Diplomats' Mystery Illness and

Pulsed Radiofrequency/ Microwave Radiation

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Abstract:

Importance: A "mystery" illness striking US and Canadian diplomats to Cuba (and now China) "has confounded the FBI, the State Department and US intelligence agencies." Sonic explanations for the so-called "health attacks" have long dominated media reports, propelled by peculiar sounds heard and auditory symptoms experienced. Sonic mediation was justly rejected by experts. We assessed whether pulsed radiofrequency/microwave radiation (RF/MW) exposure can accommodate facts - including unusual ones - reported in diplomats.

Observations: 1. Noises: Chirping, ringing or grinding noises were heard at night, during episodes reportedly triggering health problems, by many diplomats. Some reported that sounds were localized with laserlike precision; or said the sounds seemed to follow them (within the territory in which they were perceived). Pulsed RF/MW engenders just these apparent "sounds" via the "Frey effect." Perceived "sounds" differ by head dimensions and pulse characteristics, and can be perceived as located behind, in or above the head. Ability to hear the "sounds" depends on high frequency hearing and low ambient noise. 2. Signs/symptoms: Hearing loss and tinnitus are prominent in affected diplomats – and in RF/MW-affected individuals. *Each* of protean symptoms that diplomats report, also affect persons reporting symptoms from RF/MW: Sleep problems, headaches, and cognitive problems dominate in both groups. Sensations of pressure or vibration figure in each. Both encompass vision, balance and speech problems, and nosebleeds. Brain injury and brain swelling are reported in both. 3. Mechanisms: Oxidative stress provides a documented mechanism of RF/MW injury compatible with reported signs and symptoms; sequelae of endothelial dysfunction (yielding blood flow compromise), membrane damage, blood brain barrier disruption, mitochondrial injury, apoptosis, and autoimmune triggering afford downstream mechanisms, of varying persistence, that merit investigation. 4. Of note, microwaving of the US embassy in Moscow is historically documented.

Conclusions and Relevance: Reported facts appear consistent with pulsed RF/MW as the source of injury in Cuba diplomats. Non-diplomats citing symptoms from RF/MW, often with an inciting pulsed-RF/MW

exposure, report compatible health conditions. Under the RF/MW hypothesis, lessons learned for diplomats and for RF/MW-affected “civilians” may each aid the other.

Introduction:

More than two dozen American diplomats in Cuba[1,2], and their families[3], plus a smattering of Canadian diplomats in Cuba[4,5] and their families[6], reportedly developed a "mystery" illness[4,7-9] that "has confounded the FBI, the state department and US intelligence agencies"[9], "baffling US officials"[10]: "'It's just mystery after mystery after mystery'"[10]. Problems began in 2016, began to be widely reported in 2017, and as of January 2018, "'We are not much further ahead than we were in finding out why this occurred,' Undersecretary of State Steve Goldstein said"[1]. Similar problems first were recognized in China in April 2018, and "a number of diplomats at the US consulate in Guangzhou, China had been sent home with similar symptoms"[2,11-13] – by June's end, "at least eight" from the consulate in Guangzhou, and "at least 11" from China more broadly[14].

Media reports have long characterized these so-called "health attacks"[15-17] as "sonic attacks"[2,7-10,18-20].

This characterization persisted despite rejection of sonic explanations by experts[8-10,21,22]. E.g. "No single, sonic gadget seems to explain such an odd, inconsistent array of physical responses"[10]. Per psychoacoustics expert Joseph Pompei: "'Brain damage and concussions, it's not possible.'…'Somebody would have to submerge their head in powerful ultrasound transducers'"[10]. Some suggested a viral hypothesis[1], but this fails to explain many features of these cases, including the strange noises associated with inciting events in some; and there isn't a known viral illness with a compatible profile of symptoms. Though "officials told senators the US government knew of no weapon, sonic or otherwise, that could produce the effects seen in the Cuba patients"[1], to this date, some media sources continue to reference sonic attacks[2].

A different explanation is proposed that, it is suggested, better accommodates the facts – including the "odd, inconsistent array of physical responses"[10] and other "mysterious" and protean features reported. Reported features are assessed for compatibility to known effects of radiofrequency/ microwave radiation (**RF/MW**), particularly pulsed RF/MW. Symptoms and signs are assessed against symptoms and signs reported by people

that report health effects from RF/MW exposure – a condition that has been termed "radiofrequency sickness"[23], "microwave syndrome"[24], or to encompass people experiencing problems from exposures beyond a specific part of the electromagnetic spectrum, "electromagnetic hypersensitivity"[25-29], "electrosensitivity"[30-32] or "electrohypersensitivity"[33-38].

Methods:

Features of diplomats' "health attacks" – origins, symptoms, and findings are delineated, and examined in relation to evidence regarding symptoms from RF/MW.

Features to be examined for compatibility with an RF/MW-explanation include the following. Strange noises were heard by some diplomats during apparent inciting episodes[5,11]. The noises that were heard differed markedly for different diplomats[5]. The various descriptions included high pitched chirping similar to crickets or cicadas, ringing and grinding[10]. The noises were heard primarily at night[10]. Other diplomats heard no noises[5], and were not aware of any inciting episodes – just onset of symptoms. In at least some cases, incidents (and noises) were confined to "parts of rooms with laser-like specificity"[10]. And, within the area in which a sound was perceived, it seemed to follow the person around the room[11].

Auditory symptoms are a prominently reported and distinctive feature (though not present in all) and include hearing loss[6,9,10,15,17,39] and tinnitus[5,6,9,40], and particularly during inciting episodes in some, ear pain[40].

Other symptoms are protean and vary markedly from individual to individual -- "an odd, inconsistent array of physical symptoms"[10]. Sleep symptoms[6,41,42], headache[5,6,15], cognitive dysfunction[6,10,40,41], and fatigue[6,40] are prominent among the "nonspecific" symptoms. In some, problems were temporary and apparently recovered with time away from the exposure[9]; others experienced persistent problems[3,5].

Potentially objectively measurable problems with speech[9,10], balance[9,10,41,42] and vision[41,42] as well as epistaxis (nosebleed)[9] are a feature in some. Peculiar sensory symptoms of pressure and vibration are reported[41]. Brain injury[3,5,9,43], white matter abnormalities[44], and brain swelling[5, 9] have been reported.

To assess compatibility of symptoms in diplomats with those experiencing symptoms from RF/MW, we focus on those who are symptomatic in each group. "Only a minority of embassy staff were stricken"[11] and it is these who have been reported upon and studied. The appropriate comparator are the minority who are symptomatic from RF/MW exposures.

Peer reviewed publications are the primary source of information. However, the most authoritative source for information about symptoms and experiences of individuals is affected individuals themselves: peer review confers no benefit and has no power to adjudicate individuals' reports. For this reason, peer reviewed literature to address issues of science is complemented by sources that have elicited and reported on symptoms and experiences of diplomats, or of RF/MW affected individuals, extending to encompass news reports, surveys, statements of affected individuals, or when applicable other "gray literature". For diplomats, news/ media reports are complemented by a *Jama* report focused on neurological symptoms in diplomats[41]. Information that references "news," rather than science, also cites media sources.

Mechanisms by which RF/MW may cause reported problems are cursorily addressed. Sources of RF/MW reported to affect the comparator group, and potential RF/MW sources of diplomats' symptoms, are briefly reviewed.

Results:

Table 1 reviews characteristics of noises reported by diplomats in inciting episodes, and compatibility with RF/MW. Pulsed RF/MW in the 2.4-10,000MHz range produces perceived noises that resemble sounds "such

as a click, buzz, hiss, knock, or chirp" – just as diplomats report[45]. Ability to hear Frey "sounds" is reported to depend on high frequency hearing, and on low ambient noise[45] – through a phenomenon termed the "Frey effect." (Synonyms include "microwave auditory effect," "RF hearing" and variations of these.) This fits reports that noises were not universally perceived. The requirement for low ambient noise accounts for perception of "sounds" primarily at night[10]. The primary pitch perceived reportedly relates to head dimensions[45] – in addition to pulse waveform and other characteristics -- accounting for different "sounds" perceived by different diplomats. Sounds were localized with "laserlike" specificity in some cases, supposedly defying known physics[10]. This may defy the physics of sound, but not the physics of RF/MW: lasers *are* electromagnetic radiation (**EMR**). One diplomat reported that the sound seemed to follow him within the space in which it was heard[11]. Frey "sounds" are also reported to follow the person, often perceived as slightly behind the head, regardless of the body orientation relative to the source of radiation[45-47]. Of note, Frey induction is not governed by *average* radiation intensity, but the energy in a single pulse[45]. (Analogously, if a jackhammer hit each 2 minutes, the low time-averaged pressure would not explain the damage.)

Table 2 reviews diplomats' symptoms and signs, and compatibility of these with RF/MW.

Auditory symptoms, including tinnitus, hearing loss, and ear pain or pressure are prominent in diplomats[41] and in persons affected by RF/MW[48-51]. Symptoms are protean in both groups. Prevalent among non-auditory "nonspecific" symptoms are sleep problems, headaches, cognitive problems, and to a lesser degree dizziness and nausea[9,10,40,41,48-51]. Additional more specific symptoms that are in principle objectively measurable include problems with balance, speech, vision, and epistaxis, i.e. nosebleed[9,10,41,48,49,51]. Peculiar sensory symptoms are reported in both, including pressure and vibrations[41,49]. Reported brain findings have included brain swelling, problems consistent with traumatic brain injury, and white matter abnormalities. Each such feature is also observed in those with symptoms ascribed to RF/MW.

Table 3 lists symptoms commonly reported in diplomats, together with percentages reporting each symptom, for symptoms assessed in the neurological appraisal of Cuba diplomats or mentioned in news reports[9,10,40,41].

These symptoms (when elicited) are ranked by prevalence, in surveys of persons exposed to specific sources of RF/MW, or with symptoms ascribed to EMR exposure[48-51]. Fractions of symptomatic diplomats who report each symptom[41] appear similar to fractions of those symptomatic with EMR symptoms, who do so. Comparing rates in diplomats[41] to those in a peer reviewed study of EMR affected individuals[50] on symptoms tallied in both, symptom rates were: Headache 81%-vs-81%; Cognitive problems 81%-vs-81%; Sleep problems 86%-vs-76%; Irritability 67%-vs-56%; Nervousness/Anxiety 52%-vs-56%; Dizziness 67%-vs-64%; Tinnitus 57%-vs-63%[41,50]. Thus, rates conform closely.

The rates of symptoms reported for diplomats appear within reported variation, for studies of persons affected by RF/MW/EMR. Sleep problems were reported somewhat less frequently in EMR affected persons in the Kato study (76%), than in diplomats – but reported sleep problems, or their byproduct fatigue (for which prevalence was not recorded in the diplomat study), dominate the number one symptom position in studies of RF/MW affected persons (**Table 3**), and prevalence of sleep problems was higher than for diplomats in some other studies of RF/MW affected persons[52]. Of note, the Kato study was performed in Japan, where the traditional diet is rich in fish, which supply the long-chain omega-3 fatty acids that reportedly benefit sleep and reduce irritability[53,54] (the two symptoms that were >3% lower than in affected diplomats).

The protean character of symptoms in diplomats[19] (as for RF/MW-affected individuals) has led some to infer that a single cause cannot account for all. But a number of reports, in a number of nations and settings, tie RF/MW exposure (in vulnerable individuals) to each of the problems reported in diplomats. The coherence of findings in those citing affects of RF/MW, with findings in diplomats, supports a common cause within each group – and across the two groups. Of note, a protean suite of generally the same symptoms – but in a different distribution – is reported in other conditions that are tied to mitochondrial alteration and oxidative stress[55-57] (mechanisms which each promote the other[58,59]). RF/MW is tied to these mechanisms[60-66]. However the distinctive prominence of sleep and auditory symptoms, the peculiar somatic sensory experiences of pressure

and vibration, and the noises perceived during apparent inciting episodes, are relatively distinctive features – distinctive to diplomats' reports, and to reported RF/MW problems.

Table 4 reviews several mechanism considerations. Central to this is the critical role of oxidative stress, and the relevance of oxidative stress to potential auxiliary mechanisms, such as mitochondrial dysfunction, blood brain barrier disruption, membrane alterations, impaired blood flow, apoptosis, effects on voltage-gated calcium and anion channels, and triggering of autoimmune reactions. (In some cases effects are reciprocal – oxidative stress promotes mitochondrial dysfunction, calcium channel effects, inflammation, autoimmunity – which in turn can promote oxidative stress.) One analysis found that of 100 evaluated studies that examined the relationship of low level RF/MW to oxidative stress in biological systems, 93% supported a connection[60]. A role for oxidative stress in RF/MW/EMR affected persons is cemented by evidence that gene polymorphisms adverse to antioxidant defense are significantly more prevalent in persons experiencing symptoms from RF/MW/EMR[67]. Additionally, levels of a particular antioxidant – melatonin – known to be critical for RF/MW and broader EMR defense are consistently low in affected persons (assessed by a urinary metabolite)[33]. Oxidative stress has been tied to each of the symptoms and conditions reported in diplomats, and RF/MW affected persons.

Also noteworthy is the repudiation of psychogenic causation in the evaluation of diplomats[11,41], which holds for RF/MW affected persons as well. Case narratives for those affected by RF/MW underscores that for many, symptoms developed and progressed when affected parties as yet had no knowledge that an RF/MW emitting device had been introduced, nor that one could cause problems[49,52]. A Swiss Telecom funded study found that sleep problems related to the electromagnetic field strength of the transmitter, and did not correlate with personality traits tied to worry about health[48,68]. The circumstance that some report being affected severely by levels of exposure that cause others no problem, is reviewed in the context of effect modification, variations in antioxidant defenses, and demonstrated variable involvement of secondary mechanisms such as autoimmune

activation[33]. In fact, analogous marked differences in harm or development of health effects are well known for other exposures, such as peanuts, penicillin, and pesticides. For EMR affected persons[67] – as for many other exposure-related illnesses – genetic influences on phase I or phase 2 detoxification, as well as factors that inhibit or compete for detoxification systems, play a documented role in who develops health effects[69-74]. (Phase 2 detoxification encompasses protections against oxidative damage.)

Table 5 briefly addresses the range of RF/MW sources that have been presumptively tied to problems. It observes that RF/MW/microwave radiation is known to have been used on the US embassy in Moscow – there is precedent for use on diplomats[75,76]. That instance, though with presumably differing details of exposure, led to (disputed) reports of health effects in embassy staff, and shielding efforts by the US. Since the exposing device can be outside the building – and typically has been, for persons affected by RF/MW-emitting utility meters[48] – failure of the FBI to find devices in sweeps of diplomats' rooms remains compatible with this explanation.

Discussion:

Recap of Findings:

Health effects reported by US and Canadian diplomats (and family members) in Cuba and China, and the circumstances surrounding inciting episodes, are consistent with effects of RF/MW. Reports of perceived sounds fit known characteristics reported for the Frey effect (RF hearing, microwave hearing): Sounds were heard by some but not other diplomats during inciting episodes, sounds differed in character from person to person, sounds included chirping, ringing and grinding, sounds were heard predominantly at night. Sounds were localized with "laserlike" specificity in some of the cases, and within that localization, seemed to follow people. Prominence of auditory symptoms, including hearing loss, tinnitus, and ear pain in diplomat reports, typify reports of injury from pulsed RF/MW. Presence of variable additional symptoms of protean character that differ markedly from person to person, with a relative emphasis on sleep disturbance, headaches, and

cognitive problems; plus presence in smaller subsets of vision, balance, and speech problems are also characteristic. Affected persons in both groups report sensory symptoms of pressure and vibrations. Persons in both groups show evidence of brain injury. Reports in both indicate that some persons had prior head injury, and brain injury may be a predisposing factor for, as well as a consequence of, RF/MW injury[11,34]. Both show varying rates of symptom persistence. How subsequent natural history will compare, for diplomat symptoms that *might* follow more intense discrete exposure (a more intense exposure may produce problems in persons who need not have relative vulnerability), vs follow repeated less intense ones (producing symptoms, evidence suggests, selectively in persons more vulnerable to free radical injury from RF/MW, at a level to which they will likely have subsequent exposure), is not known.

Fit with Literature:

Evidence for health effects of RF/MW is not new[47,77-79]. By the early 1930s, studies were citing compatible symptoms in radio amateurs and shipboard radio operators[77]. By 1971/2 a Naval report bearing over 2300 citations, many from Russia and Eastern Europe, documented health effects of microwave/RF/MW, emphasizing "non-ionizing radiation at these frequencies"[80]. Contrary to claims by industry-affiliated parties, copious evidence documents that radiation that is not "ionizing" can also cause health effects. Entire sections of the 1971/2 report were devoted to each of a number of the symptoms that diplomats are now reporting, including insomnia, headache, fatigue, cognitive problems, and dizziness[80]. Injury from nonionizing radiation occurs also without measurable heating – nonthermal radiation[81-83]. Indeed, oxidative stress, which mediates nonthermal effects, also mediates thermal effects; and melatonin, which defends against oxidative RF/MW injury, also defends against so-called thermal injury[84-88]. Moreover, other sources of heat do not produce the same so-called "thermal" damage that RF/MW does[47]: What are deemed thermal effects may be among the manifestations of oxidative injury. While a low percentage of individuals experience overt symptoms from usual RF/MW, the absolute number may be vast: the fraction with electrosensitivity/ electromagnetic illness has been estimated at between 1 and 5%, and apparently rising[37,89-92].

Limitations:

Features of diplomats' experiences rely on media reports and one published neurological evaluation. We did not examine diplomats; however, in conditions with highly distinctive characteristics, the history is often the most important factor in the diagnosis, and diplomats' reports bear highly distinctive characteristics. The close matching of these distinctive characteristics to those of persons with health problems arising in apparent relation to pulsed RF/MW, provides a basis for concern that RF/MW exposures may underlie diplomats' symptoms and health conditions.

A tremendous number of physicians and scientists and entities and scientific studies and government reports, in many nations, over many decades, have identified that RF/MW causes symptoms consistent with the spectrum now described for diplomats. Scientific "skepticism" about RF/MW health effects is well represented in the literature, but is of the industry-fueled stripe (think tobacco): Effects of conflicts of interest on research results (as well as on funding, regulatory agencies, legislation and academics) vis a vis RF/MW, has been repeatedly documented and decried[93-97], and evidence of this influence parallels evidence of potent impact of conflict of interest in medicine more generally[98]. In one illustrative analysis, studies of health effects of cell phones that were funded exclusively by industry were least likely to report a significant effect. Relative to studies funded exclusively by public agencies or charities, the odds ratio was 0.11 (95% CI 0.02-0.78)[93] – that is, the odds were ~a tenth as great for a significant finding in a study in purely industry funded studies. The finding was not materially altered when analysis was adjusted for factors like study quality. Richard Smith, then Editor in Chief of the BMJ (the British Medical Journal) penned an article "Conflicts of interest: How money clouds objectivity." Responding to evidence tying study results on a different lucrative product (tobacco) to conflicts of interest (often undisclosed), he suggested that "far from conflict of interest being unimportant in the objective and pure world of science where method and the quality of data is everything, it is the main factor determining the result of studies"[99].

Conclusions/Implications:

Numerous highly specific features of diplomats' experiences and symptoms fit the hypothesis of RF/MW injury. To distinguish between sonic and microwave hypotheses, earplugs can be issued to diplomats for use in candidate episodes (e.g. strange noise plus ear pain): earplugs will mute sonic sources (caveat: a sound like crickets chirping may in fact be crickets chirping), but not microwave ones (which may even be intensified). Monitoring for culpable radiation sources must sensitively capture pulsed RF/MW, including that which may be used only on an intermittent basis. It should encompass the 2.4-10,000MHz range in which the Frey effect has been reported. Perhaps attention to diplomats' plight can ignite awareness of the many others affected by similar problems. Meanwhile, research already documenting compatible health effects of RF/MW in a subgroup, may inform those caring for diplomats, and those in pursuit of causative devices.

Table 1. Features of Noises Reported by Diplomats during apparent inciting episodes.
Though "sound" refers to air pressure waves, we will refer to what diplomats "heard" as (perceived) sound.

Diplomats' Reports	Compatibility with RF/MW
Strange noises were heard by many "of the 24 'medically confirmed'" affected US diplomats[1], during what were perceived as inciting episodes[10].	Sound ordinarily results from air-*pressure* waves (which are "longitudinal" waves – variation occurs along the direction of travel of the wave); whereas radiation arises from *electromagnetic* waves (which are transverse waves – variation occurs perpendicular to the direction of travel of the wave). In each case, a "frequency" is defined by the number of "cycles" of the wave (that pass, say, a given point) per second, for the respective wave type. Though electromagnetic signals are not themselves sound, RF/MW can lead to perceived noises via the so-called "Frey effect"[45] (aka microwave hearing, aka RF hearing). A 1976 Defense Intelligence Agency report stated "Sounds and possibly even words which appear to be originating intracranially can be induced by signal modulation at very low average-power densities"[78]. A 1994 Air Force Materiel Command report stated, based on knowledge at the time, that "Individuals exposed to pulsed RF/MW radiation have reported hearing a chirping, clicking or buzzing sound emanating from inside or behind the head. The auditory response has been observed only for pulsed modulated radiation emitted as a square-wave pulse train. The pulse width and pulse repetition rate are factors that appear to determine the type of sound perceived.... James Lin… reports that the sensation of hearing in humans occurs when the head is irradiated at an average incident power density level of about 0.1 mW/cm^2 and a peak intensity near 300 mW/cm2. Auditory responses have been observed for a frequency range of 200-3000 MIHz and for pulse widths from 1-100 μs"[47]. The frequency range within which sounds can be heard was broadened by 2003: it was reported that sounds can be perceived by persons exposed to RF/MW in the 2.4-10,000MHz range[45]. It was noted that the same frequency did not produce the same sound, from person to person.
Not all diplomats heard noises[10].	Ability to hear RF/MW-induced "sounds" (using the term to refer to the perception, not the stimulus) at all depends on individuals' high frequency hearing[45], as well as on low ambient noise[45].
Among those who heard noises, the noises reported differed markedly for different diplomats[5].	In RF hearing/ microwave hearing, the primary pitch heard (i.e. the perceived *sound* frequency), reportedly relates not to the *radiation* frequency (cycles/sec), but to head dimensions[45]. This comports with reports that different sounds were heard by different diplomats, even if they were exposed to the same frequency (or conceivably frequencies, plural) of radiation. Of note, whether sound is perceived from RF/MW is not governed by the *average* radiation level, but the energy in a single pulse. Injury to cells (in part through membrane damage) is also materially greater with pulsed radiation[100,101]. (Analogously, if a jackhammer hit very hard but very briefly at 2 minute intervals, the low time-averaged pressure would not explain the effects produced.) Pulses of comparatively high intensity (relative to typical exposures from technology) would have likely been necessary to produce the comparatively high prevalence of Frey-compatible sounds, and of health effects reported among US diplomats. The relatively high proportion of affected diplomats reporting Frey type noises, suggests the possibility of comparatively high intensity of pulses; and frequencies within the designated 2.4-10,000MHz range.
These noises included a high pitched "chirping," ringing and "grinding"[8, 10].	Frey "sounds" are "similar to other common sounds" "such as a click, buzz, hiss, knock, or chirp" – consistent with sounds that diplomats reported[45]. In a 2007 Dutch survey completed by 250 persons with electrosensitivity (**ES**), queries related to noise included buzzing (reported by n=96), hissing (n=80), strong low frequency sounds (n=55) and "sound of bells clanging" (n=28)[102]. The term "chirping" (if there is a Dutch equivalent) was not included among inquiries. Of note, the "strong low frequency sounds" are potentially consistent with the "blaring, grinding noise" reported by a diplomat, next section ("blaring" indicative of "strong," and "grinding" consistent with low

	frequency); while the "sound of bells clanging" is consistent with reports of diplomats who awoke to hear ringing "and fumbled for their alarm clocks, only to discover the ringing {clanging} stopped when they moved away from their beds"[5]. In the Maine Smart Meter survey report[49], comments by affected persons were included. Exemplars involving Frey noises included these: {After} "72 Itron AMI smart meters {were installed} near me in my townhome complex… I hear a constant buzzing that is driving me crazy. It keeps me awake and makes it hard to think. I am not sure if it is an actual sound, or if it is being generated inside my head, because when I put my fingers in my ears I still hear it… In addition, at about every 15 or 20 minutes, a more intense whine is added that lasts about 12-15 seconds, that hurts and gives me a mild headache which stops when the whine stops… When I go out into the state and regional parks around me where there are NO smart meters for miles, I no longer hear the buzzing and my heart doesn't race" or in other cases "The noise I have in my head since smart meters is almost unbearable, sleep is at times impossible because it is so loud"[49]. "I became electrically sensitive almost immediately upon smart meter installation. My ears buzz, hum, and click constantly, pressure in the head and ears,… agitation and irritability all since the PLC smart meter was placed on my home.. .I was able to vacation where there was no smart meter installed and it felt as if a vice had been loosened from around my head"[49]. A post regarding a woman who removed her smart meter after becoming symptomatic repeated several times that the exposure caused her to hear "grinding"[103], confirming this descriptor as among perceived RF/MW-hearing induced noises. Among those with ES who communicated with the UCSD ES Survey group; for instance, one stated that in proximity to "electrosmog producing devices, "I hear sounds like beehives and similar" (buzzing). Another stated: "The hissing in my ears is unbearable sometimes." One wrote "annoying noise" was among other symptoms.
The noises were heard primarily at night[10].	Ability to hear RF/MW-induced sounds at all depends on low ambient noise[45]. Night is generally a time of low ambient noise.
A sound that has been recorded in Cuba and reported to be "similar" to some sounds heard is consistent with chirping of crickets or cicadas (Lederman & Weissenstein, 2017). Frey effect sounds should not be able to be recorded.	Recorded sounds, if *similar* to what was "heard" by some, need not *be* what was "heard". (Just as Frey sounds are "similar to other common sounds," so those other common sounds can resemble the Frey sound.) The recorded sound does not cause symptoms in listeners. The sound does not fit reports by other diplomats of either the character of the sound; nor of strict sound localization (such as reports that when one moved from the bed, sound disappeared). Some diplomats had cited perceived sounds similar to crickets or cicadas: the recorded noises were reportedly very similar to the chirping of crickets or cicadas that are abundant along the Northern coast of Cuba[104]. Perhaps what was recorded was (or included) crickets or cicadas. Since Frey effects can sound like crickets chirping, presumably recordings of crickets chirping could resemble those Frey effect sounds. (Those deploying causative devices could of course capitalize on misguided sonic hypotheses to lead the US astray, by adding a recorded sound resembling Frey sounds; however there seems little need to postulate this.)
There was apparent "laserlike" localization of sounds in some cases.	For diplomats, "…at least some of the incidents were confined to specific rooms or even parts of rooms with laser-like specificity, baffling U.S. officials who say the facts and the physics don't add up"[10]. One incident was described in media as follows: "The blaring, grinding noise jolted the U.S. diplomat from his bed in a Havana hotel. He moved just a few feet, and there was silence. He climbed back into bed. Inexplicably, the agonizing sound hit him again. It was as if he'd walked through some invisible wall cutting straight through his room. Soon came the hearing loss and speech problems…"[10]. In claims that "the facts and the physics don't add up"[5], it was the physics of *sonic* devices that are inconsistent. The physics of EMR is, to the contrary, compatible: lasers are themselves focused EMR. Tautologically, EMR can be focused in "laser-like" fashion.
Within the room or parts of room where sounds were heard, the sound follows the listener[11].	A diplomat reported that "'a really odd loud noise that seemed to follow him in the room'"[11]. Frey "sounds" are also reported to follow the person, often perceived as slightly behind the head, regardless of the body orientation relative to the source of radiation[45-47]. (In other cases "sounds" are perceived inside or above the head[45,105,106].

Table 2. Symptoms and Signs.

Diplomats' Symptoms and Signs	Compatibility with RF/MW
I. Auditory Symptoms are Distinctively Prominent	Auditory symptoms are prominent in reports of diplomats' experience, including ear pain or pressure[41], sometimes within minutes of the perceived attack[1], tinnitus[5,6,9,10,40] and hearing loss[9,10,15,17,39,41, 42]. This, coupled with the strange noises in diplomats' reports, likely launched the sonic theory. These idiosyncratic features are key to winnowing potential causes. Symptoms like headache and fatigue arise with many exposures and in many conditions. New onset of tinnitus and hearing loss is far more distinctive. (It is particularly so in the context of the spectrum of other reported symptoms and effects, and in the context of characteristics of instigating episodes.) These distinctive auditory problems are similarly prominent in people reporting symptoms from RF/MW[48,51]. Tinnitus and hearing loss were cited by 80% and 34% respectively in the UCSD survey of 202 individuals with current symptoms from EMR, with pulsed RF/MW causing symptoms in the vast majority[52]. "Initial" symptoms were reported to include tinnitus in 50%, ear pain in 30%, and hearing loss in 11%. Case descriptions shared by affected individuals underscore auditory effects. From the UCSD survey: "I bought a Kindle W-Fi. I charged it not realizing the default setting was 'on.' After 5-10 minutes exposure, I became nauseated, had a headache, loud tinnitus… and was dizzy. I turned the Wi-Fi off and the symptoms completely resolved in 5-10 minutes"[52]. A description by former educator Brinchman characterizes her abrupt development of headaches and hearing loss following introduction of pulsed RF/MW-emitting smart meters to her (and her neighbors') homes[107]. Similarly, physicians and physician groups that assessed patients with health effects from RF/MW and recognized the connection, also highlight effects on hearing. A psychotherapist in Germany with a longtime practice described a new group of patients with a physiological illness profile encompassing organic brain disease, with constellation of symptoms compatible with other reports of RF/MW injury. *She* was the one to discern the tie between patients' symptoms and their proximity to RF/MW sources (a connection that her patients had often missed – obviating nocebo effects as a source – see **Table 4**), and to note recovery with removal from those sources[108]. She describes "sudden hearing loss" as among the symptoms (in addition to sleep problems described as "almost ubiquitous," headache as extremely frequent, also noting fatigue, cognitive problems, tinnitus, etc)[108]. A group of 114 physicians , referencing their analysis of medical complaints of 356 people in Oberfranken, signed an Open Letter to the Prime Minister of Germany in 2004 (referred to as the Bamberg Appeal), stating "The pulsed high frequency electro magnetic fields (from mobile phone base stations, from cable-less DECT telephones, amongst others), led to a new, previously unknown pattern of illnesses with a characteristic symptom complex"[109]. Prominent and repeated mention is made of hearing loss: "People suffer from one, several or many of the following symptoms: Sleep disturbances, tiredness, disturbance in concentration, forgetfulness, problem with finding words, depressive mood, ear noises, **sudden loss of hearing, hearing loss,** giddiness, nose bleeds, visual disturbances, frequent infections, sinusitis, joint and limb pains, nerve and soft tissue pains, feeling of numbness, heart rhythm disturbances, increased blood pressure episodes, hormonal disturbances, night-time sweats, nausea… It is no way only a subjective sensitivity disturbance. Disturbances of rhythm, **hearing problems, sudden deafness, hearing loss**, loss of vision, increased blood pressure, hormonal disturbances, concentration impairments, and others can be proved using scientific objective measures"[109] (emphaes added). {Note also the mention of "ear noises" (the Frey Effect).} Some studies that experimentally examine effects of RF/MW on hearing show effects, though not all do. (See **Table 4** for discussion of "inconsistent" effects.) A material consideration is that evidence is consistent with a vulnerable subgroup.

	One experimental study in humans found that 60 minutes of close exposure to EMR from a mobile phone "had an immediate effect on HTL {hearing threshold limits} assessed by pure-tone audiogram and inner ear (assessed by DPOAE) in young human subjects. It also caused a number of other otologic symptoms"[110]. Of note, melatonin – which can be depressed by EMR (see **Table 4**) and is low in those with EHS[33] – protects against oxidative radiation injury (**Table 4**) – including to the inner ear[111]. Pulsed RF/MW (more than continuous) has been shown to increase tympanic temperature, even when, for instance, colonic temperature is not increased[112]. Since blood flow is critical for cooling, and oxidative stress leads to endothelial dysfunction and may compromise blood flow, affected individuals (see below, by hypothesis those with greater oxidative stress effects) may experience greater impairment in blood flow – so less cooling, and also, impaired delivery (via impaired bloodflow) of oxygen, glucose, other energy substrates as well as antioxidant defenses). The downstream effects of oxidative stress (e.g. apoptosis, inflammation etc – see below) and impaired cell energy/ mitochondrial dysfunction (cell dysfunction and death) may contribute to auditory pathology.In a study examining the histopathology of cochlear nuclei of rats "exposed continuously for 30days" to "a GSM-like 2100MHz EMF" "with a signal level (power) of 5.4dBm (3.47mW) to simulate the talk mode on a mobile phone," compared to a control group of rats not similarly exposed, "an increase in neuronal degeneration and apoptosis in the auditory system" was observed in the RF/MW exposed group[113]. "The histopathologic analysis showed increased degeneration signs in the study group ($p=0.007$). In addition, immunohistochemical analysis revealed increased apoptotic index in the study group compared to that in the control group ($p=0.002$)"[113]. In another animal study, "a prominent effect of EMS {electromagnetic stimulation} was … severe cochlear damage and permanent sensorimotor hearing loss in experimental animals"[114].
II. Symptoms are Protean	Beyond the auditory symptoms, the profile of symptoms in diplomats varies from person to person: Different people report markedly different symptoms[5]. It was said that "The symptoms and circumstances reported have varied widely, making some hard to tie conclusively to the attacks"[115]; and "The cases vary deeply: different symptoms, different recollections of what happened. That's what makes the puzzle so difficult to crack"[5]. Reported symptoms encompass sleep problems[6,17,42], headaches[6,10,15,42], cognitive problems[10,42], nausea[10], fatigue[6], and dizziness[10,15]. Similar concerns had been raised with RF/MW injury. As noted by Dr. Aschermann (translated from German): "in the Deutsche Aerzteblatt (official journal of the German medical association – Bundesaerztekammer) did an article ask the incredulous question: How could so many different symptoms possibly be attributed to one common underlying mechanism?"[108]. Despite the protean character of symptoms, multiple survey studies verify that a strikingly reproducible suite of protean symptoms *are* reported, in setting after setting, in people citing development of symptoms in response to EMR including RF/MW (**Table 3**). The profile of symptoms is strongly similar from study to study, with sleep/fatigue, headache, and cognitive problems commonly topping the list, auditory and visual symptoms, dizziness and nausea figuring in it. A similar primary list (sometimes augmented with a few additional symptoms – often including heart rhythm problems) is mentioned in other settings. The analyses of 65 patients by Dr. Aschermann cite symptoms of learning concentration and behavioral problems, headaches, insomnia, exhaustion, hearing loss, tinnitus, hearing loss, dizziness, nerve and soft tissue pain, "inner agitation", as well as arrhythmia problems[108]. In the 2004 Bamberg appeal signed by 114 physicians to the then German Prime Minister, based on analysis of 356 patients: "The pulsed high frequency electro magnetic fields (from mobile phone base stations, from cable-less DECT telephones, amongst others), led to a new, previously unknown pattern of illnesses with a characteristic symptom complex. People suffer from one, several or many of the following symptoms: Sleep disturbances, tiredness, disturbance in concentration, forgetfulness, problem with finding words, depressive mood, ear noises, sudden loss of hearing, hearing loss, giddiness, nose bleeds, visual disturbances, frequent infections, sinusitis, joint and limb pains, nerve and soft tissue pains,", also nausea, and "feeling of numbness, heart rhythm disturbances, increased blood pressure episodes, hormonal disturbances,

	night-time sweats.…The symptoms occur in temporal and spatial relationship to exposure. It is no way only a subjective sensitivity disturbance. Disturbances of rhythm, hearing problems, sudden deafness, hearing loss, loss of vision, increased blood pressure, hormonal disturbances, concentration impairments, and others can be proved using scientific objective measures"[109]. Among individuals participating in a physiological provocation study examining heart rate variability with RF/MW, among 25 patients 40% of whom believed themselves to be moderately or severely electrosensitive: "The most common symptoms of exposure to electrosmog, as identified by this group of participants, included poor short-term memory, difficulty concentrating, eye problems, sleep disorder, feeling unwell, headache, dizziness, tinnitus, chronic fatigue …"[116]. Of note, the same symptoms also arise in the vulnerable subgroup of persons who develop health problems following *other* exposures that share a documented ability to cause mitochondrial impairment and oxidative stress[55,57,117-119]. However, the profile – which symptoms dominate – differs from exposure to exposure, based on factors such as what part (s) of the body the exposure may differentially reach, and whether additional mechanisms of injury are involved that potentiate damage to one domain. Sleep and auditory effects are clearly disproportionately represented, in diplomats and with RF/MW exposure, relative to their prevalence following other exposures that cause oxidative stress. The strong effects on sleep may relate to depressions in melatonin that can be produced with EMR/ RF/MW (see **Table 4**). Auditory effects are addressed above. A 1990 study commissioned in response to a petition by residents who cited adverse health experiences from a shortwave radio transmitter in their small town of Schwarzenburg, funded in part by Swiss Telecom, reported that sleep disruption in association with transmitters related directly to the EMR field strength of the transmitter, and affected 55% of those over age 45[48,68]. (There the denominator is *not* restricted to those who were symptomatic.) A 1994 Air Force Materiel Command reports that "Pulsed RF/MW radiation was reported to have an analeptic effect in animals. Experimental results presented by R.D. McAfee in 1971 showed that anesthetized animals could be awakened by irradiation from a pulsed 10 GHz RF/MW source…Experiments conducted on rats showed that these animals were aroused from states of deep sleep by irradiation"[47]. The prominence of auditory effects (see above for more on these symptoms) may relate in part to absence of a skull structure to protect the inner ear, producing an incident stimulus that is of greater effective intensity. The coherence of symptoms in response to RF/MW, with findings in Cuba (and China) diplomats, adds further support to the case for a common cause within each group – and across the two groups.
III. Symptoms include some that are (potentially) objectively measurable: **Speech**[9,10,42]; **Vision**[42]; and **Balance**[10, 42]; and **Nose bleeds** in some[9].	The symptoms reported in media and the Swanson article for diplomats – extending to the more specific, like dizziness/balance, vision and speech problems – are also reported in survey studies of those affected by RF/MW (**Table 3**).
	Speech problems, mentioned in diplomats, were also among symptoms elicited and reported in a survey study examining effects of RF/MW following "smart meter" introduction in Australia[48]. Reported cases illustrate speech problems arising following RF/MW exposure. In a case referenced in the *LA Times*, a woman reported that if someone fails to turn off their cellphone on entering her home, she gets symptoms within 2 hours; "'After four hours I can't speak anymore""[32]. In a case described in a 2015 Australian presentation on ES[120]: "Within hours, it felt as if someone had tied a thick rubber band around her head. Then came nausea, fatigue, ringing in her left ear – an onslaught of maladies all at once, and she had no idea why…A week or two into the job, whatever was affecting her wasn't abating, and before long her speech became so jumbled that she couldn't form a complete sentence in front of an audience…She went outside to inspect the place and found no fewer than 17 new 'smart' electricity meters strapped to the side of the building." In a case reported to UCSD investigators, new onset right-sided ear pain and hearing loss attended the inciting episode (seated for six hours, unknowingly, directly across the wall from a bank of multiple smart meters for a building, slightly toward her right), along with vis-like

	headache, concentration problems, and two nights of no sleep (followed by chronic lesser sleep impairment), and, abating over months, continued to be triggered – always exclusively or predominantly on the right side – by previously tolerated RF/MW exposures thereafter. Many months later left ear predominant ear symptoms developed for the first time. A bank of smart meters was identified to the left of where she had sat hidden by plants so missed in an initial reconnaissance. That occasion, the only one with left predominant ear and hearing symptoms, was accompanied by speech difficulty, that resolved over about a week. In these two cases, aphasia was associated with left predominant ear symptoms. {Broca's area, damage of which leads to expressive aphasia, is left prefrontal.} It is an empirical question whether left-predominant auditory involvement will prove more often tied to affected speech.
	Balance is multifactorial, involving e.g. vision, muscle strength, and vestibular function. In some media reports of diplomat health, the term vertigo is used[40]. Balance and vestibular testing were performed in diplomats[41]. Clinical examinations/objective measures raised concern for balance problems in 81% (higher than percent reporting subjective dizziness or balance problems)[41]. Vestibular function involves the same (eighth) "cranial nerve" as hearing. Vertigo, hearing loss and tinnitus can arise (as adverse effects) as a triumvirate[121,122]. Dizziness more generally, in contrast to vertigo, is a nonspecific finding, that arises with many forms of brain insult – including brain hypoperfusion (low blood flow). Of note, cerebral hypoperfusion has been reported in persons with symptoms following RF/MW[33]. In some surveys of RF/MW affected individuals, dizziness and balance are queried together[48]; other surveys only use the term dizziness. Individual reports of balance and dizziness problems were included among participant narrative reports in the Maine survey. E.g. "'Balance problems have worsened since installation of the smart meter, leading to several falls'"[49]. "'I could not understand the dizzineness which was scary. I actually thought I had a brain tumor all of a sudden'"[49]. The Cuba diplomat study considered nausea as a vestibular symptom[41]. Though it need not necessarily be, it was linked to dizziness in some RF/MW/EMR affected cases: "'Daily nausea and dizziness'"[49]. Loss of balance, with dizziness and disorientation, was identified as one of six clusters of symptoms seen in each of two smart meter surveys from different nations, with the clusters represented nearly in the same order (1. Sleep disruption; 2. Headache; 3. Ringing or buzzing in ears; 4. Fatigue; 5. Loss of concentration, memory or learning ability; 6. Disorientation, dizziness, or loss of balance)[123].
	Vision: Vision is affected by oxidative stress and mitochondrial impairment (see **Table 4**, mechanisms)[124-129], not just to the eye but to cortical systems involved in vision[130]. Effects of these mechanisms include optic nerve damage[129,131,132], "age" related macular degeneration[125,128,133-137], retinal thinning[138], and cataracts[139-143]. Where brain swelling ensues (see **Table 4**), this can affect the shape of the lens, affecting vision. Effects of RF/MW on the eye and on vision have long been reported[47,144-150]. Particular attention has gone to effects on the lens and on cataracts. RF/MW, via oxidative mechanisms, promotes aging of the lens which can lead to cataracts. Cataracts have been a reported complication – sometimes in young people – among persons working with microwave radiation[47, 144-147]. A Swiss study (Hassig et al, 2012) documented increased cataracts in calves born near cell towers: "We examined and monitored a dairy farm in which a large number of calves were born with nuclear cataracts after a mobile phone base station had been erected in the vicinity of the barn. Calves showed a 3.5 times higher risk for heavy cataract if born there compared to Swiss average. All usual causes such as infection or poisoning common in Switzerland could be excluded." Vision problems are reported in RF/MW affected persons. In a study in Spain, in persons in proximity to two GSM (Global System of Mobile Communications) cell tower base stations, analysis of the closer group – with exposure in the range 0.25-1.29V/m2, in a model adjusted for age, sex, and distance, showed that vision problems were elevated with an odds ratio of 5.8 (95% CI 1.7-19.8, p= 0.005)[151]. 11% reported problems with eyes or vision in the Australian smart meter study; since this includes respondents who are unaffected, rates are lower than in purely symptomatic individuals[48]. 26% of survey participants reported eye/vision problems in the Halteman smart meter impacts survey[51]. Vision problems were reported by 17% as "severe and new," by 38% as "moderate and new," and by 12% as "severe and worsened" in the Maine smart meter survey[49].

	An assessment of neurological problems in US diplomats in Cuba underscores potential importance of eye movement dysfunction[41] – which is also tied to oxidative and mitochondrial mechanisms[152-160].
	Epistaxis (nosebleed): In a study in Selbitz, Bavaria, nosebleed was significantly more frequently reported (p=0.01) in those <200m from a cell phone base station than 200-400m away[161]. Nosebleed was a reported symptom in each of several surveys of ES and symptoms associated with RF/MW, including in a study of smart meter symptoms[48,49,51,52] (**Table 3**). The Bamberg Appeal (on behalf of 114 physicians referencing assessment of medical complaints of 356 people with symptoms from cell tower base stations and DECT phones in their homes in Oberfranken) noted the more characteristic RF/MW symptoms (above) as well as nosebleed[109]. Comments from participants in survey studies include the following: "Severe headaches, gushing nosebleeds for the first time ever...They all went away when the smart meter was removed"[49]. "After the first day I was getting bloody noses and not understanding"[49]. Another stated "Nosebleeds, nausea, dizziness, ... ringing ears and intermittent strong agitation… When I am away from wireless devices the symptoms subside"[49]. And, another, "Had it not been for the severe nose bleeds I'm not sure I would ever have found out what was causing my health problems"[49].
IV. Peculiar Sensory Symptoms of "Vibration" and "Pressure" are Reported	"Associated sensory symptom" of "pressure" or "vibration" were reported in 43% and 14% respectively, in a neurological evaluation of diplomats[41]. The distinctive sensory symptoms of "pressure" and "vibration" are also reported by subsets of those who report symptoms from RF/MW. Neither were commonly elicited as symptoms in surveys. However, some surveys listed head pressure separately from headache, and in some cases it was more frequent. Eye pressure (Halteman, 2011) and ear pressure (Conrad & Friedman, 2013) have also been reported in surveys of RF/MW/EMR affected persons. The UCSD ES survey did include "internal pressure," which was reported as a symptom in 71% of participants who cite symptoms from EMR/RF/MW[52]. Spontaneous reports of vibration symptoms by different EMR/RF/MW affected persons, shared in a different survey study, include the following: "I experienced internal shaking and vibrating throughout my body" (along with sleep, mood, headache, head pressure, and other problems, after smart meter installation)[49]; "I can't think clearly, or find words when speaking; my body feels like it is vibrating"[49]; and "have uncontrollable jelly-like quivering throughout whole body"[49]. In online comments posted in response to articles on related topics, in which persons describe their ES symptoms, statements include "vibration through my body"[162]; and "I have a smart meter on my house and I have been experiencing strange vibrations when I watch TV or use the computer"[163]. An email to us from an affected patient (9-2017) sharing her symptoms stated: "Which feels like my brain is vibrating and spinning at night – and my tinnitus gets much worse…".
V. Brain Swelling is Reported in Some Diplomats[5,9,19].	1. RF/MW may alter blood-brain barrier function via oxidative stress. a. An analysis reported that of 100 peer reviewed studies examining whether low intensity RF/MW causes oxidative stress, 93 found that it did[60]. b. Oxidative stress disrupts the "blood-brain barrier"[164-176]. c. Consistent with this, blood-brain barrier disruption has been shown in multiple studies with RF/MW[172-174,176-179]. Other studies have not shown blood brain barrier effects[180-186]. Studies vary in many respects (e.g. exposure duration, EMR exposure characteristics, model (in vivo vs in vitro, animal, age), delay between exposure and blood-brain barrier assessment, blood-brain barrier assessment used, etc. The blood-brain barrier is functional, and barrier function need not be affected for all substances equally.) d. Since genetics of oxidative stress management[67], and levels of key antioxidants[33], relate both to RF/MW injury and to oxidative stress, these factors – together with specifics of the RF/MW exposure – may guide blood-brain barrier disruption with RF/MW. e. A study that examined gene expression in the brain of rats exposed to GSM radiation, radiation that encompasses the multiple frequencies and pulsed waveforms present in GSM exposures, identified altered gene expression of a marker of blood-brain barrier function[187].

	2. Altered blood brain barrier can lead to brain edema and "malignant brain edema"[188,189]. (Oxidative stress associated blood brain barrier disruption is, for instance, thought to underlie neuroleptic-induced cerebral edema[190].) 3. Perceived head pressure occurs with brain swelling, and is reported by many with ES. As also noted above in relation to the sensory symptom of "pressure," some surveys collate head pressure separately from headache (which, in some studies, it surpasses)[48,49,102]; one survey included eye pressure[51]; and in one, several participants spontaneously reported ear pressure[49]. Communications to the UCSD ES study included write-in comment "brain feels like it's swelling"[52]. One man with severe ES who communicated with the UCSD study group, who shared documentation of his approval for Social Security disability for his ES, reported that the severe brain swelling he experienced in response to EMR had led an eyeball to be pushed from the socket.
VI. Findings are Reported to be Compatible with **Traumatic Brain Injury**[40,43,191-194].	1. Based on findings in an fMRI study of electrosensitive individuals it was stated: "the differential diagnosis for the abnormalities seen on the fMRI includes head injury"[34]. 2. 6 of the 10 ES individuals assessed reported prior head injury[34]. However, four did not, and also showed evidence of brain injury. Moreover, prior head injury is reported to also be present in at least some, but an unstated fraction of, affected diplomats[11]. 3. Head injury could predispose to ES: Head injury, like RF/MW, promotes oxidative stress and blood brain barrier disturbance – and melatonin (which is low in those with ES) protects from these effects in head injury[195-198], as it protects against injury from radiation[111,124,141,199-227] – and from RF/MW[228-240]. 4. One RF/MW affected who communicated with the UCSD study group indicated his ES was precipitated by a serious occupational head injury. (He also had occupational exposure to EMR, but until the head injury it had not bothered him.) 5. Given findings consistent with low melatonin in those with ES[33], this condition (and/or common cause) may also predispose to more significant damage from a given impact and character of head injury – so greater likelihood that a given head impact causes problems, and is remembered and reported as a head injury. 6. The study did not report presence/absence of features indicative of greater severity of head injury – such as loss of consciousness, or symptoms or sequelae. Both because of this and point 5, there is not clarity about whether prior head impacts were in fact greater in number or intensity than in the general population. But as above, it might be expected that past head injury would be a risk factor. 7. ES symptoms are sometimes experienced as similar to a head injury. For instance, an affected Rhode Island teacher likened effects experienced with RF/MW to a concussion[241]. Just as it is important to avoid even minor head trauma following traumatic concussion, until healing has occurred, so avoidance of RF/MW (or more generally EMR) aggravation may prove important following pulsed RF/MW injury: radiation injury may be cumulative and in addition to the intensity-duration profile, the interval between exposures may be important in the clinical course[145].
VII. White Matter Abnormalities are Reported[44] in some diplomats.	In diplomats: "Medical testing has revealed that some embassy workers had apparent abnormalities in their white matter tracts that let different parts of the brain communicate"[44]. 1. White matter changes were observed in some with ES, in the fMRI study of persons affected by RF/MW/EMR[34]. 2. Oxidative stress and mitochondrial dysfunction (to which RF/MW can contribute, **Table 4**) are associated with white matter injury[242-248]. Among potential mechanisms, oxidative stress increases vulnerability of proteins (and lipids, DNA, RNA, etc) to autoimmune attack, which can include attacks on myelin[249-258]. Indeed, antibodies directed to O-myelin were reported in a subset of the 675 persons with ES that were included in a French study[33], affirming one mechanism by which white matter changes might occur. 3. Following GSM radiation exposure (study cited previously), examination of gene expression in rat brain showed alterations in myelin-related products (myelin-related glycoprotein)[187].

Table 3. Symptoms in Diplomats: Comparison to Symptom Rankings in Survey Studies that report symptoms with EMR, or in those with ES.

Percentages are given for diplomats (chosen for being symptomatic); and rankings for studies of persons reporting symptoms with EMR/RF/MW (not restricted to acute stage).

	Cuba Diplomats	**Australia** 2014	**US** 2011 Wireless Utility Meter Safety Impacts Survey	**US*** 2013 Maine Smart Meter Health Effects Survey & Report	**France** 2002	**Japan** 2012	**US*** 2015	**Nether-lands** 2007	**Sweden** 2006	**Finland** 2013	**Turkey** 2017
Citation	Study of diplomats[41] News media	Lamech[48]	Halteman[51]	Conrad[49]	Santini[259]	Kato[50]	Golomb[52]	Schoonev eld[102]	Johansson[37] Cites Swedish Language article[260]	Hagstrom[29]	Durusoy[261]
EMR- or ES-related characteristic	N/A	Smart meter exposure	Smart meter exposure	Smart meter exposure	Proximity to cell phone base station	ES	ES	ES	ES, acute phase	ES, acute phase	Cell phone use – symptoms during
Sample characteristics	~24 US and 2 Canadian diplomats to Havana reporting symptoms attributed to "health at-tacks" in news; (24 US embassy community members with neurological findings often seen after mild traumatic brain injury/concussion[41])	92 Residents of Victoria, Australia after exposure to smart meter radiation	318 US Respondents from 28 states	210 Respondents, 68% ES (142) †	530 People living near cellular phone base stations	75 Japanese with ES or sensitive to EMF	202 Persons with current ES	250 Dutch respondents with ES	22 with ES ranked symptoms. Most common were listed (not ranked)	194 with ES	2150 students in 26 high schools in Turkey.
All have symptom	Yes	No	No	No	No	Yes	Yes	Yes	Yes	Yes	No

s											
Symptom Rankings				Two rankings given: for severe *or* moderate and new/ severe and new							
Sleep	(86%) [41] Also:[6]	#1	#1	#4/ #1	#3	#4 76%	#1 94%	#5	Yes	#2	#6
Headache	(81%) [41] Also:[5,6,15] Also: (Lederman, Weissenstein, Lee et al., 2017; Panetta, 2017; Robles & Semple, 2017b)	#2	#3	#1/ #3 (pressure in head; headache is listed separately and would be #5/#5	#2	#2 81%	#2 88%	#7, #9, #10 (separated into 3 questions; #10 is pressure in head; #7 is numb feeling in head)	Yes	#4	#2
Cognitive	(81%) [41] Also:[6,19,262]	#5	#5	#2/#4	#4, #7	#3 81%	#3 85%	#2, #13	Yes	#7,#10	#4,#5
Stress anxiety irritability	67% irritability; 57% nervousness; 52% more emotional; 29% sadness [41]	#11	#2	#8/#7 (agitation)	#6 (irritability)	#9 & #10, for "irritation" and "anxiety 56% & 55%.	#6 in "initial symptoms", irritability 45%				

Tinnitus	(57%)[41] Also:[5,6]	#3	#4	#3/ #2	Not queried (except as "hearing")	#7 63%	#5; 80%	Not in main list, but by # affected in auditory list, #13		Not queried	
Fatigue	Not elicited ‡[41] Mentioned in news media[6,41])	#4	#6	#10/#9	#1	#1 (and possibly #5 "sluggish in the head") 85%	"Exhaus-tion" was a write-in symptom (Not queried)	#1	Yes	#6	#1
Dizziness or balance	(67%§)[41] Also:[5,6,15]	#7	#7	#7/#7	#14	#6 64%	#4 Initial 49%	#11	Yes	#12	#9
Vision problems	(76%)[41] Also:[42]	#12	#8	#10/#11	#12	---	#8 in Initial Symptoms 38%	#6	-----	#13 (photosensitivity)	#10
Nausea	[5,6,9]	#9	#12	---	---	---	#9 "gastrointestinal symptoms" (64%) (Nausea not separately asked)	---	Yes ("symptoms from the gastrointestinal tract")	#20	#15
Epistaxis (nose bleed)	not elicited[41] Mentioned in news/	#17	#13	#15 in symptoms that intensifie	----	---	"Noseblee ds" as a write-in symptom	--- (#12 is "nose problems"	----	----	----

	media:[9]			d. New onset in several write-ins.			(not queried)	)			
Hearing loss	(43%) [41] Also:[6,9,15,17,39]	#18 (with ear pain)	---	---	#5	---	#11 34%	#3	---	---	#14
Speech problems	**Not elicited ¶** [41] Mentioned in:[9]	*#30*	---	---	---	---	**	---	---	---	---
Comment			††	‡‡	§§		¶¶	¦		¦¦	

---- = Not queried

Surveys in the smart meter era were prioritized for inclusion; proximity of emitting devices to homes may make these more comparable to diplomat experience.
Studies of ES were also prioritized, as these focus on those who are symptomatic, providing symptom rates better suited for comparison to those in affected diplomats.
Other studies on similar themes report similar findings.
(An exception is that older studies from Scandinavia that focused on exposure to video display terminals from that time, report high rates of skin problems.)
For instance, a 2007 study of 85 persons living nearby the first mobile phone station antenna in Menoufiya governorate, Egypt reported that "The prevalence of neuropsychiatric complaints as headache (23.5%), memory changes (28.2%), dizziness (18.8%), tremors (9.4%), depressive symptoms (21.7%), and sleep disturbance (23.5%) were significantly higher among exposed inhabitants than controls: (10%), (5%), (5%), (0%), (8.8%) and (10%), respectively ($P < 0.05$)." Sleep, headache and cognitive again topped the list in frequency[263].
Some studies focus not on ranking, but dose-effect/distance relation. For instance, in Selbitz, Bavaria, those within 200m of a cell phone base station were compared on reported symptoms to those 200-400m away, and were found to report significantly more sleep problems, headache, concentration problems, "cerebral affections", depression, auditory/vestibular problems, visual problems, GI problems, dizziness, and nosebleed – also cardiovascular problems, joint problems, infections and skin problems " ($p = 0.01$" for dizziness and nosebleed, "$p=0.001$" for the rest)[161]. A 2003 survey study of the "microwave syndrome" "in Murcia, Spain, in the vicinity of a Cellular Phone Base Station working in DCS-1800MHz," reported that symptoms included fatigue, irritability, headache, nausea, insomnia, depression, discomfort, difficulty in concentration, memory loss, visual dysfunction, auditory dysfunction, dizziness (as well as several other symptoms)[24]. These were more prevalent within 150m of the station, relative to >250m, in most cases significantly so. It was noted that symptoms abated with removal from the RF/MW source[24]. A follow-on study examining rates of problems in relation to measured electric fields, and showed significance for 13 of 16 assessed symptoms, with symptom odds ratios as high as 59[151].

Our rankings do not include as a symptom, "Onset of Electromagnetic Hypersensitivity Syndrome" or "Aggravation of Electromagnetic Hypersensitivity Syndrome". We used the highest ranking if several cognitive queries were used (e.g. memory problems or concentration difficulties), or several head queries are used (e.g. headache, head pressure, heat or strange sensation in head), and exclude later exemplars of the category in ranking the lower ranked items.

***** There was no barrier to participation from outside the US, but participants are predominantly from the US

† 68% of participants had ES (N=142) of whom 63% felt certain their exposure to smart meter was responsible for initiating the ES. Of the 49 who were ES before smart meter exposure, all 49 (100%) stated that smart meter exposure made their ES not only worse but "much worse"

‡ Though fatigue was not elicited, it is noted that a number reported a "good day bad day" pattern in which mental or physical exertion on one day led to exacerbation for

several days.
§ Separates out balance (67%), dizziness (63%) and includes nausea (7%) in this category.
¶ Speech problems were not elicited but speech audiometry, speech therapy, speech pathology consultation are each mentioned totaling at least six references.
** Aphasia" was a write-in symptom (not queried).
†† 73% women; 93% over age 40; 43% over age 60; 78% from California; 49% characterize selves as EMF sensitive.
‡‡ The 1st number is severe *or* moderate and new; 2nd number is severe and new. Pressure in head and headaches were queried separately. The overlap is uncertain. The higher ranking (pressure in head) was used. Concentration and memory were queried separately. The overlap is uncertain. The higher ranking (concentration problems) was used.
§§ Memory and concentration were queried separately, ranked #4 and #7 in the original. Combined might be higher. The higher ranking is used. This analysis provides values at different distances. Orderings for the closest distance are used. Ordering shifts slightly with longer distances but in general, the more frequently reported symptoms remain the more frequently reported.
¶¶ Ratings are based on (videotaped) Commonwealth Club slide presentation. Additional symptoms were elicited but not presented.
¦ Notes buzzing ears, hissing sounds, loss of hearing, strong low frequency sounds, ear aches, and sound of bells clanging in 96, 80, 64, 545, 38, and 28 participants
¦¦ This assesses acute symptoms. It also gives fractions who report those symptoms before the acute phase, but it is unclear whether someone who reports a symptom (say, headaches, dizziness) before exposure, had those symptoms only occasionally.

Table 4. Mechanism Considerations.

Oxidative Stress – mediated by free radicals – is involved in RF/MW injury	Oxidative stress refers to a kind of injury against which "antioxidants" relatively protect, in which "reactive oxygen species" or "free radicals" produce changes/damage that can affect, for instance, lipids, proteins, DNA, and RNA. Mitochondria, which are the primary source of energy for cells (and regulate many other phenomena such as steroid hormone production and apoptosis) are a leading source and target of oxidative stress[59,264-267] – that is, mitochondrial injury not infrequently accompanies oxidative stress, and has been shown with RF/MW (see below). RF/MW produces oxidative stress. As above, in an analysis of 100 studies examining if low-level RF/MW produced oxidative injury, it was reported that ~93 found that it did[60]. Oxidative stress – and mitochondrial dysfunction are implicated in the symptoms and health effects that have been reported by diplomats (and RF/MW affected persons)[127,138,139,268-300]. For instance, oxidative stress is tied to tinnitus, antioxidants modestly alleviate it, and markers of oxidative stress in tinnitus are reported to be greater in jugular blood (near the ear) than the more commonly measured brachial blood[269,270,301]. Two findings substantially cement a role for oxidative stress in RF/MW health effects. First, persons who are "electrosensitive" (i.e. who experience symptoms at levels of radiation than many others tolerate) are significantly more likely to harbor gene variants that confer less-avid protection against oxidative injury[67]. This is an extremely important finding. People cannot manipulate their genes in response to suggestibility, and did not know their genes when they reported their sensitivity status. This powerfully supports a causal role for oxidative stress in the injury experienced. Second, a French study in electrically and chemically sensitive individuals (93% with ES), found *consistent*ly low levels of a urinary melatonin metabolite[33]. Since melatonin is an antioxidant that protects against damage to many toxins – but that has been shown in numerous studies to be *particularly* vital for defense specifically against oxidation injury *due to radiation* across the electromagnetic spectrum[111,124,141,200-208,210,211,213,214,216-222,224,225,227,302,303], including due to RF/MW[228-239,304], this dovetails with the aforementioned genetic data to compellingly support a role for oxidative stress – and to show that that those with ES – those who experience *symptoms* with radiation that others tolerate – are also experiencing *greater cellular and subcellular injury* from this radiation. Many studies show the importance of antioxidant defenses – including but not limited to melatonin – in protection against RF/MW injury. For instance, melatonin and to a lesser degree caffeic acid protect against cell phone induced oxidative stress in rats – and melatonin increased activity of other endogenous antioxidant enzymes, superoxide dismutase (**SOD**), glutathione peroxidase (**GPx**) and catalase which were depressed with the cell phone radiation[236]. Melatonin protected against laryngotracheal oxidative injury from wireless (2.45 GHz) radiation in rats[229]. Melatonin protected against skin oxidative injury in an experimental mobile phone model in rats[228]. Melatonin protected against 900MHz microwave radiation induced lipid peroxidation in rats[230]. Melatonin reversed the oxidative damage of microwaves to rat testes – including protecting testosterone level, sperm count, and protecting against DNA fragmentation (a marker of cell death)[232]. Melatonin protected against oxidative damage from cell phone radiation to rat brain[238]. Melatonin protects against oxidative damage from Wi-Fi to lens of rats[239]. Vitamins E and C protect against "900 MHz radiofrequency-induced histopathologic changes and oxidative stress in rat endometrium"[305]. Ginkgo biloba protected against cell phones induced oxidative injury in rat brain[306]. And so on. Antioxidants work together, for instance, to recycle one another to the reduced form in which they are active as antioxidants. The importance of antioxidant defenses in protection against radiation injury from RF/MW, extends what is well known for injury from radiation throughout the electromagnetic spectrum, including so-called "ionizing radiation" (which includes gamma for instance, "A positive correlation was found between GPx activity, glutathione content and cell survival following ionizing irradiation"[307]. Glutathione depletion increased with gamma radiation induced DNA damage[308] and cell death[309]. Glutathione determined the survival "shoulder" for x-ray radiation in hypoxic cells[310], and melatonin

	protected against x-ray induced lung injury[217]. Melatonin protected against radiation induced cataract[141] – and increased activity of other critical antioxidant enzymes, SOD and GPx. SOD protected against fractionated radiation induced esophagitis (and reduced the effect of that radiation on glutathione)[311]. Melatonin protected against UVB radiation-induced oxidative skin injury[222,223]; as did glutathione[312], and chocolate, which is rich in antioxidant polyphenols[313]. Melatonin has specifically been reported to protect the inner ear against radiation injury, in rats exposed to "radiotherapy" at 4-6KHz[111]. A role for oxidative stress in radiation injury transcends labels of "ionizing" vs "nonionizing", "thermal" vs "nonthermal" radiation. For this reason, those labels are of questionable utility in understanding radiation damage.
Radiation may depress melatonin – moreso in some – and in part through depressed melatonin, may depress other antioxidants	A number of studies report that EMR, including but not limited to RF/MW, can depress melatonin[302,314-322]. Evidence suggests that (like virtually all biological effects), a subgroup is more vulnerable[323,324]. {Note that sunlight, which provides EMR of a kind "expected" evolutionarily, is well recognized to govern (depress) melatonin, toward producing day-night and seasonal effects.} Light (a portion of the electromagnetic spectrum) inhibits melatonin as part of establishing circadian and seasonal rhythms[325-327].. Evolution did not plan for man-made radiation sources, and one hypothesis is that, in some people, such radiation sources may induce similar effects. "EMF {electromagnetic fields} are known to affect Ca2+ homeostasis and suppress melatonin activity in a wide wavelength range. Ca2+ ions in pinealocytes are involved in regulation of cAMP synthesis that mediates conversion of serotonin into melatonin. Their leakage from pinealocytes results in a decrease of the cAMP level and thereby suppresses production of melatonin"[328]. Long-term radar workers reportedly have increased serotonin and depressed melatonin, consistent with this impaired conversion – and effects in the RF/MW frequency range[329]. Electronic repair workers have also been reported to have lower melatonin than controls, and more sleep problems[330]. Melatonin (and its derivatives) – though better known for effects on sleep – provide a critical antioxidant defense system that protects against toxicity of an extraordinary array of toxins and conditions[274,331-355,356-382,383-416]. For this reason, to the extent that EMR does depress melatonin, it is expected to potentiate the array of adverse health outcomes tied to these toxins, and other sources of injury. Melatonin specifically protects against radiation injury at frequencies across the electromagnetic spectrum[111,200-202,205,206,208-210,212-214,216-220,223,225,226,230,233,238,239,304,417,418]. A study examining gene expression in rat brain reported that brain expression of N-acetyltransferase-1, the rate limiting enzyme in melatonin production[419], had significantly reduced expression following 915 MHz GSM-consistent RF/MW radiation (encompassing pulsed RF/MW) in rats, fold difference 0.48 ± 0.13, $p < 0.0025$[187]. Suppressed melatonin or sleep deprivation in turn increase damage to the pineal gland[420], which produces most of the circulating melatonin. Thus, sufficiently depressed melatonin can beget still further depressed melatonin – and heightened vulnerability to injury from future EMR exposure. Ability to sustain adequate melatonin production in the face of EMR/RF/MW, *may* be a critical determinant of pineal vulnerability. The pineal gland has high antioxidant needs[420,421], and in absence of such protections is vulnerable to involution[422,423]. Age-related involution of the pineal gland may help to explain why more middle-aged persons are reportedly affected by ES than younger people[424], though presumably younger adults may be more exposed to technology. {Middle-aged persons may, however, have had more years of EMR exposure.) Melatonin supports levels and activity of other antioxidants, including in the setting of radiation exposures[141,236,239]. Modest exposure to oxidative stressors (including from radiation) in persons or animals or plants whose system is not overwhelmed, can lead to antioxidant upregulation – a phenomenon called oxidative preconditioning, seen with many sources of limited oxidative stress, including limited exposure to radiation[425]. In part because of this, the net effect of an oxidant exposure on antioxidant levels depends on factors like intensity and duration of exposure, other oxidative exposure (so, mitochondrial dysfunction state), and status of antioxidant defenses, as well as time from exposure to assessment. Some studies in some

	systems show antioxidant upregulation[426] or mixed direction effects on different antioxidants[239], but many show depression of assessed antioxidants following EMR exposures[222,223,427,428] or specifically RF/MW exposure[235,236,237,239,305,429-435,436]. Such depressions, coupled with melatonin depressions, may enhance vulnerability to future EMR exposures – particularly where genetics provide for less effective variants of one or more antioxidants[67]. It is expected that mitochondrial impairment[59,264,266,267] or brain inflammation (sometimes itself a result of oxidative stress, amenable to reduction with melatonin[225,437]), since associated with greater production of free radicals and an expected less favorable balance of oxidative stress to antioxidant defenses, may be a risk factor for problems with the added oxidative stress from RF/MW, or from the depression in antioxidant defenses to which RF/MW may contribute.
RF/MW may depress xenobiotic protections	RF/MW has been reported to depress butyrylcholinesterase[438], an important xenobiotic defense enzyme. Depressed activity of this enzyme is tied to higher cardiovascular and all-cause mortality[439].
Oxidative Stress contributes to Auxiliary Mechanisms of radiation injury, such as Mitochondrial Dysfunction.	Oxidative stress contributes to multiple documented auxiliary mechanisms of RF/MW damage that likely contribute to health effects in subsets, including membrane alterations (cell membranes[440] and mitochondrial membranes[441-444]), blood brain barrier disruption[166,168-170,172,173,445-449], effects on voltage gated calcium channels[450] (affected by and affecting oxidative stress[451,452]), but also on voltage gated anion channels that are an important part of the outer mitochondrial membrane[453] – potentially contributing to mitochondrial impairment and amplification of oxidative stress, EEG spiking[233], impaired mitochondrial function[240,454] (bidirectionally related to oxidative stress[58,455,456] – and protected by melatonin[457]), impaired blood flow (e.g. via oxidative stress driven endothelial dysfunction)[458-461], autoantibodies[249,255,462-466], and apoptosis[467-476] (programmed cell death – which in turn triggers inflammation and coagulation activation[477]). Laboratory correlates for some of these were reported in ES participants in the French study: ~15% of those with ES had elevated markers of blood-brain barrier permeability; 29% in those with ES (23% in those with ES and multiple chemical sensitivity (**MCS**)) had antibodies to O-myelin[33].
Melatonin considerations: RF/MW/EMR vs diplomats	While depressions in a melatonin metabolite were the norm in participants with ES in a French study[33], this need not *necessarily* be the case for diplomats, even if a related cause (pulsed RF/MW) and related processes (e.g. tied to oxidative stress) are involved in symptom induction. In persons with "ES," lowered defenses are needed, for nominally "modest" exposures to produce problems. But if exposures in affected diplomats were more intense or otherwise injurious, lowered defenses would not be required to produce injury. To assess this, it may be prudent to assess urine melatonin metabolites at the time diplomats are identified with symptoms.
Psychogenic illness has been dismissed	Psychogenic causation has been repeatedly suggested as the basis for diplomats' symptoms[13,14,478]. This has been correctly dismissed, however, for the Cuba and China diplomats[11,40,41]. Psychogenic causation has similarly been suggested for symptoms from RF/MW[479] and has been similarly repudiated[108,480]. The Swiss Telecom funded study that documented a relation of sleep problems to transmitter field strength, also showed that symptoms were not related to a health-worrying personality[48,68]. The concordance of symptom profiles across studies, the emergence of RF/MW problems in people unaware of the exposure or its potential for problems, the concordance of symptoms and objective signs with known documented mechanisms of RF/MW injury, the presence of objective markers and ties to genetics that each cohere with known mechanisms of RF/MW injury[33,67,116] effectively preclude a psychogenic basis for the problem – were such a diagnosis meaningful. {See below, in the entry for study inconsistency, for provocation studies.} The notion that chronic symptoms can arise from psychogenic sources dates to Freud, who also pioneered the flaws associated with its application[481]. The foundation is substantially circular, a mechanism has never been physiologically defined or substantiated (much less documented to be operating in cases where the label is applied), and the label is deployed without the most basic scrutiny of the tacit assumptions[482]. Historically, many conditions that

	were presumed psychogenic (such as ulcers, seizures) were recognized as organic as evidence emerged[482].
Not all are affected – a minority of embassy personnel R, and of RF/MW exposed	How might some people experience symptoms and signs of injury from what seem to be "low levels" of an exposure, seemingly well below levels that other people tolerate? For toxins we designate an "LD50"[483-488] (dose lethal in 50%) – or an LD5. This reflects the recognition that for each potentially toxic exposure, there is a range in which some will experience an outcome and others will not. One can also define an SD50 (symptoms in 50%) – or an SD25, or SD5. It would be surprising if a highly useful and lucrative technology were *not* pushed as far into this intensity range as possible. Genetic variations in a range of free radical detoxification systems, competition for those systems, alterations in gene expression based on prior exposures, differences in vulnerability of the tissue affected (via factors like mitochondrial "heteroplasmy," past injury of that organ), and variations in secondary mechanisms triggered by oxidative stress, provide among the mechanisms by which variability is produced. The de facto intensity of the "same" exposure may differ radically (no pun intended) from person to person †. A further mode of variability arises from immune activation. Considering a more familiar "allergen," one person can eat a jar of peanut butter without problem; while another is hospitalized for exposure to a crumb of peanut. As above, oxidative stress can modify substances in a fashion that makes them vulnerable to autoimmune attack. Immune/autoimmune activation is a documented feature in a subset of those citing symptoms from RF/MW/EMR[33].
Effect modification	"Effect modification" refers to differences in effect in different individuals, and it is the rule rather than the exception in biology. Particular considerations are germane when the exposure has potential for prooxidant or antioxidant effects[489]. Many prooxidants can be antioxidant at low doses in some people (via "oxidative preconditioning" in which low level exposure to prooxidants may upregulate native antioxidant defenses; this can lead to net antioxidant effects in persons whose defenses are not already overwhelmed or maximally upregulated – as above). Conversely, many substances thought of as antioxidants are prooxidant in some settings, often including high dose[490-498]. So the same exposure can produce even opposite direction effects in different persons. Exemplifying the principle, statin cholesterol-lowering drugs are net antioxidant in many people (often tested in nonelderly males without metabolic syndrome factors), but are reproducibly prooxidant in a subset – and prooxidant dominance is tied to side effects[499,500]. These side effects (attended by net prooxidant effect[499,500]) arise disproportionately with higher doses, and in persons with conditions like older age and metabolic syndrome factors, that are statistically tied to mitochondrial impairment[56]. Side effects, too, occur disproportionately in women[56]. Women show higher rates of adverse effects from many drugs and environmental toxins (and many medical procedures); they are also more often affected by EMR[91,102,259,424,501]. There are many potential sources of effect modification from genetics (as has been documented[67]), level of exposure, and past and current environment that influence biology. Some exposures may cause mitochondrial injury or oxidative stress (competing for antioxidant defenses) or depress concentrations of antioxidants, boosting vulnerability. Other exposures may have protective effects.
Chemical exposures may serve as one source of effect modification	Many drugs and chemical exposures cause oxidative stress, cause mitochondrial injury (which also increases intracellular oxidative stress), depress antioxidant defenses, and/ or compete for or inhibit detoxification systems. Through these and other mechanisms, these exposures may magnify harm from RF/MW and vice versa. Preliminary evidence comparing chemical levels in Swedish persons with ES vs controls identifies higher levels of some organic pollutants in those with ES[26] – though larger studies are needed. Melatonin and glutathione (and other antioxidants) can be "radioprotective"[204,307,502,503] (here the root "radio" refers to radiation, not specifically to radiofrequency radiation). Other agents or conditions can be "radiosensitizing." As might be expected, glutathione depletion can be radiosensitizing, though the status of other antioxidants may be important[504-507]. The tie between low melatonin (assessed by the principle metabolite) and ES in the French study[33] supports the expectation that melatonin depletion is radiosensitizing as well. Radiosensitization is used therapeutically, to enhance killing by radiation of tumor cells[508], but its existence there is a reminder that chemicals interact with radiation to modify radiation effects. Radiation itself may be radiosensitizing – as potential effects on antioxidant systems, reviewed

	elsewhere, suggest – and reportedly ultra high frequency radiation is a particularly effective radiosensitizer[509]. Oxidative stress is an important, but not the only, means by which radiosensitization occurs[510], consistent with multiple downstream mechanisms of injury. (Of note, because critical systems that are involved in radiation defense – like melatonin, glutathione, and other antioxidant systems – are also involved in defense against toxicity of chemicals and drugs[511], and because factors that adversely affect antioxidant:oxidant balance may be adverse for oxidative stress mediated injury from either type of source, it is expected – as it is observed – that there will be overlap between chemical and electrical sensitivity[33].) Two illustrations where we can *see* the radiosensitizing effect occur with ultraviolet (**uv**) light, since due to its high frequency, the effect is primarily on the skin. Photosensitizing agents and "radiation recall" are the illustrations. Photosensitizing or phototoxic or photoallergic agents are agents that magnify damage observed with uv radiation. (For simplicity we will use "photosensitizing" to encompass each of these.) In some cases, radiation breaks down a chemical to something toxic. Drugs may also photosensitize, for instance, by augmenting one of the mechanisms of radiation injury, such as oxidative stress or mitochondrial dysfunction[512]. Fluoroquinolone antibiotics, which can cause serious problems in a vulnerable subset through oxidative stress and mitochondrial dysfunction[55], are strongly reported to photosensitize and to be phototoxic[513-531]. Fluoroquinolones have been tied to development of *persistent* phototoxicity (following withdrawal of the drug)[532] – i.e. ongoing higher vulnerability to this radiation – consistent with evidence that a vulnerable group experiences persistent damage from fluoroquinolones in which oxidative stress and mitochondrial injury play a role[55]. This "vulnerability" may be acquired, as mitochondrial injury can be cumulative, and a serious reaction sometimes follows a previous course of fluoroquinolones with a milder and time-limited reaction or none at all[55]. (Mitochondrial injury from radiation can also be cumulative[533].) Fluoroquinolones have led to reported "photosensitivity" reactions to fluorescent lighting[534]. Statins, which as elsewhere are sometimes prooxidant[499] and sometimes mitochondrially toxic[56], are also sometimes linked to photosensitivity[535,536]. (The below information about photosensitivity in Smith Lemli Opitz explains one reason that statins can be prooxidant, though they also have antioxidant mechanisms.) Given oxidative mechanisms of radiation injury that apply across the electromagnetic spectrum, it is expected that some agents that photosensitize may sensitize to other forms of radiation – potentially including RF/MW. Others have noted that photosensitizing drugs have played an apparent role in other radiation injury[537]. (Data we have presented, but not published, showed that past use of fluoroquinolones was significantly tied to development of ES; past adverse effects to fluoroquinolones, which signify oxidative-mitochondrial injury to a point producing symptoms (at least, they surpassed the symptom threshold for a time), showed a particularly strong connection[52].) There are also disease conditions tied to magnified photosensitivity[538]. Where these are tied to depressed antioxidant defenses, or increased mitochondrial injury, they might be predicted to be tied to increased risk of ES development (accounting for radiation exposure). In Smith Lemli Opitz syndrome, which many studies have tied to photosensitivity, cholesterol levels are low[539-550]. Cholesterol transports critical fat soluble antioxidants[56]. In the phenomenon of "radiation recall," injury to tissue initially caused by radiation can be made to reappear by another agent with shared mechanisms of injury, e.g. oxidative stress and mitochondrial injury – such as fluoroquinolone antibiotics – best recognized for skin reactions, since we are able to see these[551-553].
Are provocation studies contributory?	Several so-called provocation studies have been conducted in persons with ES; some focus on symptoms, some on objective markers. In most of those that focus on symptoms, those with ES fail to reliably distinguish between blinded EMR "exposed" and "unexposed" settings[554]. Major flaws in the designs have been recognized and reviewed by others[96, 102]: for instance, studies assume that the details of exposure and time course do not need to be individualized, which is contrary to the evidence. But there are further problems. The most fundamental is the assumption that in ES, symptoms serve as a meter; this is invalid. Consider the analogy of sunburn – a form of radiation injury mediated by oxidative stress, that affects some but not others at usual exposure levels. Those who are affected "believe" sun exposure is responsible. They would be unlikely to discern when they are being exposed vs not to ultraviolet radiation. (It is their failure to

know when significant injury is occurring, or has occurred that leaves them in the sun long enough to receive injury.) What is discerned is the inflammation (that follows the oxidative stress) that may only emerge late in exposure, or after the sun exposure has been "withdrawn." A blinded sham-exposed study would likely also produce inability to discern sham from active treatment.

People do not sense the EMR, but the effects produced by it, and studies show that those with ES respond to different EMR sources. In RF/MW-affected persons, as in diplomats, the effects can arise after hours of exposure, or hours after a short exposure – oxidative stress can cause apoptosis and can then trigger inflammation[477], or can cause blood brain barrier damage allowing brain swelling (see above) – progression of these mechanisms may not peak for hours or in some cases, even a couple of days. Recovery from effects can take still longer.

For such a study to have a chance to succeed, it would be essential to pretest and individualize both the control/negative exposure condition, and the active/positive exposure condition (including exposure and time course) in each individual, to define a condition that will be effective in that person – if such conditions can be successfully defined, and if cumulative effects don't alter the condition from one trial to the next. For some people the background EMR at the facility, or its parking lot or lobby; or the exposure during transit to the facility may obviate ability to define a negative exposure condition for that individual. It would be better to bring the EMR exposure to a place where the affected party is stable and asymptomatic. And the specific EMR and timing must be individualized to produce a positive condition, in a suitable time course.

To be valid, such a study must also protect against the possibility of physiological conditioning effects. These are distinct from "nocebo" effects, and arise because the true stimulus produces actual physiological harm: It is known, for instance, that chemotherapy patients may vomit when they enter the room in which they have received chemotherapy. (Chemotherapy agents, like EMR, also cause toxicity via oxidative stress[344, 555-557] and mitochondrial injury[558].) The fact that symptoms occur also with expectation of chemotherapy does not mean that the chemotherapy itself lacks toxicity (or that perceived adverse effects are due to a "nocebo" effect); rather, expectation produces symptoms *because* the exposure *is* toxic. Expectation of the noxious exposure may, via conditioning processes, produce symptoms ordinarily produced by the noxious exposure. (This is potentially evolutionarily adaptive – serving to encourage persons to avoid settings in which the toxic exposure is expected.) To ensure against conditioned effects arising with expectation, a set of negative exposure visits at the test site before (and between) each positive exposure visit may be required to ensure "extinction" of physiologically conditioned expectation effects. In essence, the setting that optimizes prospects to identify a real effect, if present, is that in which the participant believes there will *not* be an active exposure.

N-of-1 studies that focus on physiological effects of EMR have proven somewhat more able to identify EMR effects in those with ES, or subsets of them for which that physiological marker is affected. Just as symptoms vary, so physiological changes do so, so outcomes suited to one person may not apply for all. Physiological markers changed with blinded EMR exposure in a published study of a female physician with ES. She could not discern when the exposure was present or not, but measurable changes occurred and symptoms arose with the positive condition[27]. Symptoms were significantly more intense with pulsed (but not continuous) radiation than sham exposure[27]. An N-of-1 test was reportedly conducted in a former Miami organized crime prosecutor, who developed ES and chemical intolerance, with seizures an important part of his clinical profile, following a significant chemical exposure. An EEG was undertaken, turning on and off a TV, with the party blinded to the stimulus (blindfolded and with headphones to prevent him hearing when the TV was turned on or off). When the TV was shielded, no effect on the EEG was seen. With an unshielded television, EEG changes including seizure activity occurred when the television was turned on (and he experienced physical twitching)[559]. {This particular marker is unlikely to be generally useful, as seizure activity is not a usual part of the clinical profile in those affected by RF/MW.} A provocation study focused in a group of individuals showed changes in heart rate variability[116], an index of autonomic function that is tied to hard outcomes like sudden death and coronary artery disease[560,561]. Moreover, three of the four participants who characterized their ES as "intense" (though only persons in this group) exhibited striking heart rate increase of between 45 and 90 beats per minute virtually immediately with the microwave exposure, associated with marked increase in sympathetic response. Declines in parasympathetic response with RF/MW exposure were seen for 23 of 25 tested people, in all groups (including,

	though less so, those with no ES). In general, assessments of objectively measurable quantities of relevance, including both differences in affected vs unaffected persons irrespective of current exposure[33,67], and changes occurring with exposure[116], provide a more promising approach than real-time assessments of subjective outcomes for understanding this condition.
Financial conflict of interest is a major source of apparent disparities in results	One key source of disparities in study results is financial conflicts of interest. When present, financial conflicts strongly predict that study results will conform to the financial interests of authors or funders[98,99,562-566]. An analysis examined why some review articles on passive smoking concluded it was harmful while others concluded it was not: The *only* identified factor that predicted which conclusion, was industry conflict by authors – which was often undisclosed[566]. Richard Smith, the former Editor in Chief of the BMJ (the British Medical journal) observed that this suggested that "far from conflict of interest being unimportant in the objective and pure world of science where method and the quality of data is everything, it is the main factor determining the result of studies"[99]. Financial conflicts have been a concern specifically in relation to RF/MW, both for studies and for regulatory decisions[93-96,567]. In an analysis of studies looking at cell phone effects as a function of funding source, "Studies funded exclusively by industry reported the largest number of outcomes, but were least likely to report a statistically significant result" {So, they report everything that wasn't affected?} "The odds ratio was 0.11 (95% confidence interval, 0.02–0.78), compared with studies funded by public agencies or charities. Analogous to findings for a relation of industry funding to failure to find tobacco related problems[566], the finding was not materially altered in analyses adjusted for the number of outcomes reported, study quality, and other factors"[93]. It has been generally assumed that the disproportionately product-favorable results from industry-funded studies (including less evidence of product harm) arises by virtue of choices, selecting study design, exposure specifics, subjects, and outcomes to support the desired result. (See below, these can in fact influence outcomes.) But where harms of lucrative products are concerned, there is precedent for industry-funded studies going beyond those factors to hide even large and lethal harms, even for prespecified or primary outcomes – via means that have the appearance, at least, of fraud[568,569]. Special circumstances enabled the apparent shenanigans in those cases to be uncovered. Whether frank manipulation of data to hide harms of lucrative products is the rule or the exception in industry-funded studies is simply not known. Because of a robust body of evidence documents a strong relation of industry conflicts to outcomes, deliberations and standards should be based exclusively on studies in which such conflicts of interest are absent. (Industry funded-studies can be used for hypothesis generation.) This obviates one major source of apparent inconsistency in studies. But it eliminates inconsistencies due to this factor, only as far as it is possible to discern when financial conflicts are operating.
Study outcomes may appear different without "inconsistency": Details matter, to see an effect	Design features can influence outcomes, and may be selected to do so. Details of RF/MW exposure that may influence outcomes include the following (some relevant features have doubtless been missed): - Radiation frequency or frequencies[570-572] - Radiation intensity[78] - Radiation waveform[78] - Polarization[571,573,574] - Pulsed vs continuous radiation[574,575] - Pulse width[100] - Time between pulses[187]/ repetition rate[47] - Pulse waveform[47,576] - Pulse intensity[45] - Exposure duration[577,578], and

- Exposure intermittency[579] - on every time scale
- Environmental conditions – temperature, humidity, air currents[78,580]
- Concurrent (or preceding) exposures to other radiation[78,97,581] – which can cause synergistic effects[78]
- Concurrent (or preceding) chemical exposures or environment[97,581]
- State of health of the animal or subject[78]
- Species[78]
- Size of the subject relative to wavelength[78]
- Genetics of the animal[67,571]
- Antioxidant/ nutrient status of the animal or subject[234,235,304,305,434,582-588]
- Orientation of the animal or subject relative to the radiation source[78]
- Portion of the body irradiated[78]
- Time between exposure and assessment of effect[571]
- Effect measured
- Metric used to measure effect

Radiation that is pulsed, that is polarized, that is applied intermittently, that is more intense, and that is applied for a longer time, may be more likely to produce problems, for instance.

Even for studies nominally examining the "same" RF/MW exposure, different choices may be made. A range of choices are illustrated in this text: "There are 124 different channels/frequencies that are used in GSM900 mobile communication. They differ by 0.2 MHz in the frequency range between 890 and 915 MHz. The test mobile phone was programmed to use channel 124 with the frequency of 915 MHz. The signal included all standard GSM modulations. No voice modulation was applied. A GSM signal is produced as 577 ms pulses (time slots), with an interpulse waiting time of 4039 ms (seven time slots). The test phone was programmed to regulate output power in the pulses in the range of 0.02–2 W (13– 33 dBm). This power was kept constant during exposure at 33 dBm, as monitored online using a power meter (Bird 43, USA)"[187].

Studies that examine symptoms as a function of distance from cell tower base stations suggest that in important, real world settings, more intense RF/MW exposure is generally a greater problem[68,151,259,589]) – though there may be an intensity range below which this ceases to be the case.

In some conditions, nonmonotonic effects of radiation have been reported[574,590], and they are arguably expected for agents in the antioxidant-prooxidant spectrum (high dose antioxidants are often prooxidant, low dose prooxidants, via oxidative preconditioning, may be antioxidant). Opposite direction effects on a critical mechanism can produce opposite direction effects in a resulting outcome. Thus, lower doses of vitamin E fluidize, and higher concentrations stabilize membranes[591]; low vitamin E benefits and higher vitamin E harms vasodilatory function in cholesterol-fed rabbits[592]; "Low tocopherol concentrations have stronger antiinflammatory effects in PUVA-induced erythema than higher concentrations"[593]; low doses are tied to lower mortality in people, higher doses to higher all-cause mortality[594], etc. For statins, an agent class that can produce prooxidant or antioxidant effects, bidirectional effects have been shown on many outcomes[595] – female sex and features tied to greater likelihood of mitochondrial problems are risk factors for harms – as is higher dose or use of a higher potency agent[56]. It is common that where a lower amount of something may be favorable (or neutral), a higher amount may be adverse – with a transition zone in which subject characteristics and covariables matter a lot in determining the direction. (There are instances in which this directionality is flipped[596] – for instance, sometimes a sufficient concentration leads an adaptive protection to be triggered.)

Beyond characteristics of the radiation, the subject may be exposed to it differently – e.g. in animal studies, there may be whole body radiation[597] or head-only exposure[181,598], triggering a different spectrum of responses – and with in vitro exposure, even fewer of the variables that might contribute to

	effects are present. The environment in which exposure occurs may differ in ways that influence toxicity of radiation, for instance differences in temperature may produce different effects[580], or concurrent or background electromagnetic exposure[581] or chemical exposures[97,599]. Amphetamine use represents one exposure that has been reported to magnify problems with RF/MW[47]. Characteristics of the "subjects" may differ. In animal and in vitro studies, they may differ in species, strain, genetic features, cell type, cell preparation, and cell density[571,599], for instance. "Effect modification" refers to the phenomenon by which effects, including adverse effects, are not equal in all subgroups. This is a major issue throughout biology, and particularly for exposures mediated by oxidative stress and cell energy impairment. Findings with statin cholesterol lowering drugs illustrate how massive the disparity may be as a function of participant group. Like RF/MW, these agents have potential for toxicity through prooxidant and mitochondrial adverse mechanisms[56,499]. RF/MW disproportionately affects sleep and hearing (through its special extra features) – but muscle and tendon problems are sometimes reported[48,102,108]. Fluoroquinolones disproportionately affect tendons through their extra mechanisms (statins can do so too, though more rarely[600-603]). Statins disproportionately affect muscle – the most feared muscle complication is rhabdomyolysis, massive breakdown of muscle that can overwhelm the kidneys and lead to kidney failure and death (which is also reported with fluoroquinolones though more rarely[604-612]). Statins were commonly hailed as so safe they should be put in the water supply[613-616]. But analysis of insurance claims data show that (focusing on the one adverse effect) while the rate of rhabdomyolysis was rare overall, it was frankly common in identifiable vulnerable subgroups. Hospitalized rhabdomyolysis, per year of treatment, occurred in fewer than 1 in 22,000 on statin monotherapy. However, the rate was far higher for older diabetics also on a fibrate (a second class of cholesterol lowering drug), and if they were on the statin agent whose clearance was most affected by fibrates, rhabdomyolysis occurred in about *1 in 10 per year of treatment*[617]. So, depending on characteristics of the exposure, co-exposures *and the subject,* rates of a problem – and ability for science to show the problem – can vary widely. (The particular statin agent that caused the worst problems was pulled from the market, but the conceptual point stands.) Risks of harm with exposures are not distributed equally. A problem that appears very rare overall, or in one test group – often apparently not increased relative to unexposed – can be frankly common in another. If the groups most at risk are not studied, or their presence is seriously diluted, serious harms can be missed. Studies that fail to detect a harm do not invalidate those that show one – and are not of equal importance where a purpose is to establish that harms can occur.
Rates of problems	Though a minority of embassy personnel were reportedly affected[11], it is unclear how many were exposed. The fraction of US diplomats in Cuba (and now China) reporting effects may be higher than the fraction of civilians citing similar severity problems with RF/MW exposure – though in neither group can the exposure of those affected be presumed to have been typical. **Table 3** suggests that once persons are symptomatic, the profile of symptoms is similar. The reportedly high prevalence of Frey-compatible effects, and what seem a comparatively large number of diplomats in Cuba affected, suggest exposures of a more intense or more damaging character – considering intensity, frequency, pulse waveform, pulse duration, duration, polarization, interconcurrent exposures, and many other factors influence injury from RF/MW[571].
Natural History	Both diplomats[9] and RF/MW affected individuals[49,102] have shown variable time course to onset of symptoms after apparent inciting exposure; and variable time course and completeness of recovery with time away from the exposure. Doctors submitting the Bamberg Appeal to the Prime Minister of Germany noted: "The symptoms occur in temporal and spatial relationship to exposure…Some of the health disturbance disappears immediately the exposure ceases (removal of DECT telephone, temporary moving away from home, permanently moving away, using shielding)"[109]. An "intervention study" from Japan, involving the "intervention" of removing a cellular phone base station on a condominium, affirms improvement with removal of the exposure. 107 of 122 inhabitants were interviewed and had medical examinations at two time points, while the base station was in operation, and three months after it was removed. "The health of these inhabitants was shown to improve after the removal of the antennas, and the researchers could identify no other factors that could explain this health improvement…The results of these examinations and interviews indicate a connection between adverse health effects and electromagnetic radiation from mobile phone base stations"[618].

	Natural history could differ for diplomats, who may have been exposed to a more intense stimulus or one with more injurious characteristics – suggested by what appear to be a comparatively high number affected, and high prevalence of Frey effects. With a powerful exposure, depressed defenses are not equally required to produce injury. There is not a basis to know if affected diplomats will have heightened vulnerability to "usual" RF/MW exposures going forward – though this bears assessing.

† An illustration from a common drug, and a common food: "Grapefruit juice increased the mean peak serum concentration (**Cmax**) of unchanged simvastatin about 9-fold (range, 5.1-fold to 31.4-fold; $P < .01$) and the mean area under the serum simvastatin concentration-time curve {AUC (0-infinity)} 16-fold (range, 9.0-fold to 37.7-fold; $P < .05$)"[619]. Thus, just one comparatively innocuous interacting factor – grapefruit juice (which inhibits an enzyme involved in simvastatin metabolism) – led some to have a 38-fold greater blood "amount" of a drug, than that same person would have had without the juice. Potential differences are magnified comparing *different* persons with/out juice; and moreso factoring in impact of other exposures. Other risk multiplying factors are tied to the individual: The same serum level can produce a radically different impact from person to person: relevant factors include genetic differences in muscle, and factors that reduce energy supply, or that increase energy demand to muscle[56, 620-624]. Thus, what is the "same" exposure before it hits two people, can become a radically different exposure once it interacts with individuals' biology.

Table 5. RF/MW Source Considerations.

What kinds of RF/MW sources affect civilians?	In the UCSD survey, smart meters were the dominant inciting trigger (~50% of those ~70% who recognized a triggering episode), with cell phones, Wi-Fi introduction or new routers, medical radiation and other factors also reported[52]. The range of apparent triggers has been vast, with RF/MW and particularly pulsed RF/MW commonly implicated. Considering those who have communicated with us, a couple from Scotland became affected several decades ago, after they moved to a rural area, but across from a radar factory. Though they moved away, both remain "electrosensitive" decades later. Others became affected when a cell tower was placed next to their home. Dr. Gro Harlem Brundtland reports becoming sensitized following exposure to a malfunctioning microwave oven (in an episode that also reportedly blinded her for a year)[32,625]. An Australian veteran reports that he became affected during his military service, working with radiofrequency radiation (radar workers in the military were among the first groups in whom such problems were recognized, many decades ago). One who communicated with us became sensitized in association with their job placing radio collars on wildlife. An architect who contacted us was sensitized after several months working closely with Bluetooth-enabled lighting devices. Parents reported to us the onset of ES in their children with Wi-Fi introduced to the school, accommodations were denied, forcing parents to remove their children from school and move elsewhere, and forcing some teachers from their job[241,626]. In Sweden and the UK, a controversial radio system called TETRA reportedly caused health problems in some police officers: severe insomnia in a Swedish officer resolved when the officer's managers noted the connection, and placed the officer in a room without the exposure[625]. Some US firefighters were affected after municipalities placed cell towers on roofs of fire stations[627]: "Symptoms experienced by the firefighters have included neurological impairment including severe headache, confusion, inability to focus, lethargy, inability to sleep, and inability to wake up for 911 emergency calls. Firefighters have reported getting lost on 911 calls in the same community they grew up in, and one veteran medic forgot where he was in the midst of basic CPR on a cardiac victim and couldn't recall how to start the procedure over again. Prior to the installation of the tower on his station, this medic had reportedly not made a single mistake in 20 years."[628]. The International Association of Fire Fighters Division of Occupational Health, Safety and Medicine crafted a position paper[627], and firefighters were exempted in the recent proposed California bill, SB-649[628, 629], that sought to bypass local control in placing of 5G cell towers[628].) These were not "nocebo" effects: many developed symptoms prior to identifying the source of the problem (or in some cases even being aware that the exposure existed at that time). Many had no idea the exposure had potential to produce problems. They were blindsided by onset of new problems. The causes were identified by their spatial and temporal relationship to onset, worsening and abatement. Reports of problems from commercial sources of RF/MW have emerged from many nations including (e.g.) Russia[67,80], Korea[630], Japan[50], Taiwan[631], Turkey[261], Israel[632], Australia[48], New Zealand[30], France[33], England[314,633], Ireland[314,634,635], Spain[24,151,636], Italy[67,314], the Netherlands[102], Switzerland[68,92], Austria[25,90,314,637], Germany[314,638], Denmark[314,639], Sweden[36,424] (where Ericsson designer Per Segerbäck was seriously affected[640]), Norway[641] (afflicting 3-time Prime Minister Gro Harlem Brundtland, as above), Finland[29] (reportedly affecting former Nokia Chief Technology Officer Matti Niemela[642]), the US[32,34,38,91], where affected former Silicon Valley techies Peter Sullivan[643] and Jeromy Johnson[644] strive to bring attention to the problem; and Canada (where Frank Clegg, formerly head of Microsoft Canada, now of Canadians for Safe Technology – spearheads the effort toward recognition[645]).
Past RF/MW use and Diplomats	Exposure of diplomats to RF/MW is not a new phenomenon. The US embassy in Moscow was reportedly radiated with microwaves from 1953-1988 (other sources give earlier or later end dates), spawning efforts by the US to shield the embassy[75,76]. The Soviets claimed the purpose was to jam US listening devices[75]. Based on reports of past embassy staff, a number of personnel and their offspring developed health effects, some developed white blood cell count elevations, and a couple developed hematological malignancies[76]. Elevated white blood cell counts[108] (as well as depressed ones[78]) have elsewhere been reported in association with RF/MW, as have hematological malignancies[646,647], including a recent report of an occupational relationship of RF/MW to "hemolymphatic" malignancies in the military setting: "The PF {percentage frequency} of HL {hemolymphatic} cancers in the case series was very high, at 40% with only 23% expected for the series age and gender profile, confidence interval CI95%: 26-56%, $p<0.01$, 19 out of 47 patients had HL

	cancers. We also found high PF for multiple primaries. As for the three other cohort studies: In the Polish military sector, the PF of HL cancers was 36% in the exposed population as compared to 12% in the unexposed population, $p<0.001$. In a small group of employees exposed to RF/MW in Israeli defense industry, the PF of HL cancers was 60% versus 17% expected for the group age and gender profile, $p<0.05$. In Belgian radar battalions the HL PF was 8.3% versus 1.4% in the control battalions as shown in a causes of deaths study and HL cancer mortality rate ratio was 7.2 and statistically significant. Similar findings were reported on radio amateurs and Korean war technicians. Elevated risk ratios were previously reported in most of the above studies"[648]. (There was a news report of a "blood disorder" in a Cuban diplomat, but its character was unspecified[15].) A controversial Johns Hopkins study was commissioned to assess the health of Moscow embassy personnel, but was never published in peer reviewed literature. Staff from other Eastern European embassies were used as controls[649] – a problematic control group as these are the embassies most likely to have been subjected to similar exposures; indeed a FOIA request reportedly yielded claims of exposure from employees at other embassies[649]. A reanalysis asserted that Russian and Eastern European diplomats if combined, exhibited a significant increase, relative to expectation from the general US population, in three cancer types[649,650] that have each been associated with RF/MW exposure in other studies – hematological malignancy[648], brain cancer[651-654], and breast cancer[655,656]. Some complaints, such as vision problems, concentration problems, memory loss, depression and "other symptoms" were greater in the Moscow than the comparator group, in either men or women or, for vision and concentration problems, in each men and women. Given a presumed vulnerable subgroup, a problematic study design, and absence of a quality report, it is difficult to draw meaningful inferences – beyond that some diplomats were exposed, and some who were exposed reported health problems.
Current RF/MW Source Possibilities in Diplomats	The source of proposed EMR/RF/MW (probably pulsed) affecting diplomats is not a principal focus of this paper. For the diplomats in Cuba, causative RF/MW could in principle emanate from monitoring/surveillance devices (as has been speculated for microwaving of the US embassy in Moscow[75]); from efforts to jam our listening devices, as claimed by the Soviets[75]; from electronic weaponry, or conceivably from "innocent" communications sources of the type that affect some civilians (but presumably of higher typical intensity, or shorter pulse duration, or in the setting of other exposures that amplify oxidative stress, or with some other feature that amplifies the fraction affected). Surveillance-related efforts would seem perhaps the most likely, given the apparent preferential involvement of diplomats, in Cuba and China.
Room sweep by FBI yielded no devices[10]	The source of the historical microwave exposure on the US embassy in Moscow was also outside the embassy building. It reportedly originated from the building next door, and later from the building across the street[75]. Smart meters (or banks of them) – outside the room – were the number one reported instigating cause of symptoms in the UCSD survey, with other causes including base stations or cell towers outside the home. Pulsed RF/MW producing devices thus need not be in the room. The exposure can be short term or intermittent – it need not be continuous. For this reason, devices in whatever their location need not remain present, after health effects have been produced.

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