

Symptoms experienced in connection with mobile phone use

G. Oftedal*, J. Wilén†, M. Sandström† and K. H. Mild†

**SINTEF Unimed, Trondheim, Norway; and* †*National Institute for Working Life, Umeå, Sweden*

Many people in Norway and Sweden reported headaches, fatigue, and other symptoms experienced in connection with the use of a mobile phone (MP). Therefore, we initiated a cross-sectional epidemiological study among 17,000 people, all using an MP in their job. Thirty-one percent of the respondents in Norway and 13% of those in Sweden had experienced at least one symptom in connection with MP use. Next to the sensations of warmth on the ear and behind/around the ear, burning sensations in the facial skin and headaches were most commonly reported. Most symptoms usually began during or within half an hour after the call and lasted for up to 2 h. Relatively few had consulted a physician or been on sick leave because of the symptoms, but about 45% among those with an MP attributed symptom had taken steps to reduce the symptom. These results suggest an awareness of the symptoms, but not necessarily a serious health problem.

Key words: Cellular phones; medical consultations; sick leave; symptoms.

Occup. Med. Vol. 50, 237–245, 2000

Received 30 September 1999; accepted in final form 18 February 2000.

INTRODUCTION

Symptoms experienced in connection with the use of a mobile phone (MP) have been reported from Australia.¹ In Scandinavia also, some people using an MP have complained about headaches, vertigo, feelings of discomfort, sensations of warmth and other symptoms. We wished to obtain a description of the symptoms and conditions that might be important for the occurrence of symptoms, and to compare the prevalence of symptoms among people using a digital MP (GSM 900) and an analogue MP (NMT 900). Both phone systems operate with a carrier wave at 900 MHz, but whereas the NMT phones use a continuous carrier wave, the carrier wave of the GSM phones is pulsed. The two systems also differ with respect to output power. The maximum output power during a pulse from GSM phones is higher than the maximum output power from NMT phones (2 versus 1 W). However, the mean power from GSM phones is the lower, and because of regulation systems, under most conditions the GSM phones operate at much lower levels than the NMT phones.² For further details see Andersen *et al.*³

We initiated a Swedish–Norwegian epidemiological study, and the hypothesis postulated, i.e. that the

prevalence of symptoms is higher among GSM users than among NMT users, was falsified. As a corollary we observed a statistically significant association between calling time/number of calls per day and the prevalence of warmth behind/around or on the ear, headaches and fatigue.²

The aim of this paper is to describe measures taken to reduce the symptoms experienced in connection with MP use, conditions and measures experienced to be important for the symptoms, consequences with respect to medical consultations and sick leave, as well as to describe the symptoms.

MATERIALS AND METHODS

Study population

The study was performed as a cross-sectional epidemiological investigation by sending out a questionnaire to about 12,000 MP users in Sweden and 5000 in Norway. The number of people using GSM and NMT was approximately equal. A reference group of ordinary phone users was not included because we expected a comparison between MP users and ordinary phone users to be biased due to the public concern for health effects related to MP use, and we had no mean to adjust for such a bias.

The people included in the study were randomly selected from subscription registers where a company was the subscriber, but an individual was assigned to the phone. In Sweden, the number of respondents was 7803,

Correspondence to: Gunnhild Oftedal, Norwegian University of Science and Technology, Department of Physics, N-7491 Trondheim, Norway. Tel: +47 73597827; fax: +46 73591854.
e-mail: gunnhild.oftedal@phys.ntnu.no

and in Norway it was 2828. The response rate estimated by adjusting for subjects who did not receive the questionnaire was 76% for Sweden and 64% for Norway.

Questionnaire

The questionnaire included separate questions about symptoms experienced in general (an individual was defined as having a symptom if the symptom occurred at least once a week), and symptoms that occurred or were aggravated in connection with the use of an MP, an ordinary phone, or in connection with visual display terminal (VDT) work. A comparison between MP-attributed symptoms and VDT-attributed symptoms was of interest because in both Norway and Sweden there has been a concern for possible health effects in connection with exposure to electromagnetic fields from VDTs, and various skin symptoms as well as neurasthenic symptoms have been reported among VDT users. A list of symptoms was given: dizziness, feelings of discomfort, difficulties concentrating, memory loss, unusual fatigue, headaches, sensations of warmth behind/around the ear, sensations of warmth on the ear, burning sensations in the facial skin, tingling/tightness sensations in the facial skin, and other symptoms, meaning that the respondent could specify any symptom which he/she had experienced.

Exposure factors with respect to the use of MPs and possible confounding factors such as gender, age, occupation, VDT-work and psychosocial factors were registered. Four groups of occupations were defined by using the Swedish AMSYK classification of occupation.⁴

- *Management.* A leading position in companies or public administration, and politicians.
- *Professional.* At least 4 years of university education.
- *Intermediate non-manual employees.* Shorter university education.
- *Others.* No demand of university education, including blue-collar workers, secretaries and salesmen.

The psychosocial work load was estimated based on the sum of scores of four commonly used questions, as given in Table 1. Three categories were defined: low (sum, 0–2), medium (3–5), and high (6–12), where low means that the person is experiencing the lowest psychosocial work load.

The last part of the questionnaire was to be answered by those having experienced at least one symptom in connection with the use of an MP. We asked how quickly

the symptoms appeared in connection with an MP call, how long the symptoms continued, whether the symptoms had led to medical consultations or sick leave, about conditions of importance for the symptoms, and steps taken in order to reduce the symptoms.

Non-respondent analysis

After the collection of the questionnaires, about 10% of the non-respondents in each country were randomly selected for a non-respondent analysis. The subjects were interviewed by telephone by using a questionnaire made for this purpose. Questions about reasons for no response, transmitter system used, and whether symptoms had been experienced in connection with MP use were included. Because of a relative low response rate in Norway, we compared the distribution of non-respondents and respondents for various potential risk factors. For this purpose information available from the Norwegian subscription data base was used for all selected subscribers. Further methodological details are given by Oftedal *et al.*⁵

Statistical methods

Differences between the Norwegian and Swedish respondents with respect to various individual, work related, and MP related factors were tested by using Student's *t*-test. To test for relations between end point variables (e.g. symptom occurrence, medical consultation, sick leave) and various exposure factors, one-way analysis of variance (ANOVA), Dunnett's T3 was used. Linear trends with respect to the number of calls per day and calling time per day, respectively, was tested by using polynomial analysis. Pearson's chi-square test was used to analyse whether a symptom attributed to an MP was dependent on the same symptom attributed to VDT work. All analyses were done with the use of the SPSS package. A result was considered to be statistically significant if the significance probability was less than 0.05.

RESULTS

Characteristics of people reporting symptoms attributed to mobile phones

The number of respondents who had experienced at least one symptom in connection with the use of an MP, including sensations of warmth on the ear and behind or

Table 1. Basis for calculating the psychosocial work load

Question	Yes, often	Sometimes	Seldom	Never
Do you consider your job to be interesting and stimulating?	0	1	2	3
Are you overloaded in your job?	3	1	1	3
Are you able to influence your working conditions, such as working at your own pace?	0	1	2	3
Do your colleagues assist you when you have problems with your job?	0	1	2	3

around the ear, was 979 (13%) in Sweden and 871 (31%) in Norway. Compared to respondents with no MP attributed symptom, those with such symptoms were, in general, younger, had a higher number of calls per day, and were using their phone more minutes per day (Table 2). In both Sweden and Norway there were only minor differences between those with and those without a symptom regarding geographical location of

work and the period of time the MP had been used. These results are not included in the table.

The variation between the various categories of occupations with respect to the relative number of people who had experienced any MP attributed symptom may be of particular interest. For management, professionals, intermediate non-manual employees, and others the figures in Norway were 31, 30, 35 and 21%,

Table 2. Distribution of respondents without any symptom attributed to the use of a mobile phone (MP) and of respondents having at least one such symptom for individual, work related, and MP related factors, and for the self evaluated state of health. The number (*n*) of respondents with and without symptoms, respectively, is given for Norway and Sweden.

		Norway		Sweden	
		Without symptom (%) (<i>n</i> =1957)	With symptom (%) (<i>n</i> =871)	Without symptom (%) (<i>n</i> =6824)	With symptom (%) (<i>n</i> =979)
Gender	Male	90	90	86	85
	Female	9.6	10	14	15
	Missing	0.0	0.0	0.0	0.0
Age	< 30 years	9.6	14	5.6	11
	30–39 years	33	48	22	34
	40–49 years	32	28	34	36
	> 49 years	24	8.0	38	19
	Missing	1.8	2.1	0.7	0.6
Occupation	Management	35	36	26	23
	Professionals	22	21	18	20
	Intermediate non-manual employees	23	28	31	38
	Others	11	6.5	15	12
	Missing	9.6	8.6	9.8	7.8
Psychosocial work load	Low	36	33	39	33
	Medium	45	46	44	45
	High	17	20	14	21
	Missing	2.0	0.2	3.2	1.9
VDU work	No VDT work	18	17	20	21
	< 1 hour/day	18	18	22	44
	1–4 hours/day	46	45	42	20
	> 4 hours/day	15	17	14	15
	Missing	2.6	2.6	1.8	1.1
Transmitter system*	NMT	31	31	24	25
	GSM	37	31	35	27
	Mixed	32	38	41	48
Number of calls/day	< 2 calls/day	12	3.7	16	7.0
	2–4 calls/day	29	20	33	22
	> 4 calls/day	59	76	47	66
	Missing	0.6	0.0	0.9	0.1
Calling time per day	< 2 min	6.8	1.7	11	3.0
	2–15 min	44	28	47	33
	15–60 min	38	46	33	44
	> 60 min	11	25	8.1	20
	Missing	0.6	0.1	0.9	0.1
State of health	Good	83	83	72	69
	Average	14	16	24	27
	Not so good	0.9	1.0	1.4	2.3
	Missing	1.6	0.2	3.0	2.2

*NMT, people with only one NMT phone; GSM, people with only one GSM phone; mixed, people with more than one MP, people with NMT 450, and people for which transmitter system information was missing.

respectively, and in Sweden 11, 14, 15 and 10%, respectively. The difference between any two categories was statistically significant for both countries only when comparing intermediate non-manual employees and others.

We tested whether the distribution of respondents for the various factors listed in Table 2 was different between the two countries. Statistical significance was obtained for all factors except for VDU work.

Description of the symptoms

As shown in Figures 1 and 2, sensations of warmth on the ear or behind or around the ear were experienced mainly during and shortly after phone calls were made, whereas most of the other symptoms were usually delayed relative to phone calls. Headaches, for instance, typically appeared during or within 30 min after the call, and for most people this symptom continued up to 2 or 6 h after the call, but in some cases it lasted for more than 6 h.

The feelings of warmth were felt on the same side as the MP was held by about 97% of the respondents with

these symptoms. At least 62% of those with a facial skin symptom and nearly 40% of those with headaches experienced the symptom to be ipsilateral relative to the side where the MP was held, while almost all of the remaining subjects with these symptoms did not relate it to any specific side. These results were similar for both countries.

Symptoms attributed to mobile phones, ordinary phones and VDT

As indicated in Table 3, a higher percentage of the Norwegian respondents compared to the Swedish respondents had experienced the various symptoms in connection with the use of an MP. For both countries, the symptom most frequently attributed to MP use was sensations of warmth on the ear and behind or around the ear. The number of people having at least one symptom other than any of these warmth sensations was 22% in Norway and 7.4% in Sweden. Among other symptoms attributed to the use of an MP, ear, eye and neck problems were most commonly specified.

Figure 1. Distribution of people with respect to how quickly they usually experienced the symptom in connection with a call from a mobile phone (MP). Only respondents with an MP-attributed symptom who had answered the actual question are included. For each symptom, the total number of people (n) is shown below the bars.

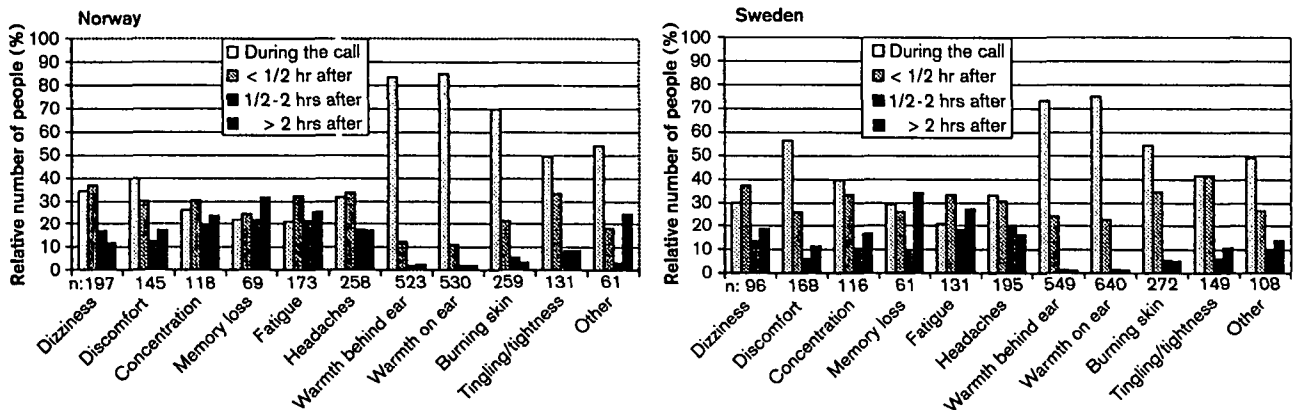
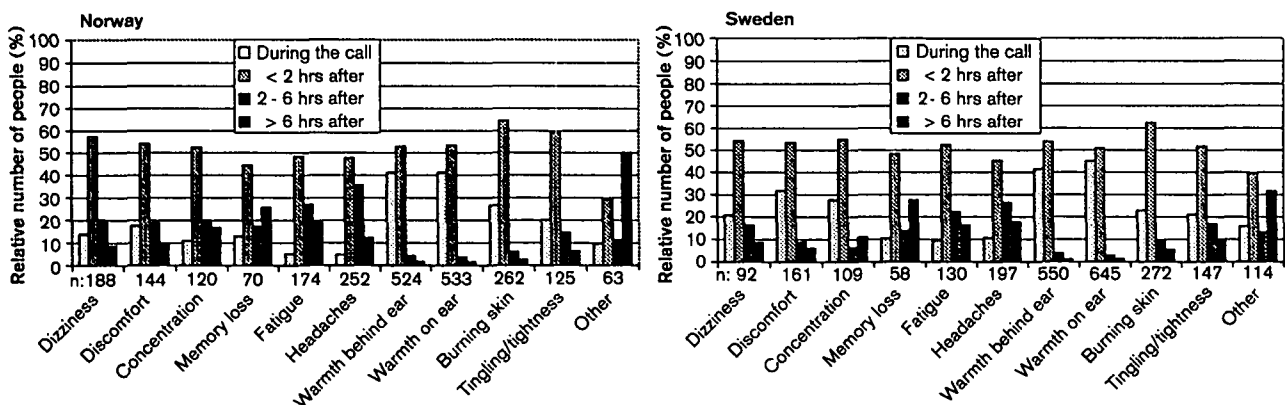


Figure 2. Distribution of people with respect to how long the symptom usually continued in connection with a call from a mobile phone (MP). Only respondents with an MP-attributed symptom who had answered the actual question are included. For each symptom, the total number of people (n) is shown below the bars.



About 1% of the respondents in both Norway and Sweden had experienced sensations of warmth on the ear or behind/around the ear in connection with the use of an ordinary phone. Any of the other symptoms had been experienced by less than 0.7% in both countries.

The percentage of people working with a VDT who had experienced the various symptoms in connection with VDT work (and not MP use), with MP use (and not VDT work), and with both of these devices is shown in Table 4. The number of people who attributed a symptom to both MP use and VDT work was relatively low compared to the number of people who attributed this symptom to either MP or VDT. Statistical analyses, however, show a statistical significant dependence between attributing a symptom to MP use and attributing the same symptom to VDT work. The only exceptions were for sensations of warmth on the ear and behind or around the ear among the Norwegian respondents.

Table 3. Occurrence of symptoms in connection with the use of at least one MP, and the number of respondents (*n*) in Norway and Sweden, respectively

Symptom	Norway (<i>n</i> =2828)		Sweden (<i>n</i> =7803)	
	Count	Percent	Count	Percent
Dizziness	228	8.1	86	1.1
Discomfort	138	4.9	173	2.2
Concentration	127	4.5	110	1.4
Memory loss	79	2.8	45	0.6
Fatigue	218	7.7	129	1.7
Headaches	308	11	197	2.5
Warmth behind ear	620	22	598	7.7
Warmth on ear	663	23	677	8.7
Burning skin	301	11	250	3.2
Tingling/tightness	145	5.1	131	1.7
Other	78	2.8	136	1.7

Table 4. Percentage of people who had experienced the symptom in connection with the use of a mobile phone (MP), in connection with VDT work (VDT), in connection with both MP use and VDT work (Both), and the significance probability (*P*) for a dependence between a symptom in connection with an MP and the same symptom in connection with VDT work for respondents (*n*) working with a VDT in Norway and Sweden, respectively

Symptom	Norway (<i>n</i> =2257)				Sweden (<i>n</i> =6188)			
	MP	VDT	Both	<i>P</i>	MP	VDT	Both	<i>P</i>
Dizziness	5.8	3.0	1.2	<0.001	0.8	1.2	0.2	<0.001
Discomfort	3.5	1.9	0.8	<0.001	1.9	1.0	0.4	<0.001
Concentration	3.4	3.6	0.8	<0.001	1.0	2.1	0.4	<0.001
Memory loss	2.4	0.6	0.3	<0.001	0.4	0.5	0.2	<0.001
Fatigue	5.0	5.8	2.2	<0.001	1.0	4.3	0.6	<0.001
Headaches	8.0	6.6	2.6	<0.001	2.0	5.4	0.6	<0.001
Warmth behind ear	22	0.1	0.1	0.095	8.0	0.3	0.1	0.002
Warmth on ear	24	0.2	0.2	0.080	9.2	0.4	0.2	<0.001
Burning skin	10	1.1	0.7	<0.001	2.8	4.7	0.6	<0.001
Tingling/tightness	4.3	1.9	0.6	<0.001	1.3	3.4	0.5	<0.001
Other	2.4	1.7	0.4	<0.001	1.4	1.7	0.3	<0.001

Medical consultations and sick leave

Among all respondents, 1.6% in Norway and 0.5% in Sweden had consulted a physician because of symptoms attributed to an MP. Among those who had experienced at least one MP-attributed symptom, these figures were 4.1% in Norway and 3.7% in Sweden. The corresponding numbers for sick leave were 1.1% in Norway and 0.13% in Sweden among all respondents, and 2.4% in Norway and 1.0% in Sweden among those who had an MP attributed symptom. People who had experienced at least one symptom other than warmth sensations (or in addition to warmth sensations) accounted for almost all of the medical consultations and cases of sick leave.

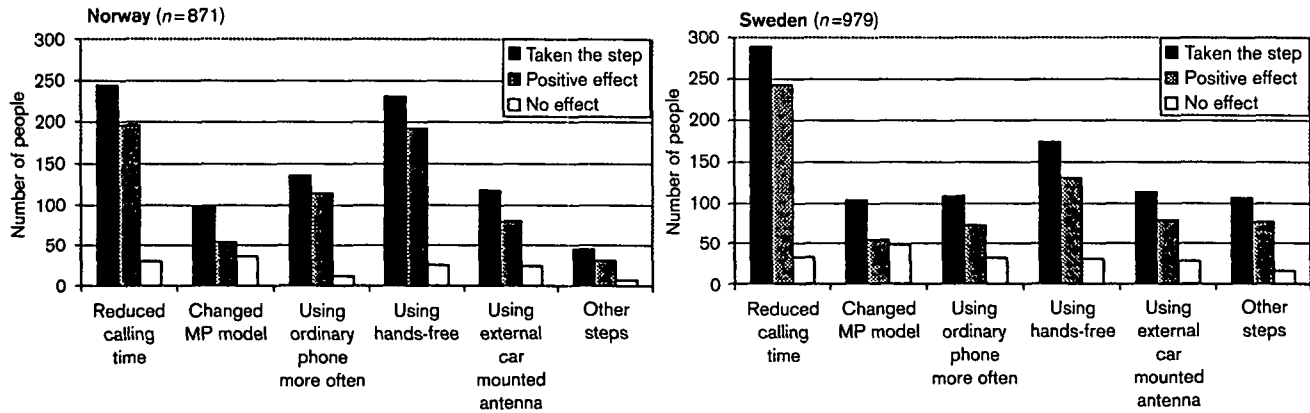
Conditions under which the symptoms were experienced

When people with an MP attributed symptom were asked about conditions under which the MP attributed symptoms occurred, 66% in Norway and 71% in Sweden indicated long duration phone calls. In Norway, 48–78% (depending on the symptom) indicated that the phone call had to be 5 min or longer to provoke the symptoms. The corresponding figures in Sweden were 38–68%. In both countries, about 16% suggested stress conditions, and about 10% suggested conditions with difficulties in hearing to be associated with the occurrence of the MP attributed symptoms.

Steps taken to reduce the symptoms

Among people with symptoms attributed to MP use, about 45% in both Norway and Sweden had taken steps to reduce the symptoms. The most common step in both countries was reducing calling time, and next came using hands-free equipment. Within the category 'other steps', changing the side at which the MP was held was most often specified, both in Norway and in Sweden. Most of the people experienced that the reported step led to a reduction of the symptoms (Figure 3).

Figure 3. Number of people who had taken steps to reduce symptoms attributed to mobile phone (MP) use (taken the step); number of people who had experienced a reduction of the symptom after having taken steps (positive effect); and the number of people who did not experience any reduction of the symptom after having taken steps (no effect). The number of people (n) with at least one MP-attributed symptom is given for Norway and Sweden, respectively.



Exposure variables versus symptom occurrence, measures, medical consultations, and sick leave

A potential health effect of MP use might be reflected in medical consultations, sick leave, and measures taken to reduce the symptoms, as well as in symptoms attributed to MP use and in the prevalence of symptoms in general. We were interested to see whether the relation between each of these end point variables and a given exposure factor (transmitter system, calling time, and number of calls per day) were consistent or not. Table 5 shows that all end point variables (except steps taken and medical consultations in Sweden) were reported more by people using an NMT MP than by those using a GSM MP. This difference was statistically significant in both countries for symptoms experienced in general, in Sweden for MP attributed symptoms, and in Norway for steps taken to reduce symptoms.

People using their MP frequently reported all the end points more often than people using the MP rarely. When comparing any two categories of number of calls per day, the difference was statistically significant for all comparisons in both countries for symptoms in general and for symptoms attributed to MPs, with one exception: the difference in Sweden between ‘less than two calls per day’ and ‘two to four calls per day’ for symptoms in general. In Norway statistically significant differences between any two categories were also obtained for steps taken to reduce symptoms. Similar results were obtained for the total calling time per day. Here the only exception from statistical significance for the mentioned end point variables was found in Norway when comparing ‘less than 2 min/day’ and ‘2–15 min/day’ for steps taken to reduce symptoms. Significance probabilities for trends between the end point variables and number of calls and calling time, respectively, are given in Table 5.

When performing the same analyses by excluding people having experienced only the warmth sensation on the ear or behind/around the ear, similar results as those presented in Table 5 were obtained.

Non-respondent analysis

The non-respondent analysis suggested that the number of non-respondents who did not receive a questionnaire was relatively high: 21% in Norway and 43% in Sweden. The number of non-respondents who had experienced any symptom in connection with MP calls was 15% in Sweden, and 17% in Norway. Potential risk factors (transmitter system, gender, geographical location and trade) were almost equally distributed for respondents and non-respondents in the Norwegian material. See Oftedal *et al.*⁵ for further details.

DISCUSSION

A relatively high number of respondents in the present study reported that they had experienced symptoms in connection with MP use. This is also the case for symptoms other than the sensations of warmth on the ear and behind or around the ear. The fact that people experience a symptom, or become aware of a symptom during or shortly after a phone call, does not necessarily imply a causal relation between the use of the MP and the symptom. In particular, it is uncertain whether symptoms that began later than 2 h after the call were a result of MP use.

The great difference in the percentage of people with an MP attributed symptom in Norway and Sweden may partly be due to a response bias in the Norwegian data. In Norway, fewer non-respondents than respondents had experienced any MP attributed symptom. This was not the case in the Swedish data. Other reasons for the observed difference in reported symptoms, may be differences between the groups of respondents with respect to age and the use of the MP. The Norwegian respondents were in general younger, used their MP more often and had longer calling times than the Swedish respondents, and young people and people using the MP the most are suggested by the data in Table 2 to have a relatively high risk for MP attributed symptoms. Furthermore, differences between the Norwegian and

Table 5. Percentage of people with any symptom occurring at least a week (symptom in general), with at least one mobile phone (MP) attributed symptom, who had taken steps to reduce an MP attributed symptom, who had consulted a physician because of an MP attributed symptom, and been on sick leave because of an MP attributed symptom, for people within different categories of A: transmitter systems; B: numbers of calls per day; and C: calling time per day.

A: Groups with different categories of transmitter system. The statistical significance probability (*P* value) for a difference between the various categories is given

	Norway				Sweden			
	Transmitter system			<i>P</i> value	Transmitter system			<i>P</i> value
	NMT	GSM	Mixed		NMT	GSM	Mixed	
Number of people	876	996	956		1902	2618	3283	
Symptom in general (%)	49*	43	50	<0.001	30*	26	33	<0.001
MP-related symptom (%)	31	27	35	<0.001	13*	9.9	14	<0.001
Steps to reduce the symptoms (%)	20*	14	23	<0.001	4.7	4.9	6.4	0.26
Medical consultations (%)	1.9	1.1	2.0	0.016	0.26	0.46	0.58	0.16
Sick leave (%)	1.0	0.75	1.7	0.024	0.16	0.08	0.15	0.69

*Statistically significant difference ($P < 0.05$) between NMT users and GSM users.

B: Groups with different categories of number of calls per day. The statistical significance probability (*P* value) for a linear trend is given

	Norway				Sweden			
	Number of calls per day			<i>P</i> value	Number of calls per day			<i>P</i> value
	<2	2–4	>4		<2	2–4	>4	
Number of people	265	742	1810		1187	2348	4208	
Symptom in general (%)	24	39	54	<0.001	21	24	36	<0.001
MP-related symptom (%)	12	24	37	<0.001	5.7	8.9	17	<0.001
Steps to reduce the symptoms (%)	7.1	13	24	<0.001	2.2	3.6	7.5	0.10
Medical consultations (%)	0.39	0.86	2.2	0.005	0.25	0.13	0.71	0.23
Sick leave (%)	0.00	0.57	1.6	0.007	0.08	0.13	0.14	0.46

C: Groups with different categories of calling time per day. The statistical significance probability (*P* value) for a linear trend is given

	Norway					Sweden				
	Calling time (min/day)				<i>P</i> value	Calling time (min/day)				<i>P</i> value
	<2	2–15	15–60	>60		<2	2–15	15–60	>60	
Number of people	148	1101	1134	433		813	3504	2677	746	
Symptom in general (%)	26	38	53	65	<0.001	21	25	35	47	<0.001
MP-related symptom (%)	10	22	35	50	<0.001	4.1	9.1	16	26	<0.001
Steps to reduce the symptoms (%)	8.4	13	22	33	<0.001	1.7	3.8	6.7	13	0.004
Medical consultations (%)	1.4	0.67	1.9	3.8	<0.001	0.25	0.23	0.56	1.5	0.07
Sick leave (%)	0.70	0.67	1.2	2.3	0.014	0.12	0.11	0.07	0.40	0.93

Swedish language may have influenced the results even though efforts were made to formulate the questionnaires so that the meaning of the questions would be identical. Some cultural differences as well as differences in the social and economic situation might have caused more people in Norway than in Sweden to report about MP attributed symptoms. We also speculated whether there had been more public concern in Norway than in Sweden about possible health effects caused by the radio frequency electromagnetic fields from the MPs.⁶ Skin

symptoms associated with electromagnetic fields from VDTs have been more focused upon in Sweden than in Norway. Accordingly, we observed more facial skin symptoms attributed to VDT work among the Swedish respondents than among the Norwegian respondents.

Despite the difference in the occurrence of symptoms between Norway and Sweden, similar results for the two countries were obtained with respect to the description of symptoms and with respect to the statistical relations between symptoms and various exposure variables.

Besides the similarity between the two countries revealed in Table 5, it is interesting to observe the consistency between the various endpoint variables: symptoms experienced in general, symptoms attributed to an MP, steps taken to reduce the symptom, medical consultations, and sick leave. The results for calling time (Table 5, part C) are also consistent with the observation that the majority of the respondents with a symptom, reported the symptom to occur in connection with long duration calls, and that most of the people who reduced the calling time to reduce the symptom, experienced a positive effect of the measure, although the experience of symptom reduction may at least partly be due to a placebo effect.

The sensations of warmth on the ear and behind or around the ear, which were the most frequently registered MP related symptoms, almost always occurred only during the phone call and also on the same side of the head as the phone was used. We have reported a statistical relation between the prevalence of some of the symptoms and the calling time/number of calls per day, and this relation was particularly pronounced for the sensations of warmth.² Törnevik *et al.*⁷ measured the temperature of some MPs. The maximal temperature increase of free phones was between 15 and 19°C and was located in the area of the ear piece. The skin temperature at the spot with maximal temperature increase was found to be between 37 and 41°C for NMT phones and between 36 and 39°C for GSM phones. These findings, together with our results, may indicate a causal relation between the use of an MP and the warmth sensations.

Most of the respondents reported the neurasthenic symptoms and the facial skin symptoms to begin during or shortly after the phone call. This is in accordance with Hocking's results.¹ He interviewed 40 people with unpleasant sensations such as burning feelings or headaches and found that the symptoms often began minutes after the beginning of the call. His indications of the duration of the symptoms are also similar to our findings. Hocking stated that the symptoms usually ceased within an hour, but the symptoms could last till evening. Thus, for some people symptoms other than the sensations of warmth also appear to coincide in time with the use of the MP, and headaches and the facial skin symptoms occurred either ipsilaterally or bilaterally relative to the side of the MP. Since these results may be influenced by a recall bias, they do not give a sufficient evidence for a causal relation between MP use and the symptoms. However, some factors have been suggested to explain a possible link between MP use and neurasthenic symptoms like headaches. Frey⁸ has pointed out the potential role of radio frequency field, and he suggests that headaches might be explained by an increased permeability of the blood-brain barrier and/or by an influence on the dopamine-opiate system. Other possible explanations might be muscle strain by holding the phone, stress caused by frequent interruptions by phone calls or by difficulties in hearing or being heard.²

The fact that nearly half of the respondents with an MP attributed symptom had taken steps to reduce the

symptom, suggests that relatively many were conscious of the symptom before they received the questionnaire. Taking measures to reduce the symptom may also indicate that the symptom was experienced as unpleasant. On the other hand, only about 4% of those with an MP-attributed symptom had consulted a physician because of that symptom. This might suggest that the symptoms were not experienced as a serious health problem. Alternatively, respondents with a symptom did not consult a physician because they took appropriate steps to reduce the symptoms as indicated by the relative high percentage of people who experienced an improvement after the step.

In both countries people who reported a symptom in connection with MP use were more likely to have the same symptom in connection with VDT work and vice versa compared to people without the symptom attributed to MP/VDT use. However, a symptom was most often attributed to only one of these devices rather than to both, suggesting that symptoms experienced in connection with MP use and symptoms experienced in connection with VDT work are usually not related.

Hocking's observations¹ included both people using an MP in connection with the job and private subscribers, suggesting that MP-attributed symptoms may occur among both groups of MP users. Our study included only people using an MP in connection with their job, and this group may deviate from private MP users with respect to the use of the MP and other factors which might influence the symptoms. Accordingly, the results in this study can not be generalized to all MP users.

CONCLUSIONS

Relatively more Norwegian than Swedish respondents had experienced symptoms in connection with the use of an MP. Otherwise there was no major difference between Norwegian and Swedish with respect to the symptom data. Next to the sensations of warmth on the ear or behind/around the ear, burning sensations in the facial skin and headaches were most commonly experienced in connection with MP use.

The warmth sensations were predominately experienced during the MP call. Other symptoms, like headaches, most often began during or within half an hour after the call and usually lasted for up to 2 h.

Although relatively many of the respondents reported MP-attributed symptoms, relatively few had consulted a physician or been on sick leave because of the symptoms. An awareness of the symptoms is suggested by the fact that nearly half of the respondents with an MP-attributed symptom had taken steps to reduce the symptom. Most commonly, they had reduced the calling time or started using hands-free equipment. Most people experienced a reduction of the symptom as a result of the reported steps. Various results are consistent with the observation that the symptoms were experienced predominantly in connection with long duration calls.

The relatively high number of people reporting the symptoms, as well as other results obtained in this

investigation, motivate the study of the reason behind the symptoms attributed to the MP.

ACKNOWLEDGEMENTS

This study was performed with the help of an international reference group who gave us guidance and advice throughout the course of the study. The group members were: Prof. Bengt Arnetz, Stockholm, Sweden; Dr George Carlo, Washington, USA; Dr Nancy Dreyer, Boston, USA; Prof. Trevor Hughes, Oxford, UK; Dr Maila Hietanen, Helsinki, Finland; Ass. Prof. Jonas Höög, Umeå, Sweden; Dr Gregory Lotz, Cincinnati, USA; Dr Mike Repacholi, Geneva, Switzerland; Dr Berndt Stenberg, Umeå, Sweden. The members were appointed by The Swedish Mobil Telecommunications Association (MTB) and the Swedish National Institute of Working Life. We also used a Norwegian reference group, who were suggested by SINTEF Unimed and approved by the Norwegian financial supporters. This group had the following members: Dr Svein Bjerneby, Oslo, Norway and Dr Fritz Bekkadal, Trondheim, Norway. The work of the reference groups is greatly appreciated. We would also like to address our gratitude to Dr Tore Tynes, Bjarte Haugsdal and Egil Hauger, who have contributed especially to the design of the study. We would also like to express our special thanks to Mr Arvid Brandberg, CEO of the Swedish MTB, for all the help we received for the completion of this study. We thank Telia and Telenor for providing us with their subscription registers. Finally we thank MTB; The Work Environment Fund of the Confederation of Norwegian Business and Industry; Telenor; and The Norwegian Post and Telecommunication Authority for financial support for the study.

REFERENCES

1. Hocking B. Preliminary report: Symptoms associated with mobile phone use. *Occup Med* 1998; **48(6)**: 357–360.
2. Mild KH, Oftedal G, Sandström M, Wilén J. Comparison of symptoms experienced by users of analogue and digital mobile phones. 1999; submitted.
3. Andersen B, Johansen C, Pedersen GF, Raskmark P. *On the Possible Health Effects Related to GSM and DECT Transmission. A Tutorial Study*. Center for Personkommunikasjon, Aalborg University, Aalborg 1995.
4. AMSYK. *Arbetsmarknadsstyrelsens yrkesklassificering. Arbetsmarknadsstyrelsen*. AMS Förlagsservice, Gnesta 1997 (in Swedish).
5. Oftedal G, Mild KH, Sandström M, Wilén J. *Comparison of Symptoms Experienced by Users of Analogue and Digital Mobile Phones: a Swedish Norwegian Epidemiological Study*. Trondheim: The Foundation of Scientific and Industrial Research at the Norwegian University of Science and Technology (SINTEF), 1998. SINTEF-report no STF78 A98134, ISBN 82-14-00937-5.
6. Sandström M, Oftedal G, Mild KH, Wilén J. A profile of mobile phone users in Norway and Sweden. 1999; submitted.
7. Törnevik C, Santomaa V, Balzano Q. Evaluation of the temperature increase at the ear of cell phone users. In: Abstracts of the The Bioelectromagnetic Society Annual Meeting, 7–11 June 1998. St Pete Beach, Florida 1998; 108–109.
8. Frey A. Headaches from cellular telephones: are they real and what are the implications? *Environ Health Perspect* 1998; **106(3)**: 101–103.