# Case study: could electromagnetic-hypersensitivity be exacerbating this case of chronic fatigue syndrome?



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## ABSTRACT

This case study describes the diagnosis and management of a female who, in her mid-30's, suddenly began to experience a cluster of symptoms and signs that were eventually diagnosed as chronic fatigue syndrome (CFS). Five years on, a rapidly growing benign, follicular thyroid nodule was also identified. Her health continued to deteriorate. A partial thyroidectomy was performed, and thyroxine therapy commenced. However, postoperatively, new rapidly growing thyroid 'cold' nodules were identified in the other lobe. She was advised to prepare for a full thyroidectomy.

The onset of illness coincided with the person moving into an apartment in one of Sydney's inner-city suburbs. Following surgery, an environmental health researcher measured the levels of anthropogenic electromagnetic radiation/fields (EMR/EMF) levels in her apartment. The radiofrequency (RF) EMR readings were within the limits set by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA), yet high according to the independent scientific guidelines. The findings prompted a trial relocation into accommodation that would reduce her night-time RF-EMR exposure by at least 16,000-fold. Except for a longer commute to work, no other changes were made. Within a few weeks, her health began to improve, and this continued over the next ten months. Objective signs included ultrasound confirmation that the thyroid nodules were now stable.

Following another relocation 10-months later, her CFS became considerably worse. Like the first presentation, this coincided with a dramatic increase in EMR/EMF exposure at home. The possibility of electromagnetic hypersensitivity (EHS) was considered. Management has since focused on minimizing unnatural EMR/EMF in line with EUROPAEM 2016 guidelines along with more targeted pharmacological, nutritional and lifestyle support. A gradual improvement in her health has ensued, yet, symptom exacerbation continues to most closely correlate with RF-EMR exposure.

The potential underlying mechanisms and pathogenesis of CFS are complex, with considerable overlay with other chronic conditions. Contention surrounding the legitimacy of EHS continues. Whether EMR/EMF is common underlying exacerbator of CFS, is yet to be determined. The challenges with navigating these controversial and unresolved issues are discussed.

**Keywords**
Chronic Fatigue Syndrome, Myalgic Encephalomyelitis, Electromagnetic hypersensitivity Syndrome, Systemic Exertion Intolerance Disease, Electromagnetic Fields

## Introduction

Chronic Fatigue Syndrome (CFS), also known as Myalgic Encephalomyelitis (ME) and more recently Systemic Exertion Intolerance Disease (SEID), is a complex and heterogeneous multi-system disorder.[1-4] Five core symptoms – disabling fatigue, post-exertional malaise, disturbed and unrefreshing sleep, cognitive impairment, and orthostatic intolerance – of greater than six-months duration are pathognomonic.[1] Other common symptoms include myalgia, arthralgia, headaches, recurrent sore throats, tender lymph nodes, chills, night sweats, irritable bowel syndrome, shortness of breath, arrythmias, allergies and sensitivities to foods, odors, chemicals, light, or noise. These arise from profound dysregulation of the central nervous and immune, endocrine, and cardiovascular systems, with proposed underlying disruption of cellular energy metabolism and ion transport.[2] Diagnosis requires the exclusion of other conditions, is often delayed, and typically involves numerous investigations and referrals to medical specialists.

The true prevalence of the condition is unknown, as it is thought that most people with CFS are yet to be diagnosed.[1] While it might not be a new disease, because similar conditions have been reported in different names,[4] CFS is gaining increasing prominence in our modern society (Figure 1). However, the condition remains controversial, with highly debated opinions on its aetiology and treatment.[1-4] People suffering from CFS often feel stigmatized, misunderstood, and trivialized[1]. It was dubbed "Yuppie Flu" in the past as it mysteriously afflicted mostly those of high socioeconomic backgrounds and relatively young. Women are at higher risk than men. With an unknown aetiology in the absence of established causative factors, management is notoriously difficult and mostly focuses on supportive therapies aimed at providing symptomatic relief and improving quality of life.[1-4]

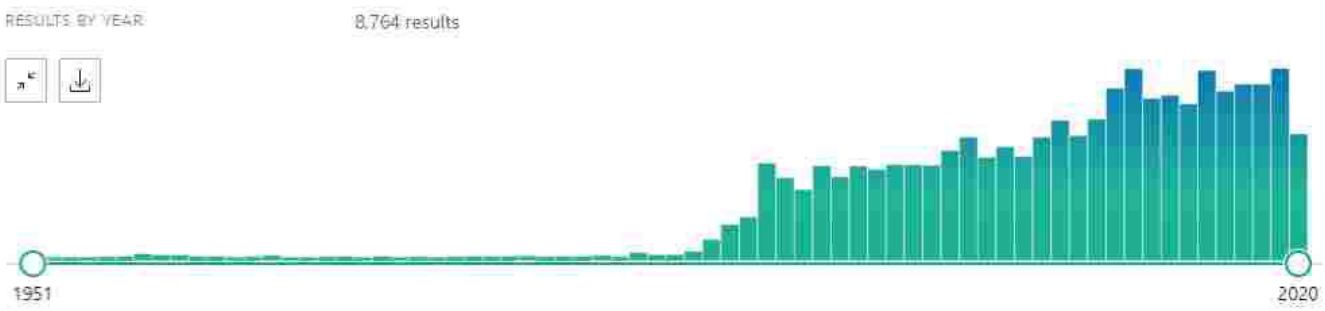



**Figure 1**. A PubMed search (on 26th August 2020) with "Chronic Fatigue Syndrome" as the search term yielded 8,764 articles published since 1951. There has been a sharp growth in the medical literature on CFS since 1983, with five or less publications for each year prior to that, except for 1957 when there were eight.

**Case Presentation**

This case report describes the diagnosis and management of a Caucasian female (KJ) who, at the age of 33 y, suddenly began to experience a cluster of symptoms and signs suggestive of CFS. Shortly after moving into an apartment in a high-density inner suburb of Sydney (around 2005), KJ started suffering from headaches that were later diagnosed as migraines and felt 'run down'. Over the next six months she developed increasing post-exercise fatigue, myalgia, sleep disturbance, waking unrefreshed, nausea, constipation, sore throats, mild flu-like symptoms, rhinitis, pre-menstrual syndrome, and thinning hair with hypopigmentation. Over the next eight years, KJ's fatigue and associated symptoms became increasingly disabling, with fatigue she described as "*bone-crushing*". Post exertional symptoms were more severe, exacerbating her sleep disturbance and myalgia and fatigue on the following day was often accompanied by feeling feverish. "*I stopped riding my pushbike to work as it was clear that exercise did not help my health and perhaps at this time was detrimental. I continued to do gentle yoga twice a week if I felt good."* Her cognitive functioning was also impacted, most noticeably mental fatigue that impacted concentration and short-term memory at times. Management was supportive, focusing on diet and lifestyle.

Raised in regional Australia, KJ moved to Sydney at the age of 19 y for tertiary education. Her time in Sydney was interjected by a few years travelling and living in Japan and Europe and a few months travelling in South America. Prior to this illness, KJ described herself as fit and active. Her only health complaint was a tendency for constipation that was managed with diet. She was a non-smoker, had a low alcohol intake and did not take any regular pharmacological or complementary medicines (CM). KJ enjoyed her work, she had a strong social network and good family support. Her hobbies included weekly salsa dancing, book club and cooking international cuisines.

Following the rapid decline in her health, KJ started consulting her general practitioner (GP) more regularly. The cluster of symptoms were only partially explained by low iron; however, oral supplementation exacerbated nausea and inflamed her liver, with liver function tests returning to normal upon cessation. Other signs of inflammation included mild thrombocytosis (platelet counts: 360 to 448 $x10^9$/L). At age of 38 y, an immunologist identified elevated immunoglobulin (Ig) E (138 kU/L) and low IgA (0.56 g/L). A rapidly growing thyroid nodule was also identified prompting an endocrinology review. Fine needle aspiration cytology of the dominant nodule was consistent with a benign, follicular lesion. Thyroid function, auto-antibodies, C-reactive protein, and erythrocyte sedimentation rate (ESR) were normal throughout, including no sub-optimal results.

Supplementation for mild iodine deficiency that included trialing combination nutraceutical products had no lasting effect. Various other approaches to optimising KJ's nutritional status at best, provided temporary mild relief, and at worse, would exacerbate. For example, along with iron supplementation, various magnesium and calcium compounds were also poorly tolerated. Over the next two years, KJ's health continued to deteriorate at an increasing rate. Finally, she underwent a partial thyroidectomy (age 41 y). Within a few months post-operation, rapidly growing thyroid 'cold' nodules were identified in the other lobe, thyroxine was commenced with no effect, prompting the advice that a full thyroidectomy was inevitable.

At this stage, an environmental health researcher (PB) measured her residential exposure to anthropogenic electromagnetic radiation/fields (EMR/EMF) levels (see Table 1). The internal levels of radiofrequency (RF) EMR that KJ was exposed to were well within the accepted levels set by the Australian Radiation Protection and Nuclear Safety Agency (ARPANSA)[5] and the International Commission on Non-Ionizing Radiation Protection (ICNIRP).[6,7] However, KJ's RF-EMR exposure was high according to independent scientific guidelines,[8,9] and recommendations of building biology practitioners.[10,11] The RF-EMR exposure was determined to be entirely from external sources (i.e. outside the apartment). KJ's sole RF-emitter, her early-model mobile phone did not change the ambient RF-EMR levels when it was in stand-by mode.

**Table 1. Comparison of EMR/EMF home assessments with national and international guidelines**

| | **Radiofrequency electromagnetic radiation (RF-EMR)** measured for 50 MHz - 3.5 GHz as power flux density in Watts/metre$^2$ (W/m$^2$) | **Extremely Low Frequency Electromagnetic Fields (ELF-EMF)** emanating from 50 Hz power supply and electrical appliances as magnetic field in milli Gauss (mG) | **Dirty Electricity (DE)** 10 kHz to 100 kHz range voltage transients/harmonics contaminating the 50 Hz electrical wiring measured in Graham-Stetzer units (GS). |
|---|---|---|---|
| **HOME ASSESSMENTS: SLEEPING AREA** | | | |
| Level high-density inner-city apartment (age 33-41 y) | $3.2 \times 10^{-3}$ | 0.6 | Below 60 without intervention |
| Level during 10-month mitigation trial (age 42-43 y) | $2 \times 10^{-7}$ | 1 | Above 250, maintained <50 with filters * |
| Level in ground floor unit inner suburban city (age 43y) | $6 \times 10^{-5}$ | Up to 10 | Above 1000, maintained <100 with filters* |
| Level in regional home (age 44-48y) | $1.7 \times 10^{-7}$ | 0.6 | Above 200, maintained <50 with filters 5 years ago, recently increased to >700 but <200 with filters* |
| **UPPER LIMIT OF GUIDELINES/RECOMMENDATIONS** | | | |
| ARPANSA standard (2002)/ ICNIRP guidelines (1998) for RF-EMR | 10 | Not applicable† | Not applicable† |
| ICNIRP guidelines (2020) for RF-EMR | 40 | Not applicable† | Not applicable† |
| ICNIRP guidelines for low frequency (2010) | Not applicable† | 2000 | Not applicable† |
| Bioinitiative Report (2012) | $3\text{-}6 \times 10^{-6}$ | 1 | Not addressed |
| German Building Biology Guidelines (2008)/Australian College of Environmental Studies (ACES) | $5 \times 10^{-6}$ for sleeping area, $10 \times 10^{-6}$ for living area | 2 for living area, 0.2 for sleeping area | 30** |
| EUROPAEM (2016) guideline for sensitive people | $1 \times 10^{-7}$ to $1 \times 10^{-4}$ depending on the source, $10^{-7}$ for WiFi | 0.3 average, 3 maximum | <0.003 V/m*** |

**EMR/EMF:** Electromagnetic fields / electromagnetic radiation; **ARPANSA:** Australian Radiation Protection and Nuclear Safety Agency; **ICNIRP:** International Commission on Non-ionizing Radiation Protection; **EUROPAEM**: European Academy for Environmental Medicine. The three categories of electromagnetic parameters correspond to anthropogenic EMR/EMF that were measured and monitored in KJ's case. *STETZERiZER filters used.[13,14] **ACES recommends this based on independent scientific reports.[11,12] ***EUROPAEM recommendation for DE frequencies refers to the electrical field in V/m (not measured in this case) whereas GS units refer to rate of change of the voltage with time (one GS Unit is 24 Volts per second). †Non applicable based on the addressed frequency range.

KJ decided to move from her city apartment to a free-standing home in outer suburbs of Sydney. Her night-time RF radiation exposure was reduced at least 16,000-fold to 2 x $10^{-7}$ W/$m^2$ (Table 1). Other EMF parameters in her accommodation were similar: extremely low frequency (ELF) magnetic fields[12] 1 mG and high frequency voltage transients travelling on 50 Hz house wiring 'dirty electricity' (DE) levels maintained below 50 GS with STETZERiZER filters.[13,14] Her daytime exposure in the workplace did not change. Except for a longer commute to work, all else remained relatively constant, including pharmaceutical and CM use, diet, and lifestyle.

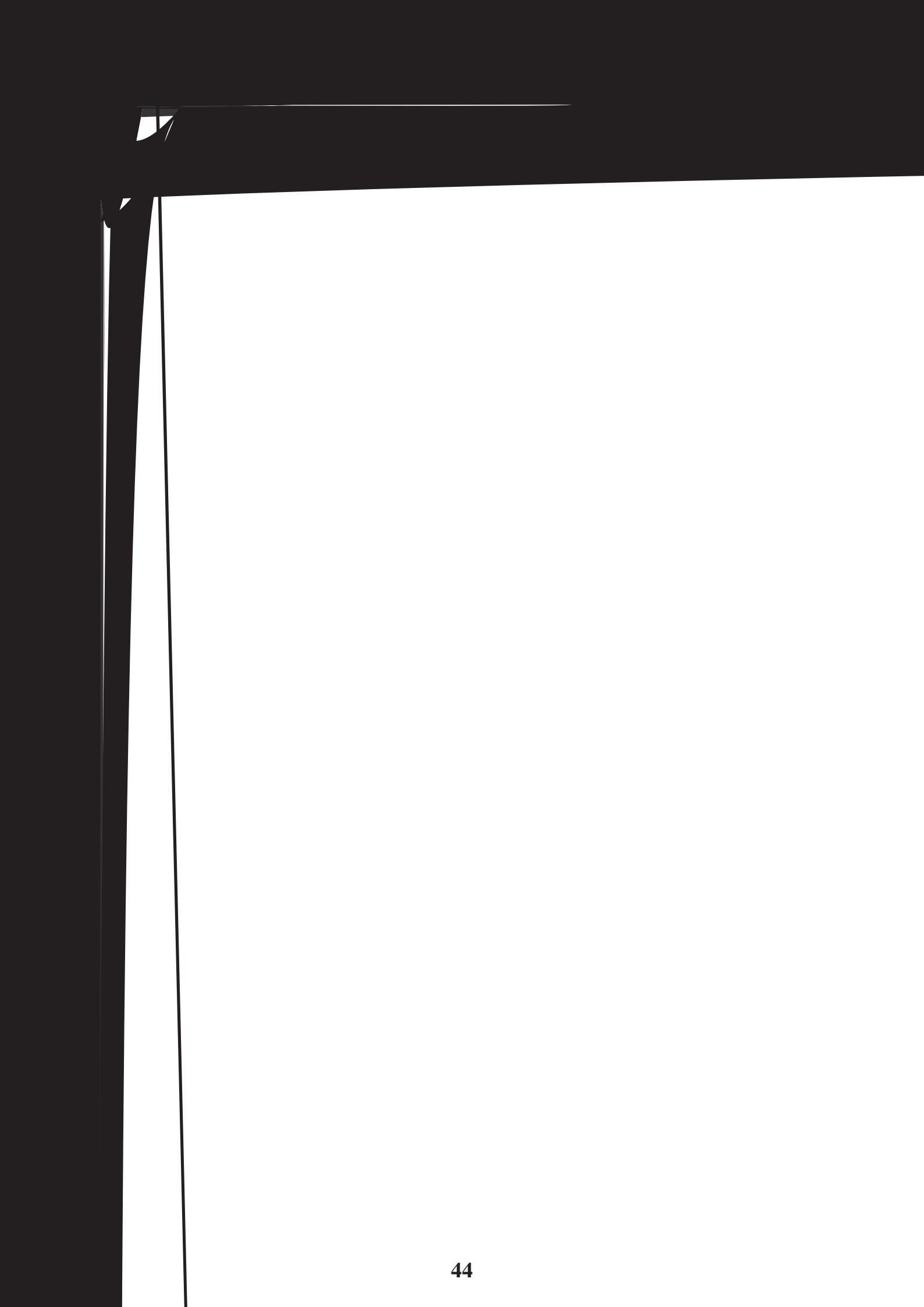
Within a few weeks of relocating, KJ began experiencing dramatic improvements in her health. Her sleep quality was restored, migraine attacks stopped, energy, muscle strength and stamina improved, digestive symptoms eased and there was less thyroid and kidney *"aching"*. Over the 10-month trial period, KJ gained muscle mass and her appearance became more vital, including hair re-pigmentation. Objective signs of improvement included her endocrinologist no longer being able to palpate here previously swollen thyroid and an ultrasound scan found that the previously rapidly growing thyroid nodules had arrested growth. Amid her recovery, KJ stated she now noticed the negative impacts of high RF-EMR exposure at work (often exceeding 1 x $10^{-2}$ W/$m^2$) and elsewhere, for example when visiting a friend's homes and unwittingly sitting close to the Wi-Fi router. 'Brain fog', mental fatigue, head pressure/headaches and return of constipation were most noticeable, along with dizziness upon entering the workplace. However, the long drive to and from work was a confounding factor. This prompted KJ to move closer into the city and her workplace.

Within weeks of the move, KJ's health started to decline again (age 43 y). Fatigue, muscle weakness and sleep disturbance were returning. Her symptoms now were markedly more neurological, including a return of migraines and increasingly severe dizziness. A neurologist then diagnosed KJ with vestibular migraine. While RF-EMR levels were lower than her previous city apartment, again, they were higher than independent guidelines (Table 1).[8,9] In addition, DE levels exceeded 1000 GS, which was not fully amenable to mitigation to bring near the recommended 30 GS.[13,14] The dwelling was subsequently found (by an electrician) to be also affected by stray ground currents conducted via old copper pipes giving undesirable ELF magnetic fields around 10 mG in some areas (originating from a faulty neutral return).

Following this second dramatic decline in health, KJ decided to relocate outside of metropolitan Sydney where there were lower ambient environmental RF-EMR levels of 1.7 x $10^{-7}$ W/$m^2$ that were similar to the levels she lived with during her initial 10-month trial period (Table 1). Similar to the previous trial period, improvement in her health ensued, yet KJ states she remains sensitive to high levels of EMR/EMF exposure, most noticeably Wi-Fi at work and in public transport. KJ installed RF-blocking film on her car windows that she reports has "*reduced the waves of nausea when driving into the city"* along transport corridors known to have relatively high RF-EMR.

Throughout the timeframe pertaining to this case report, apart from a palpable thyroid gland (pre-operatively and then 6 m post-operatively to a few months into RF-EMR-reduction trial), KJ's physical examinations were normal. Her body mass index (BMI) ranged between 19 and 21, the drop in BMI occurring when she was most unwell. Along with the results already reported, other suboptimal findings included Vitamin D levels that ranged between 51- 123 nmol/L, the highest reading was following a slow release Vitamin D injection. Following the diagnosis of iron deficiency, serum ferritin increased from a low of 13 ug/L to a maximum of 58 ug/L. KJ is homozygous for MTHFR a1298c allele with low homocysteine 4.6 - 5.6 umol/L, normal vitamin B12 and elevated folate. Other B vitamin levels were not tested. Plasma zinc ranged between 11.1 and 12.3 umol/L and serum copper 12 to 16 umol/L. Given her history of gastrointestinal symptoms and overseas travel, KJ was also extensively tested for helicobacter pylori and parasites, including giardia, blastocystis hominis and dientamoeba fragilis. All were excluded, however, a streptococcal overgrowth in the large intestine was identified. Under the supervision of her medical team that included practitioners with expertise and training in nutritional, environmental and integrative medicine, various management strategies aimed at optimising nutritional, gut and immune health were implemented with limited success.

Given the apparent correlation with EMR/EMF exposure, most notably RF-EMR, and inconsistent clinical response to various nutrition and lifestyle interventions, a provisional diagnosis of CFS with underlying electromagnetic hypersensitivity (EHS) was considered likely. In line with the EUROPAEM EMF Guideline 2016[9], management has focused on minimizing anthropogenic EMR/EMF, reducing blue light exposure after sunset, and more targeted pharmacological, nutritional and lifestyle support aimed at restoring circadian rhythms and mitochondrial function. Examples include the use of antihistamines and calcium channel blockers (both pharmaceutical and herbal) with central nervous system activity, regular exposure to morning sunlight, and cold-water swims. Most recently, KJ has trialled thiamine tetrahydrofurfuryl disulfide (TTFD) in combination with magnesium taurate, with promising effects. Notwithstanding this multi-modal approach, reducing RF-EMR exposure consistently provided the greatest



treatment of EMF-related health problems and illnesses.[9] The guidelines include a thorough review of the research proposing biological plausibility and epidemiological evidence in support of EHS. The guidelines are accompanied by an annexed questionnaire designed to assist clinicians with taking a systematic history of health problems and EMR/EMF exposure. In contrast with WHO recommendations, the EUROPAEM guidelines recommend tailoring EMR/EMF exposure according to individual tolerability and offer some precautionary guidance values for day and night-time exposures, with lower recommended levels for sensitive populations. Notably, investigations into EHS by medical professionals tend to focus on objective biochemical/physiological outcomes.[21-24] This is in sharp contrast to subjective outcomes used by psychology researchers that have been cited to refute the legitimacy of EHS.[19,20]

Research also points towards a high degree of individual variability in sensitivity to anthropogenic EMR/EMF. This evidence comes from blind provocation studies of acute RF-EMR exposures in which objective biomarkers were used as experimental endpoints.[25-29] In a randomized double-blind provocation study by the public health department of Salzburg, Austria,[25] sensitive individuals demonstrated induction of their stress responses following a maximum exposure of 2.1 x $10^{-3}$ W/$m^2$ from a nearby MPBS (slightly lower than KJ's initial city exposure when her symptoms began). Such individual variability in sensitivity to RF-EMR has also been found in numerous animal experiments, most recently with respect to DNA damage induced by RF-EMR.[30] Researchers at Yale recently published epidemiological data indicating an increased risk of thyroid cancer associated with mobile phone use (a source common RF-EMR exposure) is influenced by genetic variants.[31] This evidence of varying sensitivity, combined with studies reporting biological effects induced by extremely low levels of RF-EMR[8,9,25-30] which form a large evidence base,[32] and other studies describing biomarkers of EHS,[33-36] support the hypothesis that EHS is a physiological condition.

The potential link between EHS and CFS was highlighted in a recent discussion paper by Maisch[37] that drew attention to cases of CFS linked to electromagnetic environments where levels were undesirable according to independent experts[8,9] but within official guidelines[5-7]. Indeed, many studies have found an increased prevalence of CFS-like symptoms indicating multi-system effects, particularly with underlying central nervous system dysregulation near RF-EMR transmitters and in those with long term occupational exposure.[38-45] These include neuropsychiatric/behavioural problems and sleep disruption,[38-42] neuro-immune impacts,[43] and endocrine disruption.[44] Rare studies conducted during operation of powerful RF-EMR transmitters and following exposure cessation after their shut-down have also revealed the resolution of unexplained CFS-like symptoms.[42,45] Moreover, an Australian GP has reported CFS-like symptoms in people after wireless Smartmeters (utility meters) were installed on their homes.[46]

The findings from the above studies further strengthen the hypothesis that in KJ's case, anthropogenic EMR/EMF exposure appears to be causally linked to her CFS symptoms. Further, KJ has kept a healthy skepticism regarding EHS, making a nocebo effect less likely. Whilst a psychosomatic illness could still explain her symptomatic recovery, it is more difficult to explain the arrest of rapidly growing thyroid nodules that occurred spontaneously following a dramatic reduction in night-time RF-EMR exposure by >16,000-fold. KJ's 3rd floor apartment appeared to be exposed to RF-EMR from a range of sources including a mobile phone base station within 300m and radio broadcasting antennae 1km away. Details of the transmitted signals indicated complex EMR/EMF exposure to varying RF carrier frequencies and modulation frequencies. Complex exposure patterns from multiple sources involving numerous frequencies are the nature of real-life exposures. Specific clinical management recommendations are difficult to provide as such complexities are entirely missed in exposure regulation and research. Instead, a single device is tested only for heating effects in exposure regulation, [6,7] whereas a signal simulator or a single wireless device has been investigated in most research studies.[32,47] Environments such as public transport add to this complexity. A large number of wireless devices are concentrated in a contained space and their RF-EMR emissions are amplified due repeated reflection inside a metal cage. Japanese researchers demonstrated microwave hotspot formation with 1000-fold increase in intensity from a single mobile phone in an elevator due to reflection off metal.[48] Due to this undesirable and uncontrolled effect, some health authorities prudently caution people against the use mobile phones in spaces shielded by metal. For example, Israeli Ministry of Health (MoH) *"recommends not using cellphones in closed places (for example, elevators, buses, trains) due to amplified radiation in such places.*[49] Given the paucity of research with real-life exposures and the large evidence-base on

bioeffects[32] the precautionary approached employed by KJ to minimize unnecessary exposure to a complex array of EMR/EMF seems warranted.

## Conclusion

This case report provides important insights into potential aetiology, pathophysiology and management options for people suffering from CFS. The impact of artificial electromagnetic exposures in CFS is yet to be investigated and ought to be a priority area of study. EHS sufferers may be the 'canaries in the coal-mine' and as such provide a unique opportunity to better understand how different types and levels of EMR/EMF exposure impact human health. Most importantly, irrespective of ongoing controversy regarding the legitimacy of EHS, people claiming EHS are at a distinct disadvantage due to the nature of the Digital Revolution and associated deployments. EHS sufferers will increasingly struggle at quite a fundamental level. Uncontrolled EMR/EMF exposure will exacerbate their symptoms and impair their ability to self-advocate and interact with society, with resultant higher risks of disability, social isolation, and poverty. The rapidity and extent of the Digital Revolution is therefore likely to further marginalise and stigmatise EHS sufferers, the impacts of which warrants further research to ensure guidelines and policies, be they for clinical management or environmental exposures, are more consistent and inclusive.

## Consent for publication

All information pertaining to this case report has been deidentified, including the person's initials. Informed consent for the publication was obtained from KJ.

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