

Title: An Assessment of the Health Complaints during Sojourns in Havana
of Foreign Government Employees and their Families



Technical Report by an Expert Group of the Cuban Academy of Sciences

September 2021

Havana Cuba

Cuban Expert Group



Luis C Velázquez-Pérez, MD, DrSc
President of the Cuban Academy of Sciences
Neuroscientist; Second-degree specialist in Neurophysiology and Neurology. Senior Professor of Neurophysiology and Movement Disorders. Former director and founder of the Cuban Center for Ataxia Research



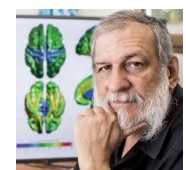
Mitchell Joseph Valdes-Sosa, MD, PhD (Standing Committee Chairman)
General Director of the Cuban Center for Neuroscience.
Neuroscientist; Second-degree specialist in Neurophysiology. Senior Professor of Neurophysiology and Cognitive Neurosciences. Member Emeritus of the Cuban Academy of Sciences



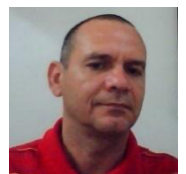
Carlos Cabal Mirabal, PhD
Senior professor of Physics, Physics Faculty, Havana University.
Former director of the Cuban Biophysics Center
Member Emeritus of the Cuban Academy of Sciences



Glauco Guillen Nieto, PhD
Research Director of the R&D Telecommunications Institute
Member of the Cuban Academy of Sciences



Pedro Antonio Valdes-Sosa, MD, PhD, DrSc
Neuroinformatics Dept. Cuban Center for Neurosciences.
Neuroscientist; Second-degree specialist in Neurophysiology; Senior Professor of Neurophysiology and Neuroinformatics. Member Emeritus of the Cuban Academy of Sciences



Evelio Gonzalez Dalmau, PhD
Head of the Magnetic Resonance Imaging Dept. at the Cuban Center for Neuroscience. Physics; Senior Professor of Physics and Bioengineering



Jose Luis Hernandez Caceres, PhD
Neural Implants Research Group. Cuban Center for Neuroscience.
Specializes in Biophysics.



Roberto Rodriguez Labrada, PhD
Deputy Director of the Cuban Center for Neuroscience.
Microbiologist. Senior Professor of Neurophysiology and Movement Disorders. Member of the Cuban Academy of Sciences



Nelson Gomez Viera, MD, PhD
Head of the Neurology Service at the Clinical & Surgical Hospital “Hermanos Ameijeiras”, Havana, Cuba.
Second-degree specialist in Neurology; Senior Professor of Neurology



Alexis Lorenzo Ruiz, PhD
President of the Cuban Society of Psychology.
Senior Professor of Psychology at the Faculty of Psychology, Havana University.



Miguel Ángel Blanco Aspiazú, MD, PhD
University Polyclinic “Ramón González Coro”, Havana, Cuba
Second-degree specialist in Internal Medicine; Senior Professor of Internal Medicine at Medical University of Havana



Dionisio F. Zaldívar Pérez, PhD
Faculty of Psychology. Havana University
Senior Professor of Psychology



Miriam de la Osa O'Relly, MD, PhD
President of the Cuban Society of Psychiatry; Head of the Psychiatry Service at the Clinical & Surgical Hospital “Hermanos Ameijeiras”, Havana, Cuba. Second-degree specialist in Psychiatry; Senior professor of Psychiatry



Antonio Paz Cordovés, MD, PhD
President of the Cuban Society of Otolaryngology
Head of the Otorhinolaryngology Service at the Clinical & Surgical Hospital “Hermanos Ameijeiras”, Havana, Cuba. Second degree specialist in Otorhinolaryngology



Manuel J. Villar Kusevic, MD
Head of the Otorhinolaryngology Service at the Hospital “Enrique Cabrera”, Havana, Cuba. Second degree specialist in Otorhinolaryngology



Juan Andres Bisset Lezcano, MD, PhD
Head of the Vector Control Department Tropical Medicine Institute “Pedro Kouri” Havana, Cuba.
Entomologist



Carlos Barceló Pérez, PhD †
Senior Professor at the National Institute of Hygiene and Epidemiology, Havana, Cuba. Physics



Yamile González Sánchez, MD
Professor at the National Institute of Hygiene and Epidemiology,
Havana, Cuba



Pedro Fleites Mestres, MD, PhD
National Center for Toxicology, Havana, Cuba.
Second-degree specialist in Toxicology.



Alejandro Torres Fortuny, MD, PhD
Head of the Audiology group. Development Direction. Cuban Center
for Neurosciences. Second-degree specialist in Neurophysiology;
Senior Professor of Neurophysiology



Ana Calzado Reyes, MD, PhD
Head of the EEG department. Cuban Center for Neurosciences.
Second-degree specialist in Neurophysiology; Senior Professor of
Neurophysiology

Table of Contents

| | |
|---|-----------|
| <i>Executive Summary</i> | 6 |
| <i>Background</i> | 8 |
| <i>"Mystery syndrome" narrative</i> | 9 |
| <i>The Cuban response</i> | 10 |
| <i>Critical appraisal of the claims supporting the "mysterious syndrome" narrative</i> | 13 |
| Claim 1: A novel syndrome with shared core symptoms and signs was found in these employees | 13 |
| Claim 2: Brain damage, originating during a sojourn in Havana, was found in all the employees | 16 |
| Claim 3: A directed source of energy that could affect people's brains from large distances after piercing physical barriers at homes or hotel rooms | 19 |
| Sound (audible; infra- and ultrasound) | 19 |
| Radiofrequency (R.F.) and microwaves..... | 20 |
| Claim 4: A weapon capable of generating such a physical agent is realizable and identified. | 24 |
| Claim 5: Evidence is unearthed that an attack has taken place. | 25 |
| Claim 6: Available evidence falsifies alternative medical explanations | 26 |
| Psychogenic and functional neurological disorders..... | 26 |
| Toxic etiology | 27 |
| <i>Conclusions</i> | 29 |
| <i>Acknowledgments</i> | 32 |
| <i>References</i> | 33 |

Executive Summary

This is a technical report by a multidisciplinary research team created by the Cuban Academy of Sciences (CAS) concerning “unidentified health incidents” reported in Havana. Employees of the U.S. complained of several symptoms when stationed in Havana, frequently linked to the hearing of strange sounds. Apparently similar symptoms emerged in some Canadian citizens, and later in other U.S. employees in other countries. A “mystery syndrome” narrative assumes that attacks with some unidentified energy weapon is the cause. The narrative rests on the following -unverified- claims: 1) A novel syndrome with shared core symptoms and signs is present in the affected employees; 2) It is possible to detect brain damage originating during a sojourn in Havana in these employees; 3) A directed energy source exists that could affect people's brains from large distances after piercing through physical barriers at homes or hotel rooms; 4) A weapon capable of generating such a physical agent is realizable and identified; 5) Evidence is unearthed that an attack has taken place; 6): Available evidence falsifies alternative medical explanations.

In this report we critically examine the plausibility of these claims and the evidence on which they are based. We conclude the “mystery syndrome” narrative is not scientifically acceptable in any of its components and has survived due to a biased use of science. Although we lack critical information, we can offer plausible interpretations that fit the available facts better than the “mystery syndrome” account. We attempt this based on published reports from the U.S. and Canada and field studies carried out in Havana. We detail in this report the arguments for these interpretations, which are listed below.

Possibly some U.S. employees while stationed in Havana felt ill due to a heterogeneous collection of medical conditions, some pre-existing before going to Cuba and others acquired due to mundane causes. Other diseases prevalent in the general population can explain most symptoms. Thus, a novel syndrome does not exist (something evident in the official U.S. reports). Only a minority of persons present noticeable brain dysfunction, most due to experiences before their stay in Havana and others due known medical conditions. No known form of energy can selectively cause brain damage (with laser-like precision) under the conditions described for the alleged incidents in Havana. The laws of physics that govern sound, ultrasound, infrasound, or radiofrequency waves (including microwaves) do not allow this. These forms of energy could not have harmed brains without being felt or heard by others,

without disrupting electronic devices in the case of microwaves, or producing other lesions (like burst eardrums or skin burns). Nothing of the sort was reported. Although there are weapons that use sound or microwaves, they are large and there is no possibility that this type of weapon would not go unnoticed (or leave a trace) if deployed in Havana under the conditions in which the strange sounds were alleged to have heard. Neither the Cuban police, F.B.I., nor Royal Canadian Mounted Police, have uncovered evidence of "attacks" on diplomats in Havana despite intense research. Finally, psychogenic and toxic explanations for many symptoms in some cases have been rejected prematurely. Specifically, all the conditions for psychogenic propagation of malaise were present in this episode, probably including an inadequate initial medical response, the early official U.S. government endorsement of an "attack" theory, and sensationalist media coverage, among others. t

CAS is willing to revise its conclusions if new evidence emerges. It welcomes attempts to disprove its counterclaims in an atmosphere of open scientific collaboration. However, it firmly rejects as an "established truth," a narrative built on flimsy foundations and faulty scientific practice. An example is the idea that an "attack took place, which is accepted without critical thinking. Some science articles -and most news stories we have read- accept as an axiom that attacks occurred in Havana, thus an idea to build theories on. Nevertheless, after four years, no evidence of attacks has emerged. It is time for a restart of the narrative. CAS reiterates its willingness to collaborate with any other U.S. or international counterparts, with the goal of better understand the health incidents involving U.S. diplomats and their families in Havana (or in any other place). Ultimately, we hope this would help alleviate suffering in affected individuals and contribute to re-establishing closer ties between the two scientific communities and eventually between the two countries.

Background

This report summarizes the work carried out by the Expert Group created by the Cuban Academy of Sciences (CAS) to assess a series of health complaints lodged by U.S. government employees (or their families) related to sojourns in Havana, Cuba. On February 17, 2017, the U.S. Embassy in Havana communicated to the Ministry of Foreign Relations of Cuba that 4 of its diplomats and one spouse had suffered "sonic attacks." Between that date and September 1, 2017, 15 additional cases emerged. There was a report of another case in 2018. In diplomatic notes (Department of State U.S., 2017), the U.S. government maintained that these employees suffered from diverse symptoms including nausea, dizziness, balance disorders, ear pain, hearing problems, facial and abdominal pain, "mental fog", headaches, and sleep disorders. Several persons reported unusual sounds or auditory sensations at the onset of their symptoms. The incidents took place at the homes of the employees or in hotel rooms. They usually affected only one person, even when several others were present. From the beginning, the U.S. Government postulated (without evidence) that long-range acoustic weapons caused these symptoms (*C-SPAN, Video Record of Senate Hearings' Attacks on U.S. Diplomats in Cuba: Response and Oversight*, n.d.; Rubio, 2018). By 2018, 24 persons had reported health problems of this type, according to Department of State (DoS) sources (Rubio, 2018).

On September 13, 2017, DoS withdrew all personnel from Havana when Secretary of State Rex Tillerson (<https://www.nytimes.com/2017/12/06/us/politics/tillerson-cuba-attacks-diplomats.html>) ordered all non-emergency personnel to leave Havana due to "health attacks" (Department of State U.S., 2017). In June 2017, the U.S. embassy informed other embassies that "attacks" were taking place. Similar (but not identical) symptoms were reported subsequently by 14 employees of the Canadian Embassy in Havana. As we write, there have been many more reports of "mysterious episodes" affecting U.S. personnel worldwide, including incidents in Austria, Germany, and even the U.S. (Barnes & Schmitt, 2021).

Medical research units in the U.S. and Canada studied several subgroups of these cases. One subgroup was initially investigated at the University of Miami (UMiami) by a team led by Professor Michael Hoffer. A team led by Professor Douglas Smith at the University of Pennsylvania's (UPenn) Center for Brain Injury and Repair studied another subgroup. The National Institutes of Health (N.I.H.) assessed another subset of cases. The Centers for

Disease Control (C.D.C.) also reviewed cases. Although some persons probably were enrolled in more than one study, the degree to which this happened is not public.

The UMiami (Hoffer et al., 2018) and UPenn teams published partial reports of their studies (Swanson et al., 2018; Verma et al., 2019) in specialized medical journals. In 2020, the DoS commissioned the National Academies of Sciences, Engineering, and Medicine (NASEM) to conduct an evaluation of the health incidents. NASEM convened a Blue-ribbon panel of physicians, engineers, and scientists, which held hearings on the topic. The panel's released an account of their deliberations in a report at the end of 2020. (National Academies of Sciences, Engineering and Medicine, 2020). The report briefly mentioned preliminary results from the N.I.H. study. A heavily redacted C.D.C. report (Centers for Disease Control and Prevention, 2019) was released soon after, but the full N.I.H. report has is not publicly available.

"Mystery syndrome" narrative

The events just described have originated a quasi-official "mystery syndrome" narrative that unfolds as follows: "Attacks on many U.S. (and Canadian) employees using with mysterious energy weapons took place at their homes or in hotel rooms in Havana. In this narrative, the symptoms reported by the employees were framed within a novel medical syndrome caused by underlying, but undetected, "brain damage". We say "quasi-official" because this story is espoused by mainstream media, by specific sectors in U.S. government agencies, groups of politicians and special interest groups in the U.S., and by some (not all) of the employees recently stationed in Havana. This narrative describes an extraordinary chain of events. Thus, it requires support from robust evidence. To sustain this narrative, one would need proof that the following claims are valid:

Claim 1: A novel syndrome with shared core symptoms and signs is present in the affected employees.

Claim 2: It is possible to detect brain damage originating during a sojourn in Havana in these employees.

Claim 3: A directed energy source exists that could affect people's brains from large distances after piercing through physical barriers at homes or hotel rooms.

Claim 4: A weapon capable of generating such a physical agent is realizable and identified.

Claim 5: Evidence is unearthed that an attack has taken place.

Claim 6: Available evidence falsifies alternative medical explanations.

Supporters of the "mystery syndrome" narrative assume solid scientific evidence for claims one to four exists (based on the scientific articles and reports published by UMiami, UPenn, and NASEM). They also advocate that evidence will emerge for claim five, and that claim six has been demonstrated.

On the contrary, we maintain that there is no convincing scientific evidence for claims 1-4. Furthermore, we sustain that there is no evidence (either U.S., Canadian or Cuban) for point five (despite intensive investigation) and that claim six has been prematurely accepted. Below, we summarize the Cuban response to these events and then examine each of the six claims in detail.

The Cuban response

Immediately after the U.S. informed Cuban authorities of the first health complaints reported by some of their employees, the Cuban Ministry of Interior initiated a criminal investigation. It also reinforced the protective services they provide to the Embassy. The Cuban Government invited the F.B.I. to investigate in Havana, and when Canadian cases emerged, an invitation was extended to the Royal Canadian police (Hernandez-Caballero, 2021). In parallel, the Cuban Academy of Sciences (CAS) created a team of Cuban scientific experts to examine the problem. A summary of the early events from the Cuban point of view and results of the initial Cuban investigations can be found in the following document with accompanying video: <http://www.granma.cu/mundo/2017-10-26/presuntos-ataques-acusticos-video>. Later CAS expanded the Expert Group, summoning scientific leaders in their respective disciplines and encompassing physicians from different fields ranging from audiology, neurology, neurophysiology, neuroimaging, epidemiology, internal medicine, psychiatry, and psychology. Other experts consulted were specialists in telecommunications, bioengineering, biology, biophysicists, and physics. The purpose was to study the reports of alleged health incidents and render an assessment based on the available information. This group was chaired by

Professor Mitchell-Valdes-Sosa, director of the Cuban Center for Neuroscience, with the active involvement of Professor Luis Velazquez-Perez, President of CAS

Although CAS accepted from the outset that some U.S. employees and family members were feeling unwell, they sought to independently identify a scientific explanation of the health complaints given the wild speculation that was appearing in the U.S. media. The CAS Expert group did not have access to medical records related to the health complaints or the patients themselves, despite repeated requests to the U.S. authorities.

In the initial communications to Cuban officials, the U.S. Government invoked "sonic attacks" that had produced ear damage. Therefore, Cuban experts in Otorhinolaryngology interviewed 20 neighbors or employees at the residences of U.S. diplomats who were affected and had complained of unusual sounds. Neighbors of Canadian diplomats were also interviewed. These interviewees did not report perceiving any distinctive sound or experiencing any new health problem. In addition, no other person who lived or worked nearby the diplomats' residences visited their community health centers for hearing problems or other conditions caused by exposure to high-pitched sound during the period in which the health incidents occurred (<http://www.granma.cu/mundo/2017-10-26/presuntos-ataques-acusticos-video>). After that, the CAS Expert Group broadened its field of inquiry to other aspects.

The lack of access to patients, their medical records, or lab reports, and barriers to direct communication with the U.S. medical researchers (at N.I.H., C.D.C., UPenn, or UMiami) working with the patients, has severely hampered the work of the CAS team. Cuban doctors only had brief contact with Dr. Hoffer from UMiami in Cuba and received a meager summary of the medical examination of the first cases. Note that the NASEM panel complained of suffering many of the same limitations.

A Cuban delegation of 6 members of the CAS Expert Group was invited to the medical department of DoS (Washington DC) in September 2019 to review evidence about the reported health incidents. They were disappointed in not being able to meet with the medical researchers directly involved with the assessments of the patients. Unfortunately, the medical staff of DoS provided no new information during this visit and simply summarized parts of an first article published in the Journal of the American Medical Association (JAMA) by the UPenn group. During this visit, the CAS team proposed conducting joint investigations on the health

incidents, something also proposed repeatedly to NASEM and the American Association for the Advancement of Science (AAAS). The collaborations never materialized.

In contrast, the Canadian Government first organized discussions of members of the medical staff from Global affairs with the CAS Expert Group in 2017 and 2019 and subsequently arranged a seminar in Havana in 2019 with the research team from the Brain Repair Center at Dalhousie University responsible for the medical research on the Canadian cases. The Dalhousie group concluded that most of their patients did not report strange sounds (Friedman et al., 2019). They hypothesized that intoxication by pesticides could have caused part of the symptoms. The Dalhousie group and the CAS team agreed to study in Havana cases of possible pesticide exposure, a project postponed due to the COVID-19 pandemic. The Dalhousie group subsequently posted their results on medRxiv (Friedman et al., 2019).

Prestigious U.S. scientists have engaged in email discussions with CAS, and several participated in the workshop "Is there a Havana Syndrome" that this organization held in March 2020 in Havana. Scientists from Europe, Canada, and New Zealand also participated together with their Cuban counterparts. The workshop was unbiased in its discussions and included a U.S. proponent of the radiofrequency hypothesis (Cuban Center for Neuroscience, 2020a, 2020b).

Thus, except for discussions with the Dalhousie group, the CAS team has had to rely on published articles, literature reviews, consultation with independent scientists worldwide and especially from the U.S., as well as carrying out field studies in Havana to reach their own conclusions. It also had access to the final report of the police investigation carried out by the Cuban Ministry of Interior, as well to the content of communications to this organization from the F.B.I. In May 2021, the IEEE (the most prominent engineering professional organization in the U.S.) organized a webinar with Prof. Kenneth Foster (UPenn) and Prof. Mitchell Valdes-Sosa as speakers. The webinar discussed "Did microwaves harm U.S. employees at its Embassy in Havana" (IEEE Philadelphia Section, IEEE Philadelphia SSIT Chapter, IEEE UK, and Ireland SSIT Chapter & SIGHT, 2021), with over 120 participants.

Critical appraisal of the claims supporting the "mysterious syndrome" narrative

Claim 1: A novel syndrome with shared core symptoms and signs was found in these employees

The UPenn group claimed in a first article in JAMA that a novel syndrome (shared by all cases) was present in the sample of 24 patients they studied (Swanson et al., 2018), a concept extrapolated by many to all other U.S. cases and even the Canadian cohort. The syndrome was proposed to consist of persistent cognitive, balance, visual/auditory dysfunction, sleep impairment, and headaches. Cognitive, vestibular, and oculomotor abnormalities, with moderate to severe sensorineural hearing loss in some individuals, were claimed to have been revealed by objective tests. The health complaints were linked to "directional sensory phenomena" in all the publications by U.S. researchers - but not by the Canadian group (Friedman et al., 2019).

An editorial by editors of JAMA (Muth & Lewis, 2018) commented on the article published in their journal by the UPenn group. This editorial cautioned that the study was a case series (not a controlled clinical trial). It lacked blinding, a comparison group, and baseline data on patients before exposure. The observations of clinicians were not standardized. It also alerted that the symptoms were nonspecific and were present in many other medical conditions. The symptoms were self-reported by patients after profuse coverage of the problem in the media. The editorial concluded that: "At this point, a unifying explanation for the symptoms experienced by the U.S. government officials described in this case series remains elusive, and the effect of possible exposure to audible phenomena is unclear" (page E2). After its publication, a flurry of letters to the editors harshly criticized this article (Bartholomew, 2018; Gianoli et al., 2018; Shura et al., 2018; Stone et al., 2018).

There are severe problems with the proposal of a novel syndrome made by Swanson et al.:

- The first problem is that there are significant differences across cases. A news article (<https://www.politico.com/news/2021/05/12/trump-havana-syndrome-probe-487716>) quotes a Department of Health and Human Services staffer as saying: "...that there was very little consistency in the symptoms across the incidents: some people reported

dizziness; others reported pain, or an unusual sound. Every person had some unique combination...".

- Formal clinical research reinforces this anecdotal indication of heterogeneity. When faced with an outbreak of illness, the standard C.D.C. procedure is to build a "case definition" (<https://www.cdc.gov/csels/dsepd/ss1978/lesson6/section2.html>) since unrelated cases (false positives) are frequently included by physician misdiagnosis or by self-diagnosis by concerned individuals. For this outbreak (Centers for Disease Control and Prevention, 2019), a presumptive case was defined as a biphasic onset of symptoms while in Cuba (or within two weeks of returning), with an initial phase with at least one of the following symptoms: head pressure, disorientation, nausea, headache, vestibular disturbances, auditory symptoms, vision changes. A secondary phase included vestibular disorders and cognitive deficits.
- Despite this lenient definition, the C.D.C. concluded that out of 95 records reviewed at the time, only 15 met their case definition (16%). However, another 31 "possible" cases were found (33%) with an even looser definition. The C.D.C. suggested that at least two sub-groups of patients were involved: one small sub-group with both phases and the another larger one with only the second phase.
- As stated on page 13 of the NASEM report (National Academies of Sciences, Engineering & Medicine, 2020): "Because of these various aspects of case heterogeneity, the committee found it difficult to know with certainty that all cases were due to the same cause(s)".
- Subjective balance, sleep, and headache complaints appear to be the most frequently reported elements. The problem is that these complaints are very frequent in the general population for the relevant age group, as documented in numerous studies (Burch et al., 2018; Chung et al., 2015; Hagen et al., 2018; Léger et al., 2008; Murrin & Schilder, 2015; Ohayon, 2011). Therefore, these highly prevalent symptoms do not sustain the claim of a novel syndrome.
- Contrary to the original UMiami and UPenn claims, objective hearing loss is not part of the proposed novel syndrome. Only 3 of 24 individuals described by Swanson et al. (2018) had abnormal audiograms, differing in their profiles. This heterogeneity in audiogram profiles indicates distinct etiologies. Furthermore, the report by UMiami (Hoffer et al., 2018)

recognized that the cases of hearing loss they found (presumably the same studied by UPenn) were due to pre-existing conditions. Pre-existing conditions were also present for the few Canadian patients with objective hearing loss (Friedman et al., 2019).

- Objective cognitive findings. Swanson et al. (2018) claimed that their cases presented widespread cognitive deficits as ascertained by neuropsychological tests. However, this finding rested on a faulty selection of thresholds for determining deviation from normality in the neuropsychological tests. This flaw was challenged in an article (Della Sala & Cubelli, 2018), a review in *Neuroskeptic* (<https://www.discovermagazine.com/mind/bad-science-of-the-havana-embassy-sonic-attack>) and a scathing editorial in the journal *Cortex*. The international Editorial Board of *Cortex* voted almost unanimously to request the JAMA article's retraction (*Cortex* Editorial Board, 2018). The first JAMA report used as their threshold the 40th percentile of the distribution values for the normal population for each of the 37 tests used. This threshold means that almost half of any group of healthy people would have "abnormal" results on each test, and almost certainly any person would be found "pathological" if they submitted to many tests (which is the case for the JAMA article). A computer simulation showed that every normal person assessed with this criterion would be considered pathological (Della Sala & McIntosh, 2018). In subsequent correspondence in *JAMA*, the authors did not defend their choice of using a 40th percentile threshold but implied that they referred to "within-individual" deviations from "their respective means" (Hampton et al., 2018). This claim is even more problematic (Della Sala et al., 2018). Also, in the Hoffer et al. paper, fourteen of the individuals considered in the study complained of cognitive impairments. These authors state that formal neuropsychological assessment confirmed these subjective complaints in nine individuals. However, the paper does not report this formal assessment.

The CAS concluded that the clinical data indicated a heterogeneous group of people whose health complaints were brought together by the interaction of other contextual psychosocial factors (Blanco-Aspiazú et al., 2021).

Claim 2: Brain damage, originating during a sojourn in Havana, was found in all the employees

The claim that brain damage originated during the employees' sojourn in Havana lacks scientific evidence. As discussed above, the first tier of evidence for this claim, the neuropsychological findings, has been discredited. A second tier would be neuroimaging findings (Verma et al., 2019). A third tier would be the oculomotor and vestibular findings claimed to demonstrate damage to the inner ear (labyrinth) by the UMiami team (Hoffer et al., 2018). Initially, Swanson et al. (2018) reported nonsignificant findings in conventional MRI neuroimaging of their cases. The subsequent article by Verma et al. (described by the authors as based on advanced neuroimaging methods) claimed: "Potential imaging-based differences between patients and controls with regard to (1) white matter and gray matter total and regional brain volumes, (2) cerebellar tissue microstructure metrics (e.g., mean diffusivity), and (3) functional connectivity in the visuospatial, auditory, and executive control subnetworks." This was again assumed to be related to "directional phenomena" allegedly perceived by the cases. However, Verma et al. cautioned that "The clinical importance of these differences is uncertain and may require further study."

There are severe problems with asserting that this study demonstrated that brain damage was found in U.S. employees linked to their stay in Havana.

- The first problem is that none of the "advanced" neuroimaging methods used in the study has been accepted for routine use in clinical practice and assessment of patients. Accepted normative data are not available for these methods that allow deciding when an individual case deviates from normality.
- The findings depend critically on the comparison of patients with a control group of healthy persons. However, there is no guarantee that the selected controls were adequately matched to patients to exclude other causes of potential imaging-based differences. Stress, rehabilitation procedures, age, functional neurological disorders, all produce changes in neuroimaging studies (Arthuis et al., 2015; De Santis et al., 2014; Ejareh dar & Kanaan, 2016; Farrell et al., 2007; Li et al., 2015), and were certainly present in the patient but not necessarily the control group. This could have generated the potential imaging-based differences. A group of people that had visited Havana under the same conditions and not reported symptoms would have constituted a better control group, if matched in critical variables.

- The reported changes show no coherent pattern: some measures show abnormalities, others show "hyper-normality" (Verma et al., 2019), suggesting that whatever caused the symptoms damaged some parts of the brain but improved others. These results do not indicate any known pathophysiological (or combination of) mechanisms.
- The study design did not allow the authors to establish if any of the imaging-based differences between patients and controls originated during the sojourn in Havana. It is troubling that Verma et al. recognize that a subset of cases (12/40) had a pre-existing brain injury. After excluding this subgroup from the analysis, the statistical significance of the many of their reported results disappeared.
- There is a concern in the international neuroimaging community about the difficulty in replicating results, as well as the possibility of erroneous and variable findings due to changes or inaccuracies in the numerous computational processing steps involved in advanced neuroimaging pipelines (Button et al., 2013; Poldrack et al., 2017; Specht, 2020). This is a pertinent caveat for the Verma et al., 2019 study given the multiplicity of analysis pipelines that were used.

The international neuroimaging community was skeptical of the Verma et al. study as summarized in The Guardian <https://www.theguardian.com/science/2019/jul/23/brain-scans-of-us-embassy-staff-to-cuba-show-abnormalities>). Professor Paul Matthews (Imperial College London) said "This paper would not meet usual standards for publication, particularly in a high-profile journal... they do not correspond to known patterns of brain injury and could not be shown to have changed in the people before and after the exposure." Professor Heidi Johansen-Berg (Wellcome Center for Integrative Neuroimaging, Oxford University) stated that the differences in the patients' brains were not clear cut. It was impossible to say whether they were linked to a particular event, the precise pattern of changes was difficult to explain and it was not clear if or how they related to the patients' symptoms. Professor Ray Dolan (Wellcome Trust Center for Neuroimaging at University College London), also cited in The Guardian article, opined that "Given what we know about functional specialisation in the brain one would expect meaningful relationships between the severity of specific deficits and the degree of change in brain regions that mediate specific functions.... The report is silent on this. I would take the findings with a pinch of salt."

The Dalhousie group studied a sample of Canadian cases. They reported alterations in white matter tracts in the posterior part of the corpus callosum and the adjacent part of the fornix (Friedman et al., 2019). However, the same caveats apply to this study, which has many discordant findings with the UPenn results. Interestingly, the NASEM report (page 15) concluded that: "the committee felt that none of the imaging studies performed so far were sufficient to serve as a basis for a case definition or management of individual subjects."

The possible vestibular involvement in most employees was hypothesized basically because of subjective complaints, which are unreliable and nonspecific as indicators of injury since they appear in a long list of medical conditions (Strupp et al., 2020). Among these are functional disorders such as persistent postural-perceptual dizziness (PPPD), a functional (not psychiatric) vestibular disorder that may be triggered by psychological conditions and which could explain chronic vestibular signs and symptoms in some patients (Popkirov et al., 2018). Also, the UPenn team used a restricted battery of vestibular tests in a small number of individuals without control group assessments (Swanson et al., 2018). Although the patients included in the UMiami study underwent a more extensive battery of vestibular function tests, very little information is available about protocols, equipment details, and normative data, which hampers proper interpretation. Furthermore, these tests were performed only on the affected group. The comparisons of patients were with historical norms, based on healthy participants possibly were not matched adequately to the target group (Hoffer et al., 2018).

Therefore, these data derived from self-reported questionnaires and limited vestibular tests are insufficient to claim the presence of a homogeneous clinical entity nor vestibular damage. The NASEM (page 14) committee concluded that: "the aggregate data derived from the subset of well-established clinical laboratory diagnostic tests presented by the four clinical groups performed weeks, months, or years after the initial onset did not identify a common pattern of structural injuries to the labyrinths or brains of patients that could explain the reported vestibular symptoms."

The UPenn team reported a high incidence of subjective oculomotor symptoms (eyestrain and convergence insufficiency). Still, the lack of baseline assessments, control group, blind examiners, and the long time between the alleged attacks and the medical interviews are important limitations. Their use of the Convergence Insufficiency Symptoms Survey is questionable due to its low specificity for convergence insufficiency (Horan et al.,

2015). Also, they described saccadic and smooth pursuit dysfunctions based on the developmental eye movements test (D.E.M.), which is used in children but does not allow for quantifying saccade dysfunction. D.E.M. performance and quantitative measures of saccadic eye movements (using established oculomotor tests) are not correlated (Ayton et al., 2009). Not enough information about the protocols and equipment used for the oculomotor assessments are available in the case of the UMiami study, which did not report specific findings of optokinetic response and saccades. Notably, the Dalhousie team using well-established methods for oculomotor assessment found no significant impairments in their patient cohort.

Claim 3: A directed source of energy that could affect people's brains from large distances after piercing physical barriers at homes or hotel rooms

Sound (audible; infra- and ultrasound)

The first hypothesis about directed energy sources causing the symptoms involved sound waves. Sound waves tallied with the auditory sensations reported by the affected individuals and with the existence of sound-based weapons used to disperse crowds (see below). The F.B.I. supplied recordings of the strange sounds allegedly heard by U.S. employees to the Cuban Government for their study. However, after some research, the idea of sound-based weapons was discarded. First, as reviewed above, it was impossible to substantiate in most patients hearing loss (a natural consequence of exposure to loud sounds). The only cases reported had pre-existing hearing loss. Second, there is no scientific report of sound causing brain damage, and to this it would have to produce devastating damage to the middle and inner ears. Third, to damage the ear sounds must be higher than 120 dB, which would have been clearly audible to any person nearby (of which no reports were ascertained despite extensive search). Fourth, recordings made by the diplomats of the alarming noises they heard were leaked to the press and posted by Associated Press online (<https://www.youtube.com/watch?v=rgbnZG85IRo>). When they were analyzed by a team of biologists from the U.S. and U.K., the grating noise they contained was identified as the mating call of the West Indies short-tail cricket (Stubbs, 2019). This team also analyzed the recordings supplied by the U.S. to the Cuban Government and found that they also contained calls from

the same species of cricket, recently described as endemic to Cuba (Yong, 2019). This result is in agreement with a previous Cuban study (Barceló-Pérez & González, 2018).

Other researchers (Yan et al., 2018) suggested that the sounds perceived by embassy staff were by-products of ultrasonic listening devices. However, ultrasound cannot produce brain damage unless the source is very close to the head since it rapidly dissipates with distance. Moreover, ultrasound would be challenging to focus on a single target, and those was also discarded as a cause for damage. The possibility of infrasound was examined since adverse health effects have been described after exposure (Lubner et al., 2020; M. Y. Zhang et al., 2016). However, several aspects have led to discount its use as a weapon. Among other factors, the large size of the infrasound generators and associated power supplies, the difficulty in concentrating their emissions, and its extremely long wavelengths compared to the target object's size make it an unlikely weapon. The *Journal of the Acoustical Society of America* published a critical review of ultrasound and other types of sound in the case of U.S. diplomats (Leighton, 2018) that rejected their contribution to the reported health effects.

Radiofrequency (R.F.) and microwaves

The NASEM report concluded (page 2): "Overall, directed pulsed R.F. energy, especially in those with the distinct early manifestations, appears to be the most plausible mechanism in explaining these cases among those that the committee considered." R.F. in this quotation refers to radiofrequency. This conclusion is puzzling because the report cites no direct evidence for the involvement of R.F. in the events in Havana or elsewhere. Moreover, the report's discussion of the scientific literature contradicts this idea in several of its paragraphs (page 21). For example: "...While there are several studies on the health effects of continuous wave and pulsed R.F. sources, there are insufficient data in the open literature on potential R.F. exposure/dosage characteristics and biological effects possible for DoS scenarios. ..." In the absence of such data, it is difficult to align specific biophysical effects within the potential R.F. exposure regime that could explain specific medical symptoms reported by DoS personnel and the variability in specific experiences and timelines of individuals."

The NASEM report indicated that symptoms such as dizziness, headache, fatigue, nausea, anxiety, cognitive deficits, and memory loss are "consistent with known R.F. effects." A recent article (Golomb, 2018) also argued that exposure to R.F. (presumably long-term

continuous waves) produces symptoms that overlap the complaints of the U.S. employees. The problem is that this constellation of symptoms is unspecific, and by the same logic could also be identified with other well-known syndromes that share the same symptoms (i.e. small vessel Cerebrovascular disease, cranial trauma, Meniere's Disease, stress disorders, "Gulf War syndrome"). The latter are not attributable to R.F. exposure. Most decisively, this conclusion is inconsistent with dozens of high-quality, double-blind experiments carried out with human volunteers. Systematic reviews of these studies have not provided evidence for a relation between the R.F. exposures and the symptoms or physiological responses that might explain embassy staff health complaints (Dongus et al., 2021; Zhou et al., 2020;) (see also <http://www.ices-emfsafety.org/expert-reviews/>). Similarly, observational studies (e.g. Elwood, 2012) have not find health effects related to alleged long-term R.F. exposures in the U.S. Moscow embassy incidents from decades ago.

Persuasive evidence for adverse health effects of microwave energy (within international exposure limits) has not been found in many authoritative reviews. This includes surveys of research in the former Soviet Union (Pakhomov & Murphy, 2000), careful assessments by Western expert groups (Scientific Committee on Emerging Newly Identified Health Risks., 2015), and international guideline committees (Vecchia, et al., 2009) A recent review reaches the same conclusion (Foster & Vijayalaxmi, 2021). While "nonthermal" microwave interactions with biological materials do exist, the required field levels are far beyond anything plausibly present (or producible) in ordinary environments (including those related to the Havana health complaints). These effects would be very damaging due to tissue heating (Foster, 2000).

Even animal experiments on R.F./microwave-induced damage to the brain have mainly produced negative results for the purposes of this review. The few observed effects have been obtained under extreme conditions not relevant to the incidents described by the U.S. employees. The experimental setups require keeping constant the geometry between the experimental subject heads and a nearby electromagnetic wave source. Firmly fixing the subject's position near the R.F. source obviously does not apply to health incidents of interest. Even so, the described effects are inconsistent and weak. A recent study (De Seze et al., 2020), with apparent effects, examined animals subjected to an intense exposure (above anything the diplomats could have experienced) with high-power, short-duration microwave

pulses (3.7 GHz, 2 G.W./m², 2.5 ns pulses, 100 pulses/sec for total of 14 min, 22 W/kg). They found an increased prevalence of cancer and a decrease in survival time. They also observed evidence of brain inflammation. However, the exposures included significant X-ray components, which probably caused the pathological effects. There were some behavioral effects; apparently, the animals avoided exposure. One cause of this could have been time-averaged exposure levels that were thermally uncomfortable. Even this does not fit reports from the DoS cases who did not experience thermal sensations.

The NASEM report argued that pulsed R.F. exposures could have caused the sounds perceived by embassy staff (and their directional dependence). The well-documented (Frey, 1961) "microwave hearing phenomenon," or "Frey effect," inspired this idea. This effect is thought to arise as follows: the R.F. pulse provokes a transient temperature rise in the head, leading to thermal expansion, which launches an acoustic wave. Thus, subjects perceive "clicks" every time an R.F. pulse (e.g., 27 μ s, 2.45 GHz pulses, 53 kW/m²) is absorbed in the head (Foster & Finch, 1974). The acoustic pressures in the typical Frey effect are many orders of magnitude too weak to cause tissue damage. People perceive audible sensations only because of the exquisite sensitivity of the human auditory system (Foster et al., 2018). Therefore, the Frey effect is a poor fit to what the U.S. employees described.

The sounds induced by pulsed microwaves are weak, even with the head exposed next to the emitting antenna they are audible only in a very quiet environment. Furthermore, it is not possible to localize in space these acoustic waves generated inside the head. Therefore, they cannot be "directional" (i.e., perceived as coming from a defined source). The U.S. employees reported sounds, and other related sensations, as originating from a particular direction, which is inconsistent with the Frey effect. This effect cannot be registered outside the head; in this case the recordings supplied by U.S. sources would be irrelevant.

The NASEM panel hypothesized short, intense microwave pulses as a cause of the health complaints. Damage thresholds increase for short pulse duration. Extrapolating from available data, Kenneth Foster (UPenn) concluded that nanosecond microwave pulses do not appear capable of producing tissue damage at feasible exposure levels that would not also be thermally damaging (Foster et al., 2016; Foster and Chou, 2021). Brain damage without skin injury is improbable. U.S. employees did not report sensations of warmth. Medical examiners did not find evidence of any type of burns (Hernandez-Caballero, 2021). Citing the Havana

incidents, a recent article models the head/brain with finite-element methods (Dagro & Wilkerson, 2021). This article concluded that: "Although the simulations show that injury thresholds could be exceeded in the case of rapidly applied large temperatures (e.g., 6 °C achieved in 1 μ s), it is unlikely that a microwave source could generate such a large temperature increase in these short timescales". Moreover, a 6 °C degree increase in temperature affecting the skin is clearly noticeable. Other attempts to model the hypothesized (but undemonstrated) microwave damage to ear and brain also require unrealistic assumptions about the R.F. sources (Lin, 2021).

Additionally, electronic equipment should have been interfered with or even disrupted by R.F. fields at the level where microwave hearing would elicit the sensation of "a loud sound". Interference with existing telecommunications, Bluetooth headsets for phones, and Wi-Fi systems (which operate in low GHz frequency bands), would also have been expected if very intense microwaves were used (Foster and Chou, 2021; Foster et al., 2015; Repacholi, 2020). However, none of the people describing the strange sounds they linked to their health complaints testified that interference with electrical devices was happening simultaneously (Hernandez-Caballero, 2021).

Notably, the Cuban police interviewed neighbors of the U.S. employees, of workers at their homes, or workers at the "Nacional" and "Capri" Hotels (implicated in some complaints). These interviews did not uncover sightings of suspicious individuals, unusual equipment, or experience of strange sounds during the times the alleged "attacks" were taking place. These locations are open and frequently visited areas (Hernandez-Caballero, 2021). These findings place severe constraints on the possibility of positioning equipment capable of generating high-energy sound or microwave beams at the locations where the events allegedly took place.

A summary of factors that decrease the plausibility of the sounds perceived by embassy staff being due to microwave hearing (from Repacholi, 2020) include:

- Massive peak and average microwave power densities would be needed to elicit the sensation of "a loud sound". This would require large microwave generating equipment, such as military radars, used close to the target.
- Embassy staff did not report any thermal sensation that high microwave average power densities would cause.

- There were no reports of electromagnetic interference that would undoubtedly result from exposure to such high peak power densities.
- The reported directional nature of the sound does not fit the description of the microwave hearing effect.

It is unfortunate that the NASEM committee did not consult more experts on the biological effects of R.F. and microwaves and that its conclusions are inconsistent with the literature they reviewed. International and Cuban experts reject the microwave hypothesis for the Havana health complaints.

Claim 4: A weapon capable of generating such a physical agent is realizable and identified.

Sound or microwave weapons already exist, which has fueled the argument that someone used them in Havana. For such weapons to be feasible in the scenarios of the alleged attacks, they would have to fit into spaces and landscapes surrounding the settings of the incidents without having attracted the attention of neighbors or other hotel guests, or the U.S. Embassy security. Also the energy produced should be able to penetrate the physical barriers at the homes and hotel rooms and be capable of selective directional beaming to affect specific individuals. We examine two well-known examples.

The first example is the Long Range Acoustic Devices (LRAD) that uses intense, disturbing sounds for crowd control (<https://www.asha.org/News/2020/Long-Range-Acoustic-Devices-for-Crowd-Control-Can-Cause-Serious-Hearing-Loss-and-Harm/>). These are large truck-based, blatantly noticeable equipment that produces indiscriminate effects on many people in large areas. They do not fit the scenarios in which the alleged attacks took place, which in conjunction with the implausibility of sound damaging the brain or labyrinth without inducing severe hearing loss, disqualifies their involvement in the events of interest. The other example is the Tactical High Power Operational Responder (THOR) developed by the United States Air Force Research Laboratory (<https://afresearchlab.com/technology/directed-energy/successstories/counter-swarm-high-power-weapon/>). This device produces high-energy microwave bursts to disable drones. Nevertheless, in addition to its large size which would have made it noticeable, it would have generated disruption of electronic devices, factors absent from the alleged incidents in Havana.

There have been reports of attempts to create smaller mobile microwave and infrasound weapons in Russia, the U.S., China, and Israel. However, what is known about these devices is inconsistent with their use for alleged events in Havana (IEEE Philadelphia Section, IEEE Philadelphia SSIT Chapter, IEEE UK, and Ireland SSIT Chapter & SIGHT, 2021). A significant difficulty in developing these weapons is related to their size and power requirements.

Claim 5: Evidence is unearthed that an attack has taken place.

This facet is outside of the purview of this report, and we refer readers to the accounts by the F.B.I., Royal Mounted Police, and Cuban police investigations, which found no evidence of an attack that could cause the reported symptoms. They concluded that sound, ultrasound, and infrasound could not be used for attacks (Hernandez-Caballero, 2021). The field studies carried out by the Cuban Expert Group, which interviewed dozens of neighbors of the U.S. employees' homes and workers at the hotels, is relevant. As stated above, none of the interviewees referred to the observation of unusual equipment or activities during the periods of interest (Hernandez-Caballero, 2021). It is interesting to note that during the same time that alleged attacks were taking place at the "Nacional" Hotel, an international symposium organized by the Kavli Foundation was taking place at that venue, with the participation of prestigious U.S. and European researchers, including a Nobel prize winner.

Also pertinent to this point are the few occasions that Cuban medical professionals had the opportunity to examine foreigners concerned about unusual sounds and possible health effects. In all cases, the investigators found a trivial explanation for the "unusual" sounds and excluded the possibility of their causing adverse health effects. For example, a foreign diplomat reported symptoms and was worried about strange sounds. When examined at the International Clinic "Cira Garcia" in Havana, the diagnosis was barotrauma caused by sea diving. In this case, police from the country of the diplomat and Cuban Police jointly investigated the strange sounds and agreed that a nearby air conditioning compressor was their origin (Hernandez-Caballero, 2021). These examples illustrate the power of the media and of declarations of U.S. government officials in inducing anxiety about "mystery attacks," resulting in what probably is a psychogenic amplification of symptoms caused by unrelated and mundane health issues.

Claim 6: Available evidence falsifies alternative medical explanations

Psychogenic and functional neurological disorders

Several letters to the Editor of JAMA -after the first UPenn report- suggested the possibility of psychogenic factors and functional neurological disorders as triggers of the neurological symptoms reported by the patients. In one of these letters, Robert Bartholomew (2018) provided arguments supporting mass psychogenic disorder in U.S. diplomats by observing that the victims were from the same social network. Mass psychogenic disorders are defined as: "the rapid spread of illness signs and symptoms affecting members of a cohesive group, for which there is no corresponding organic etiology" (Bartholomew et al., 2012; Bartholomew & Wessely, 2002). Outbreaks of psychogenic illness have resembled neurological diseases such as epilepsy, Gilles de la Tourette syndrome, and sensory disorders. When investigating suspected outbreaks of psychogenic illness and kindred phenomena, it is crucial to focus on the social context underpinning the beliefs instead of the symptoms per se (Bartholomew & Pérez, 2018).

The affected individuals, in this case, formed a closely-knit community, largely isolated from the local population, in the context of a long history of a difficult relationship between the United States and Cuban governments. The two countries had reestablished diplomatic relations only recently before the incidents began (Bartholomew, 2018), and the new administration had made clear its intentions of reversing this development. The UPenn team rejected any role for psychogenic or sociogenic factors. However, even the NASEM committee recognized that psychogenic factors and functional neurological disorders might have played a role in exacerbating, and spreading over time, the symptoms experienced by the diplomats. Significantly, the committee stated that it could not rule out the possible involvement of psychogenic disorders as they had "received no epidemiological evidence about patterns of social contacts that would permit a determination about possible social contagion." This claim is mystifying because the social patterning of the spread, which was conspicuously limited to U.S. and Canadian embassy staff and their families, was documented in two widely circulated publications that appeared well before the release of the NASEM report (Golden & Rotella, 2018; Baloh & Bartholomew, 2020).

It is also necessary to consider the possible role of functional neurological disorders in the health incidents of interest. These are real neurological disorders that produce objective signs of brain dysfunctions but are mainly triggered by psychogenic factors (Fobian & Elliott, 2019). Stone and colleagues (Popkirov et al., 2019) called attention to persistent postural perceptual dizziness (PPPD), a recently defined functional neurological disorder, as a good fit to the symptoms described by the U.S. employees. Its core symptoms are unsteadiness and dizziness (Popkirov et al., 2018), together with susceptibility to motion stimuli, cognitive disturbances, and fatigue. Consistent with this hypothesis, the N.I.H. team diagnosed PPPD in 25% of patients that they studied. Another article (Abouzari et al., 2019) that reviews the published data concluded that most patients in the Havana incidents met the International Classification of Headache Disorders criteria for vestibular migraine, which can overlap with PPPD. Likely triggers for vestibular migraine are stress and lack of sleep (Sohn, 2016), reported (Swanson et al., 2018) for many diplomats.

Toxic etiology

Toxic chemical agents were posited as a plausible cause of the health incidents after Canadian researchers found increased blood levels of temephos and pyrethroid metabolites, and decreased cholinesterase activity, in some Canadian diplomatic staff and tourists. These people had stayed in Havana during the same period as the U.S. diplomats involved in the health incidents (Friedman et al., 2019). A possible source of this intoxication was the widespread spraying of these chemical agents as insecticides against the mosquitoes causing Zika disease. Their clinical, electrophysiological, and neuroimaging assessments revealed spatial memory impairments, abnormal brain-stem auditory evoked potentials, abnormal paroxysmal slowing events in the E.E.G., and some neuroanatomical alterations (Friedman et al., 2019) in a group of cases. Previous work has shown that subacute or chronic exposure to pesticides can produce neuropsychological impairments (Rohlman et al., 2016; Sánchez-Santed et al., 2016; Zhang et al., 2016). Scientific collaboration is underway to replicate these findings in a cohort of Cuban subjects highly involved in this spraying campaign. However, this explanation does not seem to cover alleged health incidents in other countries.

The NASEM report (page 24) discarded chemical intoxication in the U.S. diplomat staff because: "...there is no convincing evidence of acute high-level exposures and the clinical

history of affected U.S. Embassy personnel is not consistent with acute organophosphate poisoning." Nevertheless, they did not rule out that the combination of pesticides and psychosocial or physical stressors can have a role in triggering some symptoms. It is disconcerting that the NASEM report ruled out the toxin hypothesis (despite the evidence found in some cases), whereas it accepted the R.F. hypothesis (for which there is absolutely no evidence in any case).

Conclusions

The evidence asserted to support the "mystery syndrome" narrative is not scientifically acceptable in any of its components. Numerous scientific publications, expert opinions, and studies on the ground in Havana contest or refute the presented evidence. Most of the claims that apparently support the narrative were even discounted by the NASEM standing committee itself, except for their perplexing endorsement of a pulsed microwave agent as the cause of the U.S. diplomats' health complaints (despite not being sustained by the evidence they reviewed). International and Cuban experts dismiss the microwave weapon idea as incompatible with the Havana events and established science.

The "mystery syndrome" narrative has survived due to a biased use of science, in which discrepant views have been suppressed, and published evidence "cherry-picked" to reinforce a narrative. Media and politicians have built on and amplified this false scientific narrative. We must explore simpler, less esoteric explanations to get closer to the truth. Due to a lack of information, CAS cannot know what happened to the U.S. employees during their sojourns in Havana. However, based on the reports from the U.S. and Canada and field studies carried out in Havana, CAS can offer a **counter-narrative** that challenges each of the claims reviewed above.

Counterclaim 1: It is possible that some U.S. employees while stationed in Havana felt ill due to a heterogeneous collection of medical conditions, some pre-existing before going to Cuba (e.g., ear trauma due to military service), and others acquired due to mundane causes such as age-related diseases, head trauma due to sports activities, and stress among many other possibilities. Thus, a heterogeneous collection of people misattributed their symptoms to a common external cause. The idea of a non-homogenous set of cases is implicit in the C.D.C., N.I.H., and NASEM reports.

Counterclaim 2: Only a minority of these cases present noticeable brain dysfunction, most due to experiences before their stay in Havana (caused by naturally acquired prevalent diseases or by head trauma), and others due to the previously mentioned functional neurological disorders. The international scientific community and the NASEM report dismiss most of the evidence presented to claim widespread brain damage in the U.S. employees. Other diseases prevalent in the general population can explain most symptoms.

Counterclaim 3: No known form of energy can selectively cause brain damage (with laser-like precision) under the conditions described for the alleged incidents in Havana. The laws of physics that govern sound, ultrasound, infrasound, or radiofrequency waves (including microwaves) do not allow this, as was recognized by U.S. and international experts. These forms of energy could not have harmed brains without being felt or heard by others, without disrupting electronic devices in the case of microwaves, or producing other lesions (like burst eardrums or skin burns).

Counterclaim 4: Although there are weapons that use sound to disperse crowds, or microwaves to disrupt drones, they are large and there is no possibility that this type of weapon would not go unnoticed (or leave a trace) if deployed in Havana. Furthermore, they cannot produce the person-selective effects described for the alleged incidents.

Counterclaim 5: Neither the Cuban police, F.B.I., nor Royal Canadian Mounted Police, have uncovered evidence of "attacks" on diplomats in Havana despite intense research.

Counterclaim 6: It is not possible to rule out the psychogenic and toxic explanations for many symptoms in some cases without further research. Specifically, all the conditions for psychogenic propagation of malaise were present in this episode.

Concerning the last counterclaim, we offer the following scenario: initially, -for whatever reason- a few individuals believed they were being "attacked" by "sonic weapons". Subsequently, an environment was created that fostered amplification of symptoms and their misattribution to improbable causes, together with a psychogenic spread of concern and the development of functional neurological disorders. The factors that created this environment were an inadequate initial medical response, the early official U.S. government endorsement of an "attack" theory, and sensationalist media coverage, among other causes.

CAS is willing to revise its conclusions if new evidence emerges. It welcomes attempts to disprove its counterclaims in an atmosphere of open scientific collaboration. However, it firmly rejects as an "established truth," a narrative built on flimsy foundations and faulty scientific practice. Each link in the chain of reasoning leading to the "mysterious syndrome" narrative is weak, so they cannot bolster each other. Additional flawed research cannot buttress the narrative. Unfortunately, farfetched speculations in some scientific fields (say neuropsychology, neuroimaging, or biomechanical modeling) are offered because they were "suggested" by other -unvalidated- conjectures.

An example is the idea that an “attack took place, which is accepted without critical thinking. Some science articles -and most news stories- we have read accept as an axiom that attacks occurred in Havana, thus an idea to build theories on. Nevertheless, after four years, no evidence of attacks has emerged. It is time for a restart of the narrative.

The CAS Expert Group deplores the lack of adequate patient medical information to carry out its work and the artificial restrictions imposed on collaboration with U.S. researchers involved in patient assessments. We sympathize with the plight of U.S. employees (or their families) that have health complaints. Since we recognize that people have been feeling ill, we think it is ethically imperative to dispel wild conspiracy theories and misattribution of symptoms to explanations that defy the laws of physics. Accomplishing the goal of cooperation and collaboration between U.S. and Cuban researchers would be a solid step to accelerate the recovery for many people affected by these incidents (Stone, 2014).

CAS reiterates its willingness to collaborate with NASEM and any other U.S. or international counterparts, with the goal of better understand the health incidents involving U.S. diplomats and their families in Havana (or in any other place). Ultimately, we hope this would help alleviate suffering in affected individuals and contribute to re-establishing closer ties between the two scientific communities and eventually between the two countries.

Acknowledgments

CAS thanks the many foreign experts (from the U.S., Europe and New Zealand) and Cuban researchers that reviewed and suggested improvements to this technical report. CAS takes full responsibility for the conclusions of the report.

References

- Abouzari, M., Goshtasbi, K., Sarna, B., Lin, H. W., & Djalilian, R. (2019). Proposal for a New Diagnosis for U . S . Diplomats in Havana , Cuba, *Medical Hypotheses*, 136: 109499. <https://doi.org/10.1016/j.mehy.2019.109499>
- Arthuis, M., Micoulaud-Franchi, J. A., Bartolomei, F., McGonigal, A., & Guedj, E. (2015). Resting cortical P.E.T. metabolic changes in psychogenic non-epileptic seizures (PNES). *Journal of Neurology, Neurosurgery & Psychiatry*, 86(10), 1106–1112. <https://doi.org/10.1136/jnnp-2014-309390>
- Ayton, L. N., Abel, L. A., Fricke, T. R., & McBrien, N. A. (2009). Developmental eye movement test: What is it really measuring? *Optometry and Vision Science*, 86(6), 722–730. <https://doi.org/10.1097/OPX.0b013e3181a6a4b3>
- Baloh, R.W., & Bartholomew, R.E. (2020). Havana Syndrome. Switzerland Copernicus Books. DOI: 10.1007/978-3-030-40746-9
- Barceló Pérez, C., & González, Y. (2018). Sonidos urbanos inusuales en una vecindad al Oeste de la ciudad de La Habana. *Revista Cubana Salud Publica*, 44(3), e1428 https://scielosp.org/scielo.php?script=sci_arttext&pid=S0864-34662018000300002&lang=pt
- Barnes, J.E., E. W., & Schmitt, E. (2021). Mysterious Ailments Are Said to Be More Widespread Among U.S. Personnel. In *The New York Times*. <https://www.nytimes.com/2021/05/12/us/politics/biden-cia-brain-injury.html>
- Bartholomew, R. E., (2018). Neurological Symptoms in U.S. Government Personnel in Cuba. *Journal of the American Medical Association*, 320(6), 602. <https://doi.org/10.1001/jama.2018.8702>
- Bartholomew, R. E., & Wessely, S. (2002). Protean nature of mass sociogenic illness: from possessed nuns to chemical and biological terrorism fears. *The British Journal of Psychiatry: The Journal of Mental Science*, 180, 300–306. <https://doi.org/10.1192/bjp.180.4.300>
- Bartholomew, R. E., Wessely, S., & Rubin, G. J. (2012). Mass psychogenic illness and the social network: Is it changing the pattern of outbreaks? *Journal of the Royal Society of Medicine, Supplement*, 105(12), 509–512. <https://doi.org/10.1258/jrsm.2012.120053>
- Bartholomew, R.E., & Pérez, D. F. Z. (2018). Chasing ghosts in Cuba: Is mass psychogenic illness masquerading as an acoustical attack? *International Journal of Social Psychiatry*, 64(5), 413–416. <https://doi.org/10.1177/0020764018766185>
- Blanco Aspiazu, M. A., Viera, N. G., Ruiz, A. L., Soza, M. V., Pérez, L. V., Simeón, A., Cordobés, P., Pérez, D. F. Z., De, M., & Reilly, O. O. (2021). Lack of scientific consistency in two investigations of case series of United States diplomats in Havana. *Revista Cubana de Medicina*, 60(2), e1945
- Burch, R., Rizzoli, P., & Loder, E. (2018). The Prevalence and Impact of Migraine and Severe Headache in the United States: Figures and Trends From Government Health Studies. *Headache*, 58(4), 496–505. <https://doi.org/10.1111/head.13281>
- Button, K. S., Ioannidis, J. P. A., Mokrysz, C., Nosek, B. A, Flint, J., Robinson, E. S. J., & Munafò, M. R. (2013). Power failure: why small sample size undermines the reliability of neuroscience. *Nature Reviews Neuroscience*, 14(5), 365–376. <https://doi.org/10.1038/nrn3475>

C-SPAN, Video record of Senate hearings 'Attacks on U.S. diplomats in Cuba: Response and oversight. (n.d.). <https://www.c-span.org/video/?439474-1/state-department-officials-testify-attacks-us-diplomats-cuba>

Centers for Disease Control and Prevention. (2019). Cuba Unexplained Events Investigation—Final Report: Havana, Cuba, August 2016 to March 2019.

Chung, K., Yeung, W., Ho, F. Y., Yung, K., & Yu, Y. (2015). Cross-cultural and comparative epidemiology of insomnia : the Diagnostic and Statistical Manual (D.S.M.), International Classification of Diseases (I.C.D.) and International Classification of Sleep Disorders (ICSD). *Sleep Medicine*, 16(4), 477–482. <https://doi.org/10.1016/j.sleep.2014.10.018>

Cortex Editorial Board. (2018). Responsibility of neuropsychologists: The case of the "sonic attack." *Cortex*, 108, A1–A2. <https://doi.org/10.1016/j.cortex.2018.10.001>

Cuban Center for Neuroscience. (2020a). *Is there the Havana Syndrome?. Day 1.* INFOMED. <https://youtu.be/ZlwGUV8M8l8>

Cuban Center for Neuroscience. (2020b). *Is there the Havana Syndrome? Day 2.* INFOMED. <https://youtu.be/-cudJV8Qmts>

Dagro, A., & Wilkerson, J. (2021). A computational investigation of strain concentration in the brain in response to a rapid temperature rise. *Journal of the Mechanical Behavior of Biomedical Materials*, 115:104228. <https://doi.org/10.1016/j.jmbbm.2020.104228>

De Santis, S., M. Drakesmith, S. Bells, Y. Assaf, & Jones, D. K. (2014). Why diffusion tensor M.R.I. does well only some of the time: Variance and covariance of white matter tissue microstructure attributes in the living human brain. *NeuroImage*, 89(100), 35–44. <https://doi.org/10.1016/j.neuroimage.2013.12.003>

De Seze, R., Poutriquet, C., Gamez, C., Maillot-Maréchal, E., Robidel, F., Lecomte, A., & Fonta, C. (2020). Repeated exposure to nanosecond high power pulsed microwaves increases cancer incidence in rat. *PLoS O.N.E.*, 15(4), 1–14. <https://doi.org/10.1371/journal.pone.0226858>

Della Sala, S., & Cubelli, R. (2018). Alleged "sonic attack" supported by poor neuropsychology. *Cortex*, 103, 387–388. <https://doi.org/10.1016/j.cortex.2018.03.006>

Della Sala, S., & McIntosh, R. D. (2018). Cognitive impairments that everybody has. *Journal of Neurology*, 265(7), 1706–1707. <https://doi.org/10.1007/s00415-018-8914-8>

Della Sala, S., McIntosh, R. D., Cubelli, R., Kacmarski, J. A., Miskey, H. M., & Shura, R. D. (2018). Cognitive symptoms in U.S. government personnel in Cuba: The mending is worse than the hole. *Cortex*, 108, 287–288. <https://doi.org/10.1016/j.cortex.2018.10.002>

Department of State U.S. (2017). Diplomatic note to the Cuban Government from the Department of State, No 94/21.

Dongus, S., Jalilian, H., Schürmann, D., & Rösli, M. (2021). Health effects of WiFi radiation: a review based on systematic quality evaluation. In *Critical Reviews in Environmental Science and Technology*. <https://doi.org/10.1080/10643389.2021.1951549>

Ejareh Dar, M., & Kanaan, R. A. A. (2016). Uncovering the etiology of conversion disorder: Insights from functional neuroimaging. *Neuropsychiatric Disease and Treatment*, 12, 143–153. <https://doi.org/10.2147/NDT.S65880>

Elwood, J. M. (2012). Microwaves in the cold war: the Moscow embassy study and its interpretation. Review of a retrospective cohort study. *Environmental Health : A Global Access Science Source*, 11, 85. <https://doi.org/10.1186/1476-069x-11-85>

- Farrell, J. A. D., Landman, B. A., Jones, C. K., Smith, S. A., Prince, J. L., van Zijl, P. C. M., & Mori, S. (2007). Effects of signal-to-noise ratio on the accuracy and reproducibility of diffusion tensor imaging-derived fractional anisotropy, mean diffusivity, and principal eigenvector measurements at 1.5 T. *Journal of Magnetic Resonance Imaging : JMRI*, 26(3), 756–767. <https://doi.org/10.1002/jmri.21053>
- Fobian, A. D., & Elliott, L. (2019). A review of functional neurological symptom disorder etiology and the integrated etiological summary model. *Journal of Psychiatry & Neuroscience : JPN*, 44(1), 8-18 <https://doi.org/10.1503/jpn.170190>
- Foster, K R, & Moulder, J. E. (2015). Can Wi-Fi Affect Brain Function? *Radiation Research*, 184(6), 565–567. <https://doi.org/10.1667/RR14282.1>
- Foster, K. R. (2000). Thermal and nonthermal mechanisms of interaction of radio-frequency energy with biological systems. *IEEE Transactions on Plasma Science*, 28(1), 15–23. <https://doi.org/10.1109/27.842819>
- Foster, K. R., & Finch, E. D. (1974). Microwave hearing: Evidence for thermoacoustic auditory stimulation by pulsed microwaves. *Science*, 185(4147), 256–258. <https://doi.org/10.1126/science.185.4147.256>
- Foster, K. R., & Vijayalaxmi. (2021). Needed: More Reliable Bioeffects Studies at “High Band” 5G Frequencies. *Frontiers in Communications and Networks*, 2(August), 1–8. <https://doi.org/10.3389/frcmn.2021.721925>
- Foster, K. R., Ziskin, M. C., & Balzano, Q. (2016). Thermal Response of Human Skin to Microwave Energy: A Critical Review. *Health Physics*, 111(6), 528–541. <https://doi.org/10.1097/HP.0000000000000571>
- Foster, K. R., Ziskin, M. C., Balzano, Q., & Bit-Babik, G. (2018). Modeling Tissue Heating from Exposure to Radiofrequency Energy and Relevance of Tissue Heating to Exposure Limits: Heating Factor. *Health Physics*, 115(2), 295–307. <https://doi.org/10.1097/HP.0000000000000854>
- Foster, K.R. & Chou C.K.. (2021). Did Microwaves Harm US Employees at Its Embassy in Havana?. <https://sciencebasedmedicine.org/did-microwaves-harm-us-employees-at-its-embassy-in-havana/>
- Frey, A. H. (1961). Auditory system response to radio frequency energy. Technical note. *Aerospace Medicine*, 32, 1140–1142. <http://www.ncbi.nlm.nih.gov/pubmed/13895080>
- Friedman, A., Calkin, C., Adams, A., Suarez, G. A., Bardouille, T., Hacohen, N., Green, A. L., Gupta, R. R., Hashmi, J., Kamintsky, L., Kim, J. S., Laroche, R., MacKenzie, D., Milikovsky, D., Oystreck, D., Newton, J., Noel, G., Ofer, J., Quraan, M., ... Bowen, C. (2019). Havana Syndrome Among Canadian Diplomats: Brain Imaging Reveals Acquired Neurotoxicity. medRxiv 190007096. <https://doi.org/10.1101/19007096>
- Gianoli, G. J., Soileau, J. S., & Wackym, P. A. (2018). Neurological Symptoms in U.S. Government Personnel in Cuba. *Journal of the American Medical Association*, 320(6), 603. <https://doi.org/10.1001/jama.2018.8713>
- Golden, T., & Rotella, S. (2018). The sound and the fury: inside the mystery of the Havana embassy. ProPublica. February 14 <https://www.propublica.org/article/diplomats-in-cuba>. Accessed 3 November 30 2019.
- Golomb, B. A. (2018). Diplomats’ Mystery Illness and Pulsed Radiofrequency/Microwave Radiation. *Neural Computation*, 30(11), 2882–2985. https://doi.org/10.1162/neco_a_01133

Hagen, K., Åsberg, A. N., Uhlig, B. L., Tronvik, E., Brenner, E., Stjern, M., Helde, G., Gravdahl, G. B., & Sand, T. (2018). The epidemiology of headache disorders: a face-to-face interview of participants in HUNT4. *Journal of Headache and Pain*, 19(1), 2–7. <https://doi.org/10.1186/s10194-018-0854-2>

Hampton, S., Swanson, R. L., & Smith, D. H. (2018). Neurological symptoms in US government personnel in Cuba-Reply. *Journal of the American Medical Association*, 320(6), 604-605. <https://doi.org/10.1001/jama.2018.8737>

Hernandez-Caballero, R. (2021). Interview in *Juventud Rebelde*. To be published.

Hoffer, M. E., Levin, B. E., Snapp, H., Buskirk, J., & Balaban, C. (2018). Acute findings in an acquired neurosensory dysfunction. *Laryngoscope Investigative Otolaryngology*, <https://doi.org/10.1002/lio2.231>

Horan, L. A., Ticho, B. H., Khammar, A. J., Allen, M. S., & Shah, B. A. (2015). Is the convergence insufficiency symptom survey specific for convergence insufficiency? A prospective, randomized study. *American Orthoptic Journal*, 65(1), 99–103. <https://doi.org/10.3368/aoj.65.1.99>

IEEE Philadelphia Section, IEEE Philadelphia SSIT Chapter, IEEE UK and Ireland SSIT Chapter, & SIGHT, S. I.-A. (2021). *Did Microwaves Harm us Employees at its Embassy in Havana? (IEEE SSIT lecture)*. <https://sciencebasedmedicine.org/did-microwaves-harm-us-employees-at-its-embassy-in-havana/>

Léger, D., Poursain, B., Neubauer, D., & Uchiyama, M. (2008). An international survey of sleeping problems in the general population. *Current Medical Research and Opinion*, 24(1), 307–317. <https://doi.org/10.1185/030079907X253771>

Leighton, T. G. (2018). Ultrasound in air—Guidelines, applications, public exposures, and claims of attacks in Cuba and China. *The Journal of the Acoustical Society of America*, 144(4), 2473–2489. <https://doi.org/10.1121/1.5063351>

Li, R., Liu, K., Ma, X., Li, Z., Duan, X., An, D., Gong, Q., Zhou, D., & Chen, H. (2015). Altered Functional Connectivity Patterns of the Insular Subregions in Psychogenic Nonepileptic Seizures. *Brain Topography*, 28(4), 636–645. <https://doi.org/10.1007/s10548-014-0413-3>

Lin, J. C. (2021). *Auditory Effects of Microwave Radiation (pp. 324-326)*. Springer, Cham.

Lubner, R. J., Kondamuri, N. S., Knoll, R. M., Ward, B. K., Littlefield, P. D., Rodgers, D., Abdullah, K. G., Remenschneider, A. K., & Kozin, E. D. (2020). Review of Audiovestibular Symptoms Following Exposure to Acoustic and Electromagnetic Energy Outside Conventional Human Hearing. *Frontiers in Neurology*, 11, 234. <https://doi.org/10.3389/fneur.2020.00234>

Murdin, L., & Schilder, A. G. M. (2015). Epidemiology of balance symptoms and disorders in the community: A systematic review. *Otology and Neurotology*, 36(3), 387–392. <https://doi.org/10.1097/MAO.0000000000000691>

Muth, C. C., & Lewis, S. L. (2018). Neurological Symptoms Among U.S. Diplomats in Cuba. *Journal of the American Medical Association*, 319(11), 1098-1100. <https://doi.org/10.1001/jama.2018.1780>

National Academies of Sciences, Engineering, & Medicine. (2020). *An Assessment of Illness in U.S. Government Employees and Their Families at Overseas Embassies* (D. A. Relman & J. Pavlin (eds.)). National Academies Press. <https://doi.org/10.17226/25889>

- Ohayon, M. M. (2011). Epidemiological Overview of Sleep Disorders in the General Population. *Sleep Medicine Research*, 2(1), 1–9. <https://doi.org/10.17241/smr.2011.2.1.1>
- Pakhomov, A. G., & Murphy, M. R. (2000). A Comprehensive Review of the Research on Biological Effects of Pulsed Radiofrequency Radiation in Russia and the Former Soviet Union. In J. C. Lin (Ed.), *Advances in Electromagnetic Fields in Living Systems* (pp. 265–290). Springer US. https://doi.org/10.1007/978-1-4615-4203-2_7
- Poldrack, R. A., Baker, C. I., Durnez, J., Gorgolewski, K. J., Matthews, P. M., Munafò, M. R., Nichols, T. E., Poline, J.-B., Vul, E., & Yarkoni, T. (2017). Scanning the horizon: towards transparent and reproducible neuroimaging research. *Nature Reviews Neuroscience*, 18(2), 115–126. <https://doi.org/10.1038/nrn.2016.167>
- Popkirov, S., Baguley, D. M., Carson, A. J., Brown, R. J., & Stone, J. (2019). The neurology of the Cuban "sonic attacks." *The Lancet Neurology*, 18(9), 817–818. [https://doi.org/10.1016/S1474-4422\(19\)30246-7](https://doi.org/10.1016/S1474-4422(19)30246-7)
- Popkirov, S., Staab, J. P., & Stone, J. (2018). Persistent postural-perceptual dizziness (PPPD): a common, characteristic and treatable cause of chronic dizziness. *Practical Neurology*, 18(1), 5–13. <https://doi.org/10.1136/practneurol-2017-001809>
- Repacholi, M. H. (2020). Rapid Response Group (R.R.G.)'s review on "An assessment of illness in U.S. government employees and their families at overseas embassies." [https://www.jeic-emf.jp/assets/files/pdf/whats_new/20201220RRG_Scientific\(ENG\).pdf](https://www.jeic-emf.jp/assets/files/pdf/whats_new/20201220RRG_Scientific(ENG).pdf)
- Rohlman, D. S., Ismail, A. A., Rasoul, G. A., Bonner, M. R., Hendy, O., Mara, K., Wang, K., & Olson, J. R. (2016). A 10-month prospective study of organophosphorus pesticide exposure and neurobehavioral performance among adolescents in Egypt. *Cortex*, 74, 383–395. <https://doi.org/10.1016/j.cortex.2015.09.011>
- Rubio, M. (2018). Attacks on US diplomats in Cuba: response and oversight. *US Senate Committee on Foreign Relations*, 9.
- Sánchez-Santed, F., Colomina, M. T., & Herrero Hernández, E. (2016). Organophosphate pesticide exposure and neurodegeneration. *Cortex*, 74, 417–426. <https://doi.org/10.1016/j.cortex.2015.10.003>
- Scientific Committee on Emerging Newly Identified Health Risks. (2015). Opinion on potential health effects of exposure to electromagnetic fields. *Bioelectromagnetics*, 36(6), 480–484.
- Shura, R. D., Kacmarski, J. A., & Miskey, H. M. (2018). Neurological Symptoms in U.S. Government Personnel in Cuba. *Journal of the American Medical Association*, 320(6), 603. <https://doi.org/10.1001/jama.2018.8698>
- Sohn, J. (2016). Recent Advances in the Understanding of Vestibular Migraine. *Behavioural Neurology*, 2016, 1801845. <https://doi.org/10.1155/2016/1801845>
- Specht, K. (2020). Current Challenges in Translational and Clinical fMRI and Future Directions. *Frontiers in Psychiatry*, 10, 924. <https://doi.org/10.3389/fpsy.2019.00924>
- Stone, J. (2014). Functional neurological disorders: The neurological assessment as treatment. *Neurophysiologie Clinique*, 44(4), 363–373. <https://doi.org/10.1016/j.neucli.2014.01.002>
- Stone, J., Popkirov, S., & Carson, A. J. (2018). Neurological Symptoms in U.S. Government Personnel in Cuba. *Journal of the American Medical Association*, 320(6), 602. <https://doi.org/10.1001/jama.2018.8706>

Strupp, M., Dlugaiczyk, J., Ertl-Wagner, B. B., Rujescu, D., Westhofen, M., & Dieterich, M. (2020). Vestibular disorders: Diagnosis, new classification and treatment. *Deutsches Arzteblatt International*, 117(17), 300–310. <https://doi.org/10.3238/arztebl.2020.0300>

Stubbs, A. (2019). Recording of "sonic attacks" on U . S . diplomats in Cuba spectrally matches the echoing call of a Caribbean cricket. *bioRxiv* 510834. <https://doi.org/10.1101/510834>

Swanson, R. L., Hampton, S., Green-McKenzie, J., Diaz-Arrastia, R., Sean Grady, M., Verma, R., Biester, R., Duda, D., Wolf, R. L., & Smith, D. H. (2018). Neurological manifestations among U.S. government personnel reporting directional audible and sensory phenomena in Havana, Cuba. *Journal of the American Medical Association*, 319(11), 1125–1133. <https://doi.org/10.1001/jama.2018.1742>

Vecchia P, Matthes R, Ziegelberger G, Lin J, Saunders R, S. A. (2009). Exposure to high frequency electromagnetic fields, biological effects and health consequences (100 kHz-300 GHz). In *International Commission on Non-Ionizing Radiation Protection* (p. 378).

Verma, R., Swanson, R. L., Parker, D., Aziz, A., Ismail, O., Shinohara, R. T., Alappatt, J. A., Doshi, J., Davatzikos, C., Gallaway, M., Duda, D., Chen, H. I., Kim, J. J., Gur, R. C., Wolf, R. L., Grady, M. S., Hampton, S., Diaz-Arrastia, R., & Smith, D. H. (2019). Neuroimaging Findings in U.S. Government Personnel with possible exposure to directional phenomena in Havana, Cuba. *Journal of the American Medical Association*, 322(4), 336-347. <https://doi.org/10.1001/jama.2019.9269>

Yan, C., Fu, K., & Xu, W. (2018). On Cuba, Diplomats, Ultrasound, and Intermodulation Distortion. *Computers in Biology and Medicine Journal*, 104 (2019), 250-266. <https://doi.org/10.1016/j.combiomed.2018.11.012>

Yong, S. (2019). The fast-calling short-tailed cricket *Anurogryllus celerinictus* Walker , 1973 (Orthoptera : Gryllidae) occurs in Cuba , Greater Antilles. *Ecologica Montenegrina*, 167, 163–167.

Zhang, M. Y., Chen, C., Xie, X. J., Xu, S. L., Guo, G. Z., & Wang, J. (2016). Damage to Hippocampus of Rats after Being Exposed to Infrasound. *Biomed Environ Sci*, 29(6), 435–442. <https://doi.org/10.3967/bes2016.056>

Zhang, X., Wu, M., Yao, H., Yang, Y., Cui, M., Tu, Z., Stallones, L., & Xiang, H. (2016). Pesticide poisoning and neurobehavioral function among farm workers in Jiangsu, People's Republic of China. *Cortex*, 74, 396–404. <https://doi.org/10.1016/j.cortex.2015.09.006>

Zhou, H., Xu, R., Ding, K., Liu, C., & Zhong, F. (2020). Effects of cell phone radio-frequency radiation on the sleep outcomes : A systematic review and Meta-Analysis of randomized controlled trials. *Chronic Diseases Prevention Review*, 13, 9–21.