

Preliminary report: Symptoms associated with mobile phone use

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Mobile phone use is ubiquitous, although the alleged health effects of low level radio-frequency radiation (RFR) used in transmission are contentious. Following isolated reports of headache-like symptoms arising in some users, a survey has been conducted to characterize the symptoms sometimes associated with mobile phone usage. A notice of interest in cases was placed in a major medical journal and this was publicized by the media. Respondents were interviewed by telephone using a structured questionnaire. Forty respondents from diverse occupations described unpleasant sensations such as a burning feeling or a dull ache mainly occurring in the temporal, occipital or auricular areas. The symptoms often began minutes after beginning a call, but could come on later during the day. The symptoms usually ceased within an hour after the call, but could last until evening. Symptoms did not occur when using an ordinary handset, and were different from ordinary headaches. There were several reports suggestive of intra-cranial effects. Three respondents reported local symptoms associated with wearing their mobile phone on their belts. There was one cluster of cases in a workplace. Seventy-five per cent of cases were associated with digital mobile phones. Most of the respondents obtained relief by altering their patterns of telephone usage or type of phone. Cranial and other diverse symptoms may arise associated with mobile phone usage. Physicians and users alike should be alert to this. Further work is needed to determine the range of effects, their mechanism and the possible implications for safety limits of RFR.

Key words: Mobile phones; radiofrequency radiation; symptoms.

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INTRODUCTION

Mobile phone usage is ubiquitous. In Australia with a population of 18 million people there are over 3 million mobile phones which utilize analogue (830 MHz FM) or digital (GSM 900 MHz, 217 Hz pulses) radio-frequency radiation (RFR). Mobile phones may be used as hand-held, hands-free fitted into a car, a 'hands-free kit' (consisting of an ear and mouthpiece connected to a transmitter worn on the belt) or a transportable (bag) mobile phone. The RFR emitted from the hand-held telephones is low, about 600 mW average for analogue and 2 W peak (125 mW average) for digital phones. Digital and analogue mobile phones also send brief location updates, four or more times an hour, to surrounding mobile phone base stations when not in use. The International Commission on Non-Ionizing

Radiation Protection has stated that the localized RFR limit for general public exposure (2 W/kg) will not be exceeded by handsets with duty cycle weighted powers less than 600 mW for 900 MHz fields.¹ This assumes an antenna to head separation of 1.4 cm (ICNIRP 1995). However, the health effects of low level RFR are a matter of controversy.

For some years prior to 1995 I had received reports from users of mobile phones regarding symptoms arising from their use, such as the following:

1. 'It has been noted that by using the mobile phone in the transmit mode, the side of the head closest to the phone heats up and at different periods of time persistent migraines appear.'
2. 'I have noticed persistent strong headaches for a period of 4 days; worsening after using the mobile phone for extended periods of time (approx. 10–15 minutes, 4–5 times a day). These headaches have been occurring on the left side of my head, adjacent to phone and aerial.'

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3. 'I've also noticed migraines to the side of the head which sort of goes away on the weekend, when we don't use the mobile phone. But it persists during the weeks since we had the phones.'

Subsequently a survey was undertaken to help better characterize the nature of the symptoms as an aid to further research. This preliminary report complements other (laboratory and epidemiological) studies currently in progress in the UK, Sweden and Finland.

METHODS

Respondents were recruited by a notice in a medical journal in 1996 which led to some media publicity. Respondents contacted the writer and were subsequently interviewed at length by telephone. The interview was conducted using a questionnaire developed for this purpose with the international collaborators in the UK and Sweden. The questionnaire had three main parts: the first elicited information about general health and headache history; the second obtained details of symptoms associated with mobile phone usage; and the third part obtained information about the types of telephones used. Data were then coded and analyzed.

RESULTS

There were 50 initial respondents of whom 40 (80%) were subsequently contacted for interview. Reasons for non-response included being overseas, non-response to calls and not wishing to participate.

Seventy-five per cent of respondents were male; the majority were aged between 30 and 49; and they lived in Queensland, New South Wales, Victoria, South Australia and Western Australia. Their occupations were diverse and included computer-related workers (six), managers (three), housewives (three), photographers (two), farmer, mechanic, pilot, solicitor, *etc.* Two worked for telephone companies.

Nearly all respondents described their health as good. Five had histories of headaches, and five had at some time suffered a migraine. Thirteen had allergies (penicillin, milk, *etc.*), but none reported they had electro-sensitivity or multiple chemical sensitivity. Twenty-nine (75%) had fillings in their molar teeth. Three had a serious illness (cancer, heart disease, hypothyroidism) which was under control.

The symptoms arising from the mobile phone mainly affected the head and, for a few, the waist (see Table 1). The most common site (17) was the 'temple' area; nine felt symptoms in the ear and nine on the occipital area. The pain radiated in a few to the jaw, neck, shoulders or arm. For 10 the symptoms were described as a dull pain; an unpleasant warmth or heating by 11 and various other painful sensations such as ache, throb, sharp and pressure by others. On a pain scale of 1-5, (1 = least, 5 = most), 18 rated the pain as 2, and 11 rated it as a 3. All could distinguish the sensations from ordinary headache.

Table 1. Symptoms reported by 40 mobile phone users

<i>Symptom</i>	<i>Number</i>	<i>(%)</i>
Cranial symptoms	35	(88)
Site on head		
Temple	17	(48)
Ear	9	(26)
Occiput	9	(26)
Type of pain		
Heat/warmth	11	(31)
Dull pain	10	(29)
Other	14	(40)
Onset		
<5 min	23	(65)
Later	12	(35)
Cessation		
<1 hr	19	(54)
Later	16	(46)
Neurological (may have more than one)		
Visual	11	(31)
Nausea/dizzy/fuzziness	15	(43)
Atypical symptoms	2	(5)
Waist symptoms	3	(7)
Total respondents	40	(100)

The majority (23) felt the sensation less than 5 min after commencing the call, but another 12 felt the sensation build up as the day progressed. For 19 the sensation lasted less than an hour after ceasing calls, but for 11 it lasted till bed time, and five felt it the next day. Generally symptoms which had rapid onset also remitted more quickly.

Sixteen suffered every time they used the mobile phone, but others replied usually (11), or frequently (eight). Twenty-two had the sensations more than 20 times. The duration of calls was considered to be an influence on symptoms by 30 respondents. Nineteen found the sensation moved to the other side of the head if the mobile phone was moved, but 18 had not tried this. None had symptoms when using an ordinary telephone handset.

Two cases had been diagnosed as migraine. One had used an analogue phone without symptoms, but on changing to a digital, developed symptoms which were investigated and diagnosed as migraine. Upon changing to a hands-free kit the symptoms ceased. Eleven cases reported some transient effects on their vision such as blurring. Fifteen cases reported feelings of nausea or dizziness or a 'fuzziness' in the head which made thinking difficult. One case had longstanding tinnitus, but after a prolonged mobile phone call developed deafness and vertigo which lasted 5 h. One female who had painful head sensations associated with mobile phone use, also associated onset of a sub-arachoid haemorrhage (from an arterio-venous malformation) to a call. A young male who used a mobile phone very extensively subsequently developed weakness of the contra-lateral leg for which extensive neurological investigation has not found a cause.

Three respondents associated symptoms about their lumbar area to wearing a mobile phone on their belt. One reported pain in the area at night time and another felt a cold area the size of a saucer. The location of symptoms was dependent on the side the mobile phone was carried and moved sides with the phone. A third person had an injury to the right flank many years ago; wearing the mobile phone caused similar pains in the previously injured muscles.

Three staff from one organization reported symptoms. About 30 mobile phones had been issued and subsequently staff informally learnt that others had symptoms. The episode was notified to the state Workcover (compensation) authority.

Two respondents had unusual symptoms. One developed a warm feeling and then a blistering loss of skin on the contralateral cheek after a prolonged call; the other reported headaches when clients in her office used their mobile phone.

Nineteen respondents had a mobile phone fitted to their car; 14 had an external aerial and did not get headaches when it was used.

The makes of mobile phones were those of major companies. Twenty-eight respondents associated symptoms with digital (GSM) phones and 10 with analogue. Of the former, 13 said they had tried an analogue without symptoms developing, and two of the latter group had no symptoms with digital phones. Twenty-two said they used the mobile phone more than five times a day. Thirty-four had changed their use of the mobile phone as a result of the symptoms, often using it as a pager and some had switched to 'hands-free kits', which had relieved their symptoms.

DISCUSSION

This paper is intended to characterize the syndrome of symptoms associated with mobile phone usage and is, to our knowledge, the first of its kind to be published. The symptoms are felt in the temporal, auricular, or occipital areas and are often described as a dull or burning pain. The unpleasant sensations may begin within minutes of beginning a call or come on with usage during the day. The symptoms may cease within the hour after a call or last till bedtime. Some cases have symptoms suggestive of intra-cranial effects on vision, inner ear and cognitive function. Symptoms do not occur with ordinary handset usage. Symptoms may occur around the waist when the mobile phone is worn on the belt.

All respondents were interviewed for 15–30 min by BH. This permitted thorough exploration of symptoms and perhaps gathered data that could have been missed by a mail-out questionnaire or interviews by non-medical personnel.

It is recognized that there may be self-selection bias with regard to the respondents. However the veracity of their symptoms is suggested by their similarity to the original unsolicited reports (reports 1–3); the recognition by respondents of symptoms before publicity began (1996); the basically favourable attitude of respondents to

mobile phones; the occurrence of symptoms in anatomical sites not immediately close to the antenna; the occurrence of reports Australia-wide; and the fact that three-quarters of respondents had spontaneously taken sensible steps to lessen symptoms by altering telephone usage argues against neurotic behaviour. Also, the occurrence of 'headaches' was noted in the laboratory setting with similar exposures 30 years ago. Frey² has described how in the course of an experiment he and his volunteers developed headaches during exposure to the side of the head from 1.3 GHz radar-pulsed RFR at 400 $\mu\text{W}/\text{cm}^2$ averaged power. (The estimated energy from a mobile phone is similar). Reports of cranial symptoms are now being reported from Sweden, the UK, the USA and New Zealand.³

The cranial symptoms differ from headaches such as migraine or cluster or tension headaches or temporomandibular joint dysfunction, by their site or time of onset or duration.⁴ Cervical neuralgia from 'cradling' the mobile phone in the neck is an unlikely explanation because several had used analogue telephones without symptoms and then on changing to a digital phone developed symptoms; it is unlikely their method of holding the mobile phone suddenly changed. The absence of skin rashes and relevant history is not consistent with electrical hypersensitivity.

The mechanism of the effect may be speculated. The fact that none of the respondents suffered symptoms when using an ordinary hand-set argues against a positional effect and also against a call-content related psychological reaction. The onset of symptoms within minutes in many respondents suggests a neural mechanism, although a vascular component could be involved. The symptoms in the flank of the person with a previous injury suggests stimulation of neuromas in damaged nerves by the location pulses.

The innervation of the scalp and ear is complex. The superior anterior part of the ear is supplied by the superficial temporal branch of the maxillary division of the trigeminal nerve. This also innervates the 'temple'. Much of the pinna and the occipital area of the scalp is innervated by the greater auricular nerve from C2 and 3. The external ear and meatus is also supplied by the glossopharyngeal and vagus nerves. These various nerves could provide the basis of nociception or referred pain such as to the arm.

Mobile phones can warm adjacent tissue due to their battery and circuits, as well as emit RFR. The respondents did not relate symptoms to the cheek which is directly heated and highly vascular. Justesen *et al.* has noted that RFR (2.4 GHz) can warm tissue and cause a prolonged sensation after the stimulus has ceased, however this requires an energy of at least 27 mW/cm^2 which is much greater than that from mobile phones.^{5,6}

Chou and Guy found that strong pulsed or continuous wave 2.45 GHz radiation was not able to elicit action potentials in isolated frog nerves.⁷ Pakhomov found nerve velocities did not change but potential amplitudes decreased using 915 MHz pulsed waves.⁸ Seaman and Wachtel observed increased firing rates of *Aplasia-ganglia* exposed to 1.5 and 2.5 GHz continuous wave radiation

which further increased when pulsed.⁹ Bolshakov and Alekseev found 900 MHz pulsed (but not CW) increased bursts of firing of *Lymnea* neurons.¹⁰ Thus, low level RFR at relevant frequencies has not been found to initiate an action potential but can affect nerve firing rates. This could cause dysaesthesia. The A delta fibres of nerves are responsible for pain and warmth feelings and require special neurophysiological techniques to evaluate them. They are particularly sensitive to 250 Hz currents;¹¹ pulsed mobile phones operate at 217 Hz. The nerves on the face are more sensitive to stimulation than those on the arms and legs and there is a wide variation in sensitivity between subjects.¹¹ Subthreshold stimulation and adaptation could account for variations in onset and remission of cranial symptoms in different respondents. A combined effect on nerves of RFR and heating may be considered.

It is feasible that a vascular component could contribute to the symptoms. An effect on blood vessels could contribute to pain¹² or to migraine or other intra-cranial symptoms.¹³ Salford¹⁴ has evidence of an effect on the blood-brain barrier from low-level exposures in mice, and French has preliminary evidence of an effect by 830 MHz RFR on endothelial cell cultures (personal communication).

Lai *et al.*¹⁵ have found that rats exposed to low levels of RFR have impairment of learning and an associated change in acetylcholine receptor levels. This may be relevant to some of the apparently cognitive symptoms. Reports of EEG changes after mobile phone use have been inconsistent. Stimulation of the semi-circular canals could contribute to otological symptoms, although click-sounds as described by Frey in radar workers were not reported.¹⁶ The above mechanisms are not mutually exclusive.

The energy from a mobile phone incident on the face has been measured by Bolzano *et al.* in studies on human models.¹⁷ The energy is mainly deposited in the cheek anterior to the ear with lesser levels elsewhere. The levels in the cheek are approximately 1 W/Kgm, which is around half of the present safety levels as set out by ICNIRP.¹

This survey does not attempt to assess the prevalence of symptoms. However, the occurrence of a cluster of cases in one workplace in this survey (and an unreported one similarly involving some four staff out of about 30) suggests a low level prevalence of susceptibility.

This survey has begun to characterize the main features of the cranial and other symptoms sometimes associated with mobile phone use as a basis for epidemiological or laboratory studies. Epidemiological studies require definition of a case and this paper is intended to help to characterize the symptoms which then constitute a case; the possibility of diverse intra-cranial effects

should be sought in any further surveys. Laboratory studies should include double blind testing of patients to confirm if RFR is causative of their symptoms. It is desirable that users and the medical profession alike recognize that mobile phones appear to cause a variety of symptoms in some individuals. In addition, the apparent occurrence of symptoms at levels below the allowable limits raises questions about the current safety levels of RFR.

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