuck in your throat? (Stuck)
- pain in the throat or neck (Pain)
- dryness in throat (Dryness)
- sore throat (Sore)
- burning sensation in throat (Burning)
- feeling thirsty (Thirst).

Although the chi-square test gave a non-significant result ($\chi^2 = 11.73$; $p = 0.110$), the RMSEA is 0.035. Therefore as the RMSEA is less than 0.080,[46] this model is an appropriate description of the data. There were correlated residuals between Pain and Sore (–0.06) and between Pain and Thirst (–0.07).

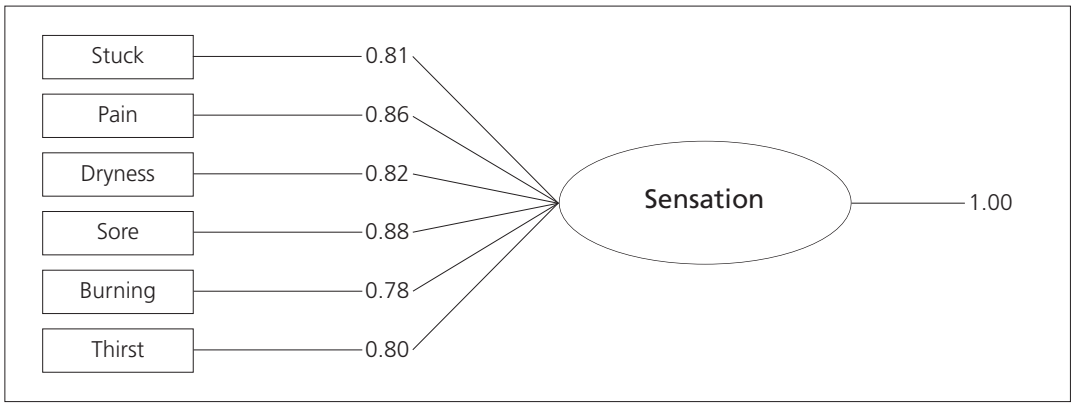


Figure 3
Measurement model for the sensation construct

$\chi^2 = 11.73$; df = 7; $p = 0.10980$; RMSEA = 0.035

The measurement model for 'acoustics' (Figure 4) consisted of eight items:

- do you have a weak voice? (Weak)
- does your voice sound creaky and dry? (Dry)
- hoarseness (Hoarse)
- volume disturbance – trouble speaking loudly (Disturb)
- voice is lower in pitch (Pitch low)
- loss of pitch range – highest to lowest note (Pitch range)
- loss of volume (Volume)
- breathiness – air escaping as you talk (Breath).

The factor loadings from the latent construct 'acoustics' to the items ranged from 0.65 to 0.93. The chi-square is significant ($\chi^2 = 51.23$ and $p = 0.000$) and the RMSEA of 0.066 is within the acceptable threshold, so the model is considered to be an appropriate representation of the data. There were five correlated residuals in this model:

- Dry and Pitch low, –0.07
- Hoarse and Pitch range, 0.15
- Disturb and Pitch range, –0.02

- Pitch low and Volume, –0.08
- Pitch low and Breath, –0.11.

All the parameter estimates were also significant.

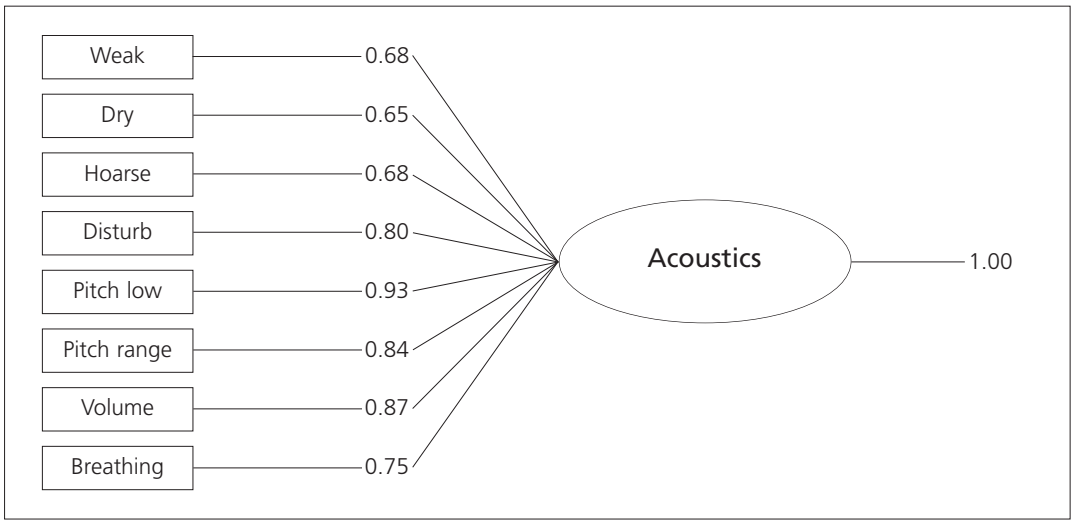


Figure 4
Measurement model for the acoustics construct

$\chi^2 = 51.23$; df = 15; $p = 0.00001$; RMSEA = 0.066

The measurement model for 'medical advice and medical conditions' is shown in Figure 5. The item loadings for this construct were:

- medical advice:
  - have you ever sought medical help for your voice? (Help)
  - have you ever been diagnosed with a voice disorder? (Diagnosed).
- medical conditions:
  - do you have swollen glands? (Glands)
  - do you have a lot of phlegm in your throat? (Phlegm)
  - do you have a blocked nose? (Nose)
  - do you often get throat infections? (Infections).

The factor loadings from the latent construct 'medical advice' to the first two items were 0.83 and 0.91, while those from the latent construct 'medical conditions' to its four items ranged from 0.59 to 0.77. There is a positive correlation between the two constructs 'medical advice' and 'medical conditions' of 0.75. The chi-square is non-significant ($\chi^2 = 13.64$ and $p = 0.092$) but the RMSEA is 0.036. Therefore, as the RMSEA is less than 0.080,[46] this model is appropriate for the data. There are no correlated residuals in this measurement model and all parameter estimates were significant.

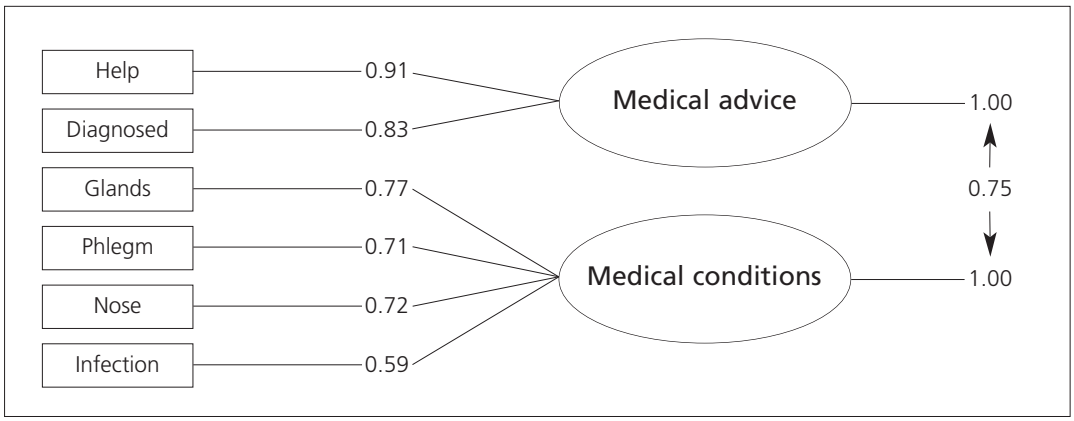


Figure 5
Measurement model for the medical advice and medical conditions constructs

$\chi^2 = 13.64$; df = 8; $p = 0.09167$; RMSEA = 0.036

The measurement model for the 'mechanical' construct is displayed in Figure 6. This model has 17 items:

- is it difficult to keep your voice going near the end of your shift? (Voice going)
- do you have difficulty attracting attention? (Attention)
- do you have throat problems while singing? (Singing)
- when talking on the phone, do people fail to hear you? (Phone)
- do you lose your voice? (Lose voice)
- do you find speaking on the telephone an effort or tiring? (Tiring)
- do you have difficulty talking against background noise? (Back noise)
- are you unable to shout or raise your voice? (Shout)
- does the sound of your voice vary throughout the day? (Sound)
- does your voice 'give out' in the middle of speaking? (Give out)
- do you cough or clear your throat? (Cough)
- increased effort to talk (Effort)
- tendency to lose voice at the end of a sentence (Lose end)
- tendency to lose voice in the middle of a sentence (Lose middle)
- voice 'breaks' during speaking (Voice breaks)
- vocal fatigue – voice tires or changes quality after speaking for a short time (Fatigue)
- shortness of breath while speaking (Shortness).

The factor loadings from the latent construct 'mechanical' to these 17 items ranged from 0.52 to 0.96 and all were significant. There are 13 correlated residuals in this measurement model:

- Voice going and Attention, 0.26
- Singing and Phone, 0.28
- Singing and Lose voice, 0.20
- Phone and Lose voice, 0.49
- Tiring and Back noise, 0.47
- Back noise and Cough, 0.16
- Shout and Sound, 0.13
- Effort and Fatigue, 0.12
- Lose end and Lose middle, 0.11
- Lose middle and Voice break, 0.19
- Voice break and Fatigue, 0.07
- Voice break and Shortness, 0.06
- Fatigue and Shortness, 0.12.

The chi-square is significant ($\chi^2 = 348.98$; $p = 0.000$) and RMSEA is 0.065, so this model is considered an appropriate representation of the data.

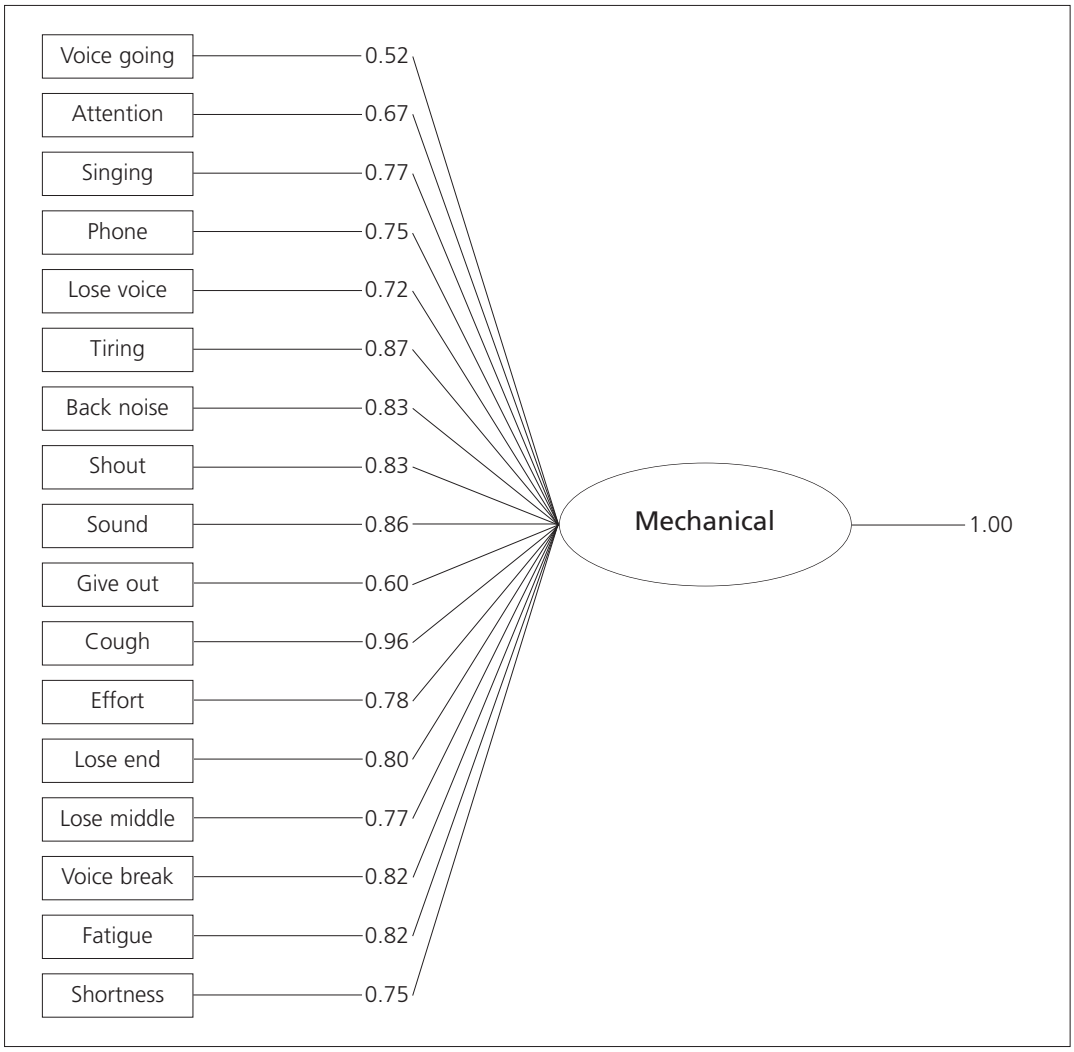
The measurement model for the 'functional' latent construct is shown in Figure 7. The 'functional' construct has five observed items:

- my voice makes it difficult for people to hear me (Hear)
- people have difficulty understanding me in a noisy room (Noisy)
- my voice difficulties restrict my personal and social life (Social)
- my voice problem causes me to lose income (Income)
- my voice makes me feel less able to do the job (Job).

The factor loadings from the 'functional' construct to the five items ranged from 0.54 to 0.70. There are two correlated residuals (Hear and Noisy, 0.07; Social and Job, 0.10). Although the chi-square was not significant ($\chi^2 = 6.52$; $p = 0.089$), the RMSEA was 0.046, ie less than 0.08,[46] and thus this model is an appropriate description of the data. All parameter estimates were significant.

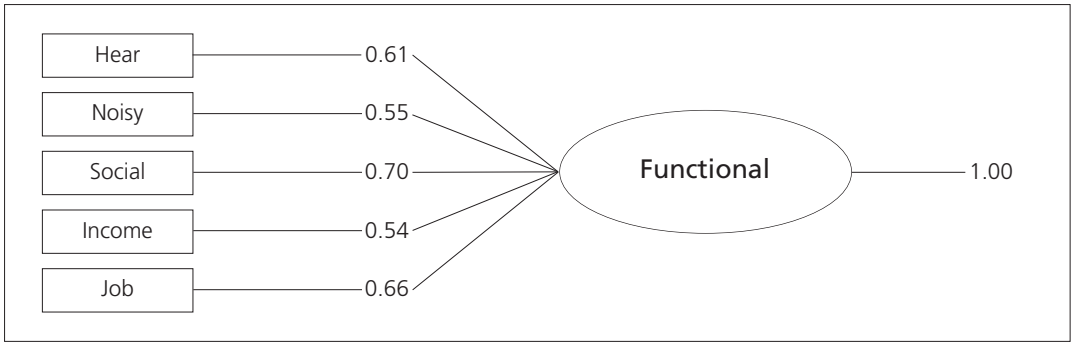
The sixth and final measurement model is for the 'emotional' construct – see Figure 4.8. This has four items:

- do you feel miserable or depressed with your voice? (Depressed)
- are you embarrassed by your voice? (Embarrassed)
- I feel left out of conversation because of my voice (Conversation)
- my voice problem upsets me (Upsets).



$\chi^2 = 348.98$; df = 105; $p = 0.00000$; RMSEA = 0.065

Figure 6
Measurement model for the mechanical construct



$\chi^2 = 6.52$; df = 3; $p = 0.08886$; RMSEA = 0.046

Figure 7
Measurement model for the functional construct

The factor loadings from the 'emotional' construct to the four items ranged from 0.66 to 0.79. There is only one correlated residual in this model (Depressed and Conversation, –0.11). As for the functional construct, the chi-square for the emotional construct was non-significant ($\chi^2 = 1.70$; $p = 0.192$) but the RMSEA was 0.035, ie less than 0.08,[46] and thus this model is appropriate for the data. All factor loadings were significant.

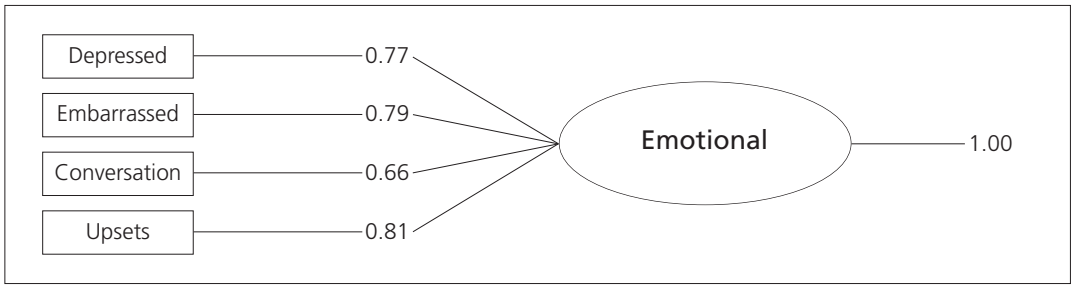


Figure 8
Measurement model for the emotional construct

$\chi^2 = 1.70$; df = 1; $p = 0.19247$; RMSEA = 0.035

4.2.11 Structural Equation Modelling (SEM)

Structural Equation Modelling (SEM) builds on and explores the relationships among the measurement models. The SEM for the constructs 'emotional' and 'functional' for the latent variable 'psychosocial health' and its relationship to 'physiological voice production' with its constructs, 'mechanical', 'acoustics' and 'sensations' is shown in Figure 9. The interpretation of the fit indices is the same as for the measurement models: in other words, this model is an appropriate description of the data ($\chi^2 = 9.51$; $p = 0.023$; RMSEA = 0.060). The parameter estimates between the latent constructs in Figure 9 and subsequent models are standardised estimates. The relationship between 'psychosocial health' and 'physiological voice production' is statistically significant ($\chi^2 = 0.84$; $p < 0.01$).

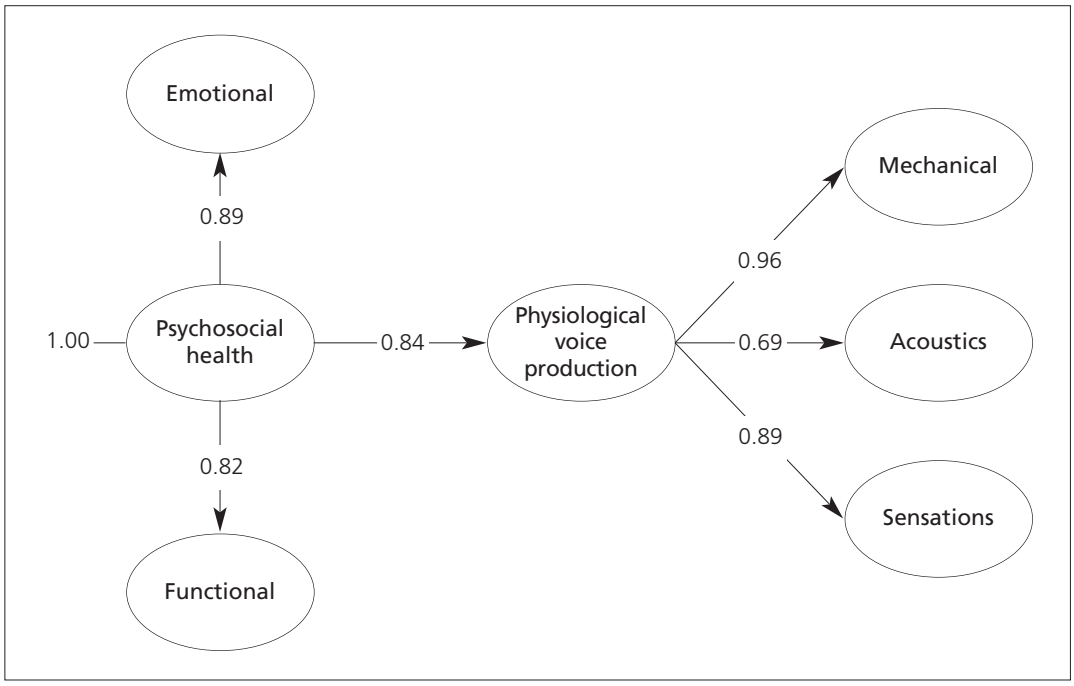


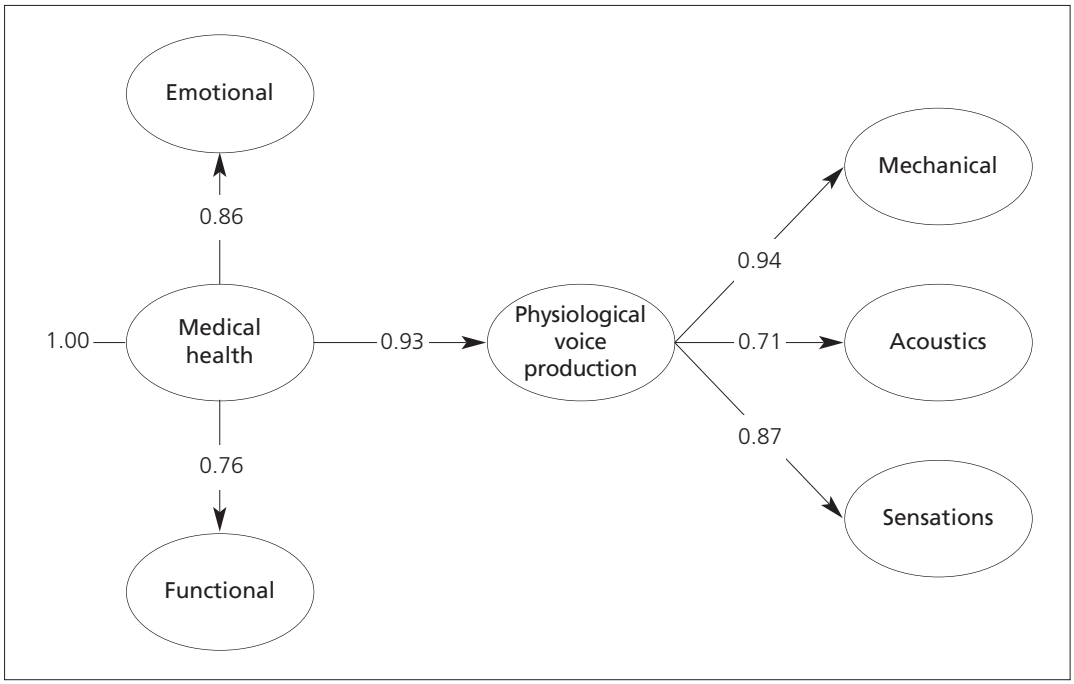
Figure 9
SEM – Psychosocial health and physiological voice production

$\chi^2 = 9.51$; df = 3; $p = 0.02321$; RMSEA = 0.060

Figure 10 shows 'physiological voice production' regressed on 'medical health', with the latter comprising 'medical conditions' and 'medical advice'. This model is also an appropriate description of the data, as demonstrated by the fit statistics ($\chi^2 = 7.27$; $p = 0.064$; RMSEA = 0.049). Therefore 'medical health' is significantly related to 'physiological voice production' ($\chi^2 = 0.93$; $p < 0.01$).

Figure 11 displays the final overall SEM for this dataset. This SEM shows 'medical health' and 'psychosocial health' regressed on 'physiological voice production', together with 'physiological voice production' regressed on a series of covariates. These covariates were included in an attempt to explore or explain the heterogeneity in 'physiological voice production'. The fit indices for this statistical model were: $\chi^2 = 157.45$; df = 71; $p = 0.000$; RMSEA = 0.045. Thus this model was considered an appropriate description of the data.

All the parameter estimates relating to the structural relations detailed in Figure 11 were statistically significant. It is clear that 'physiological voice production' is a statistically significant predictor of



$\chi^2 = 7.27$; df = 3; $p = 0.06371$; RMSEA = 0.049

Figure 10
SEM – Medical health and physiological voice production

'psychosocial health' and of 'medical health'. In addition, four of the covariates relating to 'physiological voice production' were statistically significant. The statistically significant covariates were 'gender', 'times off on sick leave', 'vocal training' and 'duration of employment'. This means that:

- women were at a higher risk than men of developing physiological voice problems
- the more times the call agent is off work on sick leave the greater the likelihood that they report physiological voice problems
- receiving vocal training reduces the risk of developing physiological voice problems
- new starters are at a higher risk of suffering from physiological voice problems.

4.3 Acoustic analysis

4.3.1 Demographics of participants and the natural conversation from sample telephone calls

A sample of natural conversation from telephone calls was selected and analysed for acoustic parameters for 70 call agents from one call centre who participated in the online survey. The characteristics of the call agents (age, gender and whether they worked full or part-time) are displayed in Table 26. The mean duration of the telephone calls was 3 minutes and the range was from 54 seconds to 5 minutes and 2 seconds.

Table 26
Demographics of call agents included in the acoustic analysis ($n = 70$)

Characteristic	Responses from call agents
Age	Mean = 23.3 years SD = 6.23 years Range = 17–60 years
Gender	Females = 32 (45.7%) Males = 38 (54.3%)
Full or part time	Full time = 50 (71.4%) Part time = 20 (28.6%)

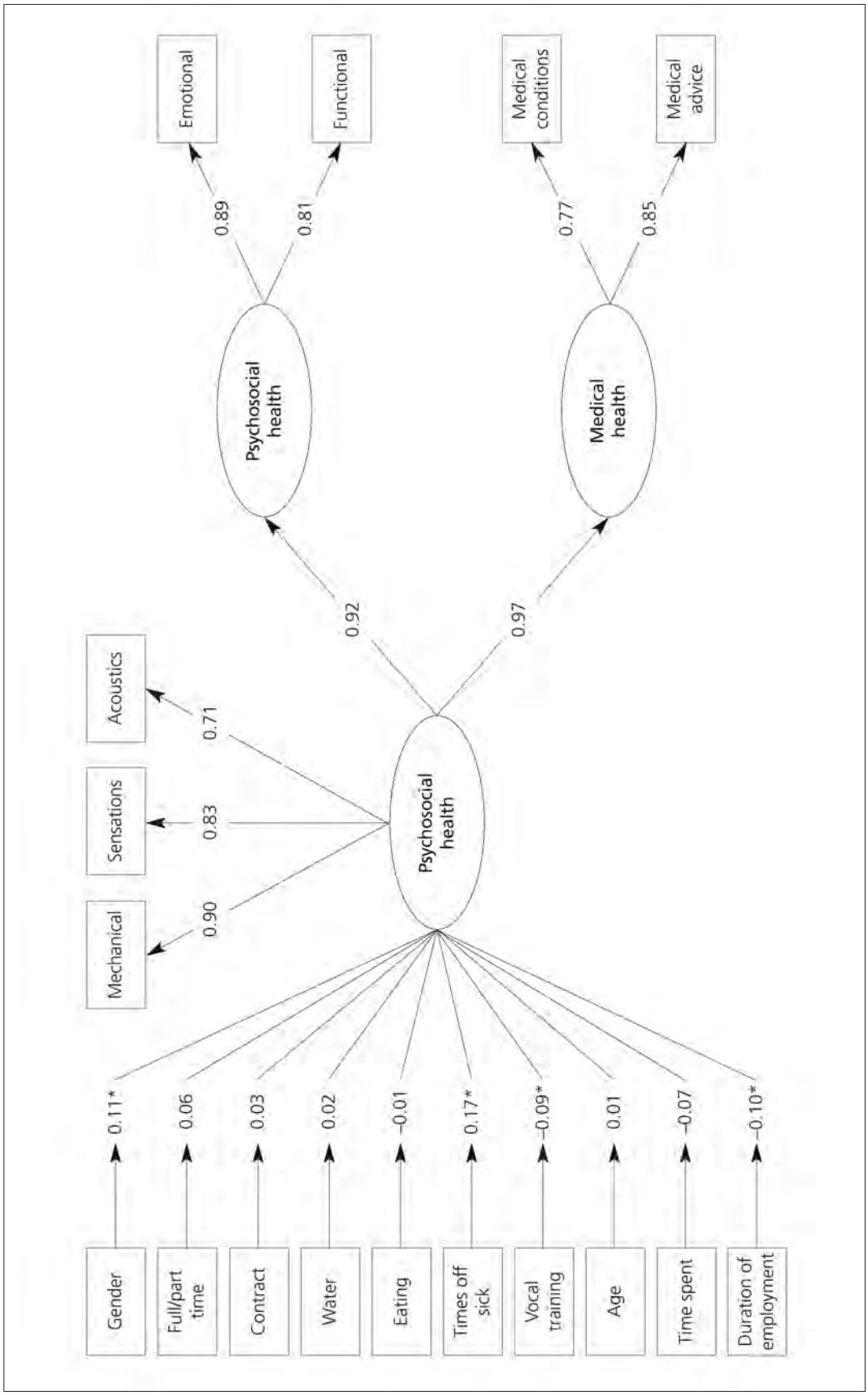


Figure 11
SEM – Psychosocial health, medical health and physiological voice production with potential confounders

* significant ($p < 0.05$)
$\chi^2 = 157.45$; df = 71; $p = 0.0001$; RMSEA = 0.045

4.3.2 Acoustic parameters of the sample calls

The mean, standard deviation (SD) and range for 14 acoustic parameters for three seconds at the start, middle and end of the sample calls are shown in Table 27. The mean readings for the following parameters decreased in the order start, middle and end during the sample calls:

- mean fundamental frequency (MF_0)
- highest fundamental frequency (Fhi)
- lowest fundamental frequency (Flo)
- standard deviation of F_0 (STD)
- jitter percentage (Jitt)
- degree of subharmonics (DSH).

Conversely, the following acoustic parameters had the opposite effect, with an increase in mean readings in the same order:

- absolute jitter (Jita)
- shimmer in dB (ShdB)
- shimmer percentage (Shim)
- peak-to-peak amplitude variation (vAm).

Two parameters, amplitude tremor frequency (Fatr) and noise to harmonic ratio (NHR), both decreased in mean readings from the start to the middle of the call and then increased at the end, while another two parameters, degree of voice breaks (DVB) and degree of voicelessness (DUV), had the opposite pattern (increased and then decreased).

Pearson correlations compared the start, middle and end of the sample calls for each of the 14 the acoustic parameters. In total, 34 significant correlations were found; these are reported in Table 28.

Table 27
Mean, standard deviation (SD) and range for 14 acoustic parameters for 3 seconds at the start, middle and end of the sample calls

Acoustic parameter	Sample calls (n = 70)								
	Start			Middle			End		
	Mean	SD	Range	Mean	SD	Range	Mean	SD	Range
Mean Fundamental Frequency (MF_0)	182.74	60.00	90.90–291.00	175.34	59.08	81.61–294.78	165.20	55.72	89.67–287.86
Highest Fundamental Frequency (Fhi)	277.80	116.41	134.65–628.41	274.64	124.60	101.06–602.98	263.74	125.67	112.14–653.09
Lowest Fundamental Frequency (Flo)	126.73	43.66	67.57–209.79	125.22	41.91	68.27–220.50	116.13	39.06	68.05–215.77
Standard Deviation of Fo (STD)	30.54	17.45	6.44–92.20	26.40	20.09	5.12–120.04	24.69	15.97	4.43–83.74
Amplitude Tremor Frequency (Fatr)	4.22	2.22	2.08–10.81	3.50	1.35	2.08–9.09	3.83	2.00	2.06–10.26
Absolute Jitter (Jita)	210.43	103.12	69.02–643.92	211.62	99.87	61.27–502.01	219.78	101.54	71.84–491.95
Jitter Percent (Jitt)	3.40	0.93	1.80–6.89	3.31	1.04	1.62–6.99	3.21	0.89	1.78–5.47
Shimmer in dB (ShdB)	1.57	0.33	0.970–2.43	1.63	0.40	0.89–2.71	1.74	0.44	0.97–3.00
Shimmer Percent (Shim)	14.32	3.06	8.96–22.20	14.47	3.61	7.71 - 24.70	15.41	3.55	9.11–23.70
Peak-to-Peak Amplitude Variation (vAm)	45.32	6.35	31.53–65.68	45.68	6.99	33.71–65.30	47.58	6.60	36.66–62.90
Noise to Harmonic Ratio (NHR)	0.31	0.93	0.15–0.61	0.30	0.09	0.16–0.54	0.32	0.11	0.16–0.72
Degree of Voice Breaks (DVB)	43.64	11.79	23.18–73.42	50.41	10.61	23.64–75.74	49.24	12.85	16.07–77.32
Degree of Sub-harmonics (DSH)	1.86	2.50	0.00–9.09	1.45	2.53	0.00–11.43	0.87	1.78	0.00–7.69
Degree of Voiceless (DUV)	59.12	11.14	36.36–85.86	59.81	12.66	21.21–86.87	59.71	13.37	33.33–83.84

Table 28
Pearson correlations for the acoustic parameters

Characteristic of sample calls	*p* value
Start and middle Mean fundamental frequency (MF_0)	0.000
Start and end Mean fundamental frequency (MF_0)	0.000
Middle and end Mean fundamental frequency (MF_0)	0.000
Start and middle Highest fundamental frequency (Fhi)	0.000
Start and end Highest fundamental frequency (Fhi)	0.000
Middle and end Highest fundamental frequency (Fhi)	0.006
Start and middle Lowest fundamental frequency (Flo)	0.000
Start and end Lowest fundamental frequency (Flo)	0.000
Middle and end Lowest fundamental frequency (Flo)	0.000
Start and middle Standard deviation of F_0 (STD)	0.000
Start and end Standard deviation of F_0 (STD)	0.002
Middle and end Standard deviation of F_0 (STD)	0.002
Start and end Amplitude tremor frequency (Fatr)	0.008
Middle and end Amplitude tremor frequency (Fatr)	0.048
Start and middle Absolute jitter (Jita)	0.000
Start and end Absolute jitter (Jita)	0.000
Middle and end Absolute jitter (Jita)	0.000
Middle and end Jitter percent (Jitt)	0.000
Start and middle Shimmer in dB (ShdB)	0.000
Start and end Shimmer in dB (ShdB)	0.000
Middle and end Shimmer in dB (ShdB)	0.000
Start and middle Shimmer percent (Shim)	0.000
Start and end Shimmer percent (Shim)	0.000
Middle and end Shimmer percent (Shim)	0.000
Start and end Peak-to-peak amplitude variation (vAm)	0.032
Middle and end Peak-to-peak amplitude variation (vAm)	0.001
Start and middle Noise to harmonic ratio (NHR)	0.000
Start and end Noise to harmonic ratio (NHR)	0.000
Middle and end Noise to harmonic ratio (NHR)	0.000
Start and middle Degree of voice breaks (DVB)	0.000
Middle and end Degree of voice breaks (DVB)	0.012
Start and middle Degree of voiceless (DUV)	0.008
Start and end Degree of voiceless (DUV)	0.000
Middle and end Degree of voiceless (DUV)	0.000

5 Discussion

The study's objectives were to investigate the work context and vocal communication demands for call agents, evaluate call agents' vocal health, awareness and performance, and identify key risks and training needs for employees and employers in call centres. This discussion section examines and explains the findings from this study for each of the above objectives relating to the hypotheses, then discusses the implications and recommendations for OSH, provides recommendations for further research, and concludes with the strengths and limitations of this study.

Call agents are professional voice users, as their voice is a valuable tool for their employment. According to Martin & Darnley,[47] effective voice production is the ability to produce voice in a manner that is easy and relaxed, with good breathing control, well-balanced posture and minimum mental stress. If the vocal mechanism is not working with sufficient breath support, the voice is under consistently more strain to produce adequate volume, flexibility or control of voice. This increases the risk of voice disorders.

In total, 14 call centres throughout the UK and Ireland participated in this study, and 13 managers (from different call centres) completed a telephone interview, 598 call agents completed the biopsychosocial questionnaire for the online survey, and acoustic analysis was conducted on sample calls from 70 call agents who completed the online survey. The hypotheses were tested, confirmed and verified.

5.1 Hypothesis testing

The hypotheses were tested using SEM based on the data from the biopsychosocial questionnaire in the online survey. Based on the overall final SEM (Figure 11), the overall hypothesis and the sub-hypotheses were substantiated.

5.1.1 Null hypotheses

The overall null hypothesis is that there is no relationship between 'physiological voice production' and 'psychosocial health' and 'medical health' among call agents within call centres. This hypothesis was rejected.

There were four related null hypotheses that there is no relationship between:

- mechanical, sensation and acoustic factors and physiological voice production among call agents in call centres
- medical conditions and medical advice factors and medical health among call agents in call centres
- functional and emotional factors and psychosocial health among call agents in call centres
- vocal training and physiological voice production.

All the hypotheses were rejected as the SEM data revealed that there were significant positive relationships between the identified variables. The findings from these null hypotheses and how they fulfil the objectives are discussed below.

5.2 Work context and vocal communication demands for call agents (objective 1)

The call centres sampled in this study were diverse in size, contracts and types of call, and were thus a good representation of the nature of this industry. The number of call agents in each call centre ranged from 12 to 1,800; most (62 per cent) were small organisations (with fewer than 50 call agents), and 15 per cent had more than 1,000 call agents. The distribution of sizes of call centres in this study was similar to that reported by the Department of Trade and Industry,[14] which noted that 62 per cent employed fewer than 50 agents, 17 per cent between 51 and 100, 6 per cent between 101 and 150, 3 per cent between 151 and 200, 3 per cent between 201 and 250, 6 per cent between 250 and 500, 3 per cent between 501 and 1,000, and 1 per cent over 1,000. Half of the managers reported that their main contracts were customer service; other contracts included sales, information gathering or a combination of all three. The majority of the call centres dealt with both inbound and outbound calls but reported that their work was mainly inbound.

From the telephone interviews, all the managers reported that they had a health and safety policy, which consisted of a range of issues including breaks, access to water, availability of headphones and monitoring of calls. The larger call centres (those with more than 100 call agents) have more detailed health and safety policies than smaller centres (with fewer than 50 call agents). These findings

indicate that there is a wide variation in the interpretation and implementation of the health and safety guidelines among call centres.

The demographic profile of an average call agent participating in the online survey was a young (in their twenties) male or female working full time for an average of two years 10 months in a call centre; however, there was a lot of variation in these characteristics. Although the mean age of the call agents was relatively young (26.5 years), the range covered the full spectrum of working ages (16–65 years). Both male and female call agents responded to the survey but there were slightly more males (53 per cent). The majority of the call agents worked full time, while 22 per cent worked part-time. Although the mean duration of time the call agent working in the call centre at the time of the survey was relatively short (two years 10 months), the range varied enormously from three weeks to 19 years, indicating that some individuals may work in a call centre as a 'stop-gap', while few others make it their career. In comparison, the demographic profile of a typical UK contact-centre worker in Department for Trade and Industry report[14] is a female in her mid-to-late twenties, and the average length of tenure is towards three years. The latter two characteristics, but not gender, were similar to the respondents in this study. The reason for the difference in gender is unknown as the authors were informed by call centre management that the call agents are both men and women but the majority are female. Nevertheless, the present study found that slightly more men than women responded to the online survey.

The call agents reported consuming water, coffee or tea, carbonated sugar drinks (eg cola) and alcohol, but water was the most frequently consumed. This supports the comments from the managers during the interviews that they encourage their call agents to drink water during the shifts by providing unlimited access to water coolers. Furthermore, water is more effective in hydration and lubrication than caffeine-based drinks, which dehydrate the vocal folds. Without adequate hydration, the voice can sound strained and lack normal resonance, and without lubrication a dry vocal tract will not function as well as a moist one, and is more vulnerable to damage.[1,48] This was validated by the findings in the present study, as water was not identified as a confounding variable as there was no association between water and physiological voice production in the final structure model (Figure 11). This may be due to the fact to managers in the interviews stated that water is freely available for all call agents.

Approximately half (54 per cent) of the call agents reported sitting upright, and this is considered as optimum sitting posture for effective voice production.[1] The posture of the call agent influences the effectiveness of voice production. Musculoskeletal problems add to laryngeal muscle tension and thus poor posture modifies the tensions and dimensions of the vocal tract, affecting the sound of the voice.[1]

The call agents reported participating in a range of activities outside work that could potentially influence the effectiveness of their voice, such as singing, shouting, smoking, drinking excessive caffeine (more than six cups per day), socialising in bars, weightlifting and drinking alcohol (Table 8). This indicates that there are multi-risk factors for the call agents in this study as identified in the literature.[12] The most frequently reported social activity was singing (58 per cent), followed by smoking (54 per cent), socialising in bars (47 per cent), weightlifting (45 per cent) and drinking alcohol (40 per cent). These responses may reflect the young age of the call agents. Singing can contribute to using the voice with excessive force or tension, adding extra laryngeal trauma where the speaking voice is already under strain.[1] Smoking can irritate the vocal folds, causing oedema and inflammation, and can increase the need to clear the throat and cough.[49,50] In a bar environment, there can be a lot of background noise, which can lead to shouting; voice loudness can increase the risk of deterioration through vocal strain.[1] Poor weightlifting technique can also lead to risk of vocal strain. It has been reported that the consumption of alcohol may contribute to dehydration.[1] These are all potentially damaging vocal behaviours if performed frequently as a habitual vocal pattern, particularly in more demanding environmental or emotional contexts.

The call agents reported various misuses of their voice (Table 9). The most reported voice misuse was having difficulty talking against background noise (60 per cent), followed by coughing or clearing the throat (43 per cent), voice sounding creaky and dry (43 per cent), people failing to hear the speaker when they are talking on the telephone (41 per cent), and finding speaking on the telephone an effort or tiring (38 per cent). These are all relevant to the work environment of the call centre. As many call agents are in one room talking on the telephone at the same time, there is often appreciable background noise, and the call agents are talking all day on the telephone, thus putting strain on their voice. These all add to the cognitive load.[12] Other factors contributing to this process include room acoustics and quality of air.[12]

It was interesting that there were a number of significant Pearson correlations found between age, gender, organisation, duration of working in a call centre, working full or part time, type of contract, time already spent in current shift, and whether diagnosed with a voice disorder, and the questions in the biopsychosocial questionnaire. This suggests that these characteristics significantly influence variables associated with demographic information, the work-related environment, social activities, voice use, voice symptoms and vocal impact.

The data from acoustic analysis, consisting of 70 sample calls containing natural conversation, revealed a number of significant correlations between the 14 acoustic parameters measured. The mean, highest and lowest fundamental frequency and standard deviation of fundamental frequency all reduced significantly from the start through the middle to the end of the call. This means that at the beginning of the telephone call the call agents appear to be using higher pitch to achieve more interest in the voice. This may reflect use of pitch variation as a skill to open the call. It is particularly important to get across the correct message at the beginning of the call, perhaps using more animation in order to gain attention.

Amplitude tremor frequency was highest at the start of the call, indicating more episodes of variation and intensity variation at the start of the call. Shimmer and jitter significantly increased from the start to the middle and end of the call. Shimmer and jitter are measures that can reflect the perception of hoarseness. Therefore, this may indicate that the call agents become more hoarse at the end compared to the middle and start of the call. In addition peak-to-peak amplitude variation was significantly higher at the end of the call compared to the middle and start of the call, indicating greater vocal instability. The literature has shown that hoarseness can have an impact on listening as the listener tends to pay less attention to a hoarse voice.[51]

The ratio of noise to harmonics was significantly higher at the start and end of the call compared to the middle of the call. This means that there is a higher proportion of noise in the vocal signal, which can be perceived as breathy or hoarse sounds, potentially reflecting musculoskeletal tension and higher vocal strain.[1] This could reinforce the need for vocal warm-up. The number of voice breaks and the degree of voicelessness increased from the start to the middle and end of the call. This could be related to vocal fatigue as the call progressed. Overall, these acoustic findings indicate that at the end of the telephone call the call agent's voice may be hoarse and have greater pitch variation compared to the start of the call. As this study investigated the work context of and vocal communication demands on call agents, it identifies the contexts and triggers that call agents perceive are causing pressure in the workplace.

5.3 Call agents' vocal health, awareness and performance (objective 2)

The call agents completed the survey while at work, so it is assumed that they represent a 'healthy' working population. However, 25 per cent of them reported experiencing various voice symptoms. The most reported voice symptom was hoarseness (66 per cent), followed by loss of pitch range (45 per cent) and finding that the voice is lower in pitch (38 per cent). This is supported by the acoustic data, as shimmer and jitter significantly increased during calls, and high shimmer and jitter values can be indicators of hoarseness. These findings are supported by the objective acoustic data, in particular the fundamental frequency and noise-to-harmonic ratio (NHR). The reported incidence of these symptoms in this study is consistent with that reported in previous studies.[10,18,21–23]

Overall, 10 per cent of the call agents reported that vocal difficulties affected their work interaction. This was expected to be low, as the call agents sampled were a 'healthy' working population. However, there was one statement that was reported more than the others: 'My voice problem upsets me' (31 per cent). The next most frequent statement was: 'My voice makes me feel less able to do my job' (14 per cent). Together, these indicate that call agents are concerned about their voice. Those who reported being upset about their voice may respond with increased laryngeal tension and laryngeal adjustments, which may lead to using an unnatural vocal style and causing further vocal strain.[1] Someone who is worried about their voice can have somatic symptoms such as hyperventilation, excessive tension and force, and hypercontraction of the larynx, which may lead to poor vocal function; cognitive symptoms, such as losing control; and emotional symptoms, including anxiety.[1] Recognition of and concern about the cause of voice disorders are important factors in identifying a voice problem and in reinforcing the individual's belief that they can control, change or prevent the condition.[52]

Furthermore, the level of sickness due to voice symptoms and vocal impact among call agents was generally low as reported by both the managers (less than 10 per cent) and call agents. The survey

was completed by those currently at work, who were asked to report on their previous sick leave, as the sample did not include those currently absent on sick leave. It has been reported in the literature that call centre workers have more sick leave than other employees in the same company.[10,21–23] Moreover, a press release last year stated that a call centre in England reported high levels of absence through sickness.[39] There are no national data available on sick leave in call centres.

This study has clearly shown that call agents currently at work in call centres, who are thus assumed to be healthy and fit for work, do report vocal health issues themselves. It is interesting that 11 per cent of the call agents involved in this study had been diagnosed with voice disorder. Overall, 25 per cent of the call agents reported voice misuse, with an average number of six types of misuse. Also, 25 per cent reported voice symptoms, with an average of four, and 10 per cent of the call agents reported that problems with their voice had an impact on them, experiencing an average of one kind of vocal impact. The only comparative data available in the literature come from the study conducted by Jones *et al.*,[18] which reported slightly higher rates than those reported in the present study. Jones et al. reported that among 304 telemarketers surveyed, 31 per cent reported that their work was affected by an average of five symptoms, compared to 25 per cent of call agents reporting an average of four symptoms in this study. However, the survey in this present study ($n = 598$) had nearly twice the sample size compared to Jones' study ($n = 304$).[18] The reasons for these differences could also be cultural (Jones' study was conducted in the US and the present study in the UK and Ireland) and related to the study design.

5.4 Key risks for employees and employers in call centres (objective 3)

This study adopted a multivariate analysis approach using structural equation modelling (SEM) to develop voice measurement models as a way of determining the construct validity of potential factors contributing to voice problems. To develop the overall SEM, a number of measurement models were created. The models determined the number of indicators used to measure each construct and identified which items to use in formulating each indicator. In the measurement models, each latent variable was represented by at least two measured or indicator variables, and each indicator represented a subscale of the questionnaire.

Six measurement models for the following latent constructs were appropriate for the data:

- sensations (physical feelings in the throat, such as pain or dryness)
- acoustics (perceptions of the sound of the voice, eg hoarseness and volume)
- mechanics (problems with physical voice production, such as difficulty talking against background noise, coughing or clearing the throat)
- emotions (psychological reactions, eg feeling depressed or embarrassed about the voice)
- functionality (problems with the effectiveness of the voice, such as people having difficulty hearing the speaker, voice making the individual less able to do the job)
- medical conditions (such as swollen glands and throat infections) and seeking medical advice about the voice (such as from a GP or voice expert, or after being diagnosed with a voice disorder.

A number of items from the questionnaire were significantly correlated to each of these constructs (see Figures 3–8).

These latent constructs were grouped with their second order latent variables as follows:

- latent variable: psycosocial health
  - constructs: emotional, functional
- latent variable: physiological voice production
  - constructs: mechanical, acoustics, sensations
- latent variable: medical health
  - constructs: medical advice, medical conditions.

The SEMs (Figures 9 and 10) showed that psychosocial health is associated with physiological voice production (0.84), and it is significant ($p < 0.05$). Moreover, medical health is associated with physiological voice production (0.93, $p = 0.064$). Furthermore, the fit indices for both of these models were appropriate for the data. Overall, the final SEM (Figure 11) showed that physiological voice production is a significant predictor of psychosocial health and medical health.

The overall hypothesis is that physiological voice production is associated with psychosocial health and medical health problems among call agents. The findings from the final overall SEM show that this hypothesis can be accepted, since psychosocial health and medical health problems are associated with physiological voice problems among call agents. Therefore, call agents who present frequent vocal symptoms are at risk of developing psychosocial health problems (both emotional and functional) and medical conditions, and are likely to seek medical advice, which in turn would be linked to further voice problems (mechanical, sensations and acoustic). This reflects a potentially recurring cycle of vocal abuse.[1] It also supports an earlier study modelling determinants of the vocal health of teachers, which indicated three statistically significant indicators of vocal dysfunction – voice related behaviours, environment and trait anxiety.[54]

From the model in Figure 11, it is evident that gender, time off on sick leave, vocal training and the duration of employment are significantly associated with physiological voice production. In particular, women are at higher risk than men of developing physiological voice problems; the more times the call agent is off work on sick leave the greater the likelihood is that they will report physiological voice problems; receiving vocal training reduces the risk of developing physiological voice problems; and people who have worked for a shorter time in a call centre are at higher risk of physiological voice production problems. Furthermore, women who have only recently started working in a call centre, who have received no vocal training and have been off work on sick leave are at the highest risk of developing physiological voice production problems. The model has therefore identified a high-risk group of call agents in respect of physiological voice problems, which allows prevention strategies to be targeted and implemented.

The findings from the SEMs (Figures 9–11) confirm the need to include a wide range of variables in the assessment and measurement of a voice disorder, and particularly in the identification of potential risk factors. Based on the overall final SEM (Figure 11), the identified risks relating to vocal health for the call agents and the call centre management are summarised in Table 29. Furthermore, the multiple risk factors involved could have a cumulative effect as stressors on vocal performance.[9,12] These risks will have an impact both on the employer and employee. For the call agent, this includes potential voice problems and disorders, resulting in discomfort, time off work on sick leave and, if prolonged, possible financial implications. This in turn may lead to increased absenteeism, lower production, higher costs and lower profits for the organisation.[9,12]

Table 29
Risks relating to vocal health

Significant risks relating to vocal health for call agents* and call centre management†	
Physiological voice problems	New starters
Psychosocial health problems	Vocal training
Medical health problems	Days off on sick leave
Female	

* Direct impact
† Indirect impact

Through this systematic mixed methods approach, the construct of physiological voice problems was tested and deemed to be a significant measure of the mechanical, sensational and acoustic parameters of musculoskeletal voice disorders. In addition, a physiological voice problem was found to be a predictor of medical and psychosocial health. The characteristics and presenting symptoms of call agents reporting voice problems are consistent with indicators in the literature of vocal strain and musculoskeletal voice problems. This study has identified the factors that predispose workers to physiological voice problems in this sample of call centre workers and found a significant relationship between vocal health and medical and psychosocial health in this population.

5.4 Training needs for employees and employers within call centres (objective 3)

Of the senior managers of call centres interviewed by telephone, nine reported having quality and quantity targets, but more emphasis was placed on quality. Overall, a range of personnel was involved in monitoring calls, but the person stated most often as being involved with this was the team leader. In some call centres, more than one person was responsible for monitoring calls.

All managers reported that they offer training for the call agents, and this is mainly organised in house. There was a range of personnel responsible for training, including the team leader, training manager and managing director. The training at all call centres involved induction and then ongoing

refreshers as required. The induction training included a range of topics, covering business-specific issues and those relating to products, services, systems, customers, the organisation and monitoring, before trainees went live on telephones. They then had back-up support available for the first few weeks. The duration of formal induction training ranged from three hours to four weeks, with monitoring up to four months. The ongoing training included refresher training as required, customer service training once a year for all staff, and updates on systems, products and customers. The frequency of ongoing training ranged from daily to once a year. From the managers' comments, it is clear that training is very individualised both from call centre to call centre and in terms of the development offered to individual call agents.

The reported training needs of call agents were wide-ranging. It is interesting that tone of voice, volume of voice, listening skills, voice projection and call handling were reported. In addition, all managers except one reported the need for and numerous benefits of voice training for the call agent and their organisation. One manager did not acknowledge the importance of vocal health and was very focused on sales targets and profit. Generally, these findings indicate that managers have identified a need for voice training and have realised the importance of effective voice use and communication for the call centre. The assumption that call agents are at risk of developing voice or throat problems was supported by five managers, who reported experience of call agents complaining of voice or throat problems. Therefore, all these findings support the importance of voice training in preventing voice problems.

From the survey, 55 per cent of call agents reported that the training they received in the call centre was good or excellent in terms of both the amount and quality of training. However, only a small proportion received specific vocal training either within the call centre (15 per cent) or outside work, such as with a personal voice coach (9 per cent). This may suggest that very few call agents are aware of the importance of vocal care to health.

The overall final SEM (Figure 11) suggests that providing vocal training in the workplace may reduce the risk of developing physiological voice problems. This finding highlights the potential benefit of providing vocal training in the workplace. Indeed, this is the first study to offer empirical evidence to substantiate this recommendation.

Therefore, this study has clearly shown that it is beneficial to give voice training to call agents. It is important that this training is appropriate and meets the specific needs of the call agents and call centre management. The findings from the online survey and interviews suggest that voice training should include:

- awareness of vocal health
- tone of voice
- volume of voice
- listening skills
- voice projection and handling
- cognitive issues
- sources of advice.

The acoustic analysis shows that towards the end of a call, agents' voices tended to be hoarse and fatigued, and they did not maintain pitch easily. This suggests that training for call agents should also include a vocal warm-up at the start of the shift and advice on pitch variation and preventing vocal fatigue. Voice training in the workplace should lead to benefits for both employees and employer. The benefits of voice training for the call agent are good vocal health, effective communication and interaction, and good communication among all staff in the call centre, resulting in satisfied customers. The employer will also benefit from this training as there should be a reduction in absenteeism and sick leave, and the employees are likely to be more effective communicators, which will improve communication among all staff and customers. Ultimately, this should result in higher output and, in the longer term, higher profits. The identified key vocal training needs and the goals for call agents and call centre management are outlined in Table 30.

Table 30
Summary of the key voice training needs and goals

Call agents	Call centre management
Voice training needs	
Awareness Vocal warm-up Pitch variation Preventing fatigue Tone of voice Volume of voice Listening skills Voice projection and handling Cognitive issues Sources of advice	Awareness Update health and safety policy
Overall key benefits of voice training	
Good vocal health Effective communication and interaction Good communication between all staff in the call centre Satisfied customers	Reduction in absenteeism and sick leave Workforce consists of effective communicators Good communication between all staff in the call centre Satisfied customers

5.5 Implications and recommendations for OSH

Call agents depend on good vocal quality as a main tool for their employment,[7] and with a growth in this industry,[14] the number of call agents will continue to increase. According to the latest Contact Centre Association (UK) Poll in 2008,[17] completed by 266 managers in over 200 private and public organisations, it was reported that the contact profile in the industry in five years will still be predominantly telephone-based (59 per cent, fixed lines and mobiles). This study has shown that call agents do self-report voice symptoms and their impact, as well as problems related to voice misuse. Therefore, the prevention and treatment of occupational voice disorders requires improved OSH arrangements.[3] Based on the findings from this study, the implications for occupational health and safety are outlined below.

5.5.1 Prevention rather than treatment of voice problems among call agents

There is emerging universal agreement among researchers in this area that preventive measures for voice disorders should be taken. Potential preventive strategies, such as voice screening, vocal health education and voice training may be required to prevent voice disorders among call agents. The overall final SEM (Figure 11) shows that vocal training in the workplace may significantly reduce the risk of developing physiological voice problems. Two studies showed that voice training led to significantly fewer voice symptoms reported by the customer service advisers.[10,22] Research suggests that educating professional voice users such as teachers to become aware of voice problems and take appropriate action may help to prevent the development of voice disorders.[13,54] In addition, employers must consider the potential occupational risks for employees as part of their duty of care, and this includes risks of voice disorders.[39] Therefore, resources should be employed in the prevention rather than only in the treatment of voice disorders. Employers would fulfil legal duty of care obligations and improve the vocal health of employees. Preventing rather than treating voice disorders could provide further benefits for the call agent and call centre in terms of communication (eg effective interaction, clearer speech, higher first time call resolution), health (eg fewer days off work on sick leave, improved vocal and psychological health and wellbeing) and economics (eg higher production levels, lower staff absenteeism, reduction in recruitment costs).[7,9,13]

5.5.2 Identification of the levels of risk of voice disorders among call agents

This study has clearly identified a group of call agents at high risk of developing physiological voice problems, namely women who have recently started to work in a call centre, who have received no vocal training and who are off work on sick leave. There is a need to determine different levels of risk of developing voice disorders in order to identify those individuals who are most susceptible to voice disorders. Call agents at the highest risk of developing voice disorders are perhaps most likely to benefit from interventions such as voice training. A suggestion is to screen call agents (perhaps during induction and then yearly) to identify those at the highest risk. A potential screening tool could be the biopsychosocial questionnaire that was used in the online survey in the present study. If the highest risk call agents can be identified and given help in advance of developing any problems, the prevention strategy may be more cost-effective.

5.5.3 OSH policies on occupational voice disorders should be established and reviewed regularly

Vocal fatigue or strain may result from musculoskeletal disorders where there is damage to the larynx or surrounding area. This is often described as a form of repetitive strain injury due to multiple forceful vocal fold closures.[1] However, further physiological evidence is needed to identify the impact and source of musculoskeletal strain.

The risk factors for occupational voice disorders, such as background noise, unsatisfactory room acoustics, poor air quality (eg dryness, dust), poor posture and vocal loading,[9,37] can be considered as a health and safety issue in the workplace. There is some debate over whether voice disorders are the responsibility of employers or employees. According to reports by the Health and Safety Executive and current UK OSH regulations,[15,38] employers are obliged to provide resources to prevent occupational risks, thus based on these reports, call agents should be provided with a safe working environment and/or with information on vocal care.

In the UK, the Industrial Injuries Advisory Council (IIAC)[16] published a position paper on occupational voice loss, which considered the risk of voice loss in people employed in occupations with high levels of noise. The report concluded that although several research studies have been published, there is insufficient current evidence for occupational voice loss to meet the requirements for prescription by the IIAC. With further research in the area, it may be possible to present adequate evidence for occupational voice loss to meet the requirements for prescription by the IIAC in the future. Therefore, it could be suggested that OSH policies on occupational voice disorders should be established and reviewed regularly in accordance with emerging evidence.

Based on the findings of this study, the authors make the following recommendations for occupational health and safety regarding vocal health:

- **Vocal information and training for call agents, especially new starters.** Vocal training should be incorporated into call agents' induction and refresher training programmes. Call agents would thereby be more aware of vocal health and thus reduce their risk of developing physiological voice problems (Figure 11). Vocal training should be considered as a prevention tool.
- **Initiatives and strategies to improve vocal health should be developed to reduce absenteeism and sick leave among call agents.** Call centres are advised to develop initiatives and strategies to reduce absenteeism and sick leave. The SEM (Figure 11) showed that the more times call agents are off work on sick leave, the greater the likelihood is that they will report physiological voice problems. Sickness absence may be indicative of lower resistance to voice-related problems.
- **Include vocal health in the call centre's health and safety policy.** Call centres should be encouraged to include and implement good vocal health guidelines among call agents as a prevention strategy for voice disorders. Based on the findings from this study, these guidelines should include:
    - encouraging call agents to drink water regularly during shifts
    - encouraging call agents to check that their posture is correct (ie that they are sitting upright)
    - making sure that both call agents and managers minimise vocal misuse, such as talking against background noise or in an excessively dry or warm environment
    - screening for all call agents, perhaps at induction and then once a year
    - introducing vocal training for all call agents (as outlined in Table 30), and tailoring the training to individual agents according to their risk level.

Although this study focused on call centre workers, the implications and recommendations in this report are appropriate for other professional voice users, such as teachers and singers. Therefore, the findings from this study are relevant to the wider communications sector.

5.7 Strengths and limitations of the study

5.7.1 Strengths

This study investigated the work context and vocal communication demands for call agents, evaluated call agents' vocal health, awareness and performance, and identified key risks and training needs for employees and employers in call centres. This was successfully achieved using three different methodologies, ie interviews, an online survey, and acoustic measurements, over 18 months. In addition, the sample size for the online survey was large ($n = 598$), providing a valuable dataset.

The data from the biopsychosocial questionnaire were analysed using multivariate analysis. The factor analysis provided the key indicators, while the SEM confirms the interactions. This analysis explored potential directional effects across a wide range of predisposing variables. The research design and associated analysis attempted to overcome the traditional complications of multiple indicators, indirect effects and measurement error by using SEM with latent variables and LISREL (linear structural relations) estimation.

This study has provided the following additions to the current literature and evidence base for vocal OSH:

- Psychosocial health and medical problems are both significantly associated with physiological voice production among call agents. Therefore, an increase in psychosocial and medical health problems leads to an increase in physiological voice problems.
- Mechanical, sensational and acoustic factors significantly contribute to physiological voice production among call agents.
- The medical conditions and medical advice factors significantly contribute to voice-related medical health among call agents.
- The functional and emotional latent factors significantly explained the homogeneity in the questionnaire items that were designed to measure the emotional aspects contributing to psychosocial health among call agents.
- A high risk group of call agents was identified, who are significantly at risk of developing physiological voice problems. These are women who have recently started working in a call centre, who have received no vocal training and who are frequently off work on sick leave.
- Delivering vocal training in the workplace significantly reduces the risk of call agents developing physiological voice problems.

5.7.2 Limitations

The researchers had difficulty recruiting call centres to participate in this study because of the current economic downturn, as organisations were operating on limited resources. Many organisations reported that it was the company's policy not to participate in research studies. However, the researchers kept recruiting and a large sample size for the online survey was achieved within the allocated time frame.

Although the acoustic measurements were objective, the interviews with call centre managers and the online survey completed by call agents were subjective. The call agents reported their own voice use, symptoms and vocal impact along with their demographics and information on their work environment. Self-reported data are often treated with caution; however, the impact of any inherent error is reduced in this study by the large sample size. As the data were self-reported, there was a lack of medical verification of physiological change to vocal function.

5.8 Recommendations for further research

Recommendations for further research among call agents include:

- determining universally accepted definitions of voice disorders, assessment and methodologies, which should be used consistently
- determining standardised measurement tools (a battery of tests), which can be used universally
- determining whether occupation is a cause of voice disorders or an aggravating factor among professional voice users
- conducting a large-scale risk assessment to identify the prevalence of precipitating and perpetuating factors contributing to occupational voice disorders and to classify the levels of risk of occupational voice disorders
- identify levels of risk for call agents of developing voice problems and also optimum levels of intervention to aid assessment and prevention of voice problems among call agents
- developing the biopsychosocial questionnaire used in the online survey as a screening tool
- confirming that voice training improves the vocal quality of professional voice users by conducting a randomised controlled trial with two groups of call agents, one receiving the vocal training programme and another receiving no training (control group) to compare and establish the effect of voice training among call agents
- investigating the efficacy of different types of voice training programme in order to develop an ideal programme for call centre workers
- investigating cost-effective methods of providing voice training to call agents
- verifying physiological change to vocal function using medical visualisation techniques.

5.9 Conclusion

This study investigated the work context of and vocal communication demands on call agents, evaluated call agents' vocal health, awareness and performance, and identified key risks and training needs for employees and employers in call centres. This was achieved through interviews with managers, an online survey and acoustic measurements. The results were interesting and contributed new knowledge to this research area. Although 11 per cent of the call agents reported having been diagnosed with a voice disorder, 25 per cent reported both voice misuse and voice symptoms. This indicates that vocal health in the call centre industry needs to be considered more carefully.

The interviews with the managers indicated that although training for call agents is regular (at induction and ongoing) and comprehensive, the majority of call centres do not include vocal training. Furthermore, the majority of managers reported that there was a need for voice training and that it would benefit their employers.

The acoustic data indicated that at the end of a telephone call, the call agent's voice may be hoarse and exhibit fatigue-related variation, and that they may have difficulty maintaining the pitch of their voice compared to the start of the call.

The SEM based on the online survey clearly showed that psychosocial health and medical health are both predictors of physiological voice production among call agents. Therefore, an increase in psychosocial and medical health problems leads to an increase in physiological voice problems. Mechanical, sensational and acoustic factors significantly contribute to physiological voice production among call agents. Where a call agent reported associated medical conditions and sought advice, this significantly contributed to medical health outcomes among call agents. Functional and emotional factors significantly contributed to psychosocial health among call agents. It was interesting that a high risk group of call agents was identified, which was women who have recently started working in a call centre, who have received no vocal training and who are frequently off work on sick leave. People in this category are significantly at risk of developing physiological voice problems. It was also shown that vocal training delivered in the workplace significantly reduces the risk of developing physiological voice problems.

Therefore, this study has identified the risks of occupational voice disorders, including musculoskeletal problems, and also highlighted the importance of vocal health among call centre workers. Furthermore, it has implications for OSH, and a number of recommendations were made. Further robust research in this area and recommendations have been given.

References

1 Mathieson L. *Greene and Mathieson's The voice and its disorders* (sixth edition). Whurr Publishers Ltd, 2006.
2 Rubin J S, Blake E and Mathieson L. Musculoskeletal patterns in patients with voice disorders. *Journal of Voice* 2007; 21 (4): 477–484.
3 Vilkman E. Occupational safety and health aspects of voice and speech professions. *Folia Phoniatrica et Logopaedica* 2004; 56: 220–253.
4 Laukkanen A-M. *On speaking voice exercises*. Dissertation, University of Tampere. *Acta Universitatis Tamperensis* 1995; ser. A, vol. 445.
5 Titze I R, Lemke J and Montequin D. Populations in the US workforce who rely on voice as a primary tool of trade: a preliminary report. *Journal of Voice* 1997; 11: 254–259.
6 Verdolini K and Ramig L O. Review: occupational risks for voice problems. *Logopedics Phoniatrics Vocology* 2001; 26: 37–46.
7 Ruotsalainen J, Sellman J, Lic P, Lehto L and Verbeek J. Systematic review of the treatment of functional dysphonia and prevention of voice disorders. *Archives of Otolaryngology – Head and Neck Surgery* 2008; 138: 557–565.
8 Mattiske J A, Oates J M and Greenwood K M. Vocal problems among teachers: a review of prevalence, causes, prevention and treatment. *Journal of Voice* 1998; 12: 489–499.
9 Vilkman E. Voice problems at work: a challenge for occupational safety and health management. *Folia Phoniatrica et Logopaedica* 2000; 52: 120–125.
10 Lehto L, Alku P, Bäckström T and Vilkman E. Voice symptoms of call-centre customer service advisers experienced during a work-day and effects of a short vocal training course. *Logopedics Phoniatrics Vocology* 2005; 30: 14–27.
11 Preciado-López J, Pérez-Fernández C, Clazada-Uriondo M and Preciado-Ruiz P. Epidemiological study of voice disorders among teaching professionals of La Rioja, Spain. *Journal of Voice* 2006; 22: 489–508.
12 Williams N and Carding P. *Occupational voice loss*. Taylor & Francis Group, 2005.
13 Duffy O M and Hazlett D. The impact of preventive voice care programs for training teachers: a longitudinal study. *Journal of Voice* 2004: 18; 63–70.
14 UK Department of Trade and Industry. *The UK contact centre industry: a study*. HMSO, 2004.
15 Health and Safety Executive. *Psychosocial risk factors in call centres: an evaluation of work design and wellbeing*. HMSO, 2003.
16 Industrial Injuries Advisory Council. *Position Paper 16: Occupational voice loss*. IIAC, 2006.
17 Contact Centre Association. *The paradoxes of contact centre management today – CCA membership poll 2008/09*. www.cca.org.uk/cca (accessed 19 August 2009).
18 Jones K, Sigmon J, Hock L, Nelson E, Sullivan M and Ogren F. Prevalence and risk factors for voice problems among telemarketers. *Archives of Otolaryngology – Head and Neck Surgery* 2002; 128: 571–577.
19 Gilardi L, Fubini L, d'Errico A, Falcone U, Mamo C, Migliardi A, Quarta D and Coffano M E. Working conditions and health problems among call-centre operators: a study on self-reported data in the Piedmont region (Italy). *La Medicina del Lavoro* 2008; 99: 415–423.
20 Cameron D. *Good to talk? Living and working in a communication culture*. Sage Publications, 2000.
21 Lehto L, Laaksonen L, Vilkman E and Alku P. Occupational voice complaints and objective acoustic measurements – do they correlate? *Logopedics* 2006; 31: 147–152.
22 Lehto L, Rantala L, Vilkman E, Alku P and Bäckström T. Experiences of a short vocal training course for call-centre customer service advisors. *Folia Phoniatrica et Logopaedica* 2003; 55: 163–176.
23 Lehto L, Laaksonen L, Vilkman E and Alku P. Changes in objective acoustic measurements and subjective voice complaints in call center customer-service advisors during one working day. *Journal of Voice* 2008; 22: 164–177.
24 Ramig L O and Verdolini K. Treatment efficacy: voice disorders. *Journal of Speech, Language and Hearing Research* 1998; 41: S101–S116.
25 Smith E, Gray S D, Dove H, Kirchner L and Heras H. Frequency and effects of teachers' voice problems. *Journal of Voice* 1997; 11: 81–87.
26 Russell A, Oates J and Greenwood K M. Prevalence of voice problems. *Journal of Voice* 1998; 12: 467–479.
27 De Jong F I C R S, Kooijman P G C, Thomas G, Huinck W J, Graamans K and Schutte H K. Epidemiology of voice problems in Dutch teachers. *Folia Phoniatrica et Logopaedica* 2006; 58: 186–198.

28 Nerrière E, Vercambre M-N, Gilbert F and Kovess-Masféty V. Voice disorders and mental health in teachers: a cross-sectional nationwide study. *BMC Public Health* 2009; 9: 370.
29 Hazlett D. *An investigation into the prevalence and causes of occupational dysphonia in teachers*. PhD thesis. University of Ulster School of Communication, 2001.
30 Ilomäki I, Laukkanen A-M, Leppänen K and Vilkman E. Effects of voice training and voice hygiene education on acoustic and perceptual speech parameters and self-reported vocal well-being in female teachers. *Logopedics Phoniatrics Vocology* 2008; 33: 83–92.
31 Rantala L and Vilkman E. Relationship between subjective voice complaints and acoustic parameters in female teachers' voices. *Journal of Voice* 1999; 13: 484–495.
32 Sapir S, Keidar A and Mathers-Schmidt B. Vocal attrition in teachers: survey findings. *European Journal of Disorders of Communication* 1993; 28: 177–185.
33 Södersten M, Granqvist S, Hammarberg B and Szabo A. Vocal behaviour and vocal loading factors for preschool teachers at work studied with binaural DAT recordings. *Journal of Voice* 2002; 16: 356–371.
34 Sala E, Laine A, Simberg S, Pentti J and Suonpää J. The prevalence of voice disorders among day care center teachers compared with nurses: a questionnaire and clinical study. *Journal of Voice* 2001; 15: 413–423.
35 Urrutikoetxea A, Ispizua A, Matellanes F and Aurrekoetxa J. Prevalence of vocal nodules in teachers. Paper presented at the First World Congress of Voice, Porto, Portugal, 1995.
36 Hazlett D E, Duffy O M and Moorhead S A. Review of the impact of voice training on the vocal quality of professional voice users: implications for vocal health and recommendations for further research. *Journal of Voice* 2010 (in press).
37 Vilkman E. Occupational risk factors and voice disorders. *Logopedics Phoniatrics Vocology* 1996; 21: 137–141.
38 Health and Safety at Work etc Act 1974. www.hse.gov.uk/legislation/hswa.htm (accessed 08 September 2009).
39 Deary I J, Wilson J A, Carding P N and MacKenzie K. VoiSS: A patient-derived voice symptom scale. *Journal of Psychosomatic Research* 2003; 54: 483–489.
40 Jacobson B H, Johnson A, Grywalski C, Silbergleit A, Jacobson G, Benninger M S and Newman C W. The Voice Handicap Index (VHI): development and validation. *American Journal of Speech–Language Pathology* 1997; 6: 66–70.
41 Kay Elemetrics Corporations. *Multi-Dimensional Voice Program (MDVP) model 5105: software instruction manual*. Kay Elemetrics Corporation, 2003.
42 Byrne B M. *Structural equation modelling with LISREL, PRELIS and SIMPLIS: basic concepts, applications and programming*. Lawrence Erlbaum Associates, 1998.
43 Jöreskog K G and Sörbom D. *Structural equation modeling with the SIMPLIS command language*. Scientific Software Inc., 1993.
44 Data Protection Act 1998. www.legislation.gov.uk/ukpga/1998/29/contents (accessed 05 November 2010).
45 Hazlett D E, Duffy O D and Moorhead S A. Occupational voice demands and their impact on the call-centre industry. *BMC Public Health* 2009; 9: 108–112.
46 Steiger J H. Structural model evaluation and modification: an interval estimation approach. *Multivariate Behavioral Research* 1990; 25: 173–180.
47 Martin S and Darnley L. *The teaching voice*. Whurr Publishers, 1999.
48 Boone D R. *Is your voice telling on you?* Singular, 1991.
49 Murphy C and Doyle P. The effects of cigarette smoking on voice-fundamental frequency. *Archives of Otolaryngology – Head and Neck Surgery* 1987; 97: 376–380.
50 Lee L, Stemple J C, Geiger D and Goldwasser R. Effects of environmental tobacco smoke on objective measures of voice production. *The Laryngoscope* 1999; 109: 1531–1534.
51 Morton V and Watson D R. The teaching voice: problems and perceptions. *Logopedics Phoniatrics Vocology* 1998; 23: 133–139.
52 Ritchie J. Vocology: the psychological underpinning of voice. *British Journal of Therapy and Rehabilitation* 1996; 3 (2): 75–81.
53 CCF Online. *Council battles sick leave*. www.callcentre.co.uk (accessed 19 August 2009).
54 McAleavy G J, Adamson G, Hazlett D E, Donegan H A and Livesey G E. Modelling determinants of the vocal health of teachers in Northern Ireland: implications for educational policy and practice. *Public Health* 2008; 122: 691–699.

Appendix – Acoustic parameters analysed with the Multi-Dimensional Voice Program (MDVP)

Acoustic analysis can be conducted using the Multi-Dimensional Voice Program (MDVP) (Kay Elemetrics Corporation, NJ, USA; model 5105), which is a software program that provides a robust multi-dimensional analysis of voice with a graphic and numerical presentation of the analysis. MDVP is the gold standard measurement tool for quantitative voice analysis. The analysis calculates 34 parameters of voice and includes voice break and subharmonic parameters, eg degree of sub-harmonics; short and long term frequency perturbations, eg jitter; short and long term amplitude perturbations, eg shimmer; noise-related parameters, eg sound pressure level; and tremor parameters, eg amplitude tremor intensity index.

Parameters

- **Average fundamental frequency (F_0 (Hz))** – for all extracted momentum fundamental frequency values (reciprocal of momentum pitch periods)
- **Mean fundamental frequency (MF_0 (Hz))** – for all extracted momentum pitch periods
- **Average pitch period (T_0 (ms))** – for all extracted pitch periods
- **Highest fundamental frequency (Fhi (Hz))** – for all extracted pitch periods
- **Lowest fundamental frequency (Flo (Hz))** – for all extracted pitch periods
- **Standard deviation of the fundamental frequency (STD (Hz))** – within the analysed voice sample
- **Phonatory fundamental frequency range (PFR)** – range between Fhi and Flo expressed in number of semitones
- **F_0 tremor frequency (Ftr (Hz))** – the frequency of the most intensive low-frequency F_0-modulating component in the specified F_0-tremor analysis range. If the corresponding FTRI value is below the specified threshold, the Ftr value is zero
- **Amplitude–tremor frequency (Fatr (Hz))** – the frequency of the most intensive low-frequency amplitude-modulating components in the specified amplitude-tremor analysis range. If the corresponding ATRI value is below the specified threshold, the Fatr value is zero
- **Length of analysed sample (Tsam (s))** – length of analysed data sample
- **Absolute jitter (Jita (μs))** – an evaluation of the period-to-period variability of the pitch period in the analysed voice sample. Voice breaks are excluded
- **Jitter percentage (Jitt (%))** – relative evaluation of the period-to-period (very short term) variability of the pitch in the analysed voice sample. Voice breaks are excluded
- **Relative average perturbation (RAP (%))** – relative evaluation of the period-to-period variability of the pitch in the analysed voice sample with a smoothing factor of three periods. Voice breaks are excluded
- **Pitch period quotient (PPQ (%))** – relative evaluation of the period-to-period variability of the pitch in the analysed voice sample with a smoothing factor of five periods. Voice breaks are excluded
- **Smoothed pitch period perturbation quotient (sPPQ (%))** – relative evaluation of the short or long term variability of the pitch period in the analysed voice sample at a smoothing factor defined by the user. The factory setup for the smoothing factor is X periods. Voice breaks are excluded
- **Fundamental frequency variation (vF_0 (%))** – relative standard deviation of the period-to-period calculated fundamental frequency. It reflects the very long term variation of Fo for all analysed voice samples
- **Shimmer in decibels (ShdB (dB))** – evaluation in dB of the period-to-period (very short term) variability of the peak-to-peak amplitude in the analysed voice sample. Voice breaks are excluded
- **Shimmer percentage (Shim (%))** – relative evaluation of the period-to-period (very short term) variability of the peak-to-peak amplitude in the analysed voice sample. Voice breaks are excluded
- **Amplitude perturbation quotient (APQ (%))** – relative evaluation of the period-to-period variability of the peak-to-peak amplitude in the analysed voice sample at a smoothing level of 11 periods. Voice breaks are excluded
- **Smoothed amplitude perturbation quotient (sAPQ (%))** – relative evaluation of the short or long term variability of the peak-to-peak amplitude in the analysed voice sample at a smoothing factor defined by the user. The factory setup for the smoothing factor is 55 periods (providing relatively long-term variability; the user can change this value as desired). Voice breaks are excluded
- **Peak amplitude variation (vAm (%))** – Relative standard deviation of the period-to-period calculated peak-to-peak amplitude. It reflects the very long term amplitude variations in the analysed voice sample.

- **Noise to harmonic ratio (NHR)** – average ratio of the inharmonic spectral energy in the frequency range 1,500–4,500 Hz to the harmonic spectral energy in the frequency range 70–4,500 Hz. This is a general evaluation of noise present in the analysed signal
- **Voice turbulence index (VTI)** – average ratio of the spectral inharmonic high frequency energy in the range 2,800–5,800 Hz to the spectral harmonic energy in the range 70–4,500 Hz in areas of the signal where the influence of the frequency and amplitude variations, voice breaks, and subharmonic components are minimal. VTI measures the relative energy level of high frequency noise
- **Soft phonation index (SPI)** – average ratio of the lower frequency harmonic energy in the range 70–1,600 Hz to the higher frequency harmonic energy in the range 1,600–4,500 Hz
- **Frequency tremor intensity index (FTRI (%))** – average ratio of the frequency magnitude of the most intense low frequency modulating component (Fo-tremor) to the total frequency magnitude of the analysed voice signal
- **Amplitude tremor intensity index (ATRI (%))** – average ratio of the amplitude of the most intense low frequency amplitude modulating component (amplitude tremor) to the total amplitude of the analysed voice signal
- **Degree of voice breaks (DVB (%))** – ratio of the total length of areas representing voice breaks to the length of the complete voice sample
- **Degree of subharmonics (DSH (%))** – estimated relative evaluation of subharmonic to Fo components in the voice sample
- **Degree of voiceless (DUV (%))** – estimated relative evaluation of nonharmonic areas (where Fo cannot be detected) in the voice sample. In case of nonsustained phonation from the beginning to the end of the data acquisition, DUV will evaluate also the pauses before, after and/or between the voice sample(s)
- **Number of voice breaks (NVB)** – shows how many times the generated Fo was interrupted from the beginning of the first until the end of the last voiced area.
- **Number of subharmonic segments (NSH)** – found during analysis
- **Number of unvoiced segments (NUV)** – detected during the autocorrelation analysis
- **Total number of segments (SEG)** – computed during the autocorrelation analysis
- **Pitch periods (PER)** – detected during the period-to-period pitch extraction.

Source: Kay Elemetrics Corporation. *Multi-Dimensional Voice Program (MDVP) Model 5105 software instruction manual*. Kay Elemetrics Corporation, 2003.

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