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1 **The link between health complaints and wind turbines: support for the**
2 **nocebo expectations hypothesis**

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16 **Abstract**

17 The worldwide expansion of wind energy has met with opposition based on concerns that the
18 infrasound generated by wind turbines causes health problems in nearby residents. In this paper we
19 argue that health complaints are more likely to be explained by the nocebo response, whereby
20 adverse effects are generated by negative expectations. When individuals expect a feature of their
21 environment or medical treatment to produce illness or symptoms then this may start a process where
22 the individual looks for symptoms or signs of illness to confirm these negative expectations. As
23 physical symptoms are common in healthy people, there is considerable scope for people to match
24 symptoms with their negative expectations. To support this hypothesis we draw on evidence from
25 experimental studies that show that, during exposure to wind farm sound, expectations about
26 infrasound can influence symptoms and mood in both positive and negative directions, depending on
27 how expectations are framed. We also consider epidemiological work showing that health
28 complaints have primarily been located in areas that have received the most negative publicity about
29 the harmful effects of turbines. The social aspect of symptom complaints in a community is also
30 discussed as an important process in increasing symptom reports. Media stories, publicity or social
31 discourse about the reported health effects of wind turbines are likely to trigger reports of similar
32 symptoms, regardless of exposure. Finally, we present evidence to show that the same pattern of
33 health complaints following negative information about wind turbines has also been found in other
34 types of environmental concerns and scares.

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Introduction

In recent years challenges to new wind farm developments have been mounted on the basis that exposure to sound, and particularly infrasound, generated by wind turbines poses a health risk (1). Unfortunately, addressing concerns about health effects has been complicated by a lack of clarity about what might be causing reported symptomatic experiences. Perceived adverse health effects said to be experienced by people living near wind turbines include symptoms such as sleep disturbance, headache, earache, tinnitus, nausea, dizziness, heart palpitations, vibrations within the body, aching joints, blurred vision, upset stomach, and short term memory problems (2). In this article we explore factors which might explain symptom reporting attributed to wind farms and put forward the case for the nocebo expectations hypothesis; that symptom reporting can be explained by negative expectations, rather than any pathophysiological link between symptoms and wind farm sound. Research consistently indicates the expectation of adverse health effects can itself produce negative health outcomes, which is a phenomenon known as the nocebo effect (3). Negative expectations generating nocebo responses have been shown to have a powerful influence on health outcomes in clinical populations (4), and reported symptom experiences in community samples (5).

The link between wind farm sound and health complaints

When investigating the cause of symptom reporting attributed to any purported environmental hazard it is axiomatic that the existence of a biological basis for symptomatic experiences is thoroughly explored, so that an organic cause of symptoms is not erroneously discounted (6). Given that symptom reporting has been attributed to wind farm sound (2), it is necessary to consider the evidence for any direct relationship between exposure to such sound and symptom reporting. Given reductions in mechanical noise, as a result of refinements to wind turbine design, aerodynamic sound is now the dominant source of noise from modern wind farms (7). This aerodynamic noise, which is generated as a result of the flow of air past the turbine blades, is present across a range of frequencies, from the audible to sub-audible infrasound (8).

At this time studies have not found a direct causal link between living in the vicinity of wind farms, audible wind farm sound exposure and physiological health effects (1). Audible sound levels, assessed at the nearest residence, have been consistently found to fall within accepted health and safety limits for ambient background noise, and evidence does not support a direct link between such sound exposure and symptom reporting (9). To elaborate further, although a small proportion of people report being annoyed by wind farm sound, particularly by detectable fluctuations of sound in the mid-frequency range (500 to 1000Hz), the evidence does not indicate that exposure to such sound is directly causing adverse physiological effects in those living in the vicinity of wind farms (8). In addition, despite concerns that audible low frequency noise (20-200Hz) produced by wind turbines is triggering symptomatic experiences, this is not suggested by the scientific evidence (10).

Further, the evidence does not substantiate conjecture that exposure to sub-audible wind farm generated infrasound (sound below 20Hz) is responsible for health complaints. It is important to note that exposure to infrasound is an everyday experience. Infrasound is constantly present in the external environment, caused by phenomena such as weather variations, air turbulence, ocean waves, traffic and other machinery (11). Notably the body and vestibular systems have evolved to prevent disturbance from infrasound generated from internal processes, such as respiration and heart rate, which is produced at higher levels than infrasound generated by wind farms (12). While sound in the infrasonic range may become audible at sufficiently high pressure levels, infrasound produced by

82 wind turbines is below the threshold of human perception (11,13), and research does not support the
83 existence of adverse health effects of exposure to infrasound at sub-audible levels (14). Importantly,
84 recent investigation found the contribution of wind turbines to measured infrasound levels at
85 residential locations near wind farms was insignificant in comparison with the background level of
86 infrasound in the environment (15). Given consistent evidence that infrasound produced by wind
87 turbines does not exceed typical levels of infrasound found in everyday urban or rural environments,
88 health impacts of infrasound produced by wind turbines are not indicated (12, 16).

89

90 As the evidence does not support a direct link between audible or sub-audible sound
91 generated by wind turbines and reported symptomatic experiences by people living in the vicinity of
92 wind farms, it is apparent that factors beyond exposure to wind turbine sound are implicated in
93 symptom reporting.

94

95

96 **Perception of health risk and expectations**

97 There is accruing evidence that some people facing the prospect of a new wind farm near their
98 residence, or currently living within the vicinity of a wind farm, are genuinely fearful of the potential
99 health effects of operating wind turbines (1). This has relevance as evidence shows a relationship
100 between assessment of health risk and symptom reporting, which does not depend upon the whether a
101 health risk is genuine (17). This is seen in community examples where there has been an error about
102 exposure to a perceived toxic agent. In one such case symptom complaints attributed to exposure to
103 electro-magnetic radiation from a mobile phone tower occurred when the tower itself was not yet
104 active (18).

105 In fact, extreme increases in symptom reports, in instances of both genuine and perceived
106 toxic exposure to harmful agents, have been repeatedly shown in community settings (19) with
107 strength of environmental concern being a critical factor in predicting the occurrence of symptom
108 complaints (20). This was highlighted in a study in which participants, from ten villages in Germany,
109 had their sleep monitored over 12 nights during which they exposed to sham signals and
110 electromagnetic field signals from an experimental base station (21). There was no evidence for
111 short-term physiological effects of electromagnetic fields emitted by mobile phone base stations on
112 sleep quality, but findings demonstrated a negative influence on objective and subjective sleep
113 quality in subjects who were concerned that proximity to mobile phone base stations might
114 negatively affect health.

115 Evidence shows that health-related worries about perceived environmental hazards inform
116 negative expectations, which in turn draw attention to body processes and shape how individuals
117 decipher symptoms (e.g. 22). Negative expectations translate into symptomatic experiences, because
118 focused attention to the body has the tendency to draw awareness to common sensations that might
119 otherwise go unnoticed (23). Further, increased anxiety itself causes a rise in physiological activity
120 giving rise to symptoms such as dry mouth and rapid heart-beat (23). Evidence suggests people may
121 misinterpret symptoms of hypervigilance and anxiety as a sign of illness, particularly if symptoms
122 experienced are consistent with concerns about health (24).

123 Recently, there has been a noticeable rise in the number of people expressing concern about
124 health effects presented by the sound generated by wind farms, and fears about health risk have
125 emerged as a key predictor of opposition to wind farm development (25, 26). Such fears are more
126 prominent in countries where wind farms are relative new-comers on the landscape, which aligns

127 with consistent evidence of associations between the introduction of new technologies, community
128 concern about related health risks, and symptom reporting (27, 28).

129 **A matter of expectation**

130 While the operation of modern commercial wind farms commenced more than 20 years ago in
131 several nations, widespread claims that exposure to wind farm sound produces adverse, often acute
132 and immediate, symptomatic experiences, are much more recent (29). This change is reflected in the
133 shifting focus of community opposition to wind farms over time. Historically community opposition
134 to wind farms has centered on concerns about depreciation of property values, problems with
135 aesthetic integration on the landscape, and apprehension about the intrusiveness of noise produced by
136 wind turbines (30, 31). However, in recent years concern about the adverse health risk of exposure to
137 wind turbine sound has repeatedly emerged as a new focal point of community opposition to wind
138 farms, indicating a change in the way in which wind farms are now perceived (1).

139 Such concern, as well as a dramatic amplification of symptom reports (29), coincided with the
140 promotion in 2009 of the self-published book *Wind Turbine Syndrome-A natural experiment* (2), also
141 available and summarized on the internet. The book portrays infrasound produced by wind turbines
142 as a threat to health, and explicitly sets out the physical symptoms and health effects to be expected
143 by those living in proximity to a wind farm. Given that wind farms simultaneously generate
144 infrasound and audible sound, negative health information about infrasound is likely to influence the
145 perception of wind farm sound in its entirety. Further, although the narrative of the book emphasizes
146 the perniciousness of the sub-audible components of wind farm sound, it also sets out health concerns
147 about audible sound, particularly low frequency audible wind farm sound. Thus health concerns
148 triggered by the type of information contained in the book are likely to inform negative expectations
149 extending to both the audible and sub-audible components of wind farm sound exposure.

150 The concurrence of the publication of *Wind Turbine Syndrome-A natural experiment* and an
151 increase in symptom reporting attributed to wind farms (29), supports the argument that symptoms
152 are more likely due to negative expectations triggered by health information, rather than being caused
153 by pathogenic exposure to wind farm sound. This is exemplified in a study assessing historical
154 complaints, in relation to 51 Australian wind farms operating from 1993 to 2012 (29). Findings
155 illustrated that, prior to 2009, health and noise complaints were rare, despite small and large wind
156 farms having operated in Australia for many years. The study found that 90% of complainants made
157 their first complaint post 2009, after anti wind farm campaigners disseminated information about the
158 purported health effects of wind farms, as purported in *Wind Turbine Syndrome-A natural*
159 *experiment*. Further, the majority of complaints were confined to the 6 wind farms targeted by anti-
160 wind farm campaigners, indicating complainants had accessed negative health information (29).

161 Additional support for the involvement of negative expectations in relation to the increase in
162 symptom reporting seen since 2009, is also provided by recent field research demonstrating that
163 people higher in negative-oriented personality traits are more likely to report higher levels of
164 perceived noise (unrelated to actual noise levels) and more non-specific physical symptoms around
165 wind farms (32). Experimental research demonstrates that individuals with higher levels of negative
166 affect are more susceptible to the influence of expectations about health effects created by suggestion
167 and more likely to report expectation consistent symptoms (33).

168 The ascription of a disease label “Wind Turbine Syndrome” is a powerful way to create health
169 concerns and set expectations. Where individuals adopt disease labels to reflect symptomatic
170 experiences attributed to environmental causes they are more likely to be concerned about the

171 environmental health risk posed, and less likely to be reassured by scientific investigation if it
172 indicates there is no link between the perceived environmental hazard and symptoms (34). The use of
173 an illness label “Wind Turbine Syndrome” (2), along with a widely publicized and explicated list of
174 syndrome symptoms, not only creates the impression that there is a risk that those living near wind
175 turbines will develop a recognized medical condition, which is likely to generate concern, but also
176 creates a comprehensive idea of expected symptoms. Simply reading about symptoms of an illness
177 can prompt self-detection of disease specific symptoms, a phenomenon seen in medical student
178 disease. Here medical students, in the course of learning about an illness, start to experience
179 symptoms indicative of the disease studied (35, 36). The process of learning about an illness appears
180 to generate a cognitive representation of the illness, or mental schema, which guides the way in
181 which internal sensory information is attended to, so that symptoms or sensations that align with the
182 schema are noticed and reported. Symptoms that are inconsistent with the schematic representation
183 of the relevant illness are likely to be overlooked or discounted (37).

184 Thus, negative expectations operate as a blue print or heuristic for the type of symptoms
185 attended to and reported. In a clinical research setting a substantial number of patients, randomized to
186 the placebo arms of placebo controlled drug trials, experience and report symptoms reflective of the
187 side effects of active treatment (e.g. 38). In an experimental study participants inhaling a benign
188 substance, described to them as a “suspected environmental toxin” known to cause headache, nausea,
189 itchy skin, and drowsiness, reported increases in symptoms, particularly in relation to symptoms they
190 had been told they might expect to experience (39).

191 Therefore, merely being aware of the type of symptoms that have been attributed to wind
192 turbines is likely to trigger an expectancy directed cognitive body search, whereby the body is
193 selectively monitored for sensations and symptoms consistent with ideas about the physiological
194 effects of exposure to wind farms. During this process individuals will be inclined to notice common
195 symptoms which align with expectations and to interpret ambiguous sensations in accordance with
196 such beliefs (40). This was demonstrated in a double blind provocation study, where participants who
197 watched material from the internet suggesting that infrasound produced by wind farms generated
198 symptoms, reported significant increases from pre-exposure assessment, in the number and intensity
199 of symptoms experienced during exposure to both infrasound and sham infrasound (41). Importantly,
200 elevations in symptom reporting, during exposure periods, coincided with information about the
201 precise symptom profile, said to be related to infrasound exposure. During both exposure periods
202 participants reported more symptoms characterized as typical symptoms of infrasound exposure, than
203 symptoms differentiated as atypical symptoms of exposure to infrasound. Results suggested that
204 expectations formed by accessing negative health information about wind farm sound could be
205 providing a pathway for symptom reporting in community settings.

206

207 **Expectations and misattribution**

208 It is important to note that many of the symptoms said to arise from exposure to wind farms, such as
209 headache, fatigue, concentration difficulties, insomnia, gastrointestinal problems, and
210 musculoskeletal pain, are commonly experienced by healthy individuals (23). If people are worried
211 about the health effects of an environmental agent and form symptom expectations they are also more
212 likely to notice and misattribute their current symptomatic experience to that environmental agent.
213 This can occur even when symptoms are more consistent with every day experiences and may, under
214 different circumstances, be explained as just part and parcel of normal life (42). Given that the

215 symptoms said to be associated with wind turbines, such as tinnitus, sleep problems and headache,
216 are extremely common in the general community (43, 44, 45), many hearing about a putative
217 connection with wind turbine exposure may be persuaded that health problems they experience can
218 be attributed to this exposure. An analysis of symptom reporting by people living in the vicinity of
219 wind turbines in Canada indicated that the prevalence of reported symptoms was consistent with
220 symptom prevalence in the general population, suggesting that people are likely to be misattributing
221 their ordinary experience of common symptoms to wind turbines, rather than becoming more
222 symptomatic (46).

223 Many of the symptoms associated with wind turbines, such as dizziness and heart palpitations, are
224 also stress related concomitants of autonomic arousal associated with anxiety and distress (47).
225 Further, evidence indicates a bidirectional relationship between anxiety and insomnia (48), so that
226 people who are anxious about the health effects of wind farms may experience sleep difficulties
227 because of this anxiety, and sleep difficulties may, in turn, exacerbate the experience of physiological
228 symptoms of anxiety. These symptoms may then be misattributed to wind farm sound, if there is an
229 expectation that wind farm sound poses a health risk. Evidence indicates that fears associated with
230 beliefs, that innocuous stimuli have dangerous health consequences, engenders associations between
231 such stimuli and stress-related symptoms, so that exposure to such stimuli may become a cue for
232 symptom expression (49). Therefore detecting wind turbine noise may facilitate symptom expression
233 because, for those concerned about the health effects of wind turbines, hearing the noise signifies
234 exposure to a perceived environmental hazard. Such an interpretation would provoke anxiety,
235 resulting in heightened physiological arousal and stress related symptoms.

236 Interestingly, evidence indicates that individuals are much less likely to be annoyed by wind
237 turbine noise if they unable to see wind turbines from their dwelling, even if the sound itself is at a
238 relatively high level (50). Where individuals are worried about the health effects of wind turbines, the
239 visibility of wind turbines from a residence is likely to be a particularly concrete reminder of their
240 concern, thus perpetuating anxiety and related physiological arousal. Therefore both audibility of
241 sound and visibility of a wind turbine may act as situational cues for symptom expression, triggering
242 stress related symptoms, thereby reinforcing health concerns (49).

243 Concerns about a perceived environmental hazard and corresponding negative expectations
244 can also lead to misattribution of current illness, so that illnesses are viewed as a reaction to
245 environmental exposure rather than the result of aging or other disease processes. Over the past 50
246 years an increasing concern about the environment appears to have led to heightened sensitivities to
247 environmental change, which have also impacted on the way people perceive illness and disease (17).
248 Individuals are more inclined than previous generations to view ill health as a by-product of a toxic
249 environment, and to worry about the enduring health effects of such environmental changes. The
250 propensity to look for external environmental causes for ill health is illustrated by research indicating
251 a tendency among cancer survivors of the ten most common cancers to believe environmental factors
252 play a much more significant role in carcinogenesis than scientific evidence warrants (51). Therefore,
253 an environmental change, particularly involving the use of an emerging technology, is likely to be
254 regarded with suspicion and trigger expectations impacting on the way individuals interpret their own
255 symptomatic experiences. Diseases such as diabetes, skin cancer and stroke, with much more
256 established etiology, have instead been ascribed to wind farms indicating a process of misattribution
257 (52).

258 **Media health warnings and expectations**

259 A recent study has demonstrated that the upsurge in noise and health complaints seen in Australia
260 since 2009 has arisen primarily in localities where there has been targeted publicity about the alleged
261 harmful impacts of wind farms, indicating that it is the communication and receipt of information
262 about purported risk which is driving symptom reporting (29). Two entire Australian states with wind
263 farms, but no history of anti-windfarm advocacy, had no reported instances of health or noise
264 complaints. Findings are consistent with research indicating that media warnings about potential
265 harm from environmental factors may create health concerns prompting symptom reporting, even in
266 the absence of objective health risk (49). Merely watching a television report about the supposed
267 adverse effects of Wifi has been shown to elevate concern about the health effects of electromagnetic
268 fields and increase the likelihood of experiencing symptoms following exposure to a sham Wifi
269 signal (53).

270 In the case of wind farms recent media stories have been shown to contain fright factors likely
271 to trigger fear, concern and anxiety about the health risk posed by wind turbines (54). Assertions
272 about the adverse impacts of wind farm sound have been widely disseminated by the media,
273 particularly via anti-wind farm internet websites, and have led to misconceptions about infrasound
274 generated by wind turbines and a conviction in some that wind farms cause a myriad of health
275 complaints (12) Conjecture about the adverse health effects of wind farms is a consistent theme in
276 public discourse about wind turbines found in media reports embodied in headlines such as “*Wind*
277 *turbines cause heart problems, headaches and nausea...*” (55); “*Coming to a house, farm, or school*
278 *near you? Wind Turbine Syndrome...*” (56); and television news items such as “*Wind Turbines cause*
279 *health problems, residents say*” (57). Further, misleading reports about the impact of living in the
280 vicinity of wind farms, such as inaccurate accounts of home abandonment and emotive references to
281 wind farm refugees, is also liable to create disquiet (58).

282 It has been confirmed from a recent double blind provocation study that the kind of
283 information disseminated in the case of wind farms elevates health concerns and creates
284 corresponding negative expectations which result in symptomatic experiences. Participants viewing a
285 DVD, containing extracts from the internet outlining the alleged health effects of infrasound
286 generated by wind turbines, reported increased concern about the health effects of sound produced by
287 wind farms, which was associated with amplification of symptom reporting during both genuine and
288 sham exposure to infrasound (41). Results showed negative expectations may be created by media
289 portrayal of alleged health risks posed by the sound created by wind turbines, which could explain
290 symptom reporting around wind farms.

291 The profound effect of the media narrative on the experience of wind farm sound was
292 confirmed in a follow up study in which subjective health was influenced in either positive or
293 negative directions, depending on how the sound was portrayed. In keeping with previous findings
294 participants with negative expectations, formed from media warnings about infrasound, reported
295 increased symptoms and deterioration in mood during simultaneous exposure to infrasound and
296 audible wind-farm sound (59). In contrast, participants delivered positive expectations derived from
297 information extracted from the internet about the alleged therapeutic effects of infrasound,
298 experienced an improvement in symptomatic experiences and mood. Findings highlighted the
299 malleability of symptomatic responses and the power of information disseminated through the media
300 to create expectations which determine how wind farm sound is experienced. It was particularly
301 telling that positive expectations about infrasound triggered a placebo response in participants
302 listening to audible wind farm sound, while being exposed to infrasound. This highlights that
303 exposure to audible wind farm sound can be a pleasurable experience, if the narrative about the sound
304 is framed positively. The study provided promising indications that if information disseminated about

305 wind farm sound was framed in more neutral or benign ways than reported symptoms or negative
306 health effects could be ameliorated.

307 **Expectations created by social interactions**

308 It is important to bear in mind that the experience of symptoms attributed to wind turbines occurs in
309 community settings, and in a social context where there are a range of opinions, concerns and
310 pressure group activity about the construction of wind farms and about possible health risks
311 associated with them (1, 30). Evidence has shown residents' fears about the health effects of wind
312 turbines are increasingly becoming the focal point of community public consultation meetings,
313 formed as part of resource consent and environmental assessment processes that relate to wind farms
314 (1). Expectations can be learned from such social interactions (60), and may also be created and
315 reinforced by observation and modeling (61). The potential effect of observation on symptom
316 experience is indicated in an experimental study demonstrating that one third of healthy controls,
317 when exposed to images of other people in pain, reported pain in the same location as the observed
318 pain (62). Further, in an experimental study in which participants inhaled an inert substance
319 portrayed as a possible environmental toxin, seeing someone exhibiting expected symptoms
320 increased participant reports of those specific symptoms, illustrating the phenomenon of contagion
321 by observation, seen in mass psychogenic illness (63).

322 There are various avenues for observation and modeling of symptoms within communities
323 where wind farms are established. Neighbors and members of the wider community may be
324 exhibiting and talking about their symptomatic experiences, which they attribute to wind farms.
325 Television reports about the health effects of wind turbines have also incorporated interviews with
326 symptomatic people describing their experiences in detail providing another medium by which
327 symptoms may be modeled (e.g. 57). These interviews can usually be accessed on the internet, so
328 people researching the effects of wind farms can find these interviews with ease.

329 There are also indications that, where symptoms are attributed to wind turbines, health
330 problems are reported by everyone within the affected household, including children (e.g. 2). This
331 suggests that familial modeling may play a role in symptom reporting, particularly in relation to
332 affected children. Parental pain and symptom modeling is implicated in the development of
333 unexplained pain and somatic complaints in pediatric populations (64, 65).

334 **Annoyance and expectations**

335 It seems apparent that elevated concern about the health effects of living in the vicinity of wind
336 farms, and the related formation of negative expectations, is exacerbating reported annoyance with
337 wind farm sound. There is much variability between studies in relation to the extent of reported wind
338 farm noise annoyance indicating that contextual matters are influencing annoyance reactions. Related
339 studies undertaken in Sweden and the Netherlands have indicated that approximately 10-20% of
340 residents living in proximity to wind farms find wind turbine noise annoying, and 6% of residents
341 find wind turbine noise very annoying, at 35-40dB exposure (7, 50, 66). However, another study
342 conducted in New Zealand reported that 59% of respondents living within 2km of a wind farm
343 experienced noise annoyance (67). The New Zealand study was undertaken at a time when there had
344 been adverse publicity about expected noise and health effects of living in the vicinity of the wind
345 farm in question, including a story which aired on free to air television (68). Understanding the
346 factors that contribute to annoyance is important because, although noise annoyance is not in itself a
347 disease or health state, annoyance is related to distress, which can lead to the experience of stress
348 related symptoms (8, 69).

349 Being annoyed by noise is related to a range of personal and situational variables, beyond the
350 acoustic characteristics of noise (70, 71), and psychosocial factors account for more variation in
351 individual annoyance, than objective measures of noise level (72). Experimental work indicates that
352 not being aware of the source of sound is associated with reduced noise annoyance in people exposed
353 to wind farm sound, further confirming that the context of sound exposure has more relevance for
354 annoyance assessment, than the acoustic properties of wind farm sound (73). Importantly, a strong
355 relationship has been found between concern about the negative health effects of noise and noise
356 annoyance (74). The evidence also shows that wind turbine noise annoyance is more strongly related
357 to other negative attitudes about wind turbines, particularly the visual impact of wind turbines on the
358 land scape, than to sound level (7, 50). Thus, rhetoric that creates health concerns about wind turbine
359 sound, and presents a negative view of wind farms, is likely to influence not just symptom reporting
360 and distress, but reported noise annoyance.

361 There is compelling evidence that creating a positive context for the experience of wind farm
362 sound, has a correspondingly positive impact on reported annoyance. A field study conducted in The
363 Netherlands indicated that respondents who benefited economically from wind turbines, by either full
364 or partial turbine ownership or by receipt of other economic benefits, such as a yearly income, were
365 less annoyed by wind turbine noise than other respondents, despite exposure to higher sound levels
366 (50). Notably, there were no differences in either likelihood to notice sound, or subjective noise
367 sensitivity between those who did or did not derive economic benefit. However, there were
368 attitudinal differences. Respondents who benefited economically were less negative both about wind
369 turbines in general, and about the visual impact of wind turbines on the landscape. Results suggest
370 that experiencing wind farm sound in a positive context decreases the likelihood of forming negative
371 views of wind turbines associated with annoyance. This provides promising indications that changing
372 the narrative around wind farms, so that worried residents become less concerned about their
373 proximity to wind farms and adopt more positive expectations and attitudes, might not only alleviate
374 symptom reporting, but reduce noise annoyance.

375 **Patterns of health complaints seen in other instances of perceived toxic exposure**

376 It is relevant to note that symptom reporting, in response to perceived exposure to a toxic agent when
377 no plausible health threat is posed, has been seen throughout history (17). Francis Bacon (1561-1626)
378 noted “*infections...if you fear them, you call then upon you*” (75). In one pertinent example a
379 dramatic elevation in reported symptoms in a community setting in Memphis followed a health scare
380 fuelled by media messages that the town was located in close proximity to an old toxic waste dump
381 (76). While a comprehensive examination of soil toxicity revealed no hazard was presented, health
382 fears did not abate until it became apparent authorities were mistaken as to the locality of the dump,
383 which had actually been situated many miles from the town (19). Although symptom reporting then
384 subsided, some residents continued to insist they experienced symptoms from the phantom dump
385 site.

386 Further, the advent of new technologies has consistently been associated with the
387 development of subjective illness complaints, involving a constellation of symptoms, akin to those
388 attributed to wind farms (28, 77). For instance, in 1889, following the increasing use of the
389 telephone, The British Medical Journal cautioned about the emergence of “*telephone tinnitus*” in
390 respect of which “*the patients suffered from nervous excitability, with buzzing noises in the ear,*
391 *giddiness, and neuralgic pains*” (78). With striking parallels, almost a century later, the experience of
392 a range of non-specific symptoms such as headache, fatigue, tinnitus, and concentration problems
393 have been attributed by some individuals to exposure to electromagnetic fields via mobile telephones

394 (79). This occurs despite the fact there is no generally accepted causal bio-electromagnetic
395 mechanism, by which such symptoms would be triggered (80). Given that provocation studies have
396 repeatedly shown that sham electromagnetic exposure is sufficient to activate symptoms in
397 individuals who believe they are sensitive to electromagnetic fields, the evidence suggests the
398 involvement of nocebo responses; that it is anxiety about exposure and related negative expectations
399 which are triggering symptomatic experiences (53).

400 **In conclusion**

401 An analysis of the evidence concerning symptom reporting attributed to sound produced by wind
402 farms supports the nocebo expectation hypothesis; that health complaints can be explained by the
403 influence of negative expectations. It is apparent that symptom reporting coincided with an increase
404 in health concern about wind farms promoted by a book and internet sites focused on highlighting the
405 purported health dangers posed by sound, particularly infrasound produced by wind turbines. Such
406 information, which has been further circulated through social discourse and media reporting, is liable
407 to trigger health concerns and related symptoms of anxiety, while also creating a blueprint for what
408 symptoms can be expected - expectations which, in turn, are likely to guide the type of symptoms
409 noticed and reported. This is supported by epidemiological evidence that increased symptom
410 reporting has occurred in locations where there has been targeted dissemination of negative health
411 information about wind farms, indicating that exposure to such information is shaping symptomatic
412 experiences. Experimental work also suggests that it is expectation rather than wind farm sound
413 exposure that is responsible for symptom complaints.

414 Symptom reporting is also consistent with patterns of health complaints seen in other
415 environmental health scares involving benign exposure, and which often follow the introduction of
416 new technologies. Importantly, indications that negative expectations are implicated in symptomatic
417 experiences ascribed to wind farms aligns with evidence that instances of symptom reporting
418 attributed to perceived environmental hazards and exposure to modern technologies have been
419 triggered by nocebo responses.

420 Understanding the underlying cause of health concerns and symptom complaints which have
421 arisen in communities in which wind farms have been proposed and developed is critical if such
422 concerns are to be addressed, and symptom reporting alleviated. Given indications of the
423 determinative role of negative expectations in creating and maintaining symptom reporting,
424 successful strategies to address health complaints are likely to involve changing the narrative about
425 wind farms, to create more positive expectations.

426

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428 manuscript

429 **Conflict of Interest Statement**

430 There are no commercial, financial, or other competing factors, which could be viewed as
431 constituting a conflict of interest influencing the article's content. The authors have not received any
432 funding for the article, which is substantially based on the authors' own epidemiological and
433 experimental research. The authors are independent, academic professionals working in the area of
434 psychological medicine, public health, and medicine, with a shared expertise about psychological
435 factors which impact on symptom reporting in response to perceived environmental risks. To this end
436 SC has previously provided expert advice on psychogenic aspects of complaints about wind farm to

437 lawyers acting for Infigen. Further, KP has previously provided expert evidence for the NZ
 438 Environment Court and the Canadian Environment Review Tribunal on psychological aspects of
 439 complaints about wind farm developments.

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