REVIEW ARTICLE

# Self-Reporting of Symptom Development From Exposure to Radiofrequency Fields of Wireless Smart Meters in Victoria, Australia: A Case Series

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## ABSTRACT

**Context** • In 2006, the government in the state of Victoria, Australia, mandated the rollout of smart meters in Victoria, which effectively removed a whole population's ability to avoid exposure to human-made high-frequency nonionizing radiation. This issue appears to constitute an unprecedented public health challenge for Victoria. By August 2013, 142 people had reported adverse health effects from wireless smart meters by submitting information on an Australian public Web site using its health and legal registers.

**Objective** • The study evaluated the information in the registers to determine the types of symptoms that Victorian residents were developing from exposure to wireless smart meters.

**Design** • In this case series, the registers' managers eliminated those cases that did not clearly identify the people providing information by name, surname, postal address, and/or e-mail to make sure that they were genuine registrants. Then they obtained consent from participants to have their deidentified data used to compile the data for the case series. The author later removed any individual from outside of Victoria.

**Participants** • The study included 92 residents of Victoria, Australia.

**Outcome Measures** • The author used her medical experience and judgment to group symptoms into clinically relevant clusters (eg, pain in the head was grouped with headache, tinnitus was grouped with ringing in the ears). The author stayed quite close to the wording used in the original entries. She then calculated total numbers and percentages for each symptom cluster. Percentages were rounded to the nearest whole number.

**Results** • The most frequently reported symptoms from exposure to smart meters were (1) insomnia, (2) headaches, (3) tinnitus, (4) fatigue, (5) cognitive disturbances, (6) dysesthesias (abnormal sensation), and (7) dizziness. The effects of these symptoms on people's lives were significant.

**Conclusions** • Review of some key studies, both recent and old (1971), reveals that the participants' symptoms were the same as those reported by people exposed to radiofrequency fields emitted by devices other than smart meters. Interestingly, the vast majority of Victorian cases did not state that they had been sufferers of electromagnetic hypersensitivity syndrome (EHS) prior to exposure to the wireless meters, which points to the possibility that smart meters may have unique characteristics that lower people's threshold for symptom development. (*Altern Ther Health Med.* 2014;20(6):28-39.)


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The Victorian Auditor-General's November 2009 report[1] criticized the rollout of smart meters, which had commenced in 2009 under a previous government's mandate from 2006. As a result, a freshly elected Victorian Premier announced in 2010 that his government would review the program. Following a number of reports, including those by Deloitte,[2] EMC Technologies,[3] and Lockstep Consulting,[4] the new Victorian government announced on December 14, 2011, that it would continue with the program. Although the program would result in an overall net cost to consumers of $319 million dollars (NPV at

2008 values), Deloitte's analysis of the costs and benefits of the program had concluded that it made economic sense to continue given that a large portion of the costs had already been sunk into the project.[2] The rollout was scheduled to conclude by the end of 2013, but the deadline has been extended because of delays caused by technical difficulties, inaccessible sites, and customer refusals.

**Issues Surrounding Rollout**

After installation of wireless smart meters began, anecdotes of people developing symptoms started to be reported in mainstream media. For example, an article in the *Herald Sun* in Melbourne reported that Marc and Maureen Florio and their 4 children had left their home, claiming that they had been experiencing constant headaches and sleep deprivation since a neighbor's smart meter had been installed 3 weeks earlier.[5]

Public concerns over a number of issues with the compulsory rollout of smart meters have since intensified and multiplied. They have included (1) adverse health effects; (2) safety issues, such as a possible increased risk of house fires; (3) the incompatibility of the smart meter with existing wiring and appliances, possibly causing damage to electrical devices in the home; (4) privacy issues surrounding the collection and on-selling of vast amounts of data that reveal customers' energy usage patterns; (5) security issues, such as those inherent in any type of wireless communication (ie, a vulnerability to hacking and to cyber-attacks); (6) cost concerns; and (7) a perceived lack of democratic process because of the way in which the rollout had proceeded.[6] In response to these concerns, Energy Safe Victoria (ESV) released a report in July 2012, "Safety of Advanced Metering Infrastructure in Victoria," which stated that "smart meters are safe,"[7] notwithstanding the fact that ESV had mentioned in their draft in May 2012 that the issue of possible health effects was "beyond the detailed scope" of the report.[8]

Victoria's smart meters are electronic meters that are capable of measuring electricity consumption in 30-minute intervals and have a transmitter/antenna that is able to broadcast the collected data wirelessly to the base.[6] Victoria's smart meters also have a second internal antenna for the Home Area Network (HAN) radio, which can be turned on when requested by the customer.[3] The electronic meter is all that is needed to implement time-of-use tariffs (ie, charging different rates for electricity at different times); however, the remote-reading function means that meter readers are no longer required and that the power companies can disconnect and reconnect power remotely.[6] In effect, a smart grid, as opposed to deployment of electronic meters, constitutes the power companies' communication system. The bulk of Victoria's power distributors use wireless mesh networks that rely on the smart meters to act as relay stations, with households' data hopping unpredictably from meter to meter, thus forming a mesh.[6] Any reflective surface can cause a deviation in the transmission route of the radiofrequency signal. One distributor has deployed a WiMax network, which involves transmission from each meter directly to a collection tower in a star-like configuration.[6,9]

Smart meters do not have to be wireless. Italy has completed the largest smart meter rollout to date. Their smart meters are hard-wired and communicate over the existing power lines.[10] Other options have been proposed, such as communication via telephone lines, whereas fiber optic cabling has already been successfully deployed in other parts of the world.[11] Claims have been made that all types of electronic meters, including wired smart meters, can introduce dirty electricity (ie, high-frequency voltage transients and harmonics) along the wiring of a house, because of their switching-mode power supply, as well as back into the main powerline.[12] The function of the switching-mode power supply is to convert alternating current (AC) coming in from the power lines to direct current (DC), which is required to run the electronic meter. This process creates high frequency voltage spikes, which are emitted constantly, 24/7, and which travel along building wires and radiate outward from them. Critics claim that this dirty electricity can lead to short- and long-term, adverse health effects.[12,13]

**Sources of Radiation**

Electromagnetic fields (EMFs) is a broad term that encompasses both natural and human-made sources of radiation. The electromagnetic spectrum describes the continuum of different frequencies put together with the associated wavelength of each frequency.[14,15] The frequency is the number of oscillations or cycles per second, whereas wavelength describes the distance between successive peaks of a wave.[16] As a result, wavelength and frequency are inseparably intertwined: The higher the frequency, the shorter the wavelength is.[14] The electromagnetic spectrum is divided into 2 main types: (1) ionizing radiation, which comprises cosmic and gamma rays, X-rays, and ultraviolet rays; and (2) nonionizing radiation.[14,15,17]

Ionizing radiation has so much energy per quantum that it is able to break chemical bonds between molecules.[14] The negative effect on health of ionizing radiation is well recognized.[17] In this report, however, the term *radiation* will be used to describe nonionizing radiation, which does not carry sufficient energy to break molecular bonds.[14]

Nonionizing radiation includes (1) extremely low-frequency fields, such as those emitted by electrical appliances and power lines; (2) intermediate-frequency fields, such as those used in some antitheft and security systems; and (3) high-frequency radiation, which includes radiofrequency fields, such as those produced by mobile telephones, television and radio transmitters, and radar, as well as microwaves, a subset of radiofrequency radiation, which have frequencies in the 300 MHz to 300 GHz range.[16] The last are used in microwave ovens and for wireless Internet.[14,15]

These definitions are arbitrary but represent a useful way of describing different parts of the nonionizing component of the spectrum. Discussions of and research on the effects of nonionizing radiation revolve around thermal and

nonthermal effects.[17] According to the main regulatory agencies in Australia and the United States, only thermal effects are capable of affecting human health[17]; however, this article will deal exclusively with the nonthermal, or biological, effects on humans of nonionizing radiation. For this reason, the author has used the terms *radiation*, *radiofrequency*, and *microwaves* interchangeably in this article.

As societies industrialize, an unprecedented increase in the number and diversity of EMF sources occurs.[18] These sources include (1) video display units (VDUs) associated with computers and mobile phones and their base stations,[18] (2) wireless Internet, (3) digital television and radio, and—more recently—(4) wireless utility meters and their associated infrastructure. For some time, individuals have reported a variety of health problems that they relate to exposure to EMF.[18]

### Electromagnetic Hypersensitivity Syndrome

Electromagnetic hypersensitivity syndrome (EHS) is characterized by a variety of nonspecific symptoms. The most common ones include dermatological symptoms—redness, tingling, and burning sensations—as well as neurasthenic and vegetative symptoms—fatigue, tiredness, concentration difficulties, dizziness, nausea, heart palpitations, and digestive disturbances.[18] This syndrome was first described by Russian researchers in the 1950s, who called it microwave sickness.[17]

Although the range of estimates of the EHS prevalence in the general population is broad, a survey of self-help groups has indicated that approximately 10% of reported cases have been considered severe.[18] The World Health Organization (WHO) has expressed a willingness to consider professional and public input on evidence supporting the inclusion of EHS into the 11th version of the International Classification of Diseases (ICD), to be released in 2015.[15] Various national governments have also recognized EHS as an emerging public problem. Sweden classifies EHS as a functional impairment,[15] whereas the Council of Europe Resolution 1815 calls for particular attention to be paid to the needs of electrosensitive people and for the introduction of special measures to protect them, including the creation of wave-free areas not covered by the wireless network.[19]

In May 2013, the author of the current study became aware that people were registering adverse health effects from smart meters on a public Web site. Two ways existed for people to register: (1) a health register and (2) a legal register. The health register requested that people send their data to a specific e-mail address if they believed that their health had been affected following installation of smart meters, asking 2 questions: (1) "Are you hypersensitive to electromagnetic radiation from sources such as smart meters and mobile phones?" and (2) "Has your health been affected following the installation of smart meters?" The legal register contained 1 similarly worded open-ended question: "Do you believe your health has been affected by the installation of smart meters?" If the answer was "yes," people were asked to state the symptoms from which they were suffering that they believed had resulted from exposure to electromagnetic radiation (EMR) that had been emitted from smart meters. The information could be submitted online or the form could be printed and filled in by hand, then sent to a designated postal address. Neither form of registration posed direct questions about types of symptoms or offered any form of tick-a-box questionnaire, thereby avoiding the suggestion of various symptoms, and both steered clear of a recruitment-style approach to the collection of information.

The author subsequently approached the managers of the Web site and the registers, and based on her status as a medical practitioner, she received permission to view people's deidentified data in both registers in hard-copy form. It was immediately apparent to the author that people from disparate parts of Victoria were listing the same or similar symptoms from exposure to smart meters. The majority of people could not possibly have known each other, and they certainly had no access to information that had been registered by others, as data sent to the registers had been kept strictly private and confidential. Because the information appeared to point to a new and ongoing public health problem for Victoria, the author decided that a case series report, based on the cases in the registers, was warranted.

## METHODOLOGY

The author began by enlisting the agreement and cooperation of the managers of the public Web site and registers and by instructing them on her planned methodology. The managers were given the task of selecting appropriate cases from both their health register and legal register. The cases were included when the managers could clearly identify the person by name, surname, postal address, and/or e-mail address to make sure that they were genuine registrants. In the case of children, name and surname, together with postal address and/or e-mail address of at least 1 parent, were considered sufficient for identification of the child.

The managers then proceeded to print or photocopy each qualifying individual's entry and to deidentify each case, providing the author with each person's gender, date of birth, and the name of his or her residential suburb. The author considered these details important for statistical purposes. Children's symptoms were reported by their parents. E-mail addresses and phone numbers were hidden by the registers' managers, and the author made no attempt to contact any person to obtain additional details or ask for clarification(s). This practice was judged by the author to be appropriate, not only for the maintenance of anonymity but also because any further questioning would have had the potential to introduce biases in reporting and interfere with its spontaneous and unsolicited nature. What was not written or written clearly was simply omitted from the report. This fact must be kept in mind when reading the case series.

The Web site's managers then proceeded to seek signed written consent to use people's deidentified data to compile a report. This request was done by sending a letter to each

individual, mainly via post, but in a few cases in which postal addresses were not available, via e-mail. In the case of children, consent had to be signed by 1 of the parents. One case was drawn directly from the public side of the earlier-mentioned Web site, and for this reason, consent was not sought for that case because it was already available in the public domain. The Web site contained a significant number of publicly available cases of symptoms from smart meters; however, the chosen case was included because it was the only one that provided fully identifiable details: name, surname, residential address, and phone number. The author subsequently removed 1 case from outside the state of Victoria and 1 from a resident of New Zealand.

Of 142 fully identifiable cases before this removal, 91 consented, with the 1 additional case being in the public domain and not requiring consent. Therefore, the sample size was 92, and the author received all deidentified submissions in hard-copy form only. They were stored in her home office under lock and key. The author intends to keep all documents for a period of 5 years after publication of this article. At the end of this period, the documents will be destroyed.

For the results, the author has used her medical experience and judgment to group symptoms into clinically relevant clusters (eg, pain in the head was grouped with headache; tinnitus was grouped with ringing in the ears). The author has stayed quite close to the wording used in the original entries. Total numbers and percentages were calculated for each symptom cluster. Percentage values were rounded to the nearest whole number.

## RESULTS

Of the 92 participants reporting symptoms from exposure to wireless smart meters, 87 were adults and 5 were children. Of the adults, the youngest person was 23 years of age and the oldest was 74; 55 (63%) were female and 32 (37%) were male. The children were aged 6, 10, and 14 years, with the ages of the remaining 2 children unknown. The children's group was composed of 2 females and 3 males. Therefore, for the total group, 57 (62%) were female and 35 (38%) were male.

Of all the individuals, 39 (42%) did not specify whether their symptoms were caused by their neighbors' or their own smart meters. This lack of information was not surprising, because that kind of information was not sought in either the health or the legal registers. Therefore, it is of note that a total of 53 people (58%) volunteered this data: (1) 27 (29%) claimed that their symptoms were from exposure to their neighbors' smart meters, (2) 20 (22%) thought the adverse health effects were from a smart meter at their own homes, and (3) 2 wrote that their symptoms were from both their neighbors' and their own smart meters. It is also interesting that 3 people stated that they experienced symptoms when visiting friends or relatives who had a smart meter, and 1 person became ill after exposure to a smart meter at work.

Only 7 people (8%) stated that they considered themselves to have been suffering from EHS prior to smart meter exposure. Of these, 2 felt that radiation from smart meters had aggravated their conditions. The place of residence of the person representing each case study was important, because the locations illustrate that individuals reporting symptoms were not concentrated in 1 geographical area but were from different and varied parts of metropolitan and rural Victoria. Figure 1 shows the residential locations of the current study's cases marked with red dots; 67% of the Victorians in this study lived within Melbourne's metropolitan area (ie, Melbourne's suburbs), which is shaded a darker green on the map. This correlates almost perfectly with current demographics for the state, which show more than 70% of all Victorians living in Melbourne's suburbs.

As Figure 2 shows, the most common symptoms were (1) insomnia, sleep disturbance, or sleep disruption—44 people (48%); (2) headaches, head pain, or dull head—41 people (45%); (3) tinnitus, ringing in the ears, or buzzing/noises in the ears—30 people (33%); (4) tiredness, lethargy, or fatigue, including chronic fatigue, exhaustion, or weakness—29 people (32%); and (5) cognitive disturbances, inability to concentrate or think, disorientation, or memory loss—28 people (30%). Table 1 identifies the symptoms that were experienced by participants, other than the 5 most common, with their incidence.

**Figure 1.** Map of Victoria and Places of Residence of the People in the Study's Cases

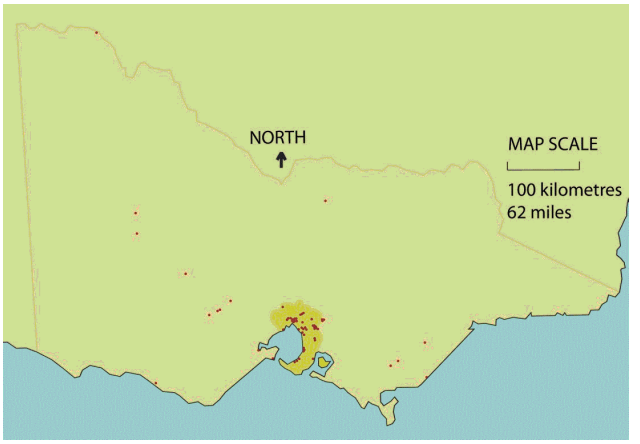



**Figure 2.** Five Most Common Symptoms

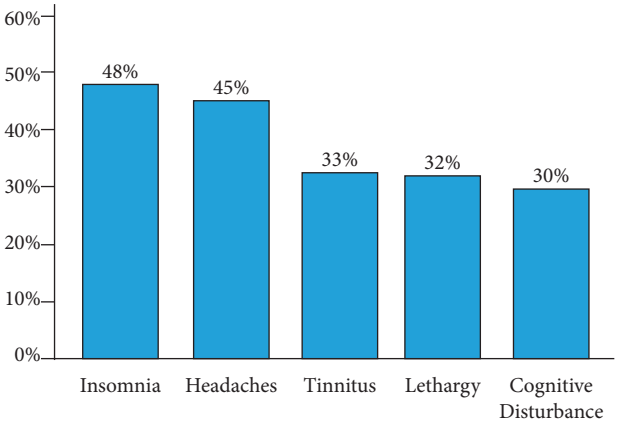


**Table 1.** Other Symptoms

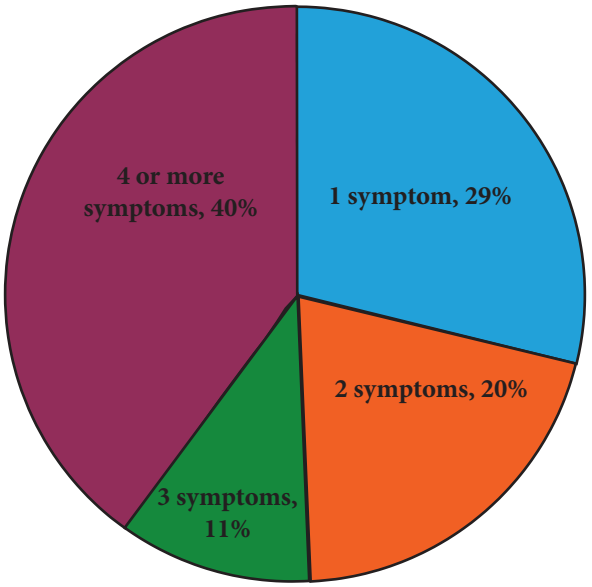
| Symptom/Symptom Cluster | n (%) |
|---|---|
| Dysesthesias, including nerve pain, neuropathy, burning sensations, tremors, cold extremities, and poor circulation | 20 (22%) |
| Dizziness/loss of balance | 19 (21%) |
| Heart palpitations | 16 (17%) |
| Nausea | 15 (16%) |
| Onset of EHS | 14 (15%) |
| Pain (in joints, bones, muscles, other and including arthritic changes) | 13 (14%) |
| Pressure/heat/weird feeling in or on head | 12 (13%) |
| Anxiety/agitation/irritability/restlessness | 12 (13%) |
| Adverse health effects not otherwise specified | 11 (12%) |
| Problems with eyes or eyesight/blurred vision | 10 (11%) |
| Chest pain/pain in the heart | 9 (10%) |
| Rashes/skin irritation/skin discoloration/dry skin | 7 (8%) |
| Aggravation of pre-existing medical condition | 6 (7%) |
| Digestive problems/bowel irritability/stomach pain | 5 (5%) |
| Muscle spasms/cramps/twitches | 5 (5%) |
| Nose bleeds | 4 (4%) |
| Ear problems (ear pain, loss of hearing) | 3 (3%) |
| Depression/loss of motivation | 3 (3%) |
| Increased rate of infections/colds | 3 (3%) |
| Allergies/food sensitivities | 3 (3%) |
| Aggravation of EHS | 2 (2%) |
| Sinus problems | 2 (2%) |
| Lump in throat/sore throat | 2 (2%) |
| Weight loss/loss of appetite | 2 (2%) |
| Swollen face/lips | 2 (2%) |
| Bladder infections/strains | 2 (2%) |
| Flu-like symptoms | 1 (1%) |
| Dehydration/thirst | 1 (1%) |
| Weight gain | 1 (1%) |
| Inability to talk | 1 (1%) |
| Loss of motor skills | 1 (1%) |
| Loss of feeling and movement from waist down | 1 (1%) |

Abbreviations: EHS = electromagnetic hypersensitivity syndrome.

It is concerning that 40% of all participants reported 4 or more symptoms, as this finding is very likely to be predictive of a greater level of disability (Figure 3). Eleven percent had developed only 3 symptoms, 20% only 2 symptoms, and 29% only 1 symptom. Note that the author counted "adverse health effect(s) not otherwise specified" as 1 symptom. She is of the opinion that even 1 symptom, depending on its type and severity, could result in significant disruption for an individual. An example of this result is the experience of the person in Case 82, an adult male who developed only 1 symptom—chronic, severe nerve pain—and had to go on a disability pension as a result.

It may reasonably be expected that a random sample of the population would also report a number of symptoms at any one time, but the difference in these cases is that all people in this study self-reported symptoms that they attributed directly to smart meters. Because EHS is a self-reported syndrome and given the current absence of a reliable assessment tool for identifying EHS in individuals, Eltiti et al[20] concluded that researchers have to rely on the

**Figure 3.** Number of Symptoms per Person




individual's self-diagnosis of their symptoms as caused by exposure to EMF. The researchers proposed an EHS screening tool that is centered on the fact that an individual explicitly attributes his or her symptoms to exposure to EMF-producing object(s).[20]

Similarly, a survey conducted by the Dutch Electrohypersensitivity Foundation in 2007 argues that EMF-affected individuals simply know, often by experimentation, that certain pieces of electrical equipment, installations, or facilities make them sick and that most of the problems are solved when these items are switched off or the EMF exposure is lowered by shielding or increasing the distance from a device.[21] This statement mirrors the experience of the majority of the Victorian cohort, who were specific in their description of their health problems as being directly related to smart meter exposure. A chronological relationship existed between the onset of exposure and symptom development.

A chronological relationship between length of exposure and an increase in the number or severity of symptoms, however, did not necessarily exist. This finding suggested a possible all-or-nothing mechanism, whereby smart meter exposure leads people to reach a personal threshold beyond which adverse health effects are consciously perceived. More than one-half (58%) of all the current participants also volunteered a statement with regard to the location of the smart meter(s) that they had identified as causing their symptom(s) and described clear alleviation of symptom(s) when they moved away from the smart meter(s) or when shielded from the smart meter(s).

As a consequence, a large number of people self-helped either by using shielding measures or by putting distance between themselves and the smart meter(s), which meant either relocating their bedrooms, moving to another residence, ceasing employment, restricting their movement in general, or moving out of the state of Victoria (Table 2).

**Table 2.** Effect on People's Lives

| Effect |
|---|
| 1. Having to go on a disability pension |
| 2. Not being able to use part of one's house |
| 3. Restricting freedom of movement |
| 4. Spending a lot of money on shielding products |
| 5. Causing financial problems |
| 6. Causing relationship problems |
| 7. Having to undergo otherwise unnecessary medical investigations |
| 8. Needing to see a psychologist and doctors |
| 9. Producing general deterioration in quality of life |
| 10. Needing to restrict time spent using a computer |
| 11. Needing to avoid all EMR-emitting devices |
| 12. Being unable to drive |
| 13. Causing secondary stress |
| 14. Having to temporarily move out of one's home while it was being shielded |
| 15. Developing concerns about long-term effects of exposure |
| 16. Relocating bedroom |
| 17. Decreased performance at work |
| 18. Being unable to work |
| 19. Being able to feel normal only when away from home |
| 20. Causing several issues, such as lethargy or cognitive impairment, secondary to sleep disturbances |
| 21. Needing to move into a caravan 25 km out of town |
| 22. Sleeping in a van for 6 months |
| 23. Relocating to another state |

Abbreviation: EMR = electromagnetic radiation.

Figure 1 shows that people in this study were from disparate parts of the state of Victoria. They were from metropolitan as well as regional and rural areas and were not concentrated in any geographical area, which makes possible causes of symptoms related to a specific location unlikely (eg, proximity to airports, wind farms, open-cut coal mines, or chemicals used in agriculture). It is also unlikely for the reported symptoms to be associated with any seasonal factor (eg, extremes of temperatures, degree of humidity, bushfire smoke, or a high pollen count), because the reporting period stretched between September 2012 and August 2013, which meant that symptoms were reported during all 4 seasons.

Smart meters represent an ubiquitous presence throughout the state of Victoria, having been rolled out across the entire state. Their presence is not subject to seasonal variation. Therefore, they are a credible possible cause of the symptoms reported in this study, although a case series cannot prove causality. It can and does, however, offer a new hypothesis, one that will have to be tested by further research.

More than one-half (55) of all the cases did not state what effect the symptoms had had on their lives. This lack is possibly caused by the fact that the registration of their symptoms occurred in an open-ended style that did not

directly ask questions other than whether they thought that smart meters had affected their health. Moreover, participants had consented for their deidentified data to be used to compile a report at a time after their initial submission to the Web site's registers. This situation had the benefit of eliminating the likelihood of a real or perceived secondary gain for registrants but also led to the writing of short, simple statements that did not elaborate on how the symptoms had affected their lives. Table 2 provides details about the effect on the lives of the 37 people who made a statement about those effects..

## DISCUSSION

### Biological Effects of Radiation

With regard to the reported symptomatology related to wireless smart meters, it is interesting to look back at a research report by Dr Zorach R. Glaser for the Naval Medical Research Institute (NMRI) in the United States, completed in 1971 and revised in 1972.[22] The report lists in excess of 2300 references on the biological responses to radiofrequency and microwave radiation in its bibliography. What is immediately apparent is the fact that most of the symptoms reported in the current case series were also present in the NMRI report. This fact indicates that biological effects from nonionizing radiation are the same irrespective of the device that emits them—accounting for frequency, intensity, and duration—and that such biological effects were already known and reported to the public in 1971. In fact, Glaser mentions 2 even earlier studies that were both published in 1969.[22] The value of Glaser's report lies particularly in its lack of bias and conflict of interest because the sponsoring department was the Bureau of Medicine and Surgery (Navy) in Washington, DC.

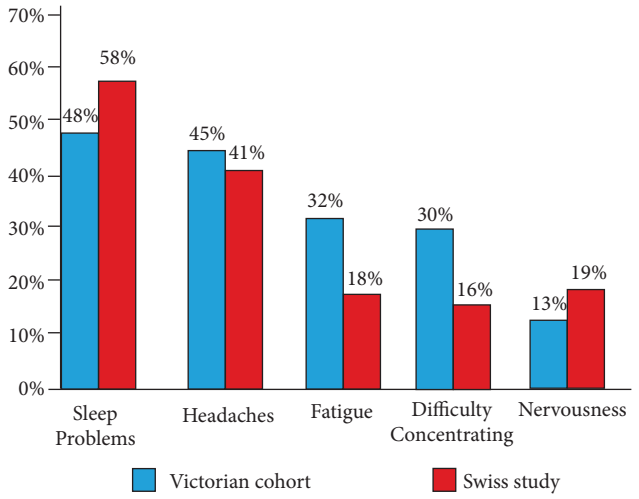
In terms of the biological symptoms listed, an almost complete overlap exists with symptoms reported in the current case series. All commonly reported symptoms in the current case series, such as insomnia, headaches, tinnitus (described as buzzing about the ears in the NMRI document), fatigue, cognitive disturbances, memory problems, dizziness, buzzing in the head, heart rate problems, eye problems, chest pain, dysesthesias, anxiety, and restlessness are very clearly biological symptoms that were listed in Glaser's report,[22] together with less common symptoms, such as heat/weird feeling in/on the head, skin problems, digestive problems, muscle cramps, sinus problems, depression, loss of appetite, and dehydration.[22]

The symptoms reported by Victorians but not mentioned in the 1971 report are (1) nausea; (2) pressure in the head; (3) pain other than head or chest pain, although the pain could be caused by changes in oxidative processes in tissues as listed by Glaser, and consequent tissue inflammation; (4) shortness of breath; (5) ear problems—pain and decreased hearing; (6) allergies and food sensitivities; (7) nose bleeds; (8) increased rate of infections/colds; (9) bladder infections/strains (10) flu-like symptoms; (11) lumps in the throat (the NMRI report instead mentions a peculiar metallic taste in the mouth); (12) swollen face or swollen lips; (13) weight gain; (14) inability to talk, which could be caused by electroencephalogram (EEG) changes and/or pyramidal tract lesions as mentioned in the 1971 report; and (15) loss of motor skills or loss of feeling and movement from the waist down, which are both consistent with pyramidal tract lesions and effects on locomotor nerves that are listed in the NMRI paper. In looking at these symptoms that were not obviously listed in the NMRI report, it is important to keep in mind that the language of that report was more technical and clinical compared with the current case series, in which the author has purposely stayed true to the wording and terms used by participants and which is, therefore, less technical and less interpretive.

In 1990, a study was commissioned in response to a petition that had been signed by a group of residents in Schwarzenburg, Switzerland, who claimed to be experiencing ill health from a shortwave-radio transmitter present in their small town. The Federal Office of Energy was charged with setting up a study group, which was chaired by Dr J. Cattin, head of the Section Energy Management, and which included the University of Berne and Swiss Telecom, among others.[23] The study was criticized, particularly because of Swiss Telecom's involvement and because of its 5-year duration, which was too short a time for any conclusive findings on long-term health effects, including cancer, to emerge.[24] It nevertheless revealed some impressive understandings on short-term effects from exposure to radiofrequency fields. The most important of these effects was that of sleep disruption, which was very common, affecting 55% of those older than 45 years, and which was directly associated with the electromagnetic-field strength of the transmitter.[23] Other symptoms reported by residents included headaches, tiredness, general weakness, irritability, nervousness, limb pain, lower-back pain, and palpitations. Most important, personality studies were carried out that showed that symptoms were not related to a health-worrying personality but displayed a dose-response relationship with logistic regression. The strong correlation between the type of symptoms experienced by the Victorian cohort and by the residents of Schwarzenburg, together with the shared high prevalence of sleep disruptions in both groups, should further inform assessment of the significance of the findings of the current case series.

A consensus paper of the Austrian Medical Association's EMF Working Group, adopted on March 3, 2012, in Vienna and titled "Guideline of the Austrian Medical Association for the Diagnosis and Treatment of EMF-related Health Problems and Illnesses (EMF Syndrome)," mentions a survey carried out in Switzerland in 2001.[25] In it, 394 respondents attributed specific health problems to EMF exposure. The following symptoms were reported: (1) sleep problems (58%), (2) headaches (41%), (3) nervousness (19%), (4) fatigue (18%), and (5) difficulty concentrating (16%). It is apparent at first glance that the first 2 symptoms are of the same order of frequency as for the Victorians in the current case series (Figure 4). A very similar percentage of people complained of headaches in both the current study (45%) and the Swiss one (41%). A similar, albeit slightly lower, number of participants reported sleep problems, such as insomnia and frequent waking, in Victoria (48%) versus those reported in the Swiss study (58%). All 5 symptoms

**Figure 4.** Victorian Cohort Versus Swiss Study




reported in the Swiss survey corresponded to symptoms experienced by the Victorian cohort, with fatigue (32%) and difficulty concentrating (30%) being more common in Victoria and nervousness (anxiety/agitation) (13%) being less common.

The Austrian Guidelines also list a number of what their authors consider to be EMF-related symptoms: sleep problems, fatigue, exhaustion, lack of energy, restlessness, heart palpitations, muscle and joint pain, headaches, depression, difficulty concentrating, forgetfulness, anxiety, urinary urgency, anomia, dizziness, tinnitus, and a sensation of pressure in the head and the ears.[25] All listed symptoms were experienced by Victorians in the current study, if the reader accepts that anomia corresponds with inability to talk and urinary urgency to bladder infections/strains.

Short-term effects from exposure to radiofrequency fields are also mentioned in another recent publication, the BioInitiative 2012 report prepared by 29 independent scientists and health experts from around the world. It documents bioeffects (ie, adverse health effects) and public health conclusions about effects of nonionizing radiation, including radiofrequency microwave fields. It replaces the BioInitiative 2007 report.[26] These effects involve cognition; memory and learning; behavior; reaction time; attention and concentration; and altered brainwave activity (altered EEG), as well as insomnia; discomfort; loss of well-being; sleep disruption; aberrant immune, allergic, and inflammatory responses in tissues; interference with normal cardiac function; alteration of circadian rhythms; and desynchronization of neural activity that regulates critical functions in the brain, gut, and heart. Radiofrequencies can act as disrupters of synchronized neural activity.

The BioInitiative report offers a detailed explanation on how environmental exposures to artificial EMFs can interact with fundamental biological processes in the human body.[26] This finding should not be unexpected because "human beings are bioelectrical systems."[26] In addition to short-term effects, the report dwells on the long-term sequelae (pathological conditions) from chronic exposure to nonionizing radiation, which include genotoxicity and DNA breakages among others.[26] It is not strictly within the scope of this case series to explain the biophysical mechanisms that may account for acute symptoms or effects or to discuss the long-term serious health endpoints associated with radiofrequency radiation; however, a summary of the nonthermal biological effects of nonionizing radiation is contained in Table 3. It is distilled from the BioInitiative report and intends to be a basic guide for clinicians.

**Table 3.** Summary of Biological Effects of Nonionizing Radiation

**Effects**

1. Pathological leakage of the blood-brain barrier, which allows toxins into brain tissues
2. Pathological leakage of the blood-gut barrier
3. Altered immune function, including increased allergic and inflammatory responses
4. Cardiovascular effects, particularly on blood pressure and heart rate
5. Disregulation of circadian rhythms and reduced melatonin production, which may account for insomnia
6. Nervous system effects, which include altered brainwave activity, changes in neuronal functioning and changes in autonomic nervous system electrophysiology
7. Desynchronization of neural activity that regulates critical functions in brain, gut, and heart
8. Lipid peroxidation of cell membranes
9. Elevated intracellular calcium with consequent disruption of cell metabolism
10. Poorly functioning mitochondria
11. Production of stress proteins as a result of the direct interaction of EMF with the DNA molecule, whereby DNA acts as a fractal antenna (because of its coiled-coil configuration)
12. Altered biochemical functions and production of hormones
13. Increased production of free radicals and deficiencies of antioxidants such as glutathione and melatonin leading to oxidative stress

Abbreviation: EMF = electromagnetic field.

It also needs to be mentioned that in 2011, the International Agency for Research on Cancer (IARC), which is part of the WHO, classified radiofrequency fields as a Group 2B Possible Human Carcinogen, based on an increased risk of glioma after 10 years or longer of cell phone use.[27] The IARC clarified that the evidence for carcinogenicity applies to exposures to radiofrequency radiation from all sources, not only cell phones (ie, it is not device-specific).[28] This finding has implications for the continued massive rollout of wireless technologies, in particular the wireless smart utility

meter, which was described in a recent statement to the UK Parliament as having triggered thousands of complaints of ill health and disabling symptoms worldwide.[29]

**Mandated, Involuntary Exposure**

With regard to smart meters, 2 unique features should be considered: (1) exposure may be involuntary and (2) exposure can be universal. In Victoria, smart meters were mandated, thereby removing the individual's choice to avoid exposure in his or her own home, and involuntary exposure also occurred to meters in neighboring homes. Each smart meter in the mesh networks transmits an unknown and variable number of burst transmissions per day, which typically reach into many thousands in number.[30] Meters on the WiMax network,[9] although not communicating with each other and deploying only bidirectional communication between a meter and the base station, nevertheless send hourly time synchronization signals in addition to their daily session transmissions.[3]

A submission by the Public Utilities Commission of California shows that only 45.3 seconds of transmissions per day (<0.1% duty cycle) still equates to 9600 transmissions.[30] Exposures are likely to be physiologically additive in nature.[25,26,31] Moreover, belief is increasing in the concept that intermittent pulses of radiofrequencies, such as those used in the smart grid, are more biologically significant compared with constant-type exposures, even when the time-averaged exposure is miniscule.[26,31] This kind of signal is biologically active and *not* invisible to the human body and its proper biological functioning, because the unpredictable pulses disrupt the synchronized biological oscillations within cells.[26] The Austrian Medical Association recommends that such periodic signals should be critically evaluated, whereas nonperiodic signals may be considered more leniently.[25]

In a 2012 memorandum titled "Health Risks Associated with SmartMeters," Dr Poki Namkung, public health officer of the County of Santa Cruz (CA, USA) stated that no scientific literature exists on the health risks of smart meters because they are a new technology.[31] This statement parallels the Austrian EMF Working Group's statement that "new technologies and applications have been introduced without certainty about their health effects."[25] Dr Namkung also explains that research on the potential health risks from radiofrequencies has been funded largely by industry because little funding is available for basic scientific research.[31]

The report indicates:

> ... exposure is additive and consumers may have already increased their exposures to radiofrequency radiation in the home through the voluntary use of wireless devices such as cell and cordless phones, personal digital assistants (PDAs), routers for internet access, home security systems, wireless baby surveillance monitors (baby monitors), and other emerging devices. It would be impossible to know how close a consumer might be to his or her limit, making safety a uncertainty if SmartMeters are mandatorily installed.[31]

Again, this statement correlates with the conclusion in the Austrian Guidelines that "multiple exposures to different EMF sources must be taken into account."[25] Dr Namkung's conclusion that "... governmental agencies are the only defense against such involuntary exposure" to mandated smart meters' nonionizing radiation emissions[31] applies in a particularly relevant way to the Victorian experience.

A similar view is also shared by Dr David O. Carpenter and 53 other scientists and doctors, who, in an article published in 2012, outline some of the effects of EMF exposure with the intent to correct some of the gross misinformation regarding wireless smart meters and advocate for the application of a precautionary principle, such as using wired meters.[32]

Although some of the studies discussed in this report offer recommendations regarding wireless smart meter deployment (Table 4), virtually no published studies are available with respect to smart meters and human health, and no long-term studies exist because of the newness of the technology.

Notably, an early voice of concern on this issue was that of Don Maisch, PhD, from Tasmania, who posed the question of whether smart meters would end up creating a public health nightmare in an article published in September 2012.[33] In it, he explained how current exposure standards are outdated and no longer relevant and warned that, given the sheer number of people exposed, simply dismissing anecdotal evidence of symptoms from smart meters as a nocebo (harmless) effect without a serious research effort would be inexcusable.

**Incidence of Effects**

This article has discussed the fact that people from various regional and metropolitan areas in the state of Victoria, of all ages and during all seasons, have reported symptoms from exposure to the radiofrequency fields of wireless smart meters as well as the onset or aggravation of EHS and the aggravation of pre-existing medical conditions after installation of the meters. Interestingly, only 8% of the participants in the current study stated that they had suffered from EHS prior to exposure to smart meters, which suggests that the threshold for symptom development appears to be significantly lower when it comes to wireless meters compared with that for other wireless devices.

Of an initial 142 people who had formally registered their adverse health effects from smart meters related to the current study, 92 consented to participation. The author considers this number to be significant and most likely to represent the tip of the iceberg in terms of total numbers. Underestimation could be caused by the fact that people do not associate their symptoms with smart meter exposure when the symptoms are not severe or do not occur concurrently. In addition, this underdiagnosis may be caused by a lack of knowledge about the effects of wireless technologies on the part of the general population and the majority of the medical fraternity. The ongoing campaign of

**Table 4.** Summary of Scientific Reports

| Title | Author(s) | Country | Year | Subject Matter and Findings | Recommendations |
|---|---|---|---|---|---|
| "Bibliography of Reported Biological Phenomena and Clinical Manifestations Attributed to Microwave and Radio-frequency Radiation" | Glaser[22] | United States | 1971 | Provides more than 2000 references on the biological responses to radiofrequency radiation | No specific recommendation; prepared for the Naval Medical Research Institute, Bethesda, Maryland; approved for unlimited public release |
| "Study on Health Effects of the Shortwave Transmitter Station of Schwarzenburg, Berne, Switzerland" | Altpeter, Krebs, Pfluger, et al[23] | Switzerland | 1995 | Notes marked deterioration of sleep quality in persons exposed to radio transmitter | No urgent protection measures; review of current exposure guidelines; further research |
| "Guideline of the Austrian Medical Association for the Diagnosis and Treatment of EMF-related Health Problems and Illnesses (EMF Syndrome)" | Austrian Medical Association's EMF Working Group[25] | Austria | 2012 | Discusses EMF-related problems and outlines clinical-management approach | Primary method of treatment of EMF-related health problems to consist of prevention or reduction of EMF exposure |
| "BioInitiative 2012–A Rationale for Biologically-based Exposure Standards for Low-Intensity Electromagnetic Radiation" | Prepared by 29 experts, edited by Sage & Carpenter[26] | Experts from more than 10 countries | 2012 | Reviews more than 1800 new scientific studies added to the BioInitiative Report 2007, which cited 2000 studies on adverse health effects from extremely low frequencies and radiofrequencies | New, biologically based public-exposure standard; precautionary approach to RF exposure levels |
| "Health Risks Associated with SmartMeters" | Namkung[31] | United States | 2012 | Indicates objective evidence supports EHS diagnosis; no scientific literature on health risks of smart meters | All available, peer-reviewed research data on EMF applicable to smart meters; governmental agencies to protect public health from involuntary exposure |
| "Smart Meters: Correcting the Gross Misinformation" | Carpenter et al[32] | Authors from a number of countries; published in Canada | 2012 | Summarizes long-term and short-term health effects of EMF exposure, in particular from smart meters | Application of Precautionary Principle, such as using wired meters |
| "Electromagnetic and Radiofrequency Fields Effect on Human Health" | Dean, Rea, Smith, Barrier (American Academy of Environmental Medicine)[17] | United States | 2012 | Discusses different types of radiation and effect of the increasing use of wireless technology on human health | Immediate caution on smart-meter installation; further research on effects of EMF and RF exposure; use of safer technology, including for smart meters |

Abbreviations: EMF = electromagnetic field; RF = radiofrequency; EHS = electromagnetic hypersensitivity syndrome.

the state government and power distributors to portray smart meters as safe has also contributed to this lack of knowledge. Even when people believe that their new symptom(s) are caused by smart meters, some are not able to report or register their symptoms because they have no Internet access, and of those who do, not all are aware of Web sites or ways to make reports.

### Limitations of Current Study

The main limitation of the current study is that, being a case series, it is a descriptive, retrospective study that does not have a control arm and can therefore help formulate a new hypothesis, but can only make limited statements on the causality of correlations observed.

Another limitation, which is specific to this type of noninterventional analysis of existing nonidentifiable data, is that the author was not able to contact individual case studies and was therefore unable to clarify or add to the information given by them. For the same reason, the author was also unable to follow up these cases longitudinally, which is something that could have potentially yielded valuable information.

## CONCLUSIONS

This case series has discussed the most commonly reported symptoms from wireless smart meters. Although some of these symptoms are also reported in relationship to other environmental exposures, such as proximity to airports

or wind turbines, Victorians in this report claimed a direct chronological association between exposure to wireless smart meters and symptom development. A look at the place of residence of people reporting symptoms does not suggest a link to any possible environmental factors that are geographically specific. Seasonal factors are also excluded, because the reporting period stretched over all 4 seasons. The effect of these symptoms on people's lives is far-ranging, from stress, financial problems, and unnecessary investigations to needing to move out of one's home and even to another state.

The author of the current study offers the hypothesis that some people can develop symptoms from exposure to the radiofrequency fields of wireless smart meters. This hypothesis cannot be disproven without further assessment of the affected individuals and the electromagnetic fields in which they live. An evidence-based approach, such as the one used in all other areas of medicine, must be applied, which would mean the establishment of a postrollout surveillance study and funding for further research into the particular effects of wireless smart meters, in conjunction with research into the short-term and long-term consequences of EMR exposure. Until more knowledge is accumulated and until this type of wireless technology can be proven safe, the author believes that communities should use a cautionary approach, asking for a moratorium on deployment of wireless smart meters and smart grids and for the use of safer technologies for smart meters, such as hard-wiring, fiber optics, or other nonharmful methods of data transmission, including reading of meters by meter readers. Living in a wireless smart grid makes the Austrian Medical Association's recommendation to "take all reasonable measures to reduce exposure to electromagnetic fields" impossible to implement.

Dr Maisch's article title, "Smart Meter Health Concerns: Just a Nocebo (Harmless) Effect or an Emerging Public Health Nightmare?", resonates strongly with the Victorian experience so far. This question is very pertinent and one that must be urgently answered.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