Annex B

Excerpt from Health Report on Arnicle Farm, Glenbarr, Tarbert, Argyll, Scotland, UK (IARO Document IARO24-C1, pp 59-71)

(Annexed to IARO Report No. IARO25-1)

The full Health Report is available at: IARO.org.nz

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INTERNATIONAL ACOUSTICS RESEARCH ORGANIZATION

Health Report on Arnicle Farm, Glenbarr, Tarbert, Argyll, Scotland

Document IARO24-C1

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International Acoustics Research Organization

IARO is an international group of researchers with a mission to investigate acoustical environments, especially with respect to features that affect humans and animals, and to publish the results. IARO holds the ethics approval for the CSI-ACHE, the Citizen Science Initiative into Acoustical Characterisation of Human Environments, the results of which are publicly disseminated.

Contacts:

IARO, 37 Weston Ave, Palmerston North, 4414, New Zealand

Tel: +64 21 033 6528

Email: HuubBakker@smart-technologies.co.nz

This Health Report accompanies the December 2023 IARO Report No. IARO23-C1—High-Resolution Infrasonic and Low-Frequency Sound Recordings conducted at Arnicle Farm, Glenbarr, Argyll, Scotland in 2022 and 2023.

IARO does not use generative language artificial intelligence tools to construct their reports.

Authors of this Report *(alphabetical)*

Mariana Alves-Pereira, Ph.D., Lusófona University, Lisbon, Portugal

Huub Bakker, Ph.D., IARO, Palmerston North, New Zealand

Susan Crosthwaite, Citizens' Initiative UK, Scotland

Rachel Summers, IARO, Palmerston North, New Zealand

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min averages), and the concomitant ill-chosen health endpoints (such as annoyance, salivary cortisol levels, hearing loss) as measures of health effects.

9 **Research on long-term exposure to wind turbine noise would provide a better understanding of the causal associations between wind turbine noise exposure and certain adverse health effects.**
In theory, this would be true, but not if the same unscientific assumptions are maintained, if the same incomplete assessment of dose is continued, and if the same non-primary and subjective adverse health effects are chosen for investigation.

10 **Technological development is unlikely to resolve, in the short term, the current issues related to perceived adverse health effects of wind turbine noise.**
"Perceived"? [296] *(see Paragraphs 45, 57 and 58).*

11 **Impact assessments and community engagement provide communities with greater knowledge and control over wind energy projects and therefore help limit annoyance.**
Annoyance is here clearly implied to be a result of psychosocial factors, and it appears to be the only health endpoint that merits attention.

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212. The work produced by the 2015 Expert Panel on Wind Turbine Noise and Health of the Council of Canadian Academies, and the conclusions at which it arrives, are only marginally relevant to the matter at hand.

6. Other studies cited in the Letter

The dearth of knowledge on the matter at hand continues to be demonstrated by the signatory of the Letter:

> *"In addition to the impacts of audible noise itself, the contribution from low frequency infrasound to health effects has also been postulated although findings from recent studies have suggested that this is not supported.* [297,298] *Similarly, Turunen et al. whilst unable to assess a causal relationship due to the*

296 See Appendix 2—Physics of Acoustics: VII. Why is a psychosomatic (nocebo) origin attributed to the effects of infrasound and low frequency noise?

297 Footnote 5 of the Letter. Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, *et al*. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. *Environmental Health Perspectives*, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/ [website added]

298 Footnote 6 of the Letter. Maijala PP, Kurki I, Vainio L, Pakarinen S, Kuuramo C, *et al.* (2021) Annoyance, perception, and physiological effects of wind turbine infrasound. *Journal of the Acoustical Society of America*, 149(4): 2238-2248. https://pubmed.ncbi.nlm.nih.gov/33940893/ [website added]

cross-sectional nature of the study, suggested that interpretations of symptoms are affected by other factors in addition to the actual exposure.[299]"

213. For educational purposes,[300] a brief review is conducted of the three studies cited above by the NHS-Highland medical representative.

I. Immediate effects of infrasound exposure

214. In the 2023 study by Marshall *et al.*,[301, 302] the objective is stated as follows:

> *We aimed to test the effects of 72 h of infrasound (1.6–20 Hz at a sound level of ~ 90 dB pk re 20 microPa,* [303, 304] *simulating a wind turbine infrasound signature) exposure on human physiology, particularly sleep.*

215. In Medical Sciences, this type of study purports to investigate the immediate effects of exposure, as opposed to long-term effects:

> *Our principal hypothesis was that exposure to infrasound in healthy individuals, at a level of ~ 90 dB pk re 20 microPa compared with the sham infrasound, increases WASO* [305] *—a measure of sleep disturbance—and worsens other measures of sleep quality, mood, WTS* [306] *symptoms, and other electrophysiological measures. In addition, as a positive control, we also tested whether audible traffic noise, a mixture of road (motorbike, truck, car) and aircraft noise*

299 Footnote 7 of the Letter. Turunen AW, Tittanen P, Yli-Tuomi T, Taimisto P, Lanki T. (2021) Symptoms intuitively associated with wind turbine infrasound. *Environmental Research*, 192: 1-9. https://pubmed.ncbi.nlm.nih.gov/33131679/ [website added]

300 As indicated in Paragraphs 37 and 40, the primary reason for such a comprehensive approach to this IARO Health Report is to provide an educational and instructive document for the NHS-Highland medical staff, with the ultimate purpose of benefiting the Scottish Citizen.

301 Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, *et al*. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. *Environmental Health Perspectives*, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/

302 Disclaimer included in the 2023 Marshall *et al.* paper: "All of the authors have superannuation accounts which are compulsory in Australia and these accounts may contain investments in both traditional and renewable energy, including wind turbines. R.T. is the founding principal of Renzo Tonin Associates who have previously worked as consultants for the NSW Department of Planning on several wind farms in NSW, Australia. None of the investigators have any other pecuniary interest or academic conflicts of interest in the outcomes of this study."

303 See Appendix 1—Medical Sciences: IV. How is noise quantified?

304 See Appendix 2—Physics of Acoustics: I. What is Sound?

305 WASO = Wakefulness After Sleep Onset is the total number of minutes that an individual is awake after having initially fallen asleep.

306 WTS = Wind Turbine Syndrome. See: Pierpont N. (2009) Wind Turbine Syndrome: A Report on a Natural Experiment. K-Selected Books: Santa Fe, New Mexico, USA. https://www.researchgate.net/publication/265247204_Wind_Turbine_Syndrome_A_Report_on_a_Natural_Experiment

(at a sound level of 40–50 dB LAeq; night and 70 dB LAFmax transient maxima) had an adverse impact on these same outcomes, when compared with sham infrasound.[307]

216. The conclusions of this study were:

> *Our study found no evidence that 72 h of exposure to a sound level of ~ 90 dB pk re 20 microPa of simulated wind turbine infrasound in double-blind conditions perturbed any physiological or psychological variable. None of the 36 people exposed to infrasound developed what could be described as WTS. Our study is unique because it measured the effects of infrasound alone on sleep. This study suggests that the infrasound component of WTN* [wind turbine noise] *is unlikely to be a cause of ill-health or sleep disruption, although this observation should be independently replicated.*

217. The dose presented to these subjects "simulating a wind turbine infrasound signature" was questioned by IARO scientists, and correspondence with co-author R. Tonin was exchanged (in May 2023) to ascertain what "simulated wind turbine infrasound" meant.

218. Regrettably, the material provided by co-author R. Tonin was regarded by IARO scientists as unsatisfactory, if "simulating a wind turbine infrasound signature" was the objective.[308]

219. Nevertheless, for the sake of scientific discussion, it will be temporarily accepted that the subjects of this study were actually presented with a properly simulated wind turbine infrasound signature.

307 Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, et al. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. Environmental Health Perspectives, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/ [Footnotes contained in the original text are not included.]

308 The acoustic pattern used to simulate the wind turbine signal had a sawtooth profile, not the short-duration pulses of WTAS, see Figure 3. A sawtooth-shaped wave has a quick onset, a slow decay, and only locally oscillates the air. WTAS has a rapid onset and decay, and 'pumps the air' (as proposed by Dr Stephan Kaula, Germany), rather than only causing the local oscillations that are typically seen in airborne, acoustic propagation phenomena.

220. The idea seems to have been to investigate immediate responses to the simulated wind turbine infrasound signature, but as measured by parameters that, perhaps, were not so relevant for assessing immediate responses.[309, 310, 311, 312, 313, 314, 315]

221. Another questionable practice was the selection of the "healthy individuals" as study subjects. To the understanding of IARO scientists, no evaluation was made regarding prior exposures [316] to infrasound and low frequency noise.[317, 318]

222. Marshall *et al.* explain the viewpoint that foundationally justifies their study:

> *People who suffer from WTS* [Wind Turbine Syndrome [319]] *report that their symptoms begin quickly when they are exposed to infrasound from wind turbines and are then sustained.*[320] *Our scientifically robust study provides evidence to address this claim. The Australian NHMRC* [National Health and Medical Research Council] *report that gave rise to our study made note of this "absence of evidence" rather than concluding an "evidence of absence" owing to the lack of any laboratory-controlled double-blind experiments of sufficient duration and intensity to hypothetically induce WTS in a human.*[321]

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309 See Appendix 4—Clinical & Biological Matters, Section 3-Occupational and Residential Exposures: I. Why are occupational exposures important to understand environmental exposures?

310 See Appendix 4—Clinical & Biological Matters, Section 3-Occupational and Residential Exposures: II. What extra-auditory medical conditions do noise-exposed workers develop?

311 See Appendix 4—Clinical & Biological Matters, Section 3-Occupational and Residential Exposures: III. Do the extra-auditory medical conditions seen in noise-exposed workers also emerge in residential infrasonic exposures?

312 Mohr GC, Cole JJN, Guild E, von Gierke HE. (1965) Effects of low-frequency and infrasonic noise on man. *Aerospace Medicine*, 36: 817-24.

313 Ponomarkov VI, Tysik A, Kudryavtseva VI, Barer AS. (1969) Biological action of intense wide-band noise on animals. *Problems of Space Biology* NASA TT F-529, 7(May): 307-9.

314 Castelo Branco NAA, Gomes-Ferreira P, Monteiro E, Costa e Silva A, Reis Ferreira J, Alves-Pereira M. (2003) Respiratory epithelia in Wistar rats after 48 hours of continuous exposure to low frequency noise. *Journal of Pneumology*, *formerly Revista Portuguesa Pneumologia*, IX (6): 474-79. https://pubmed.ncbi.nlm.nih.gov/15190432/

315 Castelo Branco NAA, Reis Ferreira J, Alves-Pereira M. (2007). Respiratory pathology in vibroacoustic disease: 25 years of research. *Journal of Pneumology*, *formerly Revista Portuguesa Pneumologia,* XIII (1): 129-135. https://pubmed.ncbi.nlm.nih.gov/17315094/

316 Including, foetal, childhood and young adult exposures in residential, occupational, and leisurely settings. See Appendix 1—Medical Sciences: II. What parameters are important when investigating the biological effects of exposures to physical agents of disease.

317 See Appendix 1—Medical Sciences: X. How are control populations selected for noise studies.

318 See Appendix 1—Medical Sciences: XI. What happens when control populations are incorrectly selected?

319 Pierpont N. (2009) *Wind Turbine Syndrome: A Report on a Natural Experiment*. K-Selected Books: Santa Fe, New Mexico, USA. https://www.researchgate.net/publication/265247204_Wind_Turbine_Syndrome_A_Report_on_a_Natural_Experiment

320 See Appendix 4—Clinical & Biological Matters, Section 1-Cellular and Tissue Biology. III. Biological tissues are viscoelastic—What does this mean?

321 Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, *et al*. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. *Environmental Health Perspectives*, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/ [Footnotes contained in the original text are not included.]

223. "Induce WTS in a human"? [322] As far as is understood by IARO scientists, WTS is not commonly viewed as an immediate effect of the exposure to this agent of disease.[323]

224. The expression "laboratory-controlled double-blind experiments of sufficient duration and intensity" as applied to the matter at hand is simultaneously unethical, dangerous, and unnecessary.[324, 325]

225. Is it the desire of the Australian NHMRC to expose subjects to a toxic agent—which is very difficult, if not impossible, to reproduce in laboratory settings—until some clearly severe health endpoint is observed? While tens of thousands of citizens are sitting in real-life laboratories being 'accused' of developing psychosomatic disorders? [326]

226. This methodology is considered by IARO scientists to reflect sub-standard practices of Scientific Inquiry.

227. In conclusion, in the opinion of IARO scientists, the effort expended by these authors to conduct this study is laudable (particularly given the position of the Australian NHMRC), even though, scientifically, within the realm of Medical Sciences and dose-response relationships, its results are inconsequential.

322 "The causes of this syndrome have been the subject of substantial international controversy. Proponents have contended that the symptoms that compose this syndrome are caused by low frequency subaudible infrasound generated by wind turbines. Critics have argued that these symptoms are psychological in origin and are attributable to nocebo effects. The Australian National Health and Medical Research Council Wind Farms and Human Health Reference Group concluded that the available evidence was not sufficient to establish which, if either, of these explanations is correct." See: Marshall N, Cho G, Toelle BG, Tonin R, Bartlett DJ, et al. (2023) The Health Effects of 72 Hours of Simulated Wind Turbine Infrasound: A Double-Blind Randomised Crossover Study in Noise-Sensitive, Health Adults. Environmental Health Perspectives, 131(3): 1-10. https://pubmed.ncbi.nlm.nih.gov/36946580/

323 Pierpont N. (2009) *Wind Turbine Syndrome: A Report on a Natural Experiment.* K-Selected Books: Santa Fe, New Mexico, USA. https://www.researchgate.net/publication/265247204_Wind_Turbine_Syndrome_A_Report_on_a_Natural_Experiment

324 What kind of "laboratory-controlled double-blind experiments of sufficient duration and intensity" were conducted for asbestos contamination leading to asbestosis? Or for issues related to second-hand smoking, use of glyphosates, etc?

325 Alves-Pereira M, Rapley B, Bakker H, Summers R. (2019) Acoustics and Biological Structures. In: Abiddine Fellah ZE, Ogam E. (Eds*) Acoustics of Materials*. IntechOpen: London. DOI: 10.5772/intechopen.82761.

326 In the opinion of IARO scientists, had this study been performed on 3 groups of people, differentiated by the extent of their prior exposures (mild, moderate, or extensive), and, abiding by appropriate selection criteria of the study population, then, perhaps, statistically useful numbers could have been obtained, and scientifically useful results could have been achieved. The inability to reproduce 'wind turbine infrasound' under laboratorial conditions, however, would still render this study as irremediably flawed, while its overall design could be deemed ethically questionable.

II. The Government-Sponsored Finnish Study

228. The 2021 study by Maijala *et al.*[327] is based on the 169-page 2020 Governmental Report on a Research Project carried out by Maijala *et al.*[328]

229. The main objective was "to find out whether wind turbine infrasound has harmful effects on human health."[329]

230. Table 3 lists the specific objectives of this 2020 Research Project.

Table 3. Specific objectives of the 2020 Research Project sponsored by the Government of Finland.[330]

	A. To characterize wind turbine noise as an exposure
1	*What are the full spectrum sound levels, down to 0.1 Hz, inside houses near the wind power plants?*
2	*What are the characteristics of the sound, both audible and inaudible infrasound?*
	B. To describe symptoms that are intuitively associated with infrasound from wind turbines, i.e., wind turbine infrasound related symptoms.
3	*What is the prevalence of wind turbine infrasound related symptoms in the vicinity of wind power plants?*
4	*What factors are associated with wind turbine infrasound related symptoms?*
	C. To study how infrasound produced by wind turbines affects humans, in particular, perception, annoyance, and physiological responses
5	*Can low-frequency and infrasound wind turbine noise be perceived at typical and at extreme noise levels?*

327 Maijala PP, Kurki I, Vainio L, Pakarinen S, Kuuramo C, *et al.* (2021) Annoyance, perception, and physiological effects of wind turbine infrasound. *Journal of the Acoustical Society of America*, 149(4): 2238-2248. https://pubmed.ncbi.nlm.nih.gov/33940893/

328 Maijala P, Turunen A, Kurki I, Vainio L, Pakarinen S, *et al.* (2020) Infrasound does not explain symptoms related to wind turbines. *Publications of the Finnish Government's Analysis, Assessment and Research Activities*, 2020:34. Prime Minister's Office: Helsinki. https://julkaisut.valtioneuvosto.fi/handle/10024/162329

329 Maijala P, Turunen A, Kurki I, Vainio L, Pakarinen S, *et al.* (2020) Infrasound does not explain symptoms related to wind turbines. *Publications of the Finnish Government's Analysis, Assessment and Research Activities*, 2020:34. Prime Minister's Office: Helsinki. pp. 6. https://julkaisut.valtioneuvosto.fi/handle/10024/162329.

330 Maijala P, Turunen A, Kurki I, Vainio L, Pakarinen S, *et al.* (2020) Infrasound does not explain symptoms related to wind turbines. *Publications of the Finnish Government's Analysis, Assessment and Research Activities*, 2020:34. Prime Minister's Office: Helsinki. pp. 6-7. https://julkaisut.valtioneuvosto.fi/handle/10024/162329.

6 *What is the dependence between the depth of amplitude modulation and annoyance at low frequencies?*

7 *Does infrasound increase reported annoyance and psychophysiological responses?*

8 *What is the reactivity of the autonomic nervous system (ANS) to audible wind turbine sounds and its infrasound?*

9 *Are individuals who attribute their symptoms to wind turbines more sensitive to infrasound? Are they more able to detect infrasound and do they experience more annoyance compared to controls?*

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231. Objectives A1 and A2 were accomplished, and Figure 7 shows a representative example of the identified 'dose.'

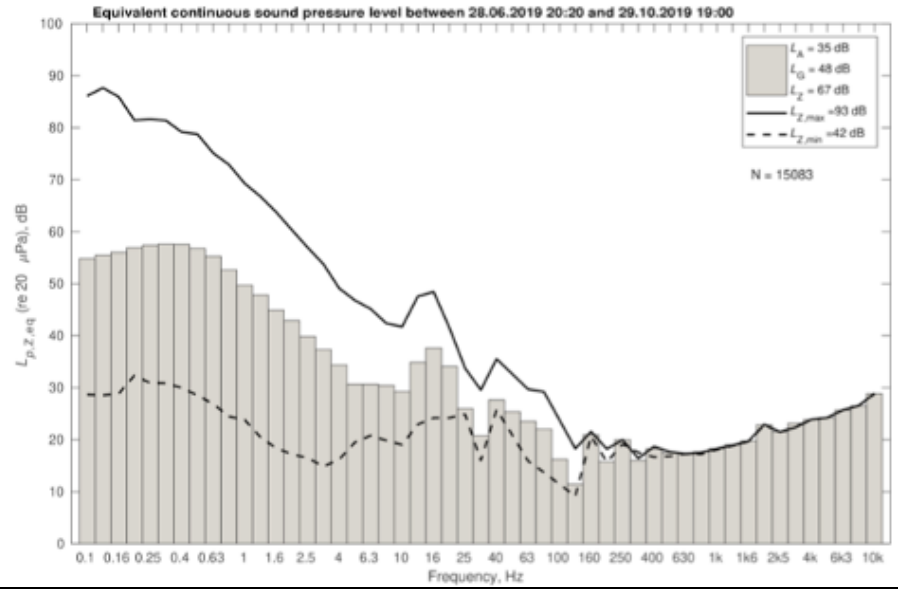

Figure 7. Representative example of the noise characterization (Raahe, indoors, 600-second sample).[331] L_Z levels refer to unweighted dB values. L_G refers to G-weighted values.[332] L_A refers to A-weighted values. Maximum and minimum L_Z values are shown as curves.

331 Maijala P, Turunen A, Kurki I, Vainio L, Pakarinen S, *et al.* (2020) Infrasound does not explain symptoms related to wind turbines. *Publications of the Finnish Government's Analysis, Assessment and Research Activities*, 2020:34. Prime Minister's Office: Helsinki. pp. 21. https://julkaisut.valtioneuvosto.fi/handle/10024/162329.

332 See Appendix 2—Physics of Acoustics: V. Can infrasound be measured in dBC or dBG?

232. Figure 7 shows a one-third-octave-band segmentation of the acoustic spectrum (similar to that shown in Figure 2). The solid black curve (L_Z max) shows the highest sound pressure levels measured in unweighted dB.

233. There is no cut-off of spectral data as was seen in Figure 6 (i.e., the lower limiting frequency is 0.1 Hz and not 10 Hz), but there is also no recognition of a "wind turbine infrasound signal" as in the previous Marshall *et al.* study (see Paragraph 214). It was however recognized that "the most important frequencies were less than 2 Hz."[333]

234. Objectives B3 and B4 (see Table 3) were more difficult to achieve, as "infrasound related symptoms" were established by questionnaires and telephone calls. While these types of surveys may have a certain usefulness, their direct results cannot be considered as a measure of Response within the realm of the Medical Sciences' dose-response relationship,[334] nor as per the WHO definition of noise-induced adverse health effects (see Paragraph 189).

235. Furthermore, there seems to not have been any stratification of the study population regarding prior noise exposure histories.[335]

236. Objectives C5 through C9 used "provocation experiments" conducted in an "infrasound chamber" whereby "systematically selected samples from real wind turbine sounds from wind power plant areas where inhabitants report symptoms associated with wind turbine infrasound or sound were used as stimuli."[336]

237. As with the study by Marshall *et al.* (Paragraphs 224 to 226), it is not entirely understood why there is a perceived need to subject individuals in laboratory to a potentially noxious agent (which is very difficult, if not impossible, to reproduce under laboratorial conditions), while tens of thousands of individuals are living in 'real-life laboratories,' awaiting an objective, clinical observational study on behalf of the competent authorities.[337]

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333 Maijala P, Turunen A, Kurki I, Vainio L, Pakarinen S, *et al.* (2020) Infrasound does not explain symptoms related to wind turbines. *Publications of the Finnish Government's Analysis, Assessment and Research Activities*, 2020:34. Prime Minister's Office: Helsinki. pp. 77. https://julkaisut.valtioneuvosto.fi/handle/10024/162329.

334 See Appendix 1—Medical Sciences: VIII. How is 'Response' measured?

335 See Appendix 1—Medical Sciences: II. What parameters are important when investigating the biological effects of exposures to physical agents of disease?

336 Maijala P, Turunen A, Kurki I, Vainio L, Pakarinen S, *et al.* (2020) Infrasound does not explain symptoms related to wind turbines. *Publications of the Finnish Government's Analysis, Assessment and Research Activities*, 2020:34. Prime Minister's Office: Helsinki. pp. 36 and 40. https://julkaisut.valtioneuvosto.fi/handle/10024/162329.

337 Although it is unclear to IARO scientists who (or what agency) could be classified as 'the competent authorities.'

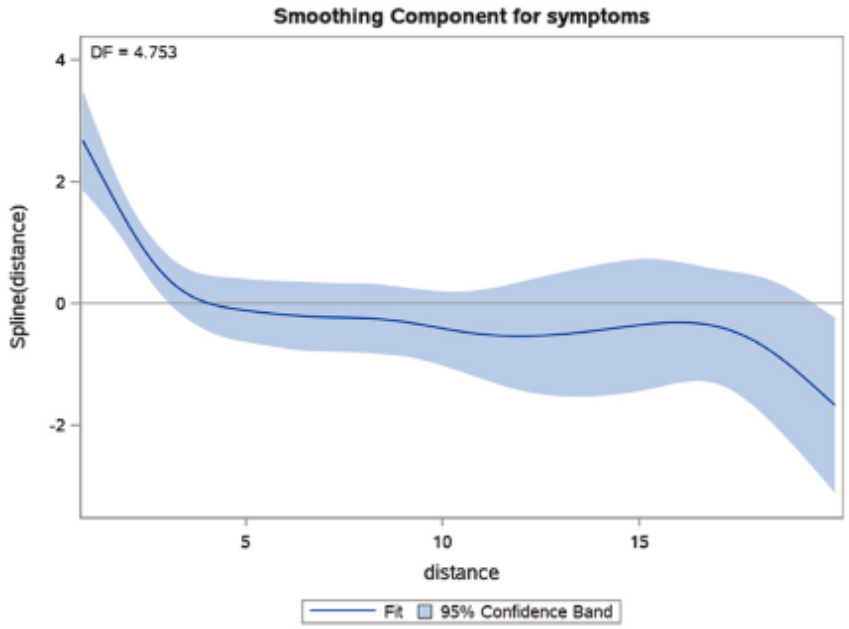
III. Intuitive symptoms

238. In the third study of this series, the goal of Turunen *et al.*[338] was to assess "the prevalence and severity of these wind turbine infrasound related symptoms:"

> *No matter what the true cause for the symptoms is, it is clear that symptoms are real and lead to worry, decreased quality of life, and potentially further to deteriorated health. High prevalence of this kind of phenomenon could be a serious threat to public health. The aim of this questionnaire study was to describe symptoms intuitively associated with infrasound from wind turbines.*[339]

239. The immense wealth of data collected by this team of scientists was used to establish the prevalence of these self-reported "intuitive symptoms" from individuals living at different distances from WPPs: ≤ 2.5 km, 2.5–5 km, 5–10 km, and 10–20 km.

240. Figure 8 provides interesting information on the variation of self-reported "intuitive symptoms" with respect to distance from the WPP.



338 Please note that the authors of this study are the same as those of the Finnish Governmental study by Maijala *et al.* (see Paragraph 228), and the data collected through questionnaires and telephone calls in the Maijala *et al.* study are the same data used in this study. See: Turunen AW, Tittanen P, Yli-Tuomi T, Taimisto P, Lanki T. (2021) Symptoms intuitively associated with wind turbine infrasound. *Environmental Research*, 192: 1-9. https://pubmed.ncbi.nlm.nih.gov/33131679/

339 Turunen AW, Tittanen P, Yli-Tuomi T, Taimisto P, Lanki T. (2021) Symptoms intuitively associated with wind turbine infrasound. *Environmental Research*, 192: 1-9. https://pubmed.ncbi.nlm.nih.gov/33131679/

Figure 8. "Smoothed association between distance to the closest wind turbine and the probability (logit scale) of wind turbine infrasound related symptoms (n = 1301)" (Footnote 339).

241. "Intuitive symptoms", however, cannot be considered a *bona fide* Response applicable to the Medical Sciences' dose-response relationships [340, 341] (see Paragraph 189).

7. 2018 WHO Guidelines for Environmental Noise

242. *Environmental Noise Guidelines for the European Region* is a 2018 document published by the WHO and that was quoted in the Letter sent by the NHS-Highland medical representative:

> *"In 2018, the WHO published guidelines[342] to provide recommendations for protecting human health from exposure to environmental noise originating from a variety of sources including that of wind turbines. The importance of complete health which encompasses mental and social well-being and not solely the absence of disease was acknowledged in the development of the guidelines. As such, impacts on well-being, self-reported sleep disturbance and long-term annoyance were also considered. The guidelines included conditional recommendations in relation to wind turbine noise due to the quality of evidence. For average noise exposure, the conditional recommendation was to reduce noise levels produced by wind turbines below 45 dB Lden* [343] [see Paragraph 66] *as wind turbine noise above this level is associated with adverse health effects, specifically that of annoyance* [344]*. It was noted that there could be an increased risk factor for annoyance below this noise exposure level but that the lack of evidence meant that it could not state whether there was an increased risk for other health outcomes below this level. Similarly, as a result of the low quantity and heterogeneous nature of the*

340 See Appendix 1—Medical Sciences: VI. What are Dose-Response relationships?

341 See Appendix 1—Medical Sciences: VIII. How is 'Response' measured?

342 Footnote 8 of the Letter. World Health Organization, Regional Office for Europe. *Environmental Noise Guidelines for the European Region.* Geneva: World health Organization; 2022. [The publication date of the document with this title is 2018.] https://www.who.int/europe/publications/i/item/9789289053563 [website added]

343 For a brief description of Lden see Table 1—Acronyms and variables used in this IARO Health Report.

344 Annoyance cannot be considered an "adverse health effect" (Response) within the context of the Medical Sciences' dose-response relationship (see Paragraphs 194 to 198), nor under the WHO definition for noise-induced adverse health effect (see Paragraph 189).

evidence the guideline group was not able to develop a recommendation in relation to sleep disturbance due to wind turbine noise at night."

243. The principal goal of this 181-page WHO document was "to provide recommendations for protecting human health from exposure to environmental noise originating from various sources: transportation (road traffic, railway and aircraft) noise, wind turbine noise and leisure noise."[345]

244. Figure 9 shows the recommendations for wind turbine noise put forth by this intergovernmental body.

Recommendation	Strength
For average noise exposure, the GDG conditionally recommends reducing noise levels produced by wind turbines below **45 dB** L_{den}, as wind turbine noise above this level is associated with adverse health effects.	Conditional
No recommendation is made for average night noise exposure L_{night} of wind turbines. The quality of evidence of night-time exposure to wind turbine noise is too low to allow a recommendation.	
To reduce health effects, the GDG conditionally recommends that policy-makers implement suitable measures to reduce noise exposure from wind turbines in the population exposed to levels above the guideline values for average noise exposure. No evidence is available, however, to facilitate the recommendation of one particular type of intervention over another.	Conditional

Figure 9. WHO recommendation for wind turbine noise (GDG=Guideline Development Group).[346] Although not specifically indicated, the Lden metric implies the use of A-frequency weighting [347, 348, 349] (see Paragraph 66).

345 World Health Organization. (2018) *Environmental Noise Guidelines for the European Region.* Regional Office for Europe: Geneva. pp. xiii. https://www.who.int/europe/publications/i/item/9789289053563

346 World Health Organization. (2018) *Environmental Noise Guidelines for the European Region.* Regional Office for Europe: Geneva. pp. xiii. https://www.who.int/europe/publications/i/item/9789289053563.

347 "When prominent low-frequency components are present, noise measures based on A-weighting are inappropriate"— World Health Organization. (1999) Guidelines for community noise. Stockholm University & Karolinska Institute: Stockholm, Sweden. pp. xiii. https://www.who.int/publications/i/item/a68672.

348 See Appendix 2—Physics of Acoustics: IV. Can infrasound and low frequency noise be measured in dBA?

349 See Appendix 2—Physics of Acoustics: VII. Why is a psychosomatic (nocebo) origin attributed to the effects of infrasound and low frequency noise?

245. Curiously, a search of this document for the word 'infrasound' revealed one single instance, reproduced in Figure 10.

> Wind turbines can generate infrasound or lower frequencies of sound than traffic sources. However, few studies relating exposure to such noise from wind turbines to health effects are available. It is also unknown whether lower frequencies of sound generated outdoors are audible indoors, particularly when windows are closed.
>
> The noise emitted from wind turbines has other characteristics, including the repetitive nature of the sound of the rotating blades and atmospheric influence leading to a variability of amplitude modulation, which can be a source of above average annoyance (Schäffer et al., 2016). This differentiates it from noise from other sources and has not always been properly characterized. Standard methods of measuring sound, most commonly including A-weighting, may not capture the low-frequency sound and amplitude modulation characteristic of wind turbine noise (Council of Canadian Academies, 2015).

Figure 10. The only instance of the word 'infrasound' appeared within the context of the above paragraphs, under the sub-section heading of "Additional considerations or uncertainties."[350, 351]

246. "Standard methods of measuring sound, most commonly including A-weighting, may not capture the low-frequency sound and amplitude modulation characteristic of wind turbine noise"—this assertion is referenced with the 2015 Expert Panel of the Council of Canadian Academies (see Paragraph 212).[352]

247. And yet, in 1999, the WHO already had much of this information (even though WPPs were not yet an issue at that time):

> *A noise measure based only on energy summation and expressed as the conventional equivalent measure, LAeq, is not enough to characterize most noise environments. It is equally important to measure the maximum values of noise fluctuations, preferably combined with a measure of the number of noise events. If the noise includes a large proportion of low-frequency components, still lower values than the guideline values below will be needed.* When

350 World Health Organization. (2018) Environmental Noise Guidelines for the European Region. Regional Office for Europe: Geneva. pp. 85. https://www.who.int/europe/publications/i/item/9789289053563.

351 Amplitude modulation is a technically incorrect, although commonly used, expression for the audible acoustic disturbances associated with the "whooshing" and "swishing" sounds emanating from WPPs. The preponderance of attention given to this audible disturbance [Institute of Acoustics (UK) Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise, 2013] further underlies the limited focus of acousticians and health professionals who restrict their study of WPP acoustic disturbances exclusively to the audible range. See: Annex A—Technical Background for Laypersons, Section 3: II. Harmonic Analysis. Paragraphs 45 to 49, and Figure 15.

352 The Expert Panel on Wind Turbine Noise and Human Health, Council of Canadian Academies (2015) *Understanding the evidence: wind turbine noise.* Council of Canadian Academies: Ottawa. pp. xiii-xviii. https://cca-reports.ca/wp-content/uploads/2018/10/windturbinenoisefullreporten.pdf.

prominent low-frequency components are present, noise measures based on A-weighting are inappropriate.[353] [Emphasis added.]

248. To finalize this section of the Letter, a final paragraph is transcribed, reiterating the acceptance, on behalf of NHS-Highland Public Health, of a Dose (in the form of Lden[354]) and a Response (in the form of annoyance, see Paragraphs 194 to 198) both of which are at odds with the foundational axioms of the Medical Sciences' dose-response relationship:

> *"As detailed above, we have undertaken a review into the potential health effects of the noise from wind turbines. This review has identified that whilst much of the literature is more limited in both quality and quantity, it is recognized that exposure to excessive wind turbine noise can impact on health through that of annoyance. Having said this, it is acknowledged that other factors can also play a contributory part in this over and above that of exposure to noise alone. In order to reduce potential impacts on health the noise levels produced by wind turbines should be below 45 dB Lden."*

8. The Diagnosis, or Rather, the Misdiagnosis

I. "This is a commonly recognized phenomenon"

249. IARO scientists are often duty-bound to point out the more absurd statements that are generally contained in these types of documents, particularly those emanating from acousticians.

250. But here, a didactic stance[355] must be maintained considering that:

a. The signatory of this Letter is a medical professional, representing the position of NHS-Highland on this matter, and

b. The authors of this IARO Health Report are vigorously attempting to make this document an educational tool, for the benefit of the Scottish citizen.

251. To that end, the final paragraphs of the Letter will now be scrutinized:

353 World Health Organization. (1999) Guidelines for community noise. Stockholm University & Karolinska Institute: Stockholm, Sweden. pp. xiii. https://www.who.int/publications/i/item/a68672.

354 For a brief description of Lden, see Table 1—Acronyms and variables used in this IARO Health Report.

355 As laid out in Paragraphs 37 and 40, a comprehensive approach is being taken by IARO scientists with this Health Report to educate and inform NHS-Highland medical staff, for the benefit of the Scottish Citizen.