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The prevalence of tinnitus and the relationship with neuroticism in a middle-aged UK population ☆

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ABSTRACT

Background: Previous research has suggested that a substantial proportion of the population are severely affected by tinnitus, however recent population data are lacking. Furthermore, there is growing evidence that the perception of severity is closely related to personality factors such as neuroticism.
Objective: In a subset (N = 172,621) of a large population sample of >500,000 adults aged 40 to 69 years, (from the UK Biobank dataset) we calculated the prevalence of tinnitus and that which is perceived as bothersome, and examined the association between tinnitus and a putative predisposing personality factor, neuroticism.
Method: Participants were recruited through National Health Service registers and aimed to be inclusive and as representative of the UK population as possible. The assessment included subjective questions concerning hearing and tinnitus. Neuroticism was self-rated on 13 questions from the Eysenck Personality Inventory. Associations between neuroticism and tinnitus were tested with logistic regression analyses.
Results: Prevalence of tinnitus was significantly higher for males, and increased with age, doubling between the youngest and oldest age groups (males 13% and 26%; females 9% and 19% respectively). Of those with tinnitus, females were more likely to report bothersome tinnitus. Neuroticism was associated with current tinnitus and bothersome tinnitus, with the items: 'loneliness', 'mood swings', 'worrier/anxious' and 'miserableness', as the strongest associations of bothersome tinnitus.
Conclusions: Neuroticism was identified as a novel association with tinnitus. Individuals with tinnitus and higher levels of neuroticism are more likely to experience bothersome tinnitus, possibly as a reflection of greater sensitivity to intrusive experiences.

Introduction

Tinnitus is the perception of sounds in the head or ears, usually defined as a ringing, buzzing or whistling sound. Tinnitus can be objective or subjective. Objective tinnitus is caused by sounds generated by an internal biological activity. However, subjective tinnitus is much more common and results from abnormal neural activities which are not formed by sounds [1]. Subjective tinnitus is a common and disturbing phenomenon, with a reported prevalence ranging from 7 to 20% [2–5] in the general population, and an estimated 10 year incidence rate in adults aged over 48 years of 13% [6]. Approximately 5% of the population is severely affected by their tinnitus [7], for example experiencing sleep disorders, concentration difficulties, and symptoms of anxiety and depression.

Tinnitus can affect a person's satisfaction with quality of life [8], and their physical, emotional, and social functioning [9], as well as leading to a higher incidence of anxiety and depression [10]. However, not everyone with tinnitus will experience the same amount of distress and impairment of quality of life. It is likely that psychological factors – including

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personality characteristics – mediate the impact of tinnitus. Personality type can influence the vulnerability to, and the severity of, the problem by influencing the tendency to be aware of it [11].

Personality characteristics previously reported to be associated with tinnitus include hysteria and hypochondriasis [9,12], introversion [13], withdrawal [9], and emotional isolation [14]. Additionally, particular cognitive strategies, for example, dysfunctional and catastrophic thoughts can increase patients' emotional distress and perceived tinnitus severity, and are thought to be closely related to personality factors [15]. Neuroticism is expressed as "individual differences in the tendency to experience negative, distressing emotions" [16] (p. 301). At one extreme, individuals are characterized by high levels of vulnerability to experience negative emotions, including sadness, fear, anxiety, anger, frustration, and insecurity [17]. At the other end of the spectrum, individuals who score low in neuroticism are more emotionally stable and less reactive to stress. Neuroticism has been associated with adverse outcomes in various health conditions, including increased likelihood of morbidity in those with testicular cancer [18], and an increased likelihood of arthritis, kidney/liver disease, and diabetes in the general population [19]. There is evidence that neurotic traits are stronger in tinnitus patients [20], particularly in those with higher levels of tinnitus annoyance, and recent evidence that neuroticism may predict the development of severe tinnitus in patients already experiencing some tinnitus [21]. In a cross-sectional sample of 530 participants (50% with chronic tinnitus), Bartels and colleagues [22] studied the role of type D personality (the tendency towards negative affectivity and social inhibition) on health-related quality of life and self-reported tinnitus-related distress. Tinnitus patients with type D personality reported greater tinnitus-related distress and poorer health-related quality of life compared to those with other personality types. The authors concluded that some personality characteristics are associated with having tinnitus and are likely to contribute to its perceived severity.

UK prevalence estimates for tinnitus are relatively dated; data for the widely cited National Study of Hearing (NSH) [2] were collected in the 1980's. It is possible that prevalence figures may have changed since then, for example, due to more recreational noise exposure. In addition, neither the NSH nor any other large-scale, population-based study has provided comparisons between tinnitus and neuroticism. The objectives of this study were to provide a detailed description of the prevalence of tinnitus in a large population study of UK adults aged 40 to 69 years, according to age and sex, (following on from a previous study [5]), as well as to examine the link between tinnitus severity and neuroticism.

Methods

The UK Biobank is a large dataset which was established as a resource for the investigation of the genetic, environmental and lifestyle causes of common diseases [23]. It provides an excellent opportunity to study a range of factors associated with hearing-related problems, including tinnitus. Recruitment of adults aged 40 to 69 years was carried out through National Health Service registers and aimed to be inclusive and as representative as possible of the UK population. Overall, 9.2 million invitations were sent out and 503,325 participants were recruited over the course of 2006–2010, giving a response rate of 5.47%. It is possible that the low response rate may have led to unknown biases; however, due to the size and coverage of the sample, UK Biobank suggests that associations observed in the sample should be generalizable to the UK population [23]. Participants completed a single assessment of approximately 90 minute duration at one of the 22 assessment centres located in England, Scotland, and Wales. The UK Biobank self-completed touch-screen questionnaire included data relating to a broad range of health-related issues, including hearing, lifestyle, occupation, family history, and psychological state. The present study reports data related to tinnitus and personality.

Demographic questions

Demographic data were collected during the assessment, including age, sex and socioeconomic status. The Townsend deprivation score was used in UK Biobank as a proxy for socioeconomic status. This is a geographic based measure where census data are available and were used as a measure of deprivation using the 2001 census returns.

Tinnitus

Two self-report questions on tinnitus were included in the touchscreen questionnaire, answered by 172,621 participants. The first question was *"Do you get or have you had noises (such as ringing or buzzing) in your head or in one or both ears that lasts for more than five minutes at a time?"* Participants who gave a yes response were then asked to categorise the duration from a predefined list. Current tinnitus was identified if the participant responded: 'Yes, now most or all of the time', 'Yes, now a lot of the time' or 'Yes, now some of the time'. The second question was concerned with severity of tinnitus: *"How much do these noises worry, annoy or upset you when they are at their worst?"* The response options were 'not at all', 'slightly', 'moderately', or 'severely'. Bothersome tinnitus was defined as those who responded 'severely' or 'moderately'. Participants could also respond 'do not know' or 'prefer not to answer' to these questions. The UK Biobank assessment protocol did not include any tinnitus scale, nor did it measure the loudness of the tinnitus, however the subjective questions included have been deemed reliable in similar studies [2].

Hearing difficulty

Participants (n = 497,984) were asked *"Do you have any difficulty with your hearing?"* Participants could respond 'yes', 'no', or 'I am completely deaf'. Those that responded 'I am completely deaf' were excluded from answering subsequent hearing-related questions. A second question asked: *"Do you find it difficult to follow a conversation if there is background noise (such as TV, radio, children playing)?"* Again, participants could respond 'yes', or 'no'.

Neuroticism

The Eysenck Personality Inventory (EPI) [24] is a questionnaire assessing personality type. Eysenck describes personality according to three biologically-based independent dimensions of temperament measured on a continuum: extraversion/introversion, neuroticism/stability and psychoticism/socialisation. Of these, the thirteen questions related to neuroticism/stability were included in UK Biobank (see Table 1). A total of 501,776 participants responded to these questions. The response options were: 'yes', 'no', 'do not know', 'prefer not to answer'. These

Table 1
Neuroticism subscale from the EPI [23].

Description	Question
Mood swings	Does your mood often go up and down?
Miserableness	Do you ever feel 'just miserable' for no reason?
Irritability	Are you an irritable person?
Sensitivity/hurt feelings	Are your feelings easily hurt?
Fed-up feelings	Do you often feel 'fed-up'?
Nervous feelings	Would you call yourself a nervous person?
Worrier/anxious feelings	Are you a worrier?
Tense/highly strung	Would you call yourself tense or 'highly strung'?
Worry too long after embarrassment	Do you worry too long after an embarrassing experience?
Suffer from nerves	Do you suffer from 'nerves'?
Loneliness/isolation	Do you often feel lonely?
Guilty feelings	Are you often troubled by feelings of guilt?
Risk taking	Would you describe yourself as someone who takes risks?

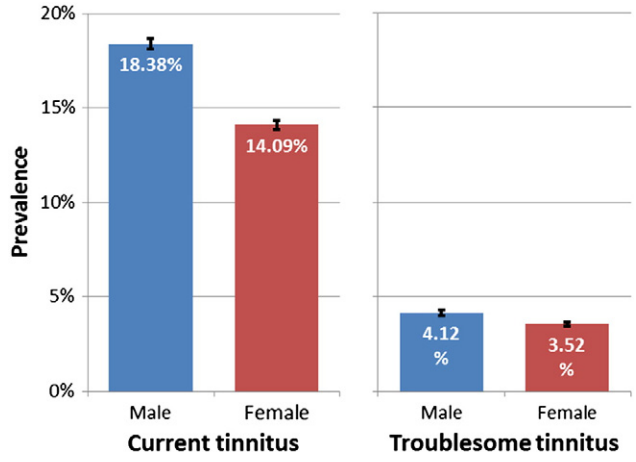

Fig. 1. Age-standardised prevalence of current tinnitus (left), and bothersome tinnitus (right) for males and females aged 40 to 69 years (base: UK 2011 census; 95% CI shown).

variables were combined to create an overall measure of 'neuroticism' on a continuous scale, as per the EPI scoring protocol, i.e. a score of 13 would indicate responding 'yes' to all 13 questions. No formal diagnosis of neuroticism was made.

Analysis

Analysis was conducted in three phases. First of all, prevalence rates of tinnitus and bothersome tinnitus were obtained for males and females separately. Overall prevalence rates were age-standardised by reference to the 40–69 year old age profile from the 2011 UK census; they were also standardised for deprivation using the Townsend index. Standardisation of the national deciles of the Townsend score means that the range from 0 to 1 corresponds to the range from the least deprived to the most deprived. The neuroticism score was similarly scaled to range between 0 and 1, by division of 13, to facilitate comparison with other effects. Further analyses were performed using binary logistic regression to examine whether neuroticism is associated with tinnitus and tinnitus severity, while controlling for demographic factors (age, sex, deprivation) and hearing difficulty. All analyses were conducted in R using the mice package for multiple imputation [25]. Initially a binary logistic multiple regression analysis was performed with current tinnitus as the dependent variable ('no tinnitus' as the reference category) with all participants being at risk. A subsequent, conditional binary logistic multiple regression analysis was performed based on all participants with current tinnitus, with severity (tinnitus not bothersome as the reference category) as the dependent variable. In both cases, age, sex, hearing difficulty, hearing difficulty in background noise, deprivation, and neuroticism were the predictor variables. For all questions, participants had the option of choosing 'do not know' or 'prefer not to answer'.

Questions relating to hearing, including the two questions regarding tinnitus, were introduced at a later stage than other questions. For example, all participants (n = 501,776) were asked the personality questions but approximately one third of participants (n =172,621) were asked the questions relating to tinnitus. Only this subset of participants was included in the analysis. Inspection of patterns of missing data due to participants choosing not to respond to particular questions suggested that data were not Missing Completely at Random (MCAR) but that missing data might be in some way informative. Missing responses for each of the individual personality type questions ranged from 1.9% to 4.9%. Consequently, such missing responses were multiply imputed by chained equations using 20 imputation chains [26].

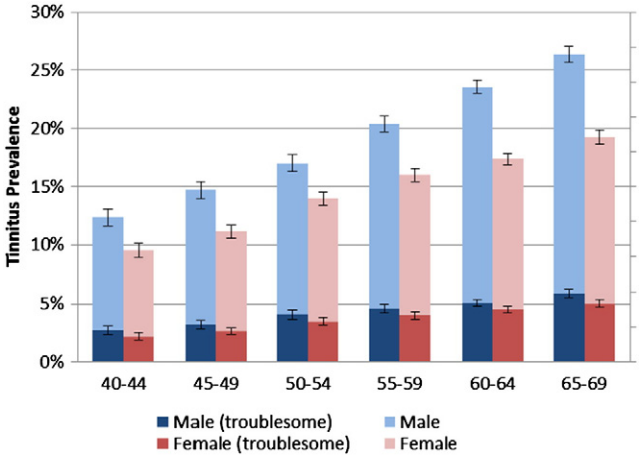

Fig. 2. Prevalence estimates for self-report of current tinnitus (light shade) and current bothersome tinnitus (dark shade) among males and females (N = 172,621), 95% CI shown.

Table 2
Logistic regression predicting likelihood of reporting current tinnitus and bothersome tinnitus.

Variable	Current tinnitus		Bothersome tinnitus	
	Odds ratio (95% CI)	p	Odds ratio (95% CI)	p
Sex (male)	1.29 (1.26–1.33)	<0.001	0.83 (0.79–0.88)	<0.001
Age at recruitment[a]				
45–49	1.11 (1.04–1.19)	0.001	0.98 (0.85–1.13)	0.774
50–54	1.32 (1.24–1.40)	<0.001	1.05 (0.92–1.21)	0.448
55–59	1.53 (1.45–1.63)	<0.001	1.05 (0.92–1.19)	0.468
60–64	1.69 (1.60–1.79)	<0.001	1.07 (0.94–1.21)	0.287
65–69	1.84 (1.74–1.95)	<0.001	1.09 (0.96–1.24)	0.172
Deprivation (Townsend score)	1.24 (1.18–1.30)	<0.001	1.46 (1.32–1.62)	<0.001
Hearing difficulty (yes)	3.51 (3.38–3.63)	<0.001	2.09 (1.94–2.26)	<0.001
Hearing difficulty in background noise (yes)	1.28 (1.23–1.32)	<0.001	1.26 (1.16–1.36)	<0.001
Neuroticism	2.11 (2.00–2.22)	<0.001	4.11 (3.69–4.58)	<0.001

[a] 40–44 years is the reference category.

Results

Prevalence

Just over half of the sample were female (54.4%, n = 273,488). The mean age was 56 years old (S.D. = 8). Prevalence rates for 40–69 year olds, given in Fig. 1, are age-standardised in accordance with a reference population as reported in the UK 2011 census returns [27]. Overall, the prevalence of tinnitus was 16.2% and was higher for males than females (18.4% vs 14.1%). Prevalence of bothersome tinnitus was 3.8% overall and slightly higher for males than females (4.1% vs 3.5%). Estimates of age-specific prevalence rates of

Table 3
Association between individual aspects of neuroticism and tinnitus.

Neuroticism[a]	Current tinnitus		Bothersome tinnitus	
	Odds ratios (95% CI)[b]	P	Odds ratios (95% CI)[b]	P
Mood swings	1.10 (1.06–1.14)	<0.001	1.25 (1.16–1.35)	<0.001
Miserableness	1.14 (1.10–1.18)	<0.001	1.15 (1.07–1.24)	<0.001
Irritability	0.95 (0.92–0.99)	0.005	0.99 (0.93–1.06)	0.867
Sensitivity/hurt feelings	0.96 (0.93–0.99)	0.006	1.10 (1.03–1.18)	0.005
Fed up feelings	1.14 (1.10–1.18)	<0.001	1.11 (1.03–1.20)	0.005
Nervousness	1.05 (1.01–1.10)	0.013	0.96 (0.88–1.04)	0.307
Worrier/anxious	1.01 (0.98–1.04)	0.597	1.17 (1.09–1.25)	<0.001
Tense/highly strung	1.09 (1.05–1.13)	<0.001	1.12 (1.04–1.22)	0.003
Worry after embarrassment	1.08 (1.05–1.12)	<0.001	1.11 (1.04–1.19)	0.003
Suffer from nerves	1.08 (1.03–1.12)	<0.001	1.11 (1.03–1.20)	0.009
Loneliness	1.13 (1.09–1.17)	<0.001	1.28 (1.20–1.38)	<0.001
Guilty feelings	1.01 (0.98–1.05)	0.525	1.06 (0.99–1.13)	0.096
Risk taking	1.03 (1.00–1.06)	0.084	1.10 (1.03–1.17)	0.007

[a] Responding yes.
[b] Adjusted for age, sex, deprivation, and hearing difficulty.

current tinnitus and current bothersome tinnitus are given in Fig. 2. It is apparent that all rates of prevalence in this population are higher for males than for females, with a clearly increasing trend with age for both sexes. The proportion of participants reporting current tinnitus who state that their tinnitus is bothersome remains fairly steady for males of all ages at 22%, whereas for women this proportion increases from 23% to 26% with increasing age.

Neuroticism as a risk factor for severe tinnitus

The results of the binary logistic regression can be seen in Table 2. Odds ratios and 95% confidence intervals are shown for the predictors: sex, age, deprivation, hearing difficulty, hearing difficulty in background noise, and neuroticism.

The results confirm that males were more likely to experience tinnitus, but of all tinnitus sufferers, females were more likely to find their tinnitus bothersome. Increasing age was associated with tinnitus, but not in terms of tinnitus being bothersome. Deprivation was significantly associated with current tinnitus and bothersome tinnitus, with higher deprivation being associated with tinnitus/bothersome tinnitus. Hearing difficulties in background noise were associated with tinnitus and bothersome tinnitus, but self-reported hearing difficulties were more strongly associated. Neuroticism (measured on a continuous scale from 0 to 1) was found to be associated with tinnitus and bothersome tinnitus. The odds ratio for neuroticism describes the effect on prevalence of tinnitus of the highest levels of neuroticism relative to the lowest level of neuroticism. Comparing these two extremes of neuroticism accounted for more difference in the prevalence of tinnitus than any other factor with the exception of self-reported hearing difficulty. With regard to whether participants found their tinnitus to be bothersome, differences in neuroticism appeared to have a much stronger effect than any other factor. Following on from this, because neuroticism was measured on a continuous scale from 0 to 1, it was considered worthwhile examining the individual aspects of neuroticism, to see if any particular items were associated with tinnitus, more so than others. Table 3 shows the adjusted odds ratios (controlling for age, sex, deprivation and hearing difficulty) for the individual neuroticism items as predictors for tinnitus.

When the individual items of neuroticism were examined, all but 'worrier/anxious', 'guilty feelings', and 'risk taking' were significantly associated with current tinnitus in the multivariate adjusted model. However, of these three items, only one is not significant of having bothersome tinnitus ('guilty feelings'). All other items, apart from two ('irritability', and 'nervousness') were significantly associated with bothersome tinnitus. The item with the greatest association with bothersome tinnitus was 'loneliness', followed by 'mood swings', 'worrier/anxious', and 'miserableness'.

Discussion

This study reports the prevalence of tinnitus in a large population sample, while further exploring the link between tinnitus severity and neuroticism (previously only examined in clinical studies). After controlling for age, sex, hearing difficulty and deprivation, this study found that neuroticism was associated with tinnitus and bothersome tinnitus. The effects were stronger for bothersome tinnitus. As neuroticism is a stable personality trait [28] it is unlikely to develop as a result of experiencing tinnitus. It is more likely that those who are more neurotic and experience tinnitus are more likely to perceive the tinnitus as being bothersome, compared to those who are less neurotic. These findings do suggest that tinnitus patients with higher levels of neuroticism may be more prone to distress and consequently more severe tinnitus.

Loneliness was the most significant association with bothersome tinnitus which supports previous research showing that tinnitus sufferers are likely to experience loneliness [29], possibly as a result of withdrawing from social interactions [9] and thereby increasing feelings of isolation and loneliness. Tyler and Baker [30] found that over a third (36.1%) of tinnitus patients reported emotional problems such as despair, frustration and depression, while nearly a fifth (16.6%) reported insecurity, fear and worry. Furthermore, clinical studies have also shown higher rates of anxiety and depression among tinnitus patients compared with those without tinnitus [31], which supports the finding that 'mood swings', 'worrier/anxious' and 'miserableness' were significant associations of bothersome tinnitus in the current study.

The present study further expands on our earlier work [5] by providing a more detailed breakdown of tinnitus prevalence according to age and sex. The prevalence of 16% overall, is slightly higher than the National Study of Hearing [2] which found that the prevalence of tinnitus was around 13%, (for adults aged 40 to 70 years) and no significant differences between males and females were noted. Other epidemiological studies, the Blue Mountains Hearing Study [32] and the Beaver Dam study [4], reported prevalence rates of tinnitus of 30% and 10.6% respectively, although the former included past tinnitus as well as current tinnitus. The Beaver Dam study also found that tinnitus was higher for males than for females (11.9% vs 9.4%), and noted increasing trends in prevalence by age group for men, women and both sexes, consistent with the pattern found in the present study.

In the present study, 3.8% of current tinnitus sufferers reported bothersome tinnitus. Even though males were more likely to report tinnitus, females were more likely to be bothered by their tinnitus. This accords with previous research showing that female sex is a risk factor for bothersome tinnitus [33,34]. The under-reporting of bothersome tinnitus in men may be partly explained by a tendency for men to deny or play down the severity of the symptoms of ill health [35].

Self-reported hearing difficulty was the strongest association with tinnitus. Previous research has shown that around 40% of 55–74 year olds with hearing difficulties also report tinnitus [36], and the majority of tinnitus patients have some degree of hearing loss [37]. No single theory explaining the cause of tinnitus is universally accepted, but one theory suggests that tinnitus may result from an increase of central gain (to compensate for deprived sensory inputs) which amplifies neural noise in order to maintain neural homeostasis [38]. It is likely that the severity of tinnitus is influenced by a complex interaction involving auditory, psychological and emotional networks [39,40]. It is interesting that neuroticism is a strong association with current tinnitus, albeit not as strong as hearing difficulty. Furthermore, of those who have tinnitus, neuroticism has a stronger effect on the perceived severity than hearing difficulty. One explanation could be that those who are more neurotic may think their tinnitus is indicative of a more serious condition and therefore find the tinnitus more bothersome. The finding that personality traits such as neuroticism can contribute to tinnitus awareness and distress is important when considering treatment approaches because personality traits are generally stable over time [41], although the absolute level of personality traits can change [42]. Thus it is possible that psychological interventions may be beneficial for tinnitus patients although the effects may be gradual [11].

The primary limitation of these analyses was that the UK Biobank test protocol did not include a validated tinnitus questionnaire. More detailed data on lateralization, pitch, and loudness of the tinnitus may be informative as previous research suggested that the level of intrusiveness is moderated by the specific quality or type of tinnitus (e.g. fluctuating versus non-fluctuating) [43]. Furthermore, no information was available on the duration that the participant experienced tinnitus. It is possible that long-term tinnitus sufferers may develop successful coping strategies and are better able to manage their condition, whereas those who have had tinnitus for a relatively short duration may not have learned coping strategies and thus are more bothered by tinnitus [43]. Although such data would be desirable for better characterisation of tinnitus, a full tinnitus questionnaire would not have been practical to administer within the crowded UK Biobank assessment protocol.

Conclusion

Analysing data from a large population of UK adults, we have shown that the prevalence of tinnitus increases with age, and that a high proportion of sufferers report tinnitus as being moderately or severely bothersome, although age was not related to the perceived severity of tinnitus. Women were especially likely to report bothersome tinnitus. This study confirms previous research suggesting that hearing loss is a strong predictor of tinnitus, but we have also shown that personality factors identified as neuroticism are associated with the experience of tinnitus, particularly in those reporting that their tinnitus is severe. Although causality cannot be determined, the study supports an interpretation that otherwise stable personality factors and mood influence the ways in which tinnitus is experienced and managed. From a clinical management point of view, clinicians would benefit from an

understanding that tinnitus severity is a very complex interaction involving auditory, psychological and emotional networks. Long-term psychological approaches may be effective in helping tinnitus sufferers.

Conflict of interest

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

We confirm that the manuscript has been read and approved by all named authors and that there are no other persons who satisfied the criteria for authorship but are not listed. We further confirm that the order of authors listed in the manuscript has been approved by all of us.

We confirm that we have given due consideration to the protection of intellectual property associated with this work and that there are no impediments to publication, including the timing of publication, with respect to intellectual property. In so doing we confirm that we have followed the regulations of our institutions concerning intellectual property.

We understand that the corresponding author is the sole contact for the Editorial process (including Editorial Manager and direct communications with the office). She is responsible for communicating with the other authors about progress, submissions of revisions and final approval of proofs. We confirm that we have provided a current, correct email address which is accessible by the corresponding author and which has been configured to accept email from abby.mccormack@nottingham.ac.uk.

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