

Comparison of symptoms experienced by users of analogue and digital mobilephones: a Swedish-Norwegian epidemiological study.

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Summary

In 1995 many people reported subjective disorders experienced while using mobile phones. Among the symptoms were headaches, feelings of discomfort, warmth behind/around or on the ear, and difficulties concentrating. The number of complaints from users of MP's was larger for GSM users, i.e. with pulse modulated fields. In the scientific literature there is a tendency for lower thresholds for biological effects from exposure to modulated fields. Our main hypothesis was that GSM users experience more symptoms than NMT users. A cross-sectional epidemiological investigation was initiated including 6379 GSM users and 5613 NMT users in Sweden, and 2500 from each category in Norway. The people were randomly selected from subscription registers where a company was the subscriber, but an individual was assigned to the phone. Questionnaires were used to register exposure factors, symptoms (both in general and symptoms related to the use of the mobile phone), and possible confounding factors such as gender, age, VDT work and psychosocial factors for which the calculated odds ratios were adjusted. The estimated adjusted response rates were 64% for Norway and 76% for Sweden. The response rates were almost equal for the GSM subscribers and NMT subscribers. For those with no symptoms the prevalence was significantly higher for GSM users than for NMT users. Our hypothesis was therefore falsified. However, we observed a statistically significant lower risk for warmth sensations on, behind or around the ear for GSM users compared with NMT users. The same trend was seen in the Swedish data for headaches and fatigue. Factors distinguishing the two systems (radio frequency emission, the temperature of the phones, and various ergonomic factors) may be responsible for these results, as well as for the side finding: 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.

Background

During 1995 many people with complaints of symptoms experienced while using the mobile phone (MP), contacted manufacturers, net operators and researchers working with electromagnetic fields. The symptoms reported were for example headaches, feeling of discomfort, warmth behind/around and on the ear, and difficulties to concentrate.

Present knowledge of health effects caused by low level microwave radiation is limited. Symptoms have previously been described in connection with exposure to low level radio frequency fields or microwaves, but no studies linking the effect to the exposure has been published.

It was thought of interest to start an epidemiological study to find out more about the prevalence of the symptoms and if there was any connection to the use of MPs and if so to a particular transmitter system, i.e NMT or GSM.

In the scientific literature of biological effects of weak microwaves there is a tendency for lower thresholds of reported biological effects from exposure to modulated fields. The number of complaints from users of MPs was larger for GSM users, i.e. with pulse modulated fields. Our main hypothesis was there for that GSM users experience more symptoms than NMT users. Two groups of users, one of each of the different system, were identified, NMT 900 and GSM.

Materials and methods

The study population was people with a mobile phone where a company was the subscriber, but an individual was assigned to the phone. In both countries we used the register of the net operators supporting services for both NMT and GSM. The final mailing lists consisted of 6379 GSM and 5613 NMT users in Sweden, and in Norway the corresponding figures were 2500 for each category.

Questionnaire

To be able to include the best description of symptoms we randomly selected 10 people from those who had called us individually, and asked them to participate in a medical interview. These interviews were done in spring 1996. Based on these interviews and knowledge from the literature of low level RF effects and our own experience from earlier questionnaire studies of similar phenomena among video display terminal (VDT) users we formulated questions about symptoms.

Questions about exposure factors included requests about transmitter system, makes and model, calling time and number of calls per day. Possible confounding factors registered were gender, age, occupation, geographical location, psychosocial factors, and VDT work. The questionnaire was divided into two parts; the first to be filled in by all participants, the second was to be used by those who experienced symptoms and complaints connected to the use of an MP or an ordinary phone. In addition we wanted information about how swift symptoms developed, how long they lasted, and conditions under which the symptoms typically occurred etc.

In the main, the results from the first part of the questionnaire are reported here.

Each questionnaire was type-set for optical reading and markings were read by computer. Handwritten information and comments filled in by the participants were manually typed.

To estimate the psychosocial work load an index was created. It was based on the four commonly used questions, and obtained by summing the “score” of each of them.

Many people in our study had more than one MP. The most commonly occurring combination was one NMT 900 and one GSM phone. For each person we added the calling time for all MPs and the number of calls for all MPs respectively .

Odds ratios (OR) were used as a measure of the different risk factors and the outcome variables. The OR is an estimation of the relative risk of having a symptom. A result was considered to be statistically significant when the result was within the 95% confidence interval.

Results

The adjusted response rate to the questionnaire was 64% for Norway and 76% for Sweden. The response rates were almost equal for the GSM and NMT subscribers.

The respondents also evaluated their state of health. The relative number of respondents who indicated that their state of health was good was higher among the Norwegian respondents (83%) than among the Swedish respondents (71%). There were only small differences in the state of health between GSM users and NMT users.

An individual was defined as having a symptom if he/she had marked that the symptom occurred at least once a week. The results suggest that both individual factors as well as all work related factors might influence the prevalence of some symptoms. For instance factors such as age, gender, psychosocial work load, occupation, and amount of VDT work are important for the prevalence of most of the symptoms. Also the exposure factors *calling time* and *number of calls per day* are of importance for the prevalence of symptoms. In the analysis of the effect of transmitter system and other exposure factors we therefore adjusted for these variables.

In general, there is a higher prevalence of symptoms among the Norwegian respondents as compared to the Swedish respondents. Fatigue seems to be a more dominating symptom in Sweden while feeling of warmth on/behind ear is more dominating in Norway. In Norway, 3% and in Sweden 5% of the respondents reported “other symptoms” and here eye, ear and neck problems were dominating. In Sweden, also facial skin complaints were rather common.

We analysed whether people that reported sensation of warmth on the ear and behind the ear experienced other symptoms more often than did people without the warmth sensation experience. The risk for having a nervous system symptom was about two to four times higher among those who had reported sensation of warmth on or behind the ear compared with those who did not report any of these symptoms. One exception was the facial skin symptom tingling/tightness for which this relative risk was about 5 to 8 times higher. People reporting one of the two warmth sensation

symptoms had 10 to 20 times higher risk of also having the other warmth sensation symptom and the sensation of burning skin.

Symptoms versus exposure factors

Our main hypothesis was that the users of GSM phones experienced more symptoms than NMT users. For most symptoms there were no statistically significant differences between the different transmitter systems with regard to the prevalence of symptoms. Our hypothesis is therefore falsified. However, both in Norway and in Sweden the study indicated a statistically significant lower risk for warmth sensation on and behind ear for GSM users compared to NMT users. The same trend was also seen in the Swedish data for headache. See table 1.

The effect of transmitter system and *number of calls* or *calling time per day* was analysed by using the category with the lowest number of calls/the shortest calling time irrespectively of the transmitter system reference category. An increased risk was observed for most symptoms for groups with longer calling times and higher number of calls per day. The effect was particularly pronounced for the warmth sensation variables. Among the nervous system symptoms the most pronounced effects were seen for headache and fatigue, see further table 2.

Symptoms experienced in connection with mobile phone calls

In Sweden 13% and in Norway 30% of the respondents had experienced at least one symptom in connection with MP calls.

In addition to asking for symptoms experienced in connection with MP use, we asked whether symptoms occurred or were aggravated in connection with the use of ordinary phone and VDT. More people attributed their symptoms to MP use than to the use of ordinary phone. According to paired sign tests the differences were statistically significant ($p < 0.001$) for all symptoms.

Discussion

The hypothesis originally postulated, that GSM users had a higher prevalence of symptoms than NMT users, was falsified by the study. In fact, for some symptoms the result came out opposite to the hypothesis, i.e. GSM users experienced less problems than the NMT users for the phenomena of warmth sensations on the ear and behind/around the ear. As a side finding, we also observed pronounced positive trends with respect to both *calling time* and *number of calls* per day for the warmth variables and for some of the nervous system symptoms. Several factors, emission as well as design, and other factors related to the use of mobile phones might have been responsible for the differences seen between the NMT users and the GSM users and for the increased prevalence of symptoms with increasing *Calling time/Number of calls*. The role of the different factors such as radio frequency radiation, heated phones as well as the possible influence of methodological defectiveness and problems are open for discussion.

The radio frequency output power is lower for the GSM phones than for the NMT 900 phones, and the temperature increase of NMT phones due to the heating from the

current drawn from the battery is usually more pronounced than of GSM phones. In addition to factors related to electromagnetic fields, factors such as audio quality, size and shape also differ between GSM and NMT phones. In the analogue system (NMT phones), the speech may be partly masked by noise, and this is most prominent when the connection with the base station is poor. On the other hand, the audio quality of the digital system might be reduced by interruptions of silent periods. When the connection with the base station is too poor, it closes completely. All these audio disturbances may cause stress and might thereby indirectly be a source of nervous system symptoms such as headache and fatigue.

Factors that might be important for the observed difference between GSM users and NMT 900 users are also actual candidates for explaining the increase in prevalence for warmth sensation and several of the listed nervous system symptoms with increasing *calling time* and *number of calls*. We found about the same tendencies for GSM users as for NMT users. Because the output power as well as the phone heat are lower from GSM phones than from NMT phones, for GSM users the influence of factors such as modulation and low frequency magnetic fields can not be excluded.

Among the various potential methodological reasons for the observed results, bias might to a certain extent be responsible for the correlation between symptom occurrence and *number of calls/calling time*. Furthermore there might be confounding factors that have not been identified and taken into account. We observe that the effect of *number of calls* and *calling time* is more marked for warmth sensation than for the various nervous system symptoms, furthermore, there is a good correlation between the occurrence of warmth sensation and each of the symptoms headache and fatigue, suggesting that these symptoms may be related to the sensation of warmth.

Conclusions

The hypothesis originally postulated, that GSM users had a higher prevalence of symptoms than NMT users, was falsified by the study. In fact, GSM users reported warmth sensation on the ear and behind or around the ear less frequently than NMT users. Based on these results we can not deduce the role of radio frequency emission, temperature of the phones or other physical differences between GSM and NMT phones.

Demonstrable statistical association between both *calling time* and *number of calls* per day and the occurrence of warmth sensation as well as headache and fatigue were found among NMT and GSM users in both countries. Whether this association also demonstrates a causal relationship between MP use and the genesis of the different symptoms can not be determined. The findings, however, give rise to the hypothesis that the *calling time* and *number of calls* are associated with the sensation of warmth and some nervous system symptoms. Further studies are required to test this hypothesis and to explore the role of the various physical factors in genesis of the observed symptoms.

Table 1. Adjusted OR and in brackets 95% confidence interval for different symptoms with respect to transmitter system. Reference category is “NMT 900”.

| | OR (95% C.I.) | |
|-------------------|-------------------------|-------------------------|
| | Norway | Sweden |
| Fatigue | 1.07 (0.83-1.37) | 0.85 (0.70-1.03) |
| Headache | 0.94 (0.71-1.24) | 0.78 (0.63-0.97) |
| Warmth behind ear | 0.71 (0.56-0.91) | 0.74 (0.55-0.99) |
| Warmth on ear | 0.71 (0.56-0.90) | 0.56 (0.43-0.73) |
| Burning skin | 0.83 (0.60-1.15) | 0.99 (0.72-1.36) |

Table 2. Adjusted ORs and in brackets 95% confidence intervals for calling time. Reference category is calling time less than 2 min/day. A: Norway, B: Sweden.

A: Norway

| Symptoms | OR (95% C.I.) | | | | | |
|-------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| | NMT | | | GSM | | |
| | 2-15 min/d | 15-60 min/d | > 60 min/d | 2-15 min/d | 15-60 min/d | > 60 min/d |
| Fatigue | 1.14 (0.64-2.02) | 1.59 (0.89-2.81) | 2.47 (1.16-5.24) | 1.10 (0.63-1.92) | 1.55 (0.88-2.74) | 4.14 (1.86-9.22) |
| Headache | 1.81 (0.82-3.98) | 3.31 (1.53-7.18) | 6.36 (2.57-15.8) | 1.94 (0.90-4.20) | 2.69 (1.24-5.88) | 6.31 (2.35-17.0) |
| Warmth behind ear | 2.42 (1.20-4.89) | 4.29 (2.13-8.62) | 18.1 (7.83-41.8) | 1.68 (0.83-3.40) | 2.93 (1.45-5.92) | 16.0 (6.34-40.4) |
| Warmth on ear | 2.65 (1.35-5.18) | 5.30 (2.72-10.3) | 12.4 (5.52-27.8) | 1.65 (0.84-3.24) | 3.94 (2.02-7.71) | 8.37 (3.41-20.6) |
| Burning skin | 1.44 (0.53-3.94) | 4.29 (1.65-11.1) | 11.8 (4.14-33.6) | 1.56 (0.59-4.13) | 3.48 (1.33-9.07) | 8.42 (2.70-26.2) |

In bold p<0.05

B: Sweden

| Symptoms | OR (95% C.I.) | | | | | |
|-------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|-----------------------------------|
| | 2-15 min/d | NMT | | 2-15 min/d | GSM | |
| | | 15-60 min/d | > 60 min/d | | 15-60 min/d | > 60 min/d |
| Fatigue | 1.33 (0.94-1.89) | 2.26 (1.54-3.32) | 2.32 (1.06-5.07) | 1.25 (0.89-1.75) | 1.80 (1.25-2.59) | 1.40 (0.65-3.00) |
| Headache | 1.81 (1.22-2.69) | 3.24 (2.12-4.95) | 3.40 (1.43-8.12) | 1.49 (1.02-2.19) | 2.50 (1.66-3.75) | 2.83 (1.37-5.85) |
| Warmth behind ear | 4.28 (1.90-9.64) | 10.7 (4.74-24.1) | 30.3 (11.2-81.8) | 2.63 (1.16-5.98) | 9.00 (4.05-20.0) | 21.9 (8.46-56.7) |
| Warmth on ear | 6.18 (2.92-13.1) | 15.3 (7.19-32.5) | 47.8 (18.9-121) | 2.73 (1.26-5.91) | 10.2 (4.81-21.5) | 22.4 (9.10-55.0) |
| Burning skin | 1.05 (0.61-1.81) | 2.12 (1.20-3.74) | 4.17 (1.59-11.0) | 1.06 (0.64-1.77) | 2.34 (1.40-3.92) | 2.77 (1.13-6.75) |

In bold p<0.05