

Definition, Epidemiology and Management of Electrical Sensitivity

Report for the Radiation Protection Division of the Health Protection Agency

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Approval: October 2005
Publication: November 2005
£13.50
ISBN 0 85951 570 2

This report reflects understanding and evaluation of the current scientific evidence as presented and referenced in this document.

FOREWORD FROM HPA RPD

A recent review of the health effects of exposure to electromagnetic radiation by the National Radiological Protection Board (now the Radiation Protection Division of the Health Protection Agency, HPA RPD) found no compelling causal evidence for health effects other than those accounted for by current exposure guidelines¹.

Responses made during consultation and other questions and comments from the public and special interest groups emphasised that the phenomenon of electrical sensitivity (electrical hypersensitivity, ES) had not been adequately considered².

This review was commissioned by the NRPB to consider the definition, epidemiology and management of ES. It is based around a standard public health needs assessment model. It will be used to enhance HPA understanding of the condition and to inform advice where appropriate. It does not consider the aetiology of ES. Provocation studies have recently been reviewed elsewhere³.

The questions considered by the review include:

- a Is there a characteristic set of symptoms associated with ES?
- b Are the triggers the same in all sufferers?
- c Is there a characteristic time course and prognosis for the condition?
- d Is the condition more common in certain groups in the population?
- e Is there a diagnostic test or pathophysiological marker characteristic of ES?
- f Are there management strategies that are known to be effective?
- g Is there an overlap with other syndromes such as multiple chemical sensitivity or other environmental illnesses?

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SUMMARY OF FINDINGS

This review considers electrical sensitivity (ES) in terms of the subjective attribution of symptoms to electric and magnetic fields and radiations (EMFs), at levels below those shown to cause adverse health effects. The use of the term ES in this review does not imply the acceptance of a causal relationship between symptoms and attributed exposure, however.

The starting point for this review is recognition, by the Radiation Protection Division of the Health Protection Agency (HPA RPD), of the need to consider ES in terms other than its aetiology, as this position alone is failing to meet the needs of those who consider themselves affected by ES.

The review was commissioned to identify and appraise the literature in order to describe and define ES, review the information on its course, prognosis and treatments, and examine its overlap with other conditions such as multiple chemical sensitivity. Specifically excluded from the review were attributed health effects in terms of specific disease processes, and examination of the ongoing debate around the aetiology of ES.

Electrical sensitivity symptoms can be broadly grouped into facial skin symptoms attributed to exposure to visual display units (VDUs) and more general, non-specific symptoms across a range of body systems. Neurological symptoms such as headache and fatigue predominate in this latter group. There may be progression from skin-only symptoms to more generalised symptoms, although this may be relevant only to Sweden.

Facial skin symptoms and their attribution to VDUs are largely a phenomenon of the Nordic countries, and Sweden in particular. In other countries, ES sufferers tend to describe general symptoms attributable to a wide range of EMF sources. With the exception of facial skin symptoms and VDUs, there is no consistent symptom type and attributed source association. Some subjects are only symptomatic to specific sources; others claim sensitivity to a range of sources.

There is no typical time period from exposure to onset of symptoms.

Electrical sensitivity can have severe consequences for the social functioning of those affected. Experience from Sweden is that subjects with general symptoms have a worse prognosis than those with skin-only symptoms.

There is no consistent scientific evidence of sensitive or specific pathophysiological markers.

There is geographical variation in terms of symptomatology, the attributed source of exposure and the estimated prevalence of ES.

There is only limited evidence to guide the management of affected individuals. The majority of conventional medical effort to date has been directed at psychological therapy, such as cognitive behavioural therapy. Evaluation of this approach has been limited to date, but shows some potential for success.

There is considerable overlap between ES and other conditions known as symptom-based conditions, functional somatic syndromes or idiopathic environmental intolerances.

From what little description of the UK experience exists in the published literature and from some case reports on support group websites, the general symptom group appears to predominate in the UK. However, no useful estimate of prevalence in the UK was found.

Recommendations for future research include carrying out studies to describe and understand ES and estimate its prevalence within the UK; engaging with therapists currently treating sufferers in order to source evaluations not identified by this review, and to identify treatment areas where such evaluation might be feasible; and conducting robust trials of cognitive behavioural therapy (CBT).

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1 BACKGROUND TO THE REPORT

1.1 Introduction

This report was commissioned by the National Radiological Protection Board (NRPB). Since commissioning, the NRPB has become the Radiation Protection Division of the Health Protection Agency (HPA RPD). References to past work still use the title of the NRPB but the recommendations are now for the HPA to consider.

Electrical sensitivity (ES) is one of a number of terms (see Box 1) used by some people to describe symptoms they attribute to exposure to commonly occurring electric, magnetic, and electromagnetic fields (EMFs). Field strengths are at orders of magnitude below those shown to cause health effects. Many reports predate the extensive roll out of mobile telephony.

BOX 1 ES synonyms

Electrical hypersensitivity
Electromagnetic sensitivity
Electromagnetic hypersensitivity
Electrosensitivity
Electrosupersensitivity
Electrohypersensitivity
Electrical oversensitivity

The use of the term ES by this review does not imply acceptance of a causal relationship between symptoms and attributed exposure.

Currently, there is considerable debate around the aetiology of ES. While sufferers and their support groups are firmly convinced of a causal relationship with EMFs, the majority of mainstream scientific opinion does not consider there to be robust evidence of such a relationship. This position is supported by a recent systematic review of 31 blind or double-blind provocation studies, involving exposure to VDUs, mobile phones and a variety of other sources of weak EMFs¹. ES advocates argue, however, that such studies may fail to produce significant findings for a number of reasons: the study failed to exclude all extraneous background EMFs, the subjects chosen were not sufficiently sensitive, the wrong symptoms were measured, the wrong exposure was used, the follow up was too short, no allowance was made for hangover effects, and the studies may have been insufficiently powered to show an effect.

In addition, a small number of observational studies suggest a multifactorial aetiology with contributions from both environmental (high workload, lack of social support and indoor climate conditions) and individual factors².

In its review of the scientific evidence for limiting exposure to EMFs in the range 0–300 GHz, the NRPB considered evidence from studies in the areas of epidemiology, biology and dosimetry³. The NRPB found no compelling causal evidence for health effects other than those accounted for by current exposure guidelines, although it

recognised scientific uncertainties associated with new technologies particularly mobile telephony. Specific comment on ES in the report is limited to the effects of EMFs at frequencies below 100 kHz, and concentrates on the largely negative results of a review of provocation tests.

Responses received⁴ in the consultation period for the new NRPB advice on limiting exposure to EMFs of 0–300 GHz⁵ complained that the text trivialised the condition and failed to adequately reflect the breadth of different individual experiences. A number of respondents stated the need to recognise ES as genuine, recognise it in the public exposure guidelines and provide appropriate NHS services to sufferers.

The starting point for this review is the HPA view that ES needs to be considered in terms other than its aetiology, as this position alone is failing to meet the needs of those who consider themselves affected by ES. This review was commissioned to enhance HPA RPD understanding of ES and to inform future policy in this area where appropriate to its remit.

1.2 Project scope

Typically, a public health project of this type is based on a needs assessment model. A picture of the ability of the population in question to benefit from an intervention is developed; based on evidence from epidemiology, evidence of the effectiveness of an intervention, analysis of existing policy/service provision and views of various stakeholders⁶.

Intervention options for the management of ES include:

- a recognition of ES as a distinct medical condition,
- b provision of information on ES to the public,
- c decreasing exposure to EMFs in the whole population through the setting of new regulations or the enforcement of existing ones, or enhanced labelling to allow the public to gauge exposures,
- d provision of evidence-based treatment for affected individuals, including physical approaches such as shielding, pharmacological or psychological treatments.

Given the project's resource constraints, and following a series of individual meetings with stakeholders, it was agreed the project should concentrate on attempting to define the phenomenon of ES through a review of the relevant literature.

2 AIMS

To identify and appraise the literature in order to:

- a describe and define ES,
- b review the information on course, prognosis and treatments,
- c examine its overlap with other conditions such as multiple chemical sensitivity.

This review considers ES in terms of symptoms attributed to EMF exposure. Health effects in terms of specific disease processes are excluded. The review does not examine the aetiology of ES.

3 METHODOLOGY

A list of study questions was formulated, following those suggested by Kreutzer⁷ as the basis for a descriptive study of multiple chemical sensitivity (Box 2).

BOX 2 Questions for a descriptive study of ES

What kind of symptoms do subjects experience? How severe are they? Are they different or similar for different perceived exposures?

How do people perceive that they have been exposed?

What types of exposures do they believe cause these symptoms? What is the time course and how consistent is the experience?

Was there a precipitating exposure event that caused the problem?

How do subjects determine they are sensitive to EMFs?

How has the reported sensitivity affected a person's daily activities, their social roles and their self-image?

Do people who report ES have demographical similarities?

Do reports of ES vary in different populations?

Are there laboratory correlates with some discernible group of people who report ES?

3.1 Search strategy

Relevant papers were identified from Medline (1966 – June Week 2, 2004) and PsycINFO (1974 – May Week 5, 2004) databases, and from the reference lists of retrieved articles. The following search terms were used:

Electrical sensitivity (and its synonyms as in Box 1)
Electromagnetic fields [MeSH]
Electricity [MeSH]
Environmental illness [MeSH]
Hypersensitivity [MeSH]
Dermatitis
Visual display

Grey literature was sourced using the Google search engine during January – June 2004, using the search term electrical sensitivity and its synonyms (Box 1).

The first 200 hits under each synonym were assessed. Relevant sites were bookmarked for further examination. A small number of additional peer-reviewed and grey literature sources from outside the search dates specified have been included, as it was felt they

added significantly to the review. The review was limited to information published in the English language. Thus, foreign language papers were included only if they had been described in an English language review. Given the nature of the study questions and the limited quantity of available and relevant literature, no quality criteria were applied. Where appropriate, study methodology is appraised in the body of the report.

4 RESULTS

Papers were identified from across the evidence spectrum; from expert opinion through to randomised controlled trials, and reviews of the literature. Although the majority of the literature found by this search was Swedish in origin, most appears to have been published, or the results referred to, in an English language paper.

Material identified through the internet search could be broadly categorised as follows:

- a reports of the experiences of ES sufferers,
- b information from support/pressure groups,
- c scientific reports from various institutions/individuals,
- d commercial companies offering products for sale.

Inevitably, given resource constraints, a small number of potentially relevant sources not easily accessible, such as university theses and collections of conference proceedings, have not been included in this review.

In all studies, subjects were selected based on the subjective attribution of their symptoms to an EMF source(s). A minority of studies stated that potential subjects were excluded if an alternative medical or psychiatric diagnosis was found to possibly explain symptoms. Otherwise no objective signs or tests were applied to subject selection.

4.1 Description of the problem

4.1.1 Symptom type

4.1.1.1 Skin symptoms

Electrical sensitivity was first reported in the early 1980s in terms of skin symptoms attributed to exposure to visual display units (VDUs) in the workplace. Operators complained of stinging, burning or itching sensations involving skin on their faces, upper bodies or arms^{8,9,10}. Despite initial descriptions of a papular rash and clinical similarities to rosacea¹¹, there is no consistent evidence to date of a significant difference between exposed and non-exposed groups in terms of clinically objective skin signs (see section 4.4). Until recently, skin complaints were the major presentation of ES in Sweden¹².

4.1.1.2 General symptoms

In the late 1980s a more generalised syndrome, with symptoms such as headaches, dizziness, nausea, fatigue, concentration problems, palpitations and pain (and also incorporating skin symptoms in some cases), became apparent¹³. Information is available from four sources:

- a surveys of sufferers, published in the peer-reviewed literature,
- b provocation studies,
- c survey of occupational medicine centres and self-aid groups within EU member states,
- d sufferer/advocate experience.

Surveys of sufferers, published in the peer-reviewed literature

Studies have described symptoms in sufferers from general populations, work-based populations and from clinic attenders. Examples where symptom type is described in more detail are provided in Table 1. In all examples subjects were asked to describe the symptoms attributed to ES. Skin symptoms, fatigue, headache, difficulty concentrating and palpitations are present in the majority of reports.

TABLE 1

Study	Description	Symptoms
Bergdahl, 1995 ¹⁴	Interview of 20 patients referred to dermatology or occupational health departments in a Swedish university	Various skin symptoms, fatigue, pain, dizziness, headache, difficulties concentrating, various eye symptoms, memory problems, palpitations, GI symptoms, anxiety, irritation, lack of strength, allergy, olfactory disturbance, tactile disturbance Oral symptoms: gustatory disturbance, burning mouth, TM joint dysfunction, dry mouth, toothache, oral lesion, and increased secretion of saliva
Bergdahl et al, 1998 ¹⁵	Questionnaire survey of 28 ES patients referred to a school of dentistry in Sweden	Skin complaints, fatigue, various eye symptoms, pain, headache, dizziness, palpitations Oral symptoms: burning mouth, craniomandibular dysfunction symptoms, gustatory disturbance, dry mouth
Hillert et al, 1999 ¹⁶	Questionnaire survey of ES cases in a Swedish IT company and of ES patients referred to a university occupational health department	Skin symptoms: redness, heat or burning sensation, tingling, smarting pain or soreness, swelling/blisters, dry skin/mucosa Non-skin symptoms: myalgia, dizziness/vertigo, nausea, headaches, palpitations, fatigue, physical and mental exhaustion, and difficulty concentrating/remembering
Stenberg et al, 2002 ¹⁷	Questionnaire survey of 250 patients with ES registered at the University Hospital of Northern Sweden	Fatigue, heavy headedness, headache, nausea, vertigo, difficulties concentrating, eye irritation, dry eyes, nasal symptoms, dry facial skin, facial erythema, facial sensory symptoms, body itch, burning mouth, dry mouth, palpitations
Roosli et al, 2004 ¹⁸	Questionnaire survey of 394 people who complained about EMF-related symptoms to Swiss institutions	26 symptoms reported by at least 6 cases were: sleep disorder, headache, nervousness/distress, fatigue, concentration difficulties, tinnitus, dizziness, limb pain, heart disease, arthropathy, skin rash, oculopathy, depression, back pain, circulatory disturbance, tremor, nausea, breathing difficulties, gastroenteropathy, sweat, carcinoma, perception difficulties, neurological disease, earache, difficult menstruation, anxiety

Provocation studies

Provocation studies examine the ability of volunteers with self-reported ES to discriminate between active and inactive EMF sources, and are widely used as tests of a causal relationship between ES and EMFs. The majority have been unable to show such an association, however. One widely cited study of 100 patients with multiple chemical sensitivity, who also complained of sensitivity to EMFs, claimed to identify 16 subjects with reproducible reactions (defined as a 20% increase in number or intensity of background symptoms, or changes to measurements of the subjects' irises) to EMFs at specific frequencies (Table 2)¹⁹.

TABLE 2

Study	Description	Symptoms
Rea et al, 1991 ¹⁹	Provocation test of 100 ES patients in the Dallas Environmental Health Centre. 16 patients with reproducible reactions were identified	Neurological: tingling, sleepiness, headache, dizziness, unconsciousness Musculoskeletal: pain, tightness, spasm, fibrillation Cardiovascular: palpitation, flushing, tachycardia, oedema Oral/respiratory: pressure in ears, tooth pain, tightness in chest, dyspnea Gastrointestinal: nausea, belching Ocular: burning Dermal: itching, burning, prickling pain 2 of the 16 patients gradually became depressed and finally became unconscious

Survey of occupational medicine centres and self-aid groups within EU member states in 1997¹²

This project, led by a group of European experts, investigated the occurrence of ES across Europe on behalf of the European Commission. Questionnaires were sent to centres for occupational medicine (COMs) and self-aid groups (SAGs) in the EU member states regarding their awareness of ES, estimates of the extent, situations where problems appear, symptoms and consequences for the affected individuals. Results were complemented by a review of the literature and the expert opinion of group members.

A response rate of 45% was achieved for the 138 questionnaires sent to COMs. Ten replies were received from the 15 questionnaires sent to SAGs in the different countries. Seven replies were received from the nine UK COMs surveyed. UK-based SAGs were not surveyed. Respondents were not named in the document reviewed.

Respondents were asked to list the five most common symptoms reported in connection with the use of electrical appliances or proximity to EMF sources. Symptoms were classified into four groups:

- a skin symptoms: objective, subjective or undefined,
- b nervous system symptoms: sleep disturbance, decreased arousal, neurasthenia (fatigue), stress, irritation, anxiety and headache,
- c hormonal and metabolic disorders, general body symptoms, cardiovascular symptoms, eye symptoms, ear/nose/throat problems and digestive problems,
- d other responses concerned different types of cancer, allergy, reproductive and pregnancy problems and various symptoms attributed to the sick building syndrome.

Overall the most common symptoms for ES were various neurasthenic (fatigue-type) symptoms, headache and skin symptoms.

The relative prevalence of different symptoms differed between European countries, however. Nervous system symptoms were reported by COMs and SAGs in all countries as among the most common symptoms (with the exception of the Swedish SAG). The second most common group was skin symptoms. Geographical variation was evident in this case, with substantial reporting from Finland, Iceland, Norway and Sweden, and very limited or none at all from other countries. The one UK COM which responded to this section of the questionnaire reported only nervous system symptoms.

Sufferer/advocate experience

Sufferers, their support groups and other ES advocates tend to describe a much wider range of symptoms and diseases as ES. One comprehensive example is that provided by Philips and Philips²⁰ (Box 3). The majority of this description is referenced to 'research by a Swedish trade union' in 1993 and 1996.

The range of associations also extends to reports of sufferers inadvertently interfering with electrical equipment function. Smith reports that one patient made a robotic system

BOX 3 Symptoms in ES sufferers²⁰

Eye: smarting, irritation, pain, grittiness, visual difficulty

Skin: dryness, redness, tingling, rashes

Face and head: swollen face, blisters, warmth, burning sensation, dry mucous membranes, swelling of nose, throat, ear and sinuses, blocked ears, nasal itching, abnormal thirst, facial pain, metallic taste, headaches, loss of memory, depression, buzzing sound

Joint, muscle, limb and nerve sensations: aches, pain, numbness, weakness, prickling sensations, cramp – can lead to chronic severe pain, fibromyalgia

Tiredness and dizziness: abnormal tiredness, weakness, tremor, faintness and dizziness

Ingestion and digestion disturbances: dry mouth, loss of appetite, nausea, thirst, taste loss, gagging, sickly feeling, stomach upset, bowel disturbance

Breathing: shallow laboured breath, breathlessness, pressure in chest, intolerance to perfume

Haematological: nosebleeds, blood pressure changes

Cognitive: unable to think, difficulty concentrating, short-term memory loss, missing time, blackouts

Psychological: extreme rage, violence, destructiveness, irritability, feeling hostile, crying, depressed, unsociable, withdrawn, suicidal tendencies, anxiety, hysteria, feeling insane, out of control, mind interfered with

Behavioural disturbances: rolling on the floor, restless, agitated, disturbed, spontaneous snapping out of neck vertebrae, lower backache, 'poltergeist' phenomena

Others: impending influenza feeling, weight gain, low body temperature and pulse rate, lupus-like symptoms, abdominal pressure and pain, paralysis, balance problem, body/muscle spasms, convulsions, confusion, sleep disturbance, increased temperature in the groin and rectal areas, rectal twitching and pain, loss of libido, feel vibration from surrounding walls, loss of sense of touch, exquisite sensitivity to daylight, hyperaesthesia

Associated conditions: include thyroid disease, myasthenia, Sjogrens, immune system abnormalities and resonance migraines. The growth of bacteria and yeasts is affected by specific frequencies

in a factory malfunction when near it; another had the electronic ignition system on successive new cars fail as soon as an ES reaction was triggered by diesel fumes²¹. This review found no published reports in the peer-reviewed literature of attempts to replicate these observations.

4.1.1.3 Specificity of symptoms

Symptoms described by ES sufferers are non-specific in type and found commonly in some general populations (see, for example, Blaxter²²).

In a questionnaire survey of 338 randomly selected people in the German City of Regensburg, Frick et al found that more than 95% reported at least one mild symptom in the previous 30 days from a list of potentially EMF-related symptoms generated by a literature review (Table 3)²³. However, a response rate is not reported and there may be some selection bias as subjects were asked to participate on the basis of an investigation of environmental illness. Thus the frequency of such symptoms in the general population may have been overestimated.

TABLE 3

Relative frequency of potentially EMF-related symptoms in the general population (n=338)²³

Symptom	Relative frequency	Symptom	Relative frequency
Abdominal pain	29.5%	Headache	50.9%
Nausea	22.8%	Muscle pain	25.5%
Dry skin	35.2%	Neuralgia	10.9%
Intestinal trouble	11.2%	Toothache	13%
Vomiting	5.2%	Muscle cramps	20.2%
Numb limbs	66.3%	Neck pain	51.3%
Breathlessness	10.4%	Sleeping problems	43.1%
Tachycardia	15.7%	Feeling too hot	25.4%
Irregular heart beat	12.1%	Problems with short-term memory	44.1%
Problems in concentrating	56.8%	Fatigue	65.1%
Dizziness	33.7%	Feebleness	35.2%
Chest pain	15.4%	Blurred vision	21%
Increase in blood pressure	16.7%	Flickering before the eyes	19.5%
Rash	25.5%	Hair loss	11%
Itching skin	16%	Swollen eyes	19.5%
Restlessness	44.7%	Swollen joints	15.7%
Irregular bowel movement	23.6%	Tenseness	47.3%

On the other hand, three studies of Swedish populations suggested an increased prevalence of self-reported facial skin symptoms in ES sufferers compared to the general population or non-case groups^{16,17,24}. Evidence for an increased prevalence of self-reported neurological symptoms in ES sufferers was conflicting. These findings reflect the Swedish experience and, given the reported geographical variations in this phenomenon, are likely to be different for populations elsewhere¹².

Hillert et al²⁴ analysed a cross-sectional questionnaire survey on environmental health carried out on the population of Stockholm County in 1997. In total, 15,000 men and women aged 19–80 years were randomly selected from the 1.3 million inhabitants. A response rate of 73% was achieved. The study compared responses from self-declared ES sufferers with those from non-sufferers. The study found that self-reported facial skin problems, eye irritation, runny or stuffy nose, hoarse or dry throat, sense of pressure in the ear, fatigue, sense of heaviness in the head, headache, nausea or dizziness, and concentration difficulty were all greater ($p < 0.05$) in the ES cases than in the non-sufferers. When compared with those reporting asthma/hayfever only, facial skin problems (36.3% : 19.1%), eye irritation (23.2% : 9.8%), fatigue (45.5% : 34.8%) and heaviness in the head (24.6% : 13.5%) remained greater ($p < 0.05$).

A cross-sectional questionnaire survey of 241 employees of a large Swedish IT company (representing a 71% response rate) was analysed to compare symptom prevalence in 40 self-reported cases and 201 non-cases¹⁶. Cases and non-cases were similar in gender, age and educational level. The skin symptoms more frequently reported in the cases compared to the non-cases ($p < 0.05$) were redness, heat/burning sensation, tingling, smarting pain/soreness, swelling/blisters and dry skin/mucosa. For non-skin symptoms, myalgia, dizziness/vertigo and nausea were more common in cases ($p < 0.05$). Headaches, palpitations, fatigue, physical and mental exhaustion, and difficulty concentrating/remembering did not differ. However, any study of illness in an occupational setting is prone to the healthy worker bias. Thus, those cases most severely affected with neurological symptoms (and consequently unable to work) may not be represented in the study.

The same study population was also tested with composite indices based on the three most commonly reported skin symptoms (heat or burning sensation, tingling, redness) and general symptoms (difficulty concentrating, fatigue, headache) from a previous survey.

An additional group of 22 people referred to a university occupational health department was recruited to provide a (presumably) more severely affected group for comparison. The skin index was significantly different in the ES group compared to the control group, and this increased further in the group referred to the occupational health department ($p < 0.05$). While the neurovegetative index showed a similar trend, this was not statistically significant.

A questionnaire survey of 50 patients with multiple symptoms attributed to different electrical sources and 200 with skin symptoms attributed to light-emitting sources, registered at a Swedish University hospital, was analysed to compare symptoms in subjects with those derived from an identical questionnaire study (unpublished) of 2154 people randomly selected from the Swedish population¹⁷. When compared with the general population data, facial skin symptoms were reported at a higher prevalence ($p < 0.01$) in each gender and attribution subgroup. Fatigue was not reported at a significantly higher prevalence by any of the subgroups.

4.1.2 Exposures

The precise nature of the alleged exposure receives little attention in the peer-reviewed literature, the bulk of the description coming from grey sources.

While initial reports of ES were linked to VDU exposure, symptoms are now attributed to a much wider range of EMF sources^{20,25,26}. This includes extremely low frequency (ELF) and very low frequency (VLF) sources, radio broadcast bands, infrared radiation, and sunlight (Box 4).

BOX 4 Exposures provoking the symptoms of ES²⁰

Laptop computers used from the mains; televisions; battery operated appliances; fish tank heaters or lights; telephones, ansaphones and faxes; mobile and digital cordless phones; refrigerators, freezers, electric cookers (including induction hobs), vacuum cleaners etc; photocopiers; signalling circuits for cable TV; lamps with attached or built-in transformers, dimmer switches; fire/burglar alarms; fluorescent lights; low energy, mercury and sodium lights; fuse panels; pylons, power lines, substations; underground electric cables; water and gas pipelines with associated 'net' currents; uninterrupted power supply (UPS); electric fields due to house wiring; hearing-aid induction loops; electrical noise in trains, underground trains, trams, buses and cars; mobile phone base station masts; fan rooms; high frequency amplitude-modulated light; heat; VDUs; electronic medical procedures, especially MRI scans; daylight, weather changes; laser beams in supermarkets; electronic 'anti-theft' tagging scanners at the exits to many department stores; thyristors; some new, up-market cars, especially those with RF communications systems

Variation in the alleged exposure type exists at individual and population levels. Individuals also vary according to whether they react to one or to several source types.

A survey of centres of occupational medicine and self-aid groups in different European countries found evidence of pronounced differences between countries in the attribution of symptoms to a specific source¹². Sources emphasised ranged from radiofrequency (RF) EMF sources such as telecommunication masts or microwave ovens to low frequency sources such as power lines or transformer stations, or electrical appliances at home. VDUs and fluorescent lights were reported primarily from Denmark, Finland, Norway and Sweden. The survey also noted differences in where problems arose most often with variations in indoor/outdoor and home/workplace environments evident.

A questionnaire survey of 50 patients registered at a Swedish university hospital with self-perceived symptoms due to sensitivity to electrical sources in general found attributed sources to be mainly light-associated electrical devices¹⁷. Sources of exposure were VDUs (62%), TV screens (54%), fluorescent lights (70%), light bulbs (24%) and other devices such as mobile phones, transporting vehicles, household devices, sunshine, radios, power lines, and visits to banks and shopping centres (42%).

In contrast, a questionnaire survey of 394 Swiss residents who had complained to public institutions of symptoms they attributed to EMFs found that complainants related their symptoms most frequently to exposure to mobile phone base stations (74%), followed by mobile phones (36%), cordless phones (29%) and power lines (27%)¹⁸. About half of the complainants did not relate their symptoms to sources from a sole frequency range.

A widely cited provocation study that claimed to identify 16 patients with reproducible reaction to EMFs, found that each subject reacted to a range of different frequencies in the range 0.1 Hz to 5 MHz¹⁹. However, although the study is described as double blind, the exposure equipment and operators were present in the room during the test¹.

The same research group was unsuccessful in reproducing these results with an improved design^{1,12,27}.

4.1.2.1 Relationship of symptom type to attributed exposure

A review of the literature in terms of the attribution of skin complaints and disorders to VDU exposure concluded that an excess occurrence of subjectively reported skin symptoms or complaints is apparently found among VDU users, although this conclusion is based primarily on Swedish and (to a lesser extent) Norwegian studies¹². The reviewers reported that two questionnaire studies from the USA gave conflicting evidence for an association of symptoms with VDU exposure, with one Italian study reporting a positive association, but with a much lower prevalence of symptoms than the Swedish studies. The one study published from the UK on this topic showed no difference in skin symptomatology between VDU users and non-users²⁸.

Even in Sweden, this does not appear to be an exclusive relationship as subjects with exposure to VDUs may also have other more generalised symptoms, a state usually associated with a worse prognosis^{12,29}. Supported by such research, clinical opinion would tend to subdivide ES sufferers on the basis of symptom groups as opposed to their alleged source of exposure.

The potential difference between VDUs and other sources, in terms of attributable symptoms, was also explored in a study of 20 patients referred to dermatology or occupational medicine departments in a Swedish university¹⁴. Ten patients who self-attributed symptoms to VDU, TV or fluorescent light exposure and ten attributing symptoms to electrical sources without visible light were interviewed. The study found that in both groups skin symptoms predominated. Those in the VDU group reported fewer other non-skin symptoms, however. Notwithstanding the very small numbers, this methodology is unreliable as prior knowledge of the ES debate could well have influenced the subjects' choice of group.

There is little description of the consistency of reaction to the alleged source for an individual. Self-reported experience in the grey literature specifically describes a consistent reaction among some subjects³⁰.

A questionnaire survey of 394 people with self-attributed ES who complained to institutions in Switzerland found that the frequency of the ten most frequently described symptoms did not differ statistically significantly according to the three attributed exposure categories ($p=0.21$) – namely, mobile communication and broadband technology; computer and TV displays; and use of electricity (power lines, transformer, lighting, electrical devices)¹⁸.

4.1.2.2 Time course for development and recovery of symptoms

Although again there is little in the literature, there appears to be variation in the time course experienced by subjects for the onset and recovery of symptoms.

In a Swedish questionnaire survey of 201 consecutive patients referred for assessment of VDU-attributed skin symptoms, 19% claimed their skin problems got better overnight,

21% over the weekend, and 28% with a holiday of at least one week. Thirty-two per cent said they had not noticed any direct relationship to the work period³¹.

A questionnaire survey of 394 people with self-attributed ES who complained to institutions in Switzerland showed similar variation¹⁸. Of the subjects in this study, 90% reported that symptoms appeared after entering an exposure area and decreased on leaving it. Symptoms appeared typically within a few minutes in 53%, within a few hours in 21% and within a few days in 17%. The subsequent decline in symptoms on leaving the exposure area is described as 'similar but slightly slower'. No further detail is given.

Support/pressure group literature suggests that when the condition has progressed sufficiently in its course, symptoms may become more persistent, lasting up to several weeks after the attributed exposure³².

4.2 Natural history

4.2.1 Stages of development

Information concerning the course of ES is heavily dependent on experience in Sweden.

The Swedish Association for the Electrically and VDT Injured (FEB) considers that ES begins with skin symptoms from exposure to VDUs, and progresses to a more generalised syndrome involving a range of possible exposures (Box 5)³². However, this experience may be relevant *only* to Sweden or some other Nordic countries, given the difference in attributed exposure sources between different European countries¹².

BOX 5 Stages in ES development: Swedish FEB³²

The warning signs of developing ES are:

- unnatural warmth/burning sensation in the face,
- tingling, stinging, pricking sensation in the face or other body areas,
- dryness of upper respiratory tract or eye irritation,
- problems with concentration, dizziness, memory loss,
- swollen mucus membranes causing non-viral/bacterial swelling of nose, throat, ear and sinuses.

Initial symptoms are usually alleviated when the VDU is switched off or when the VDU is far enough away from the user. For some, the problem gets gradually worse with facial skin symptoms lasting longer (recovery time changing from overnight to several weeks after exposure) and becoming more severe.

Eventually the whole body becomes affected with symptoms such as difficulties in concentration, dizziness, headache and nausea, teeth/jaw pains, muscle and joint aches, cardiac palpitations, memory loss, coordination problems and a feeling of impending influenza.

When symptoms get this severe at the VDU, then the same symptoms appear at other times as well and due to other electrical exposures.

A recent publication based on letters and statements from over 400 people with ES made to a Swedish public hearing in 2000 describes how ES is initially 'triggered' not only by VDUs and other EMF sources, but also by other exposures such as various chemicals and by the presence or removal of dental amalgam²⁵. Once ES has been contracted it is no longer just the triggering factor that produces symptoms.

Few people initially perceive their symptoms to be related to EMFs²⁵. Attribution to electrical sources occurs when:

- a a direct connection between the source and symptoms is perceived,
- b symptoms disappear on sufferers staying in an environment perceived to be free from electricity and recur on returning to their normal environment,
- c sufferers recognise accounts of ES in newspapers or books,
- d other people 'understand' what is happening to the sufferer.

In its review of ES, the EC expert group recognises these experiences (Bergqvist and Vogel¹²). The group concludes that ES begins with health complaints of an unclear origin and that, in their search for an explanation, some people might consider environmental factors. Whether EMFs are considered responsible then depends on factors such as the level of awareness of ES within the population. Depending on the individual's attribution, avoidance behaviour may result.

The group further illustrates its findings by describing three stages in the typical development of ES (Box 6).

BOX 6 Stages in ES development: Bergqvist and Vogel¹²

Stage 1	The patient experiences temporary symptoms. Usually they have heard of the existence of ES and may consider a possible association with their symptoms.
Stage 2	If the symptoms persist and increase in intensity, duration or number of symptoms, the assumption of an association with EMFs develops towards certainty and the patient may start to look for further confirmation of their ES hypothesis. Avoidance behaviour may follow.
Stage 3	This stage is reached by a few people only. Frequently neurovegetative symptoms are reported to be triggered by vicinity to most EMF sources. Avoidance behaviour may reach extreme measures.

4.2.2 Prognosis/impact on functioning

Electrical sensitivity appears to have a range of impacts on sufferers: from mild transitory facial skin symptoms which do not affect work capacity to severe consequences for the individual's social functioning. The latter is evident from the reports of pressure/support groups such as the Swedish FEB³² (Box 7), case reports of ES sufferers^{25,30,33} and from personal correspondence. In extreme situations people may withdraw from modern day society.

BOX 7 Impact on functioning³²

Those affected cannot readily visit friends, go the cinema, theatre or travel by train, underground or bus. Those severely sensitive can, at best, travel short distances in a modified car or use the telephone for a few minutes per day. The situation worsens with protracted pain and heightened sensitivity. In extreme cases people can be forced to flee from our electrified society. Some have taken refuge in an isolated cottage or camper/caravan. Others sleep in their cars. It is not uncommon for those people to have an over-sensitivity to exposure to daylight – they must live in darkness behind closed curtains. Can cause temporary or permanent rift in the family.

In its survey of centres of occupational medicine and self-aid groups in European countries, the EC expert group found the proportion of 'severe' cases to the total number of cases was consistently estimated at around 10%¹². The questionnaire did not define what it meant by 'severe handicap', however.

A survey of 394 Swiss ES sufferers presenting with a wide range of symptoms reported the subjects' self-perceived degree of physical, mental and social impairment¹⁸. All subjects were sufficiently distressed by their symptoms to have complained to a variety of public bodies. Of the subjects, 53% reported severe or very severe physical impairment and 35% medium impairment; 41% reported severe mental impairment and 33% medium impairment. Social impairment was reported as none to medium by 76%. No further explanatory detail was provided. A 'few' respondents stated they were unable to have a social life due to the need to avoid exposures; 17% stated they were at least partly incapacitated for work due to their health complaints.

Experience in Sweden suggests that those with skin-only symptoms have a better prognosis than those reporting a wider range of symptoms (Table 4).

TABLE 4

Study	Description	Results
Berg, 1988 ³¹	Questionnaire survey of 201 patients referred to Swedish hospital with skin problems attributed to VDU exposure. Followed up at 8 months (average period)	No further problem in 14% while 52% had less severe problem and 28% had similar complaints. 6% had increased problem. 87% continued to work at VDUs
Eriksson et al, 1997 ²⁹	5 year follow up by questionnaire in 1994 of 163 cases and controls from Swedish office workers first surveyed in 1988 (all VDU workers). Response rate 87.5%. Case definition: self-reported itching, stinging, tight or burning sensation in facial skin and erythema or dry skin every week in past 3 months. 65 cases and controls responded	63.1% of original cases no longer met case definition. 4.6% (3/65) controls became cases. Worse prognosis associated with more general (mental fatigue, feeling heavy-headed, headache, nausea/dizziness and difficulty concentrating) and mucosal (itching/burning/irritation of eye, irritated/stuffy/runny nose, hoarse dry throat and cough) symptoms compared with other groups. General and/or mucosal symptoms, lack of information and low job satisfaction all associated with a higher risk of getting persistent or permanent skin symptoms ($p < 0.05$). With all three factors, there was 83.7% probability of symptoms persisting at 5 years, compared to 3.7% if none of these factors was present
Stenberg et al, 2002 ¹⁷	Follow up (0–10+ years) questionnaire survey of 344 patients with ES registered (1980–98) at University Hospital of Northern Sweden. Baseline data from medical notes. Response rate 73%. 50 with ES (skin/general/cognitive symptoms) and 200 with VDU skin symptoms. Inclusion criteria: medically unexplained symptoms within 24 hours of exposure to an EMF source, no alternative explanation for symptoms (129 patients excluded)	12.8% of the ES group had been on sick leave for up to 2 years versus 2.1% for the VDU group. 66% ES group reported no change in symptoms regardless of length of follow up, compared to 49.2% (short follow up) and 25.8% (long follow up) VDU group. ES group significantly less likely to be able to work at time of follow up (75%, as opposed to 25% for VDU group)

4.3 Characteristics of sufferers

Almost all the published reports of ES are in adults. Clinical anecdote from Sweden holds that ES is a condition of well-educated women with good social networks³⁴. However, this does not appear to be the case within other settings (Table 5). Surveys within occupational groupings in Sweden find no association with age, gender or position within the organisation, whereas population surveys in Stockholm County and California suggest an association with low income. Further work is needed to assess these findings both within and between other populations.

A number of studies have examined personality traits and other psychological parameters in ES sufferers. These have not been included within this review.

TABLE 5

Study	Description	Personal characteristics of ES sufferers
Berg et al, 1992 ³⁵	Random selection of subjects from cohort of VDU workers (at least 20 hours work per week); those reporting facial skin symptoms (19) and healthy controls (28)	No systematic difference re: age; gender; job classification; alcohol, coffee or smoking habits
Hillert et al, 1999 ¹⁶	Questionnaire survey of 40 ES cases and 201 non-cases in a Swedish IT company and of ES patients referred to a university occupational health department	No association between ES and: gender, age, marital status, educational level, mental wellbeing; neurotic personal traits; mental demand at work; intellectual discretion and control over work process; anxiety; sleep quality
Hillert et al, 2002 ²⁴	Cross-sectional postal questionnaire survey in 1997 of 15,000 men and women aged 19–80 in Stockholm County, Sweden, self-reporting ES. Response rate 73%	Prevalence higher in: women (1.8%) than men (1.1%); low income groups; early retirement or disability pension; unemployed; being disturbed/affected by other environmental nuisances; asthma, hayfever, allergic conjunctivitis
Levallois et al, 2002 ³⁶	Cross-sectional telephone questionnaire survey of 2072 randomly selected adults in California reporting ES. Response rate 58.3–84.1%. Study sample was older and contained more females than the general California population	Self-reported or medically diagnosed MCS strongest associated factor. Other associations: unable to work; earning <US\$15,000 annually; race other than Black/White/Hispanic
Roosli et al, 2004 ¹⁸	Postal questionnaire survey of 394 people who complained about EMF-related symptoms to Swiss institutions	Compared to respondents in General Swiss Health Survey, more cases in 40–70 age group, more married and higher educational level

4.4 Pathophysiological markers

Several studies have examined potential associations between self-reported ES and a number of pathophysiological correlates. Studies where this was a main feature are presented below (Table 6). These have focused on clinical and histological skin examination, various hormone blood levels, and on physiological parameters in the neurological and cardiovascular systems.

Most studies appear to be of people who attribute symptoms to VDUs and mains powered appliances; although for some, either other exposure sources were cited, or no specific detail was given.

TABLE 6

Study	Description	Variable	Outcome
Berg et al, 1990 ³⁷	Examination of random sample of employees (809) from 36 Swedish companies (with and without VDU exposure)	Objective facial signs or clinical diagnoses	Only finding more common in exposed group were small papules (RR 2.35; 95%CI 1.15–4.81). Not recognised as a specific dermatosis
Berg et al, 1990 ³⁸	83 patients with skin complaints with (66) or without (17) skin lesions and with VDU exposure; and 51 subjects with (28) or without (23) skin lesions with no VDU exposure	Blinded assessment of skin biopsy from cheek under light microscope for variety histological parameters	No parameter statistically significantly more common in exposed than non-exposed persons with equivalent skin signs. Non-significant tendency for mast cells to be more common in exposed
Berg et al, 1992 ³⁵	Random selection of subjects from cohort of VDU workers (at least 20 hours work per week); those reporting facial skin symptoms (19) and healthy controls (28)	Blood samples analysed for cortisol, prolactin, oestradiol, testosterone, thyroxine and growth hormone. Urine analysed for adrenalin and noradrenaline.	Higher levels of prolactin (10.1 versus 6.9 mcg/l; $p < 0.05$), and thyroxine (126 versus 110 nmol/l; $p < 0.01$) in symptom group during a work day, but not on a day off work. Correlated with increased levels of occupational strain in this group
Bergqvist and Wahlberg, 1994 ³⁹	Dermatological examination of 353 office workers (with and without VDU exposure)	Blinded dermatological examination	Statistically non-significant tendency for increased occurrence of seborrheic eczema and non-specific erythema among VDU users
Johansson et al, 1994 ⁴⁰	2 patients with screen dermatitis	Punch biopsies of anterior neck skin taken before and after provocation test using proximity to TV set. Examination using immunohistochemistry together with antisera to cellular and neurochemical markers	'High/very high' numbers of mast cells and somatostatin-immunoreactive dendritic cells before provocation. Somatostatin-positive cells disappeared after provocation
Andersson et al, 1996 ⁴¹	17 patients referred by occupational medicine and from dermatological clinics. Symptoms attributed to VDUs and other electrical sources such as fluorescent lights and TV	Blood electrolytes, transaminases, fibrinogen, cholesterol, triglycerides, apolipoproteins, prolactin, testosterone, dehydroepiandrosterone, and cortisol; measured during exposure to electric and magnetic fields in double-blind provocation study	No biological effects from exposure were identified
Arnetz and Berg, 1996 ⁴²	47 VDU workers in Sweden; 19 with reported work-related facial skin symptoms, and 28 asymptomatic	Melatonin and ACTH measured on workday and day off work	No significant association between melatonin/ACTH and symptoms

TABLE 6 *Continued*

Study	Description	Variable	Outcome
Johansson et al, 1996 ⁴³	3 groups of subjects: no VDU work and no symptoms (3); VDU work and subjective skin symptoms (4); VDU work and subjective and objective symptoms (8)	Blinded examination of facial skin biopsy by indirect immunofluorescence technique to demonstrate neuropeptides and neuroactive substances	Clear differences between normal skin and that from screen dermatitis patients found for CGRP, SOM (polyclonal), VIP, PHI, NPY, S-100, NSE, PGP 9.5 and PNMT. No single marker 100% sensitive
Sandstrom et al, 1997 ⁴⁴	10 patients from University Hospital, Umea, with neurological/skin symptoms from exposure to a VDU, TV, or fluorescent light. 10 controls	Electroretinography and VEPs measured during exposure to amplitude monitored light of differing frequencies	Higher frequency of brain cortical responses (VEP) at all frequencies of stimulation compared with controls (1.02 versus 0.81 mcvs; $p < 0.05$). No difference for ERG
Lonne-Rahm et al, 2000 ⁴⁵	24 patients with self-reported ES recruited by local advertisement or referral from GPs or dermatologists, Stockholm. 24 age/sex matched controls	Measurements of melatonin, prolactin, ACTH, neuropeptide Y, growth hormone, peptides, cellular markers and cytokines and skin biopsies (for mast cells) under conditions of induced mental stress and during variable electrical and magnetic fields from a VDU (as part of a double-blind provocation test)	No differences in blood hormone levels between groups or under different EMF conditions. No differences in skin biopsies re mast cells
Hillert et al, 2001 ⁴⁶	14 patients with EMF-related fatigue referred to Environmental Illness Research Centre, Stockholm. Attributed exposures to fluorescent lights, TV sets, cars, commuter trains etc	Blood acetylcholinesterase measured at time of fatigue due to EMFs and at time of no fatigue	No difference in measurements between times sampled
Lyskov et al, 2001 ⁴⁷	20 ES patients with neurological/skin symptoms referred to University Hospital, Umea. 20 controls	Measurements of BP, heart rate, sympathetic skin response, critical fusion frequency threshold, EEG, VEP; taken before and after provocation test with magnetic field exposure	Differences ($p < 0.05$) between cases and controls before provocation: CFF 43.8/39.1 Hz; latency of electrodermal response 1.18/1.31 s; amplitude of electrodermal response 2355/1241 mcV; diastolic BP 78.9/73.2 mmHg; pulse 78.4/68.5 min^{-1} . Magnetic field exposure did not affect variables examined in case or control groups
Sandstrom et al, 2003 ⁴⁸	14 ES patients from University Hospital, Umea. Symptoms perceived within 24 hours of exposure to a VDU, fluorescent light, TV or other electrical sources. 14 age/sex matched controls	ECG, heart rate, heart rate variability, and magnetic field exposure monitored for 24 hours	ES patients had disturbed pattern of circadian rhythm of heart rate variability – decreased parasympathetic tone at night

Studies to date are generally limited by a combination of small numbers of subjects and the potential heterogeneity of the populations studied. This review has not assessed the rationale underlying the choice of test measure, the methodology used to derive the measure, or the clinical significance of the results.

Despite earlier case-report-based suggestions of an association with rosacea¹¹, it is now generally accepted that no specific clinical dermatosis is associated with VDU exposure. However, there is conflicting evidence from histological studies of skin regarding an increase in mast cells in screen dermatitis cases. Whereas suggested by Berg et al³⁸ and Johansson et al⁴⁰ (and supported by a provocation study of healthy volunteers exposed to TV screens not otherwise reported here⁴⁹), no such association was noted by Lonne-Rahm et al⁴⁵. Johansson et al^{40,43} have also reported other histological and biochemical differences in skin in small numbers of patients.

Differences in physiological parameters of the cardiovascular and neurological systems between cases and non-cases have been suggested by three of the studies described above^{44,47,48}. Further work would be needed to describe their specificity and sensitivity.

4.5 Management

One published comprehensive programme for the management of ES was found (Box 8)². This is based on clinical experience in Sweden together with:

- a guidelines from the Swedish National Board of Health and Welfare,
- b programmes at local centres of occupational and environmental medicine in Sweden,
- c recommendations of the Norwegian Board of Health,
- d report from the EC group of experts.

Where possible, the evidence base for some of the individual components of this programme is presented in the following text.

4.5.1 Provision of information

The EC expert group report is the only source to address the provision of information on EMFs and ES to the population¹². Based on expert opinion the group suggests the provision of balanced information on what is known about suspected health effects from the use of electricity or from exposure to EMFs. This should comprise:

- a a better understanding of the fields and national regulations,
- b current understanding of the causes and appearance of ES,
- c current knowledge on the possibility of disorders such as cancer being linked to EMF exposure.

The group also reinforces the need to tailor information to specific social groups and national populations.

BOX 8 Managing ES²**Prevention of ES**

Information to public and target groups on EMFs and what is known about ES

Risk factor reduction/elimination – this should focus on indoor air climate, air pollution, workload, psychosocial factors, ergonomics, vision ergonomics, lighting and ensuring adherence to EMF standards for all electrical appliances

Early intervention

Thorough medical investigation based primarily on signs and symptoms

Information on the different possible aetiologies of symptoms and ill-health, EMFs and ES

Investigation of environmental risk factors as above

Investigation of psychosocial factors by psychologist/psychotherapist

Prompt action at any sub-optimal factor

Treatment as far as possible within primary care

Illness certification based on a broad evaluation of illness and disability (ES not a medical diagnosis in Sweden)

Focus on reducing disability and improving quality of life, as opposed to pursuing a causal factor

Treatment of individuals with persisting symptoms

Individualised support and programmes are necessary

Choice of therapy to be based on clinical presentation as well as response to treatment. Treatments may include:

- cognitive behavioural therapy
- acupuncture
- Shaitsu
- hypnosis
- low dose antidepressant (where anxiety, depression, chronic pain are part of the picture)

Patients should note that a psychological approach to treatment is not the equivalent of a diagnosis of a purely psychological illness

Avoidance of EMFs

Avoidance is by no means necessary for improvement

The advantages and disadvantages to the patient and to others in his social/occupational network of monitoring/measuring EMFs must be considered carefully

4.5.2 EMF avoidance/hygiene measures

Avoidance of EMF exposure is the mainstay of advice given to the ES sufferer by most support/pressure group material surveyed. This would appear to be supported by the individual experiences of interventions by sufferers^{30,32}. These reports are also clear, however, that symptoms can persist despite radical steps to reduce exposure being taken. Explanations for this include³²:

- a prolonged exposure from which the body can no longer recover,
- b shielding around cables acting as an antenna for microwaves,
- c houses that have been electrically cleaned being even more sensitive to outside sources such as mobile phone masts or cars with alarms.

A number of observational studies report subjective sufferer experience. These provide conflicting evidence of improvement through such strategies.

In a questionnaire study of 201 patients referred to a Swedish dermatology department with VDU-related skin problems, only 4% stopped working with VDUs over the average eight month follow up period as a result of their symptoms³¹. The majority (52%) had improved symptoms over time, despite receiving no specific therapy, with only 6% reporting worse symptoms. While 45% of those advised to use an electrostatic shield claimed to notice an improvement, only 10% of the shields used eliminated the field on testing. No control group was used. As with all surveys in the workplace there is a potential healthy worker bias, in that only those who are well enough to be in work in the first place are being studied.

Similar findings were reported by Eriksson et al in a five year follow up study of 65 cases and 65 controls selected from a group of VDU workers (experiencing a mixture of skin and general symptoms), in which 63.1% of original cases no longer met the case definition after five years²⁹. Subjects were asked about interventions in the electrical environment including exchange of monitors and computers, installation of a monitor filter, modification or dismounting of fluorescent tubes and grounding of electrical devices. At least one kind of intervention was reported by 50% (12/24) of those who remained as cases over the follow up period and 39% (16/41) of those no longer cases. Of those for whom some intervention had been performed, 43% reported a positive outcome solely due to the intervention; 50% of this latter group reported a positive effect from monitor exchange. Other interventions were reported as very much less successful.

Hillert reported two retrospective investigations (Swedish language) of the experience of ES sufferers after alterations at work (29 people) or at home (36 people)². Neither study had a control group. Interventions varied widely from extensive measures to replacement of fluorescent lighting. Subjects generally reported reduced symptoms but not full recovery.

TABLE 7

Study	Study population	Intervention	Outcome
Oftedal et al, 1995 ⁵⁰	20 people with VDU-related skin symptoms. Selected on the basis of a questionnaire, interview and dermatological examination	Symptom severity measured during three two-week exposure periods at the workplace (no filter/active/inactive VDU screen filter). Randomised. Double blind. Both filters reduced static, ELF and VLF electric fields. Difference was most pronounced for VLF. Little or no effect on magnetic fields	Small reduction in severity of 'tingling, pricking or itching' symptom between active/inactive (0.1 on scale 1–9), p=0.03
Oftedal et al, 1999 ⁵¹	42 people from companies and official institutions, with VDU-related skin symptoms, selected by questionnaire	Symptom severity measured during initial week with no filter, then for two three-month periods with/without active VDU filter. Randomised. Double blind. Active filter reduced ELF and VLF field compared with inactive filter	No difference in skin symptoms between active and inactive periods. Significant differences between no filter and any filter in severity scores for skin, eye, headaches and fatigue

A study of 394 Swiss residents is also relevant, and is reported in section 4.5.5¹⁸.

Two randomised double-blind placebo-controlled studies have examined the effects of reductions in static and low frequency electric fields on VDU-related skin symptoms (Table 7). There is no consistent evidence of a beneficial effect.

4.5.3 Reported treatment evaluations

Several reports of evaluation of treatment for ES sufferers were found (Table 8). The majority are of Swedish origin.

The studies reviewed suffer from a combination of the small numbers of subjects included and the potential variation both within and between study populations. Little information is given as to the attributed exposures of the subjects. These factors limit their general applicability outside the immediate study group. For those studies where detail was available, only two were placebo controlled (see Arnetz et al⁵³ and Hillert et al⁵⁶, Table 8).

TABLE 8

Study	Study population	Intervention	Outcome
Choy, 1989 ⁵²	3 subjects with self-reported ES	Application of neutralising chemical dilution and water claimed to be potentised with a neutralising EMF frequency	Neutralisation of EMF-provoked symptoms
Gustavsson et al, 1992 [†]	24 patients	Investigation by occupational medicine specialist and follow up in 4–33 months	11/24 improved; 6/24 gone back to VDU work (reduced VDU work time seemed to facilitate)
Arnetz et al, 1995 ⁵³	23 patients with ES, randomly selected from a list referred by occupational medicine to the dermatology department of a Stockholm teaching hospital. Patients had variety of symptoms. Psychiatric or somatic conditions needing treatment excluded	Randomly assigned to receive superficial or deep acupuncture for 5 weeks. Completed symptom scores before and after treatment. 6 month follow up period after treatment	Symptom index decreased continuously over time ($p < 0.05$). More able to work >30 mins at VDU at 6 months (50% versus 30%; $p < 0.05$). Lack of difference between the treatment groups raises question of placebo/Hawthorne response
Andersson et al, 1996 ⁴¹	17 patients referred by occupational medicine and from dermatological clinics in the Stockholm area. Inclusion criteria meant that patients would be significantly affected by ES. Psychiatric disorders needing immediate treatment excluded. Symptoms attributed to VDUs and other electrical sources such as fluorescent lights and TV	Part of a provocation study. CBT administered to randomly chosen group (9 patients). Questionnaire of six disability variables before and after treatment, for intervention and control groups	Treatment group had reduced subjective disability rating: 36.7 before, and 15.0 after treatment (scale 0–100). Significant difference compared to control group (42.1 versus 42.5) ($p < 0.05$). Subjects did not reduce their EMF exposure in the study period
Liden et al, 1996 [†]	220	Company-based occupational health service multidisciplinary interventional programme. 2 year follow up	60% had no symptoms (in full time VDU work), 30% improved

Continued

TABLE 8 *Continued*

Study	Study	Study	Study
Harlacher et al, 1998 [†]	80	Investigation by a dermatologist; extra time given at consultation and special interest given to psychosocial factors. 0–26 month follow up	30/80 recovered
Harlacher et al, 1998 [†]	26; 13 pairs	CBT: 9–12 month follow up including 3–5 months of treatment	50% improved or recovered; significant reduction of complaints after therapy as compared to control group
Hillert et al, 1998 ⁵⁴	22 patients referred to an occupational and environmental health department at a university hospital. Inclusion criteria: reported ES (skin, eye and neurovegetative symptoms); symptoms had to show some variation due to perceived exposure; aged 18–65; work at least 1 week in past 3 months. Excluded if medical or psychological explanation	CBT administered to randomly chosen group (10 patients) over 6 months. Questionnaire follow up after 6 months. 12 controls comparable for age and severity of symptoms	Small reduction in the subjectively rated degree of ES ($p < 0.05$) between therapy and control groups at 6 month follow up. Reduction in self-rated discomfort to different triggering factors significant over time for therapy group ($p < 0.05$)
Ockerman, 1998 ⁵⁵	34 subjects aged 29–63 with self-reported ES of at least 6 months duration	Antioxidants, pulsed magnetic fields, minerals, acetyl-cystein, melatonin, gamma linoleic acid. Follow up after 2 months of treatment. Self-rated symptoms, erythrocyte fragility, mobility of white blood cells	Symptoms reduced from 29.5–15.1 (scale 0–40). Reduced erythrocyte fragility and improved white blood cell motility
Eliasch [†]	36	Shiatsu offered to people on sick leave due to ES. 12–18 month follow up	78% were very satisfied 12 months after treatment, 47% in work
Hillert et al, 2001 ⁵⁶	16 patients referred to Environmental Illness Research Centre, Stockholm. Inclusion criteria: reported ES; reported change in symptoms within 24 hours of exposure change; history of VDUs or fluorescent lights as initial triggers. Excluded if medical or psychological explanation	Randomised, double-blind, crossover, placebo-controlled study. Vitamins C and E and selenium given for 3 week period. Daily reporting of symptoms, extent of ES, and serum levels, uric acid and DPPH	No significant differences in reported symptoms or extent of ES between treatment and placebo. Serum DPPH/uric acid no correlation with extent of symptoms of ES
Hillert, 2002 ³⁴	22 patients referred to Environmental Illness Research Centre, Stockholm, with medically unexplained symptoms perceived as due to ES. Age 18–65, <1 year of sick leave due to ES. Excluded if medical or psychological explanation	Multidisciplinary group intervention using salutogenic approach for 8 weekly sessions with 6 month follow up	Individual differences in progress across work capacity, subjective well being, coping ability, body awareness and physical fitness. Generally, muscular tension reduced, body awareness increased but no significant change in symptoms

[†] These Swedish language papers were reviewed by Hillert, 1998². No further detail is available within the constraints of this review.

The earliest report described a therapy based on water 'potentised by subject-specific neutralising EMF frequencies'⁵². Details of the responses of three patients were reported, with success claimed for around 60 patients at the time of reporting. Treatment methods were described in further detail in a later report⁵⁷.

Two studies examined the effect of antioxidant treatment on sufferers of ES^{55,56}. The earlier, published on the internet, reported an improvement in symptoms in 34 subjects after two months of treatment with various antioxidants, pulsed magnetic fields, minerals, acetyl-cystein, melatonin and gamma-linoleic acid⁵⁵. However, the study had no control arm. The author also made reference to an earlier successful trial of antioxidants, not identified by this review. A more recent paper from a different group described a randomised, double-blind, crossover, placebo-controlled study of vitamins C and E and selenium taken for three weeks⁵⁶. This showed no effect on symptoms.

Three studies examined the effectiveness of cognitive behavioural therapy (CBT)^{2,41,54} and a fourth included CBT as part of a wider management strategy³⁴. All reported control arms. Broadly, CBT focuses on the patient's reactions to their symptoms and how to improve their coping ability, rather than re-evaluating the original trigger for their illness. Three of the studies reported limited success; although were subject to the methodological limitations described in section 4.5.3.

Success has also been reported with trials of acupuncture⁵³ and Shiatsu². One view is that the trend towards improvement from the majority of the studies described in Table 8 (a diverse range of therapies) suggests that success may have more to do with offering a caring environment as opposed to a specific treatment². This is further supported by positive outcomes for the two studies which appear to have specifically studied this effect (Gustavvson and Harlacher, reported by Hillert²).

4.5.4 Other treatment

In addition to those already examined in Table 8, a variety of other therapies are suggested (Box 9). The majority fall outwith conventional biomedical practice.

The search strategy employed for this review found no reports of any evaluation of these techniques. Consultation in the future with appropriate practitioners/therapists in this field may help identify such sources.

BOX 9 Other therapies (non-evaluated)^{20,26,33}

Adequate hydration	Anticonvulsants
Filtered water	Olanzipine
Oral tryptophan	Healing/spiritual healing
Avoidance of GM foods	Oxygen therapy
Vitamin C supplements	Green clay baths
Trace element supplements	Topical sea salt/baking soda
Chiropractice	Negative air ionisers
Reflexology	Crystals
Nambudripad allergy elimination technique	Plants in the environment
Magnet therapy	

4.5.5 A population's treatment experience

A questionnaire survey of 394 people with self-attributed ES who complained to institutions in Switzerland provides a useful description of the type of actions taken by this population to reduce their symptoms and a subjective outcome measure for each¹⁸.

Sixty-five per cent of subjects had taken some type of action. The majority of these (45% of subjects) avoided exposure situations where possible. This included changing address, work or the place of their bed. In addition, 25% shielded their dwelling area with a curtain or net, 22% removed indoor sources, and 22% used drugs (no further explanation of 'drugs' is provided).

For each action taken a mean efficiency rating from one (ineffective) to six (very useful) was derived (Table 9).

Overall, 25% of those who had taken some form of action stated their symptoms were unchanged, 37% felt 'a little improvement' and 29% 'a substantial improvement' after action was taken. When asked in an open question 'about the best help for them', 39% stated removing of a specific EMF source, 13% a ban on EMF radiation, 11% a reduction in field levels, 9% information and appreciation of their symptoms, 9% changing living place, and 7% lower EMF standard limits.

TABLE 9

Subjective efficiency rating of actions taken to mitigate symptoms attributed to EMFs¹⁸

Action category	Mean efficiency rating
Disconnecting electricity	4.5
Removing indoor source	4.3
Avoiding exposure	4.2
Reconstruction	3.4
Information	3.2
Meditation/body work	3.2
Drugs	3.2
Shielding devices	3.2
Alternative medicine	3.1
Shielding of the dwelling	3.0
Changing lifestyle	2.3
Law complaint	1.1

4.6 Prevalence

Estimates of the prevalence of ES can be derived from studies of both workplace and general populations (Table 10). The majority of studies are based in Swedish occupational settings. However, two more recent studies have estimated prevalence in general populations. ES was defined in all studies on the basis of self-reported symptoms.

In 1993, the Swedish support group FEB estimated that a minimum of 10,000 people in Sweden suffered problems related to VDU use or more generalised electrical sensitivity³². The basis for this was not stated.

TABLE 10

Study	Description	Prevalence
Berg et al, 1990 ³⁷	Questionnaire survey re skin symptoms of 3877 randomly selected employees (VDU and non-VDU users) from 36 companies in four Swedish cities. 96.6% response rate	Prevalence of reported skin complaints 34.7% among VDU operators and 18.8% among non-users
Koh et al, 1990 ⁵⁸	Questionnaire survey of 694 full time female VDU operators in Singapore re skin complaints on the face, neck, hands, arms. 96.8% response rate	One year prevalence of skin complaints 12.2%
Carmichael and Roberts, 1992 ²⁸	Questionnaire survey of 3500 employees in DVLA, Wales. 41% response rate. VDU operator = >2 hours work daily	Facial skin complaints reported by 14% of VDU operators and by 11% of non-users
Eriksson et al, 1997 ⁵⁹	Questionnaire survey of 3233 VDU workers. Case definition: self-reported itching, stinging or burning sensation in facial skin and facial skin erythema or dry skin every week during the preceding 3 months	133/3233 (4.1%)
Hillert et al, 2002 ²⁴	Questionnaire survey of 15,000 people in Stockholm County, Sweden. Defined as hypersensitivity or allergy to electric or magnetic fields. Response rate 73%	1.5%
Levallois et al, 2002 ³⁶	Questionnaire survey of 2072 people in California, USA. ES defined as 'being allergic or very sensitive to getting near electrical appliances, computers or power lines'	68/2072 (3%) reported ES (adjusted prevalence 3.24%; 95%CI 2.8–3.68%)

The EC expert group also attempted to estimate the extent of ES within EU countries¹². The group reported that estimates of the total number of cases differed substantially between the countries as well as between the answering groups, with self-aid group (SAG) estimates consistently around ten times higher than those of centres of occupational medicine (COM). Estimates ranged from less than a few cases per million of the population (COM estimates from UK, Italy and France) to a few tenths of a per cent of the population (SAG in Denmark, Ireland and Sweden). Of the seven UK COM responses, three stated they received calls concerning ES. Two estimated the numbers of calls received each week: less than one in both cases. The UK prevalence estimate is based on the response of one COM.

The group concluded that the differences in prevalence were at least partly due to the differences in available information and media attention around ES that exist in different countries¹². Similar views have been expressed by other commentators^{13,60}.

4.7 Overlap with other conditions

The coexistence of ES and multiple chemical sensitivity (MCS) is widely reported by sufferers, their advocates and therapists^{19,21,25,26,30}.

MCS is, in turn, widely regarded as being part of a family of conditions known variously as symptom-based conditions⁶¹ or functional somatic syndromes (FSS) (Box 10)⁶² or, where linked to a putative environmental exposure, idiopathic environmental intolerances (IEI) (Box 11)⁶³.

BOX 10 Shared features of symptom-based conditions^{61,62}

Characteristic symptoms potentially involve multiple organ systems and not a recognisable pattern of complaints

Characteristic symptoms are not consistently associated with objective physical signs or laboratory abnormalities

Characteristic symptoms are similar, particularly fatigue, headaches, muscle/joint pains, cognitive difficulties, and sleep disturbances

Characteristic symptoms are commonly caused by varied psychiatric and medical illnesses

Concurrent psychiatric disorders are frequently present

Young to middle-aged, well-educated women are most commonly diagnosed

Similar multifactorial aetiologies are suspected

A tendency for sufferers to respond to similar therapies

BOX 11 Idiopathic environmental intolerance⁶³

Acquired disorder with multiple recurrent symptoms

Associated with diverse environmental factors tolerated by the majority of people

Not explained by any known medical or psychiatric disorder

The literature suggests that ES shares several of these characteristics, most notably a similar non-specific symptomatology (Box 12), and an absence of consistently demonstrated objective physical signs or laboratory abnormalities. Although this review has not examined the scientific evidence for the aetiological hypotheses of these conditions, it would appear that all are subject to ongoing debate similar to that surrounding ES⁶⁴.

While the evidence base for management decisions for ES is currently very limited, it points towards a trend for improvement with cognitive behavioural therapy, a feature common to some other conditions regarded as FSS/IEI^{64,65}.

4.8 UK experience

This review found little description of the UK experience of ES. Internet sites belonging to three UK support/advocate groups were found^{33,66,67}. These contain descriptions of the ES phenomenon. One site provides details of a small number of case reports of UK sufferers³³. When added to the reports of Smith and co-workers^{52,57} and the UK responses to an EU survey¹², this limited information suggests that ES in the UK is mainly characterised by general symptoms attributed to a range of EMF sources. There is also a small amount of anecdotal information and personal correspondence to show that some people in the UK are severely affected.

Details were found of small numbers of UK-based therapists and UK-based organisations selling EMF protection equipment. Only one UK-based therapy is described in any detail, however^{52,57}.

BOX 12 Symptoms commonly associated with symptom-based conditions⁶¹

Chronic fatigue syndrome: fatigue, postexertional malaise, muscle/joint pain, impaired memory, difficulty concentrating, confusion, dizziness, paraesthesias, sleep disturbances, unrefreshing sleep, sore throat, tender adenopathy, feverishness, anorexia, nausea, anxiety and depression

Fibromyalgia: widespread musculoskeletal pain, multiple tender points, fatigue, morning stiffness, headaches, paraesthesias, cognitive complaints, sleep disturbances, rhinitis, dysmenorrhoea, and gastrointestinal problems (abdominal pain, constipation and diarrhoea)

Multiple chemical sensitivities: allergy-like complaints, rhinitis, shortness of breath, fatigue, headache, malaise, muscle/joint pain, problems with memory and concentration, dizziness, irritability, insomnia, palpitations, and gastrointestinal disturbances

Food allergy: fatigue, headache, nasal stuffiness, nausea, abdominal bloating, bowel disturbances, dizziness, sleep problems, memory loss, tinnitus, paraesthesias, palpitations, shortness of breath and depression

Chronic candidiasis: fatigue, headache, dizziness, problems with memory and concentration, sleep problems, muscle/joint aches, skin rash, rhinitis, sore throat, cough, shortness of breath, gastrointestinal problems (constipation, diarrhoea, flatulence, abdominal pain), genitourinary problems, sexual dysfunction, menstrual difficulties, irritability, hyperactivity, anxiety and depression

Silicone-associated atypical rheumatic disease: myalgia, polyarthralgia, fatigue, paraesthesias, skin rashes, mucosal and conjunctival dryness and cognitive difficulties

Sick building syndrome: dry, watery or itchy eyes, dry skin and rashes, respiratory tract complaints (dry and irritated throat, rhinitis, sinus problems, cough and shortness of breath), fatigue, headache, dizziness, and difficulty remembering and concentrating

Gulf War syndrome: fatigue, headache, muscle/joint pains, difficulty remembering and concentrating, sleep problems, skin rash and depression

There is only very limited information on the numbers of sufferers of ES in the UK.

- a While the survey carried out by the EC expert group reported UK prevalence at less than ten cases, this is based on the responses of three centres of occupational medicine, only one of which gave a quantitative response¹².
- b In an annex to the appendices to the Minutes of Evidence of the 1999 Third Report of the Science and Technology Committee, an 'expert consultant' at the Breakspear Allergy Hospital reported that over 500 patients suffering from ES had been treated⁶⁸.
- c A prominent UK advocate for ES reports a database of 60 sufferers (personal correspondence)⁶⁹. Closed head injury, spinal injury, electric shock and metallic implants are reported as frequent premorbid factors. The database was not examined in the course of this review.

There is also reported UK experience of the perceived adverse effects of radiofrequency (RF) EMFs – in particular, mobile phones and base stations. Members of the public who have written to the Department of Health in England in relation to RF exposure have complained of a wide variety of symptoms, including dizziness, chronic headache, fatigue, clicking in the ears, hearing loss, tinnitus, sore eyes, nosebleeds, insomnia, stroke, heart attack, irregular heart beat, nausea and vertigo, loss of memory and concentration, skin rashes and diabetes⁷⁰. This phenomenon has not yet been widely labelled as ES in the UK.

In oral evidence to the Independent Expert Group on Mobile Phones, a representative of a mobile phone shielding device manufacturer claimed to hold a database of symptoms attributed to RF exposures reported by over 2000 people⁷¹.

In addition, since the 1970s some people in the UK have complained of hearing a low frequency noise, which is inaudible to the majority of the population, and of other phenomena^{72,73}. People complain of headache, insomnia, nausea, fatigue, tension, dizziness, intense head, temple or ear pressure, difficulty concentrating, skin burning, blurred vision, eye strain, nosebleeds, muscle spasms and heart palpitations.

5 DISCUSSION

5.1 Definition/description

It has not been possible to construct a meaningful definition of ES, beyond that advanced in section 1.1 (paragraph 2) of this review.

There is wide variation in the reported experience of ES in terms of symptomatology, time course, prognosis and the attributed exposures. This variation exists at both individual and population levels. Similarly, the review found no consistent evidence of objective clinical signs or sensitive/specific pathophysiological markers.

Thus it would appear there is considerable overlap between ES and other conditions known collectively as symptom-based conditions, functional somatic syndromes or idiopathic environmental intolerances. The significant difference between ES and these others is the attribution by the sufferer of symptoms to an EMF source. Other than noting the ongoing debate about this attribution, however, this review is unable to comment further.

5.2 Policy/management options

Given that the project did not specifically address the question of aetiology, it is unable to inform policy in terms of setting exposure guidelines. However, a precautionary approach has been advocated in another similar situation – namely that concerning children and mobile phone exposure⁷⁰.

There is also little evidence to guide the management of affected individuals.

- a The few relevant published studies identified do not provide robust evidence in support of the electromagnetic hygiene/avoidance strategies widely advocated by sufferers and their support groups.
- b While various complementary/alternative medical therapies are promoted there is a similar paucity of published robust evaluation.
- c The similarity with FSS/IEI has clearly prompted some therapists to adopt largely psychologically based management strategies. The very limited studies to date point to some success.

5.3 Limitations of review methodology

While the review methodology has resulted in a systematic search of a range of literature types, achieved within available resource constraints, there are two significant limitations.

In order to focus the search on what is commonly understood to be ES (namely, non-specific symptoms, rather than specific disease processes) the search terms comprised ES and its synonyms, as opposed to a much wider 'adverse effects of electromagnetic fields' approach. This strategy may therefore have missed literature relating to similar phenomena not yet labelled as ES. This may be more likely in the case of newer technologies, and especially in populations, such as in the UK, where the medical, scientific and public attention paid to these attributions has historically been less than in other populations.

The search strategy for peer-reviewed literature was biased towards biomedical scientific literature. Literature from other science or complementary medicine sources may not have been apparent, unless signposted on the internet or through the references of biomedical literature. The very limited involvement of sufferer/advocate stakeholders may not have been sufficient to counteract this deficit.

5.4 Application to radiofrequency (RF) EMF exposures

The established biological effects of RF EMF exposures are not necessarily generated by the same mechanism as lower (power) frequency effects. This difference may also apply to ES effects and means that these phenomena may need to be considered separately. Symptoms attributed to RF and other EMF exposures are usually considered together as ES in the grey literature, but the majority of peer-reviewed scientific literature considers ES in terms of exposure to VDUs and other electrical appliances. Thus, while one might speculate that some of the reviewed studies where the attributed exposure was not specified have included subjects who attributed symptoms to RF EMF, the applicability to RF exposures of the majority of the scientific literature reviewed is open to question.

Of increased recent interest in the UK is the attribution of subjective symptoms to mobile phones and their base stations, with these now discussed in terms of ES in a recent HPA RPD document⁷⁰.

While the search strategy in this review largely failed to identify systematic studies examining symptoms attributed specifically to these exposures, work outside the search strategy of the review has identified reports of symptoms similar to those widely reported as ES⁷⁴. Symptoms such as tinnitus, headache, dizziness, fatigue, sensations of warmth, scalp sensations, visual symptoms, memory loss and sleep disturbance have been investigated in relation to mobile phone use; with fatigue, sleep disturbances and frequent headaches attributed to living near base stations.

Further weight is given to this observed similarity by the Roosli et al study¹⁸ of a Swiss population of EMF complainants. In this study, symptoms did not significantly differ

($p=0.21$) according to which of three main exposure categories attribution occurred (mobile communication/broadband, computer and TV, and use of electricity).

Debate around the aetiology of these attributions continues and a specific research programme is ongoing⁷⁵.

Thus, although symptoms attributed to RF EMF (such as mobile phones/base stations) and other exposures appear to be similar in type, the findings of this review cannot apply in full to these attributions.

5.5 Future research

Interpretation of the research around ES to date is made difficult by the lack of a specific case definition for the phenomenon. As in similar situations, the potential for heterogeneity within and between study populations mean there is no assurance that study results are generalisable⁶¹. Future studies must therefore attempt to ensure homogeneous subject groups, defined on the basis of dimensions such as the severity of their illness and their attributed exposures¹⁶.

Although this paper has not focused on the aetiological debate, it recognises that a robust understanding of the aetiology of ES would have implications for its prevention and management. Continued research in this area is essential.

This review identified very little UK-based literature from any source. In particular, there would appear to be a need for research to describe the phenomenon and to estimate its prevalence within the UK. Useful information could be gained from a questionnaire survey of the type performed by Roosli et al in Switzerland¹⁸. This should include all those complaining of symptoms due to EMFs. While primarily directed at ES sufferers identified through support group networks, it should also include people who complain of symptoms attributed solely to mobile phones, their base stations, and other newer technologies, and whose condition has not been labelled as ES.

Research currently funded by the UK-based Mobile Telecommunications and Health Research (MTHR) programme includes provocation experiments, a descriptive study of ES and an estimation of the prevalence of ES⁷⁵.

In addition, future research should also prioritise the management of affected individuals.

- a Researchers should engage with therapists currently treating sufferers in order to source evaluations not identified by this review; and to identify treatment areas where such evaluation might be feasible.
- b Future treatment studies must control for the placebo effect.
- c Good quality, sufficiently powered, clinical trials of cognitive behavioural therapy should be conducted.

ACKNOWLEDGEMENTS

I am grateful to the following individuals who contributed to this review process:

Ms A Arnold Silk	Mr S Allen
Mr and Mrs A Philips	Dr A McKinlay
Mr G Hooker	Mr D Perry
Dr J Rubin	Dr Z Sienkiewicz
Professor S Wessely	Dr J Stather

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