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A Systematic Review of the Behavioral and Physiological Effects of Fireworks Noise on Domestic Dogs

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ABSTRACT

The dog is considered the man's best friend, and noise can significantly affect its behavior. In this context, the aim of the research was to determine the effects of fireworks noise on dogs. The methodology applied was the PRISMA 2020 statement; the literature review was conducted on digital databases such as Scopus, ScienceDirect, Taylor & Francis, Wiley, and Ebsco, the annual growth of scientific production was calculated using the digital tool Calcuvio, and data analysis was carried out using Microsoft Office Excel and VOSviewer. The annual growth of production (between 1965 and 2023) was 6.11%, the highest scientific production per year was concentrated in 2018 and 2020, and the pioneering country in scientific production was the United States, the keywords with the highest number of appearances are 'dog' and 'magnetic resonance imaging'. The study concludes that the effects of fireworks noise on dogs were observed in changes in behavior and physiological responses. Furthermore, specific regulations should be in place to help reduce the hearing damage to which dogs are exposed and thus improve people's emotional relationships with their pets. It is recommended that future research determine the effects on different breeds of dogs.

1. INTRODUCTION

Dogs (Canis familiaris) are like children in that they pay attention to facial expressions, gestures, and gaze, which serve as a means for them to communicate and connect with humans [1, 2]; they possess brain regions for temporal face recognition that they use to determine the meaning behind human language [3, 4], consequently, all these characteristics enable them to play important roles in society, such as police dogs, guide dogs, and search and rescue dogs [5]. Dogs have a global population of approximately 700 million [6] and are the species that have maintained the closest and oldest relationship with humans compared to other domestic species [7, 8], this is how they have earned the title of 'man's best friend'.

Noise is the unwanted sound that is omnipresent and causes harm to the biological system of individuals and communities, such as in humans and animals [9-11]; similarly, it is measured in the equivalent continuous A-weighted sound pressure level, with the unit being decibels (dB) [12, 13]. Acoustic pollution is the anthropogenic physical alteration of the environment [14, 15]. There is no universal term to refer to dogs' fear of noise, and it has different denominations such as noise sensitivity, noise aversion, noise stress, or noise reactivity [16-18]. Furthermore, there are differences between 'anxiety' (anticipation of a negative outcome without a specific provoking stimulus), 'fear' (adaptive response to a potentially dangerous stimulus), and 'phobia' (extreme and enduring reaction, possibly triggered by a low-intensity stimulus, which in human psychiatry is termed irrational) [19-21].

Dogs detect sounds four times farther away than humans because they possess more precise auditory capabilities [22]. Surveys indicate that approximately 50% of dogs are likely to experience extreme reactions to some noise during their lifetime [21, 23], additionally, between 40 and 50% exhibit fearful behavior upon exposure [19]. The most frequent noise sources that cause fear reactions in dogs are sirens and alarms, followed by thunder, fireworks, and gunshots [24, 25], thus, noises associated with machinery and vehicles can provoke fearful, phobic, or anxious responses [26]. Similarly, a study determined that 53.5% of dogs showed fear of other noises (sirens, vacuum cleaners, etc.), 73.8% to gunshots, and 92.9% to fireworks [19], furthermore, the effects caused by fireworks noise included panting, trembling, hiding, fleeing, and increased attention and alertness [24], another study indicated that the sound of thunder causes fear and anxiety [27]. Additionally, in studies measuring noise from fireworks, the majority exceeded the WHO value [28].

In this context, the objective of the research was to determine the effects of fireworks noise on dogs, establishing the following research questions (RQ):

RQ1: What is the geographic distribution of studies by year/country and annual scientific production?

RQ2: Which journal presented the highest number of studies?

RQ3: Which breed was the most studied, and what were the most frequent effects of noise?

RQ4: Which keywords have the highest number of appearances?

2. MATERIAL AND METHODS

For the systematic review, the PRISMA 2020 statement was applied [29], tool that helps to understand, summarize and prepare for review [30].

2.1 Document eligibility

In order to have a larger number of articles selected for the review, the following inclusion criteria were considered, (1) scientific research articles, (2) worldwide, (3) in all languages (translation services required), and (4) without restriction on publication years up to 2023.

The exclusion criteria discarded (1) duplicated articles, (2) closed-access articles, (3) those with titles and abstracts unrelated to the study's objective, and (4) qualitative research studies.

2.2 Sources of information extraction and search methods

The boolean operators 'AND'/'OR' were used to connect the terms, and thus search them in the title, abstract, and keywords. Data collection was carried out from September 11th to December 31st, 2023, in 5 digital databases (Table 1). The following equations were used in the search strategy:

Table 1. Search procedure

Digital Databases	Search Methods
Scopus ScienceDirect Taylor & Francis Wiley EBSCO (Academic Search Ultimate, Biological & Agricultural Index Plus, Environment Complete, GreenFile and Veterinary Source)	TITLE-ABS-KEY (dogs AND noise) TITLE-ABS-KEY (dogs AND effects OR impact AND noise)

2.3 Selection and extraction of information

For the selection of articles, 2 authors were grouped in order to extract the information from each digital database, any disagreements were resolved at the end of the selection process by discussing with the corresponding author (MRI), The information collected from the selected articles had to respond to the general objective, and the limitations were resolved by applying the exclusion criteria. In the systematization of article selection, the online tool allowing for the creation of the PRISMA 2020 flow diagram [31] was utilized. Initially, 2 621 772 articles were identified, and after applying the eligibility criteria, 33 articles remained for review (Figure 1).

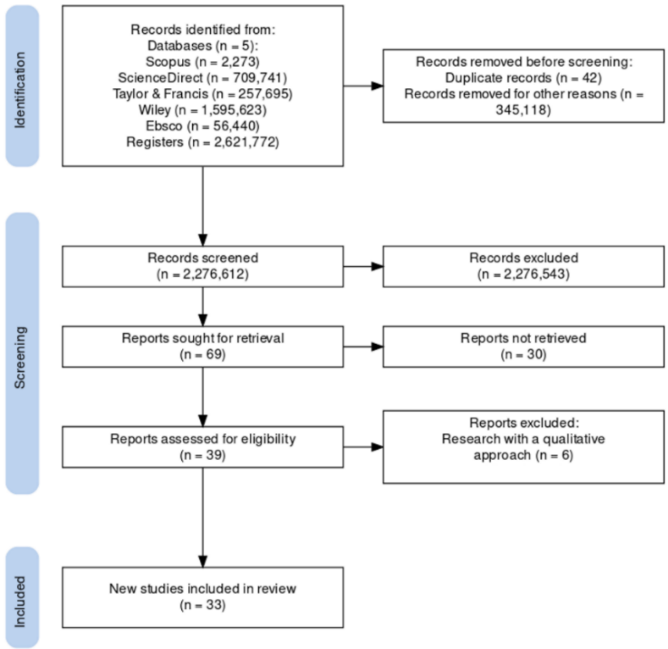

Figure 1. Item selection process

2.4 Compound annual growth rate (CAGR)

The CAGR indicates the annual growth of a variable over a period exceeding one year [32], in this regard, with the assistance of the online calculator [33], the annual growth of scientific production (from 1965 to 2023) was determined for its accessibility, speed, and ease of use [34], utilizing the following formula:

$$CAGR\ \% = 100 * \left(\left(\frac{V_f}{Vi}\right)^{\frac{1}{t}} - 1\right)$$

where, V_i=Initial value; V_f=Final value; t=Years.

2.5 Evaluation of information

The information was downloaded in CSV to be processed in Microsoft Office Excel 2016 to determine the distribution of studies by year and country, the analysis was performed with VOSviewer 1.6.19. [35], used in the scientific field to represent and visualize bibliometric networks in many colors that will facilitate the discovery and understanding of co-authorship (by number of citations or documents), journals, countries, institutions, and keyword co-occurrence relationships [36-38], thus, it was employed in the study for the analysis of keyword co-occurrence.

3. RESULTS AND DISCUSSIONS

The most frequent effects of noise are changes in behavior (fleeing, hiding, restlessness, whining, and cowering) and physiological responses of the dog (excessive salivation, decreased heart rate, loss of appetite, and sleep (Table 2), likewise, common aversive effects of noise include panting, escaping, crouching, hiding, and salivation [39-41].

On the other hand, the most frequent causes of noise aversion are fireworks, gunshots, and thunderstorms [19, 21].

Another frequent effect is the increase in cortisol, which is in response to the stress caused by noise, resulting in excessive salivation in dogs [42]. Likewise, chronic stress damage's immune function and consequently increases the risk of contracting diseases [43]. The effects found will serve to raise awareness of the harm suffered by dogs, as well as to enact measures to mitigate these impacts, which are currently uncontrolled, much less in developing countries.

In 20% of the studies, dogs were subjected to thunderstorm noises, as the most reported noise phobia causing disorders in dogs are thunderstorms [18, 44, 45], likewise, the prevalence of phobia in the canine population is estimated to range between 15-30% [39].

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On the other hand, in their study demonstrated that, in a sample of 2577 dogs, fear of thunderstorms was the second most common phobia (31%) followed by fear of fireworks (32%) [46], while another survey conducted with 337 dog owners indicated that 86% and 74% of their dogs had phobia of thunderstorm and fireworks noise, respectively [47], these studies support the findings of the review, with fireworks being the second most common noise to which dogs were subjected. Dog owners and handlers are the main actors in solving the problem, they should demand preventive measures from their authorities and enforce the provisions implemented in the future.

Table 2. Sound pressure levels and effects of fireworks noise

Reference	Source of Emission	Equivalent Continuous Sound Pressure Level	Race	Effects
[48]	MAG-V magnitofone	100-105 dBA	NR	Decrease in the cardiac rhythm
[49]	F-86F jet engine	100 to 120 phons	NR	Minor variations in basal gastric juice secretion
[50]	Two earphones	$2x10^{-4}$ ubar	German boxers	No effects
[51]	Miniature earpieces	less than equal to 100 dBA	Mongrel	Delayed onset of the migratory motor complex
[52]	Earphones	80-90 dBA	Mongrel	114% delay in the appearance of the migratory motor complex and plasma cortisol increased by 215%
[53]	Recorder (random music)	80-90 dBA	Mongrel	Significant lengthening of the gastric and jejunal postprandial pattern and a slowing of gastric emptying of both liquid and solid phases of the meal
[54]	Earphones	less than equal to 90 dBA	Mongrel	131% delay in the onset of the migratoring motor complex and plasma cortisol increased by 516%
[55]	Alarm	75 dBA	Mongrel	Tachycardia, hypertension, and increases in adrenomedullary secretion, adrenal vascular conductance and increases in cortisol secretion
[56]	HFT transducer, Tucker–Davis Technologies, Gainesville, FL	55 dBA	Beagle	Partial hearing loss
[57]	Environmental noise	70-100 dBA	NR	Physical and psychological stress
[58]	iPod (Apple Store) music player and Eos wireless speakers (classical and heavy music)	NR	NR	Heavy metal music causes stress and anxiety, classical music causes sleep. la música heavy metal
[59]	Environmental noise	102 and 110 dBA	Mongre	Hearing loss
[60]	Recorder	83.9 dBA	Beagle	Fear and anxiety
[61]	Two speakers (thunderstorms)	60-80 dBA	Rhodesian ridgebacks, boxers, Labrador retrievers, Border collies, Dachshund and Mixed-breed dogs	Hiding, running away, seeking attention from the tester, panting and lowering of the body posture
[62]	Environmental noise	64.62 dBA	NR	No effects
[63]	Magnetic resonance imaging	55 dBA	NR	Significant reduction in frequency-specific cochlear function
[64]	Music concert	NR	Border collie–kelpie cross	No effects

[65]	Loudspeaker (thunder)	103-104 dBA	Beagles	Restlessness, trepidation and shock
[66]	Thunderstorms	NR	Shepherd of merenma	Sporadic panics
[67]	Wet-dry vacuum	NR	Labrador retrievers, Australian shepherds and Boxer	Did not elevate baseline serum cortisol concentrations above 55 $nmolL^{-1}$
[68]	Firearm	143.1 dBA	NR	Acoustic trauma
[69]	Handy recorder ZOOM H2n (people talking, dogs barking, and metal kennel doors shutting)	68 dBA	Collie (Rough), Shih Tzu, Retriever (Labrador), Mixed Breed, Airedale Terrier, Nova Scotia Duck Tolling Retriever, Papillon, American Cocker, Lowchen, Welsh Corgi (Pembroke), Chihuahua, Dachshund, Bulldog, Welsh Corgi and Doberman Pinscher	Increase in respiratory rate
[70]	Speakers (gently flowing water, electrical storm, fireworks, equipment and weapon noises)	56 dBA	Labrador retriever, Golden retriever, Cocker spaniel, Jack Russell terrier, Australian shepherd, standard poodle, Miniature dachshund, Keeshond, bull terrier, German shepherd, Basenji, Borzoi and Greyhound	Erratic body movements, less continuous
[71]	Football stadium	79.32 dBA	NR	Severe trembling, excessive salivation, agitation/restlessness, whining and appetite loss
[72]	Fireworks	NR	NR	Increased locomotion, panting, vocalisations, blinking and hiding
[73]	Environmental noise (traffic, construction, fireworks, storms/thunderstorms, vacuum cleaners, gunshots and household appliances)	NR	NR	Fear and anxiety
[74]	Bose Co. bluetooth speakers Framingham, MA (thunder and fireworks)	90 dBA	Cur, Lab, Hound, Boxer, Shepherd, Dane, Schipperkee, Springer Spaniel and Pit.	Cowering, trembling, vocalizing, being destructive and tail tucking
[75]	Piano (high pitch, low pitch, fast tempo, and slow tempo)	NR	Boxers, labrador, Australian Kelpie and Mastiff	The low tones increased the level of alertness and made them more disturbing
[76]	Thunderstorms	NR	NR	Fear and anxiety
[77]	Recorder (thunderstorms)	NR	Beagles	Elevated cortisol as a biochemical response to stress and anxiety
[78]	Recorder (fireworks, gunshots and motorcycle horns)	15-79 dBA	NR	Whimpering, moaning, startled and frightened
[79]	Environmental noise	NR	NR	Chronic stress, restlessness, reduced food and drink consumption, slept less during the day
[80]	Firearm	110 dBA	Labrador retrievers and Golden retrievers	Increased basal cortisol levels generating stress

* NR: Not reported

On the other hand, the most frequent causes of noise aversion are fireworks, gunshots, and thunderstorms [19, 21]. An increase in cortisol, which is in response to the stress caused by noise, resulting in excessive salivation in dogs [42], likewise, chronic stress damages immune function and consequently increases the risk of contracting diseases [43]. The effects found will serve to raise awareness of the harm suffered by dogs, as well as to enact measures to mitigate these impacts, which are currently uncontrolled, much less in developing countries.

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Based on the results, future research on hormonal changes, neurotransmitters and specific neuronal responses to noise could be proposed, as well as the creation and validation of tools to help measure stress through observation and behaviors, hormonal analysis and non-invasive measures. Moreover, it would be complemented with the study of pharmacological and non-pharmacological interventions to mitigate fear and anxiety in dogs.

The scientific production has evolved steadily from 1965 to 2020, followed by a gradual decline up to the present, the years with the highest number of publications are 2018 and 2020, both with 4 publications (Figure 2). The CAGR is an important instrument to determine the growth per year of a set of articles in a given subject, in this sense, the compound annual growth rate of scientific production between 1965 and 2023 is 6.11%, indicating a low annual growth rate up to the present.

The geographical distribution of studies with the highest number of publications is the United States (9) (Figure 3); hearing loss is the third most common chronic disease in the country, despite people having access to hearing protection as well as recreational recommendations and occupational regulations [81-83]. Comparing this with the canine population, which does not have these opportunities, it is likely that the risk of hearing loss is higher for dogs, due to the importance of noise effects on dogs, it becomes the country with the highest number of publications, additionally, the country ranks second in the Global Innovation Index 2022, investing 3.45% of its GDP in research and development in 2021 [84].

The keywords with the highest number of appearances per word are 'dog' and 'magnetic resonance imaging' with 132 and 44 appearances, respectively, on the other hand, 6 clusters were formed, with the word 'dog' being the cluster with the highest linkage with 9 keywords (Figure 4).

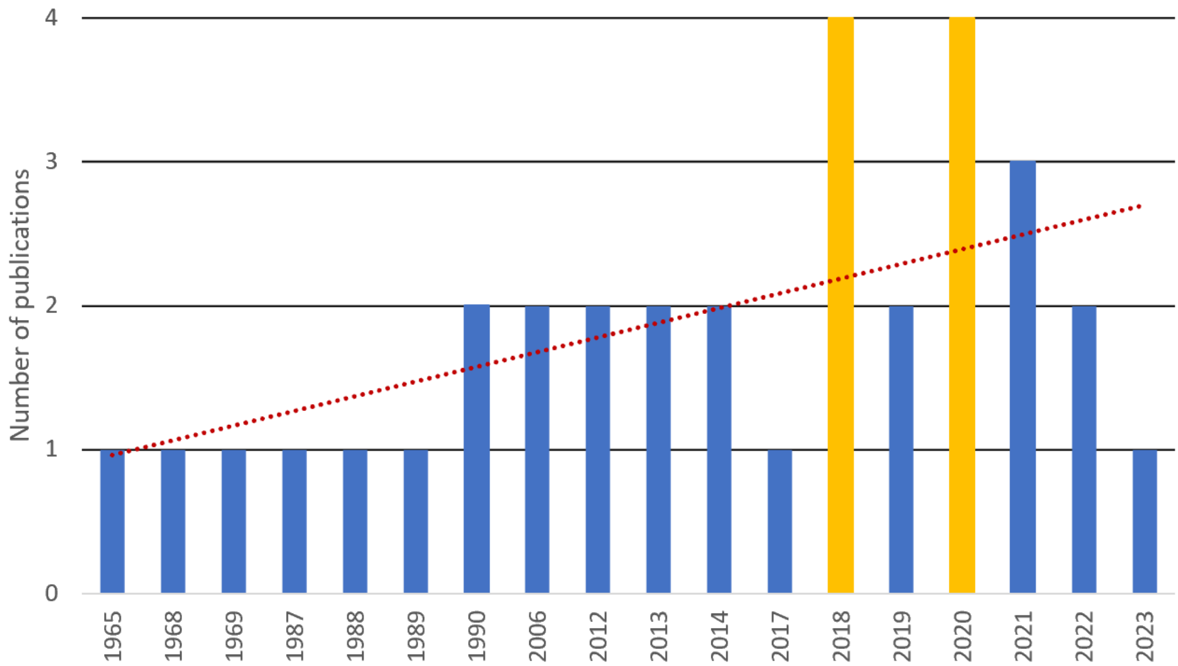

Figure 2. Distribution of studies per year

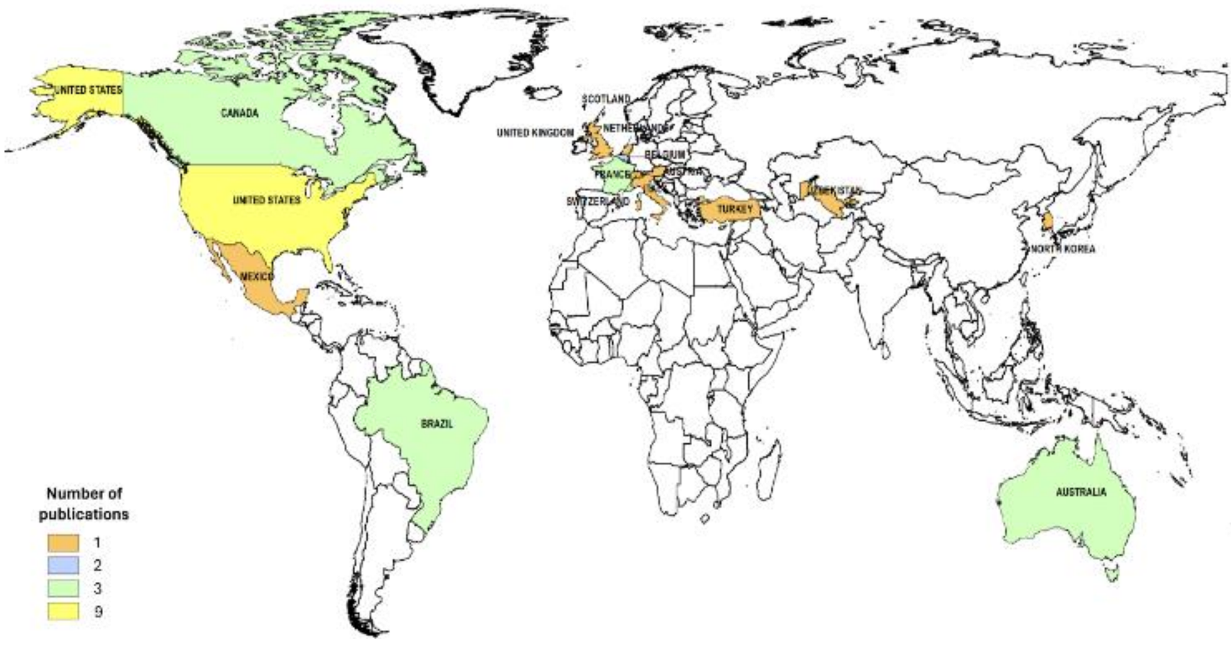

Figure 3. Distribution of studies per country

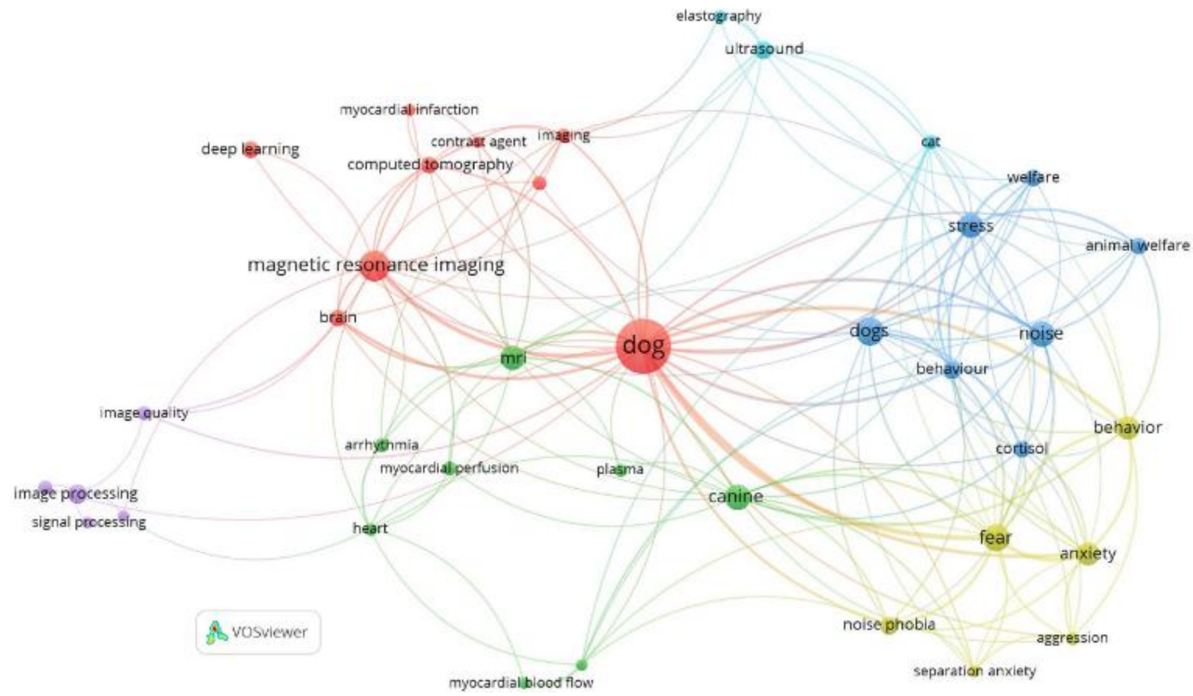

Figure 4. Cooccurrences by keyword

4. CONCLUSIONS

The research peaked in 2018 and 2020, the annual growth of scientific production indicates that it will continue to decrease as the years progress, which is concerning considering that these pets are a fundamental part of human daily life, furthermore, the country with the highest number of publications was the United States. On the other hand, in the studies, dogs were mostly subjected to noises from thunderstorms and fireworks, which are impulsive noises with high levels of continuous equivalent sound pressure that they are sporadically exposed to and cause serious harm.

The most frequent effects on dogs were changes in behavior and physiological responses, which are detrimental as they generate stress and inhibit their normal activity in tasks they may be assigned to (such as police work, guiding, search, and rescue). Dog owners should take preventive measures to mitigate the effects of noise generated by fireworks through insulation, and environmental regulations should prohibit the use of fireworks at events, thus helping to reduce noise and air pollution. For future research, it is recommended to determine if the effects of noise manifest in the same way across different dog breeds.

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REFERENCES

[1] Soproni, K., Miklósi, Á., Topál, J., Csányi, V. (2001). Comprehension of human communicative signs in pet dogs (Canis familiaris). Journal of Comparative Psychology, 115(2): 122–126. https://doi.org/10.1037/0735-7036.115.2.122

[2] Albuquerque, N., Guo, K., Wilkinson, A., Savalli, C., Otta, E., Mills, D. (2016). Dogs recognize dog and human emotions. Biology Letters, 12(1): 20150883. https://doi.org/10.1098/rsbl.2015.0883

[3] Cuaya, L.V., Hernández-Pérez, R., Concha, L. (2016). Our faces in the dog's brain: Functional imaging reveals temporal cortex activation during perception of human faces. Plos One, 11(3): e0149431. https://doi.org/10.1371/journal.pone.0149431

[4] Andics, A., Gácsi, M., Faragó, T., Kis, A., Miklósi, Á. (2014). Voice-sensitive regions in the dog and human brain are revealed by comparative FMRI. Current Biology, 24(5): 574–578. https://doi.org/10.1016/j.cub.2014.01.058

[5] Mallikarjun, A., Shroads, E., Newman, R.S. (2019). The cocktail party effect in the domestic dog (Canis familiaris). Animal Cognition, 22(3): 423–432. https://doi.org/10.1007/s10071-019-01255-4

[6] Hughes, J., Macdonald, D.W. (2013). A review of the interactions between free-roaming domestic dogs and wildlife. Biological Conservation, 157: 341–351. https://doi.org/10.1016/j.biocon.2012.07.005

[7] Botigué, L.R., Song, S., Scheu, A., Gopalan, S., Pendleton, A.L., Oetjens, M., Taravella, A.M., Seregély, T., Zeeb-Lanz, A., Arbogast, R.M., Bobo, D., Daly, K., Unterländer, M., Burger, J., Kidd, J.M., Veeramah, K.R. (2017). Ancient European dog genomes reveal continuity since the early neolithic. Nature Communications, 8(1): 16082. https://doi.org/10.1038/ncomms16082

[8] Schwalb, B., Michel, M., Zacher, B., Hauf, K.F., Demel, C., Tresch, A., Gagneur, J., Cramer, P. (2016). TT-Seq maps the human transient transcriptome. Science, 352(6290): 1225–1228. https://doi.org/10.1126/science.aad9841

[9] Francis, C.D., Kleist, N.J., Ortega, C.P., Cruz, A. (2012). Noise pollution alters ecological services: enhanced

pollination and disrupted seed dispersal. Proceedings of the Royal Society B: Biological Sciences, 279(1739): 2727–2735. https://doi.org/10.1098/rspb.2012.0230
[10] Merrall, E.S., Evans, K.L. (2020). Anthropogenic noise reduces avian feeding efficiency and increases vigilance along an urban–Rural gradient regardless of species' tolerances to urbanisation. Journal of Avian Biology, 51(9). https://doi.org/10.1111/jav.02341
[11] Kight, C.R., Swaddle, J.P. (2011). How and why environmental noise impacts animals: An integrative, mechanistic review. Ecology Letters, 14(10): 1052-1061. https://pubmed.ncbi.nlm.nih.gov/21806743/
[12] Risojević, V., Rozman, R., Pilipović, R., Češnovar, R., Bulić, P. (2018). Accurate indoor sound level measurement on a low-power and low-cost wireless sensor node. Sensors (Switzerland), 18(7): 2351. https://doi.org/10.3390/s18072351
[13] Naef, A.C., Knobel, S.E.J., Ruettgers, N., Jeitziner, M.M., Holtforth, M. grosse, Zante, B., Schefold, J.C., Nef, T., Gerber, S.M. (2022). Methods for measuring and identifying sounds in the intensive care unit. Frontiers in Medicine (Lausanne), 9: 836203. https://doi.org/10.3389/fmed.2022.836203
[14] Buxton, R.T., McKenna, M.F., Mennitt, D., Fristrup, K., Crooks, K., Angeloni, L., Wittemyer, G. (2017). Noise pollution is pervasive in U.S. protected areas. Science, 356(6337): 531-533. https://doi.org/10.1126/science.aah4783
[15] Lokhande, S.K., Pathak, S.S., Kokate, P.A., Dhawale, S.A., Bodhe, G.L. (2018). Assessment of heterogeneous road traffic noise in Nagpur. Archives of Acoustics, 48(1): 113-121. https://www.researchgate.net/publication/323725442_Assessment_of_Heterogeneous_Road_Traffic_Noise_in_Nagpur.
[16] Overall, K.L., Dunham, A.E., Juarbe-Diaz, S.V. (2016). Phenotypic determination of noise reactivity in 3 breeds of working dogs: A cautionary tale of age, breed, behavioral assessment, and genetics. Journal of Veterinary Behavior: Clinical Applications and Research, 16: 113-125. https://doi.org/10.1016/j.jveb.2016.09.007
[17] Korpivaara, M., Laapas, K., Huhtinen, M., Schöning, B., Overall, K. (2017). Dexmedetomidine oromucosal gel for noise-associated acute anxiety and fear in dogs-a randomised, double-blind, placebo-controlled clinical study. Veterinary Record, 180(14): 356. https://doi.org/10.1136/vr.104045
[18] Sherman, B.L., Mills, D.S. (2008). Canine anxieties and phobias: An update on separation anxiety and noise aversions. Veterinary Clinics of North America - Small Animal Practice, 38(5): 1081-1106. https://doi.org/10.1016/j.cvsm.2008.04.012
[19] Blackwell, E.J., Bradshaw, J.W.S., Casey, R.A. (2013). Fear responses to noises in domestic dogs: prevalence, risk factors and co-occurrence with other fear related behaviour. Applied Animal Behaviour Science, 145(1-2): 15-25. https://doi.org/10.1016/j.applanim.2012.12.004
[20] Perusini, J.N., Fanselow, M.S. (2015). Neurobehavioral perspectives on the distinction between fear and anxiety. Learning and Memory, 22(9): 417-425. https://doi.org/10.1101/lm.039180.115
[21] Storengen, L.M., Lingaas, F. (2015). Noise sensitivity in 17 dog breeds: Prevalence, breed risk and correlation with fear in other situations. Applied Animal Behaviour Science, 171: 152-160. https://doi.org/10.1016/j.applanim.2015.08.020
[22] Milligan, S.R., Salest, G.D., Khirnykh, K. (1993). Sound levels in rooms housing laboratory animals: An uncontrolled daily variable. Physiology & Behavior, 53(6): 1067-1076. https://doi.org/10.1016/0031-9384(93)90361-I
[23] Tiira, K., Lohi, H. (2014). Reliability and validity of a questionnaire survey in canine anxiety research. Applied Animal Behaviour Science, 155: 82-92. https://doi.org/10.1016/j.applanim.2014.03.007
[24] de Souza, C., de Medeiros, M. (2016). Risk factors and co-occurrence with other behavioral disorders in domestic dogs with exaggerated fear of sounds. Brazilian Journal of Veterinary Medicine, 38(2): 175-182. https://bjvm.org.br/BJVM/article/view/193
[25] Gates, M.C., Zito, S., Walker, J.K., Dale, A.R. (2019). Owner perceptions and management of the adverse Behavioural effects of fireworks on companion animals: An update. New Zealand Veterinary Journal, 67(6): 323-328. https://doi.org/10.1080/00480169.2019.1638845
[26] Ley, J., Coleman, G.J., Holmes, R., Hemsworth, P.H. (2007). Assessing fear of novel and startling stimuli in domestic dogs. Applied Animal Behaviour Science, 104(1-2): 71-84. https://doi.org/10.1016/j.applanim.2006.03.021
[27] Fagundes, A.L.L., Hewison, L., McPeake, K.J., Zulch, H., Mills, D.S. (2018). Noise sensitivities in dogs: An exploration of signs in dogs with and without musculoskeletal pain using qualitative content analysis. Frontiers in Veterinary Science, 5(17). https://doi.org/10.3389/fvets.2018.00017
[28] Reategui-Inga, M., Rojas, E.M., Casas, G.V., Lu, J.K.G., Valdiviezo, W.A., Alvarez, M.Ñ., Durand, R.P., Coaguila-Rodriguez, P., Álvarez-Tolentino, D. (2024). A Systematic review of fireworks noise and its exceedance of who outdoor limits: Global trends and implications. International Journal of Sustainable Development and Planning, 19(2): 663-670. https://doi.org/10.18280/ijsdp.190223
[29] Page, M.J., McKenzie, J.E., Bossuyt, P.M., et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. International Journal of Surgery, 88: 105906. https://doi.org/10.1016/j.ijsu.2021.105906
[30] Posada, Z., Vásquez, C. (2022). Ejercicio Físico Durante La Pandemia: Una Revisión Sistemática Utilizando La Herramienta PRISMA. Revista Iberoamericana de Ciencias de la Actividad Física y el Deporte, 11(1): 1–19. https://doi.org/10.24310/riccafd.2022.v11i1.13721
[31] Haddaway, N.R., Page, M.J., Pritchard, C.C., McGuinness, L.A. (2022). PRISMA2020: An R package and shiny App for producing PRISMA 2020-compliant flow diagrams, with interactivity for optimised digital transparency and open synthesis. Campbell Systematic Reviews, 18(2): e1230. https://doi.org/10.1002/cl2.1230
[32] Bornmann, L., Haunschild, R., Mutz, R. (2021). Growth rates of modern science: A latent piecewise growth curve approach to model publication numbers from established and new literature databases. Humanities and Social Sciences Communications, 8. https://doi.org/10.1057/s41599-021-00903-w

[33] Calcuvio. (2023). Calculadora de Tasa de Crecimiento Anual Compuesto o CAGR. https://www.calcuvio.com/crecimiento-anual, accessed on Jan. 10, 2024
[34] Reategui-Inga, M., Rojas, E.M., Tineo, D., Araníbar-Araníbar, M.J., Valdiviezo, W.A., Escalante, C.A., Castre, S.J.R. (2023). Effects of artificial electromagnetic fields on bees: A global review. Pakistan Journal of Biological Sciences, 26(1): 23-32. https://doi.org/10.3923/pjbs.2023.23.32
[35] van Eck, N.J., Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics, 84(2): 523-538. https://doi.org/10.1007/s11192-009-0146-3
[36] Castillo-Vergara, M., Alvarez-Marin, A., Placencio-Hidalgo, D. (2018). A bibliometric analysis of creativity in the field of business economics. Journal of Business Research, 85: 1-9. https://doi.org/10.1016/j.jbusres.2017.12.011
[37] Veiga-del-Baño, J.M., Cámara, M.Á., Oliva, J., Hernández-Cegarra, A.T., Andreo-Martínez, P., Motas, M. (2023). Mapping of emerging contaminants in coastal waters research: A bibliometric analysis of research output during 1986–2022. Marine Pollution Bulletin, 194: 115366. https://doi.org/10.1016/j.marpolbul.2023.115366
[38] Li, L., Wan, N., He, Y., Zhang, Y., He, X., Lu, L. (2023). A global bibliometric and visualized analysis of the status and trends of bone metastasis in breast cancer research from 2002 to 2021. Journal of Bone Oncology, 42: 100500. https://doi.org/10.1016/j.jbo.2023.100500
[39] Dreschel, N.A., Granger, D.A. (2005). Physiological and behavioral reactivity to stress in thunderstorm-phobic dogs and their caregivers. Applied Animal Behaviour Science, 95(3-4): 153-168. https://doi.org/10.1016/j.applanim.2005.04.009
[40] Dale, A.R., Walker, J.K., Farnworth, M.J., Morrissey, S.V., Waran, N.K. (2010). A survey of owners' perceptions of fear of fireworks in a sample of dogs and cats in New Zealand. New Zealand Veterinary Journal, 58(6): 286-291. https://doi.org/10.1080/00480169.2010.69403
[41] Dobson, J. (2012). Fears, phobias and anxiety disorders in cats and dogs. Veterinary Times, 12: 8-11. https://acortar.link/QiJtEJ.
[42] Siniscalchi, M., Quaranta, A., Rogers, L.J. (2008). Hemispheric specialization in dogs for processing different acoustic stimuli. PLoS One, 3(10): e3349. https://doi.org/10.1371/journal.pone.0003349
[43] Protopopova, A. (2016). Effects of sheltering on physiology, immune function, behavior, and the welfare of dogs. Physiology & Behavior, 159: 95-103. https://doi.org/10.1016/j.physbeh.2016.03.020
[44] Overall, K.L., Dunham, A.E., Frank, D. (2001). Frequency of nonspecific clinical signs in dogs with separation anxiety, thunderstorm phobia, and noise phobia, alone or in combination. Journal of the American Veterinary Medical Association, 219(4): 467-473. https://doi.org/10.2460/javma.2001.219.467
[45] Cottam, N., Dodman, N.H. (2009). Comparison of the effectiveness of a purported anti-static cape (the Storm Defender®) vs. a placebo cape in the treatment of canine thunderstorm phobia as assessed by owners' reports. Applied Animal Behaviour Science, 119(1-2): 78-84. https://doi.org/10.1016/j.applanim.2009.03.014
[46] Landsberg, G., Hunthausen, W., Ackerman, L. (2013). Behavior problems of the dog and cat (3rd ed.). https://n9.cl/65u14b.
[47] Denenberg, S., Landsberg, G.M. (2008). Effects of dog-appeasing pheromones on anxiety and fear in puppies during training and on long-term socialization. Journal of the American Veterinary Medical Association, 233(12): 1874-1882. https://doi.org/10.2460/javma.233.12.1874
[48] Mukhamedov, T. (1965). The effect of the combined action of I-123 and noise on the cardiac activity of the dog. Bulletin of Experimental Biology and Medicine, 59(2): 43-47. https://doi.org/10.1007/BF00782714
[49] Kim, C.Y., Ryu, J.S., Hong, S.S. (1968). Effect of air-craft noise on gastric function. Yonsei Medical Journal, 9(2): 149-154. https://doi.org/10.3349/ymj.1968.9.2.149
[50] Tielen, A.M., Kamp, A., da Silva, F.H.L., Reneau, J.P., van Leeuwen, W.S. (1969). Evoked responses to sinusoidally modulated sound in unanaesthetized dogs. Electroencephalography and Clinical Neurophysiology, 26(4): 381-394. https://doi.org/10.1016/0013-4694(69)90088-1
[51] Gue, M., Fioramonti, J., Frexinos, J., Alvinerie, M., Bueno, L. (1987). Influence of acoustic stress by noise on gastrointestinal motility in dogs. Digestive Diseases and Sciences, 32: 1411-1417. https://doi.org/10.1007/BF01296668
[52] Gue, M., Honde, C., Pascaud, X., Junien, J.L., Alvinerie, M., Bueno, L. (1988). CNS blockade of acoustic stress-induced gastric motor inhibition by kappa-opiate agonists in dogs. American Journal of Physiology-Gastrointestinal and Liver Physiology, 254(6): G802-G807. https://doi.org/10.1152/ajpgi.1988.254.6.G802
[53] Gué, M., Peeters, T., Depoortere, I., Vantrappen, G., Buéno, L. (1989). Stress-induced changes in gastric emptying, postprandial motility, and plasma gut hormone levels in dogs. Gastroenterology, 97(5): 1101-1107. https://doi.org/10.1016/0016-5085(89)91678-8
[54] Gué, M., Junien, J.L., Pascaud, X., Buéno, L. (1990). Antagonism of stress‐induced gastric motor alteration and plasma cortisol release by fedotozine (JO 1196) in dogs. Neurogastroenterology & Motility, 2(4): 258-264. https://doi.org/10.1111/j.1365-2982.1990.tb00033.x
[55] Engeland, W.C., Miller, P., Gann, D.S. (1990). Pituitary-adrenal and adrenomedullary responses to noise in awake dogs. American Journal of Physiology-Regulatory, Integrative and Comparative Physiology, 258(3): R672-R677. https://doi.org/10.1152/ajpregu.1990.258.3.r672
[56] Poncelet, L., Deltenre, P., Coppens, A., Michaux, C., Coussart, E. (2006). Brain stem auditory potentials evoked by clicks in the presence of high-pass filtered noise in dogs. Research in Veterinary Science, 80(2): 167-174. https://doi.org/10.1016/j.rvsc.2005.05.004
[57] Coppola, C.L., Enns, R.M., Grandin, T. (2006). Noise in the animal shelter environment: building design and the effects of daily noise exposure. Journal of Applied Animal Welfare Science, 9(1): 1-7. https://doi.org/10.1207/s15327604jaws0901_1
[58] Kogan, L.R., Schoenfeld-Tacher, R., Simon, A.A. (2012). Behavioral effects of auditory stimulation on kenneled dogs. Journal of Veterinary Behavior: Clinical Applications and Research, 7(5): 268-275. https://doi.org/10.1016/j.jveb.2011.11.002
[59] Scheifele, P., Martin, D., Clark, J.G., Kemper, D., Wells,

J. (2012). Effect of kennel noise on hearing in dogs. American Journal of Veterinary Research, 73(4): 482-489. https://doi.org/10.2460/ajvr.73.4.482
[60] Araujo, J.A., de Rivera, C., Landsberg, G.M., Adams, P.E., Milgram, N.W. (2013). Development and validation of a novel laboratory model of sound-induced fear and anxiety in beagle dogs. Journal of Veterinary Behavior: Clinical Applications and Research, 8(4): 204-212. https://doi.org/10.1016/j.jveb.2012.10.008
[61] Siniscalchi, M.; McFarlane, J.R.; Kauter, K.G.; Quaranta, A.; Rogers, L.J. (2013). Cortisol levels in hair reflect behavioural reactivity of dogs to acoustic stimuli. Research in Veterinary Science, 94(1): 49-54. https://doi.org/10.1016/j.rvsc.2012.02.017
[62] Hewison, L.F., Wright, H.F., Zulch, H.E., Ellis, S.L.H. (2014). Short term consequences of preventing visitor access to kennels on noise and the behaviour and physiology of dogs housed in a rescue shelter. Physiology & Behavior, 133: 1-7. https://doi.org/10.1016/j.physbeh.2014.04.045
[63] Venn, R.E., McBrearty, A.R., McKeegan, D., Penderis, J. (2014). The effect of magnetic resonance imaging noise on cochlear function in dogs. Veterinary Journal, 202(1): 141-145. https://doi.org/10.1016/j.tvjl.2014.07.006
[64] Meade, J., Formella, I., Melfi, V. (2017). A note on the effect of concerts on the behaviour of domestic dogs canis lupus familiaris at taronga zoo, sydney. International Zoo Yearbook, 51(1): 225-231. https://doi.org/10.1111/izy.12141
[65] Maccariello, C.E.M., Franzini de Souza, C.C., Morena, L., Dias, D.P.M., De Medeiros, M.A. (2018). Effects of acupuncture on the heart rate variability, cortisol levels and behavioural response induced by thunder sound in beagles. Physiology & Behavior, 186: 37-44. https://doi.org/10.1016/j.physbeh.2018.01.006
[66] Ogi, A. (2018). A case of thunderstorm phobia in a maremma sheepdog. Dog Behavior, 4(1): 37-42. https://www.researchgate.net/publication/325957895_A_case_of_thunderstorm_phobia_in_a_Maremma_sheepdog.
[67] Gin, T.E., Puchot, M.L., Cook, A.K. (2018). Impact of an auditory stimulus on baseline cortisol concentrations in clinically normal dogs. Domestic Animal Endocrinology, 64: 66-69. https://doi.org/10.1016/j.domaniend.2018.03.002
[68] Özlem, Ş. (2018). Does acoustic trauma occur in pointers due to firearm noise? A prospective study on 50 hunting dogs. Ankara Üniversitesi Veteriner Fakültesi Dergisi, 65(4): 365-372. https://doi.org/10.1501/Vetfak_0000002869
[69] Stellato, A.C., Hoffman, H., Gowland, S., Dewey, C.E., Widowski, T.M., Niel, L. (2019). Effect of high levels of background noise on dog responses to a routine physical examination in a veterinary setting. Applied Animal Behaviour Science, 214: 64-71. https://doi.org/10.1016/j.applanim.2019.03.009
[70] Overall, K.L., Dunham, A.E., Scheifele, P., Sonstrom Malowski, K. (2019). Fear of noises affects canine problem solving behavior and locomotion in standardized cognitive tests. Applied Animal Behaviour Science, 221: 104863. https://doi.org/10.1016/j.applanim.2019.104863
[71] Carrieri-Rocha, V.M., Henriques Lage Duarte, M., da Silva Vasconcellos, A. (2020). Acoustic stress in domestic dogs (Canis Familiaris) living around football stadiums. Journal of Veterinary Behavior, 37: 27-35. https://doi.org/10.1016/j.jveb.2020.04.002
[72] Gähwiler, S., Bremhorst, A., Tóth, K., Riemer, S. (2020). Fear expressions of dogs during new year fireworks: A video analysis. Scientific Reports, 10:16035. https://doi.org/10.1038/s41598-020-72841-7
[73] Gruen, M., Case, B.C., Robertson, J.B., Campbell, S., Korpivaara, M.E. (2020). Evaluation of repeated dosing of a dexmedetomidine oromucosal gel for treatment of noise aversion in dogs over a series of noise events. Veterinary Record, 187(12): 489. https://doi.org/10.1136/vr.106046
[74] Morris, E.M., Kitts-Morgan, S.E., Spangler, D.M., McLeod, K.R., Costa, J.H.C., Harmon, D.L. (2020). The impact of feeding cannabidiol (CBD) containing treats on canine response to a noise-induced fear response test. Front Vet Sci, 7. https://doi.org/10.3389/fvets.2020.569565
[75] Amaya, V., Descovich, K., Paterson, M.B.A., Phillips, C.J.C. (2020). Effects of Music Pitch and Tempo on the Behaviour of Kennelled Dogs. Animals, 11(1): 10. https://doi.org/10.3390/ani11010010
[76] Perdew, I., Emke, C., Johnson, B., Dixit, V., Song, Y., Griffith, E.H., Watson, P., Gruen, M.E. (2021). Evaluation of Pexion® (Imepitoin) for treatment of storm anxiety in dogs: A randomised, double-blind, placebo-controlled trial. Veterinary Record, 188(9): e18. https://doi.org/10.1002/vetr.18
[77] Masic, A., Landsberg, G., Milgram, B., Merali, Z., Durst, T., Vindas, P.S., Garcia, M., Baker, J., Liu, R., Arnason, J. (2021). Efficacy of souroubea-platanus dietary supplement containing triterpenes in beagle dogs using a thunderstorm noise-induced model of fear and anxiety. Molecules, 26(7): 2049. https://doi.org/10.3390/molecules26072049
[78] Stolzlechner, L., Bonorand, A., Riemer, S. (2022). Optimising puppy socialisation–short- and long-term effects of a training programme during the early socialisation period. Animals, 12(22): 3067. https://doi.org/10.3390/ani12223067
[79] Schork, I.G., Manzo, I.A., Beiral De Oliveira, M.R., Costa, F.V., Palme, R., Young, R.J., de Azevedo, C.S. (2022). How environmental conditions affect sleep? an investigation in domestic dogs (Canis Lupus Familiaris). Behavioural Processes, 199: 104662. https://doi.org/10.1016/j.beproc.2022.104662
[80] De la Fuente-Moreno, E., Paredes-Ramos, P., Carrasco-García, A., Hernandez-Cruz, B., Alvarado, M., Edwards, C. (2023). Salivary cortisol in guide dogs. Animals, 13(12):1981. https://doi.org/10.3390/ani13121981
[81] Schneider, D.C., Foss, K.D., De Risio, L., Hague, D.W., Mitek, A.E., McMichael, M. (2019). Noise-Induced hearing loss in 3 working dogs. Top Companion Anim Med, 37: 100362. https://doi.org/10.1016/j.tcam.2019.100362
[82] Malowski, K.S., Steiger, J. (2020). Hearing loss in police K9 handlers and Non-K9 handlers. International Journal of Audiology, 59(2): 109-116. https://doi.org/10.1080/14992027.2019.1663450
[83] Dornbusch, J., Boston, S., Colee, J. (2020). Noise levels in an academic veterinary intensive care unit. Journal of Veterinary Emergency and Critical Care, 30(6): 632-637.

https://doi.org/10.1111/vec.12997
[84] OMPI. (2022). Global Innovation Index 2022. https://www.wipo.int/global_innovation_index/en/2022/, accessed on Jan. 28, 2024.