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# Correlation between cellular phone use and epithelial parotid gland malignancies

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*Y. Duan, H. Z. Zhang, R. F. Bu: Correlation between cellular phone use and epithelial parotid gland malignancies. Int. J. Oral Maxillofac. Surg. 2011; xxx: xxx–xxx.* 

*Abstract.* The authors investigated the association between cellular phone use and epithelial parotid gland malignancy. The subjects were 136 cases who were treated for this condition at the authors' hospital from January 1993 to March 2010, and 2051 controls who did not have salivary gland tumours and were admitted to the oral and maxillofacial surgery department during the same period. Logistic analysis was used to examine the relationship between cellular phone use and risk of epithelial parotid gland malignancy and mucoepidermoid carcinoma. Overall, the frequency of cellular phone use was not significantly associated with epithelial parotid gland malignancy. Female gender, advanced age, married status, high income, and smoking were associated with an elevated risk of epithelial parotid gland malignancy, especially mucoepidermoid carcinoma. Residence in a rural area was associated with reduced risk of epithelial parotid gland malignancy. The results suggest a possible dose–response relationship of cellular phone use with epithelial parotid gland malignancy. The authors suggest that the association of cellular phone use and epithelial parotid gland malignancy and mucoepidermoid carcinoma requires further investigation with large prospective studies.

Keywords: epithelial parotid gland malignancies; case–control study; cellular phone use.

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Cellular phones are an important type of wireless communication that meet the needs of fast-paced modern societies, accommodate increasingly mobile populations, and are the most convenient and efficient communication tool for work and social life. Based on data from the International Telecommunication Union[11], there were 4.6 billion global subscriptions for cellular phones at the end of 2009, and more than 67% of people world-wide are cellular phone subscribers. Cellular phone subscriptions in China have increased dramatically since 2000. According to the Ministry of Industry and Information Technology of the People's Republic of China[16], there were 747 million Chinese cellular phone subscribers by the end of 2009, corresponding to an average of 56.3 cellular phone subscribers per 100 inhabitants. China has the largest number of cellular phone subscribers world-wide.

As the prevalence of cellular phone use has increased[4], there have been concerns about the potential carcinogenic effects of exposure to the electromagnetic fields (EMFs) that are emitted by cellular phones. Numerous epidemiological studies have examined the association of cellular phone use and risk of cancer, and most of these have focused on intracranial tumours such as meningioma, glioma, acoustic neuroma, and pituitary tumour[1–3,5–9,12–15,19–21,23]. The INTERPHONE project[10,22], a series of epidemiological studies supported by the European Union in which all 13 participating countries followed the same study design[10], examined the relationship of exposure to

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radiofrequency fields from cellular phones and tumour risk. In addition, there were four published studies that examined the association of cellular phone use and parotid gland tumours[2,8,14,17]. Given the small number of cases studied, the use of different experimental designs, and the presence of bias, the association of cellular phone use and parotid gland tumours remains controversial.

In the present study, the authors used a retrospective case–control design to investigate the effect of cellular phone use on the risk of epithelial parotid gland malignancy, especially mucoepidermoid carcinoma of the parotid gland. This study provides an important complement to the previously published epidemiological studies of the health effects of cellular phones[1–3,6–9,12–15,17,20,21,23].

## Materials and methods

In this hospital-based case–control study, all cases had histologically or cytologically confirmed epithelial parotid gland malignancies and underwent oral maxillofacial (OMF) surgery in the authors' department from January 1993 to March 2010. All diagnoses were validated by a single surgeon. Histological typing of epithelial salivary gland tumours was based on the 1991 WHO guidelines[22].

Controls were individuals who did not have salivary gland tumours but who were treated during the same period as the eligible cases. This group included patients with impacted teeth, maxillofacial trauma, infections, temporomandibular joint disorders, maxillofacial nerve disorders, non-cancerous potentially oral and maxillofacial tumours (without salivary gland tumour involvement), salivary gland infections, congenital cleft lips and palates, or maxillofacial deformities. Patients with OMF malignancies and those with potentially cancerous tumours (including cysts and tumour-like lesions) were excluded from the control group. This included 11 cases with OMF malignancies, six cases with odontogenic keratocysts, two cases with pigmented nevi, one case with odontogenic myxoma, one case with giant cell tumour of the mandible, and one case with osteoclastoma. The authors considered the non-cancerous potentiality of OMF benign tumours in the pilot study for this research. As far as the authors know, there is no positive correlation between cellular phone use and the development of non-cancerous (benign) OMF tumours.

Data were obtained by case registration, and personal or telephone interviews and included patient identification, gender, date of birth, age at initial diagnosis, tumour location, pathological diagnosis, place of residence, marital status, educational background, monthly income, smoking status, and cellular phone exposure data.

Cellular phone use was considered a proxy for exposure dose to EMFs. All cellular phones were classified as first generation (1G), second generation (2G), or third generation (3G). IP phones, satellite phones, professional radio communication phones, car phones, and cordless phones were excluded. Exposure was characterized according to: frequency of use, with regular use defined as at least one call per week for 6 months or more before the time of diagnosis; end date of exposure, defined as the date of the initial histological diagnosis and the associated reference dates of relevant controls; exposure intensity, defined as the duration since the first use of a cellular phone to the time of diagnosis, calculated duration of cellular phone use, average daily use, average daily longest time of a single cal, average daily number of calls, number of calls since first use, and time of calls since first use; and preferred side for cellular phone use amongst regular users. The exposure intensity was based on median and quartiles of controls who were regular users and on previously published long-term exposure data: ≤median, >median to ≤third quartile, >third quartile to ≤10 years, >10 years. The others were based on median and quartiles of controls who were regular users: ≤median, >median to ≤third quartile, and >third quartile.

### Statistical methods

The $\chi^2$ test and $\chi^2$ test for linear trend were used to analyse the effect of demographic characteristics and preferred ear for cellular phone use in the cases and controls using SPSS13.0 for Windows (SPSS Inc., Chicago, IL, USA). Unconditional logistic regression analysis, both univariate analysis (Table 1) and multivariate analysis (Tables 2 and 3), were used to calculate odds ratios (ORs) and 95% confidence intervals (95% CI). A $p$-value less than 0.05 was considered statistically significant.

## Results

During the study period, there were 221 eligible cases and 2643 eligible controls. At the time of this study, 136 patients in the case group and 2051 patients in the control group were living and agreed to participate. The overall participation rate was 78% for controls, 62% for cases with epithelial parotid gland malignancies, and 47% for cases with mucoepidermoid carcinomas. The male to female ratio of the cases with epithelial parotid gland malignancies was 1.23:1, the male to female ratio of the mucoepidermoid carcinoma group was 1.21:1, and the male to female ratio of the control group was 1.30:1. Amongst cases, the age range was 7–80 years and the mean age was 45.5 years (45.2 years for males, 45.8 years for females). 110 of 136 cases (91%) were 30–70 years old.

Compared with the controls, the cases had higher overall cellular phone use, except for those aged 30–39 years. In the control group, cellular phone usage was maximal for 40–49-year olds (80%) and 30–39-year olds (79%). In the case group, usage was 85% for 40–49-year olds, 67% for those less than 30 years old, and 67% for 60–69-year olds. Cases who were 40–49 years old (87%) and 60–69 years old (88%) had the greatest cellular phone usage (Fig. 1).

Covariates, such as female gender, advanced age, married status, high monthly income, and tobacco smoking, were positively associated with the presence of epithelial parotid gland malignancy (OR $>$ 1 and $p < 0.05$ for all), especially mucoepidermoid carcinoma (OR $>$ 1 and $p < 0.05$ for all). Residence in a rural region was associated with reduced risk of epithelial parotid gland malignancy (OR $>$ 1 and $p < 0.05$ for all), and especially mucoepidermoid carcinoma (OR $>$ 1 and $p < 0.05$ for all).

Univariate analysis indicated an association between frequency of cellular phone use and risk of epithelial parotid gland malignancy (OR = 1.559, 95% CI = 1.080–2.252). Multivariate analysis indicated no significant association between frequency of cellular phone use and epithelial parotid gland malignancy (OR = 1.142, 95% CI = 0.720–1.811) or mucoepidermoid carcinoma (OR = 1.369, 95% CI = 0.638–2.101) (Tables 2 and 3).

Multivariate analysis identified 13 cellular phone usage variables that were independently associated with epithelial parotid gland malignancy (Table 2). The three variables with the greatest ORs were: more than 42,000 calls since first use (OR = 15.363, 95% CI = 13.344–17.382); use for more than 9–10 years (OR = 7.699, 95% CI = 6.200–9.199); and average daily use of more than 2.5 h (OR = 6.012, 95% CI = 1.474–24.524). The variables significantly associated with parotid gland malignancy were: 9–10 years of use more than 10 calls per day on average; 7–8 years of use;

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*Table 1*. Correlation between risk of epithelial parotid gland malignancies, mucoepidermoid carcinoma and use of cellular phone (univariate analysis)[#].

| | Epithelial parotid gland malignancies | | | | Mucoepidermoid carcinoma | | | |
|---|---|---|---|---|---|---|---|---|
| | Case $n = 136$ $n$(%) | Control $n = 2051$ $n$(%) | OR[†] | 95% CI[†] | Case $n = 64$ $n$(%) | Control $n = 2051$ $n$(%) | OR[†] | 95% CI[†] |
| **Frequency of use**[*] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| Regular use | 91(66.9) | 1158(56.5) | 1.559 | 1.080–2.252 | 44(68.8) | 1158(56.5) | 1.697 | 0.993–2.889 |
| **Duration since the first use of a cellular phone to the time of diagnosis (years)**[§] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| 0.5–6[*] | 67(49.3) | 595(29.0) | 2.235 | 1.510–3.306 | 28(43.8) | 595(29.0) | 2.101 | 1.173–3.764 |
| 7–8 | 6(4.4) | 337(16.4) | 0.353 | 0.149–0.836 | 1(1.6) | 337(16.4) | 0.132 | 0.018–0.991 |
| 9–10 | 3(2.2) | 198(9.7) | 0.301 | 0.093–0.977 | 2(3.1) | 198(9.7) | 0.451 | 0.105–1.945 |
| >10 | 15(11.0) | 28(1.4) | 10.631 | 5.306–21.300 | 13(20.3) | 28(1.4) | 20.73 | 9.379–45.821 |
| **Calculated duration of cellular phone use (years)**[§] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| 0.5–6[*] | 67(49.3) | 595(29.0) | 2.235 | 1.510–3.306 | 28(43.8) | 595(29.0) | 2.101 | 1.173–3.764 |
| 7–8 | 7(5.1) | 337(16.4) | 0.412 | 0.184–0.923 | 2(3.1) | 337(16.4) | 0.265 | 0.062–1.140 |
| 9–10 | 2(1.5) | 198(9.7) | 0.2 | 0.048–0.833 | 1(1.6) | 198(9.7) | 0.226 | 0.030–1.690 |
| >10 | 15(11.0) | 28(1.4) | 10.631 | 5.306–21.300 | 13(20.3) | 28(1.4) | 20.73 | 9.379–45.821 |
| **Average daily use (hours)**[¶] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| ≦0.5 | 53(39.0) | 627(30.6) | 1.677 | 1.113–2.528 | 29(45.3) | 627(30.6) | 2.065 | 1.158–3.684 |
| 0.5–2.5 | 30(22.1) | 521(25.4) | 1.143 | 0.711–1.836 | 8(12.5) | 521(25.4) | 0.686 | 0.300–1.568 |
| >2.5 | 8(5.9) | 10(0.5) | 15.876 | 5.978–42.162 | 7(10.9) | 10(0.5) | 31.255 | 10.799–90.456 |
| **Average daily longest time of a single call (hours)**[¶] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| ≦0.5 | 66(48.5) | 627(30.6) | 2.089 | 1.411–3.093 | 31(48.4) | 627(30.6) | 2.208 | 1.247–3.909 |
| 0.5–2.5 | 25(18.4) | 531(25.9) | 0.936 | 0.567–1.544 | 13(20.3) | 531(25.9) | 1.095 | 0.540–2.220 |
| >2.5 | 0(0.0) | 1(0.0) | 0 | 0.000–0.059 | | 1(0.0) | | |
| **Average daily no. of calls**[¶] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| ≦8 | 77(56.6) | 724(35.3) | 2.111 | 1.442–3.088 | 37(57.8) | 724(35.3) | 2.282 | 1.313–3.966 |
| 40,431 | 11(8.1) | 283(13.8) | 0.774 | 0.394–1.511 | 4(6.3) | 283(13.8) | 0.631 | 0.214–1.862 |
| >10 | 3(2.2) | 151(7.4) | 0.394 | 0.121–1.285 | 3(4.7) | 151(7.4) | 0.887 | 0.260–3.022 |
| **No. of calls since first use**[¶] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| ≦24,000 | 78(57.4) | 604(29.4) | 2.563 | 1.751–3.752 | 41(64.1) | 604(29.4) | 3.031 | 1.758–5.224 |
| 24,001–42,000 | 12(8.8) | 295(14.4) | 0.807 | 0.421–1.547 | 2(3.1) | 295(14.4) | 0.303 | 0.070–1.303 |
| >42,000 | 1(0.7) | 259(12.6) | 0.077 | 0.011–0.559 | 1(1.6) | 259(12.6) | 0.172 | 0.023–1.291 |
| **Time of calls since first use (hours)**[¶] | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| $x \leqq 1350$ | 57(41.9) | 595(29.0) | 1.901 | 1.269–2.848 | 30(46.9) | 595(29.0) | 2.251 | 1.267–4.002 |
| 1351–4320 | 26(19.1) | 275(13.4) | 1.876 | 1.136–3.098 | 9(14.1) | 275(13.4) | 1.461 | 0.658–3.246 |
| >4320 | 8(5.9) | 288(14.0) | 0.551 | 0.257–1.183 | 5(7.8) | 288(14.0) | 0.775 | 0.288–2.084 |
| **Preferred side of calling** | | | | | | | | |
| Never or rarely | 45(33.1) | 893(43.5) | 1 | | 20(31.3) | 893(43.5) | 1 | |
| Ipsilateral | 26(19.1) | 326(15.9) | 1.583 | 0.961–2.607 | 19(29.7) | 326(15.9) | 2.602 | 1.371–4.938 |
| Contralateral | 20(14.7) | 308(15.0) | 1.289 | 0.749–2.217 | 15(23.4) | 308(15.0) | 2.175 | 1.100–4.300 |
| Bilateral | 45(33.1) | 524(25.5) | 1.704 | 1.112–2.612 | 10(15.6) | 524(25.5) | 0.852 | 0.396–1.834 |

[#] Univariate non-conditional logistic regression; unadjusted for covariates such as gender, age, resident area, marital status, education background, occupation, monthly income, smoking status. Because these covariates except occupation were included in the final statistical model. Occupation was not included in the final model most of them are blank in case group.

[†] OR, odds ratio; 95% CI, 95% confidence interval; SD, standard deviation.

[*] Regular use was defined as at least one call per week for 6 months or more before initial diagnosis time.

[§] Duration classification were based on median and quartiles amongst controls who are regular users as well as long term exposure in the literature: data divided in to ≤median, >median to ≤third quartile, >third quartile to ≤10 years, >10 years.

[¶] Classification based on median and quartiles amongst controls who are regular users: data divided in to ≤median, >median to ≤third quartile, >third quartile.

more than 10 years of use; at least 4320 h of total usage; no more than 240,000 calls since first use; and 0–6 years of usage.

Multivariate analysis identified 12 cellular phone usage variables that were independently associated with mucoepidermoid carcinoma (Table 3). The three variables with the greatest ORs were: use for 7–8 years (OR = 19.629, 95% CI = 17.478–21.779); average daily use of at least 2.5 h (OR = 12.733, 95% CI = 2.309–70.221); 24,001–42,000 total calls since first use (OR = 11.851, 95% CI = 9.774–3.928). The other significant variables associated with mucoepidermoid carcinoma were: 7–8 years of use; 9–10 years of use; at least 42,000 calls; more than 10 years of use; 9–10 average calls per day;

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*Table 2*. Collective result of multivariate analysis of correlation between risk of epithelial parotid gland malignancies and use of cellular phone[#].

| | *B* | S.E. | Wald | Sig. | OR[†] | 95% CI | |
|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper |
| **Frequency of use[*] X1** | | | | | | | |
| X1 = 0 (never or rarely) | | | | | 1.000 | | |
| X1 = 1 (regular use) | 0.133 | 0.235 | 0.319 | 0.572 | 1.142 | 0.720 | 1.811 |
| **Duration since the first use of a cellular phone to the time of diagnosis (years)[§] X2** | | | 39.083 | 0.000 | | | |
| X2 = 0 (never or rarely) | | | | | 1.000 | | |
| X2 = 1 (0–6) | 0.525 | 0.245 | 4.602 | 0.032 | 1.691 | 1.046 | 2.731 |
| X2 = 2 (7–8) | 1.428 | 0.471 | 9.181 | 0.002 | 4.172 | 3.248 | 5.096 |
| X2 = 3 (9–10) | 1.679 | 0.648 | 6.717 | 0.010 | 5.359 | 4.090 | 6.629 |
| X2 = 4 (>10) | 1.419 | 0.435 | 10.666 | 0.001 | 4.133 | 3.282 | 4.985 |
| **Calculated duration of cellular phone use (years)[§] X3** | | | 38.629 | 0.000 | | | |
| X3 = 0 (never or rarely) | | | | | 1.000 | | |
| X3 = 1 (0–6) | 0.524 | 0.245 | 4.580 | 0.032 | 1.689 | 1.045 | 2.728 |
| X3 = 2 (7–8) | 1.307 | 0.447 | 8.539 | 0.003 | 3.695 | 2.818 | 4.571 |
| X3 = 3 (9–10) | 2.041 | 0.765 | 7.121 | 0.008 | 7.699 | 6.200 | 9.199 |
| X3 = 4 (>10) | 1.419 | 0.434 | 10.675 | 0.001 | 4.135 | 1.765 | 9.688 |
| **Average daily use (hours)[¶] X4** | | | 7.312 | 0.063 | | | |
| X4 = 0 (never or rarely) | | | | | 1.000 | | |
| X4 = 1 (<0.5 h) | 0.197 | 0.257 | 0.590 | 0.443 | 1.218 | 0.736 | 2.016 |
| X4 = 2 (0.5 h < $x \leqq$ 2.5 h) | 0.072 | 0.291 | 0.062 | 0.804 | 1.075 | 0.505 | 1.645 |
| X4 = 3 (>2.5 h) | 1.794 | 0.717 | 6.254 | 0.012 | 6.012 | 1.474 | 24.524 |
| **Average daily longest time of a single call (hours)[¶] X5** | | | 9.203 | 0.010 | | | |
| X5 = 0 (never or rarely) | | | | | 1.000 | | |
| X5 = 1 (<0.5 h) | 0.418 | 0.248 | 2.843 | 0.092 | 1.518 | 0.934 | 2.468 |
| X5 = 2 (0.5 h < $x \leqq$ 2.5 h) | 0.423 | 0.314 | 1.814 | 0.178 | 1.527 | 0.911 | 2.144 |
| **Average daily no. of calls[¶] X6** | | | 14.488 | 0.002 | | | |
| X6 = 0 (never or rarely) | | | | | 1.000 | | |
| X6 = 1 (0–8) | 0.445 | 0.244 | 3.332 | 0.068 | 1.560 | 0.968 | 2.516 |
| X6 = 2 (9–10) | 0.527 | 0.421 | 1.572 | 0.210 | 1.694 | 0.870 | 2.519 |
| X6 = 3 (>10) | 1.514 | 0.689 | 4.826 | 0.028 | 4.543 | 3.193 | 5.894 |
| **No. of calls since first use[¶] X7** | | | 22.055 | 0.000 | | | |
| X7 = 0 (never or rarely) | | | | | 1.000 | | |
| X7 = 1 (≤24,000) | 0.577 | 0.238 | 5.879 | 0.015 | 1.780 | 1.117 | 2.838 |
| X7 = 2 (24,001–42,000) | 0.564 | 0.382 | 2.187 | 0.139 | 1.758 | 1.010 | 2.506 |
| X7 = 3 (>42,000) | 2.732 | 1.030 | 7.035 | 0.008 | 15.363 | 13.344 | 17.382 |
| **Time of calls since first use (hours)[¶] X8** | | | 10.663 | 0.014 | | | |
| X8 = 0 (never or rarely) | | | | | 1.000 | | |
| X8 (≤1350) | 0.353 | 0.251 | 1.983 | 0.159 | 1.424 | 0.871 | 2.328 |
| X8 (1351–4320) | 0.217 | 0.316 | 0.471 | 0.492 | 1.242 | 0.669 | 2.308 |
| X8 (>4320) | 1.024 | 0.458 | 5.002 | 0.025 | 2.784 | 1.887 | 3.681 |
| **Preferred side of calling X9** | | | 2.608 | 0.456 | | | |
| X9 = 0 (never or rarely) | | | | | 1.000 | | |
| X9 = 1 (ipsilateral) | 0.136 | 0.312 | 0.190 | 0.663 | 1.146 | 0.621 | 2.114 |
| X9 = 2 (contralateral) | 0.212 | 0.347 | 0.373 | 0.541 | 1.236 | 0.556 | 1.915 |
| X9 = 3 (bilateral) | 0.292 | 0.266 | 1.209 | 0.271 | 1.339 | 0.796 | 2.254 |

[#] Collective result of multivariate non-conditional logistic regression analysis; X1–X9 represented corresponding variates, any two of which was not simultaneously analysed in multivariate logistic regression; all covariates except occupation, most of which are blank in case group, were included in the final statistical model.

[†] OR, odds ratio; 95% CI, 95% confidence interval.

[*] Regular use was defined as at least one call per week for 6 months or more before initial diagnosis time.

[§] Duration classification based on median and quartiles amongst controls who are regular users as well as long term exposure in the literature: data divided in to ≤median, >median to ≤third quartile, >third quartile to ≤10 years, >10 years.

[¶] Classification based on median and quartiles amongst controls who are regular users: data divided in to ≤median, >median to ≤third quartile, >third quartile.

average daily use of 0.5–2.5 h; and use for at least 4320 h.

Univariate analysis indicated that the risk of epithelial parotid gland malignancy was 1.704-fold greater (95% CI = 1.112–2.612) for those who used cellular phones bilaterally (Table 1). Multivariate analysis indicated no significant association between preferred side of calling and risk of epithelial parotid gland malignancy (Table 2). Amongst the study cases, a $\chi^2$ test of linear trend indicated no significant linear trend between side of tumour and preferred side of calling for regular phone users ($\chi^2 = 0.036$, $p = 0.850$) (Table 4). Multivariate analysis indicated no significant association between preferred side of calling and risk of mucoepidermoid carcinoma (Table 3). In addition, amongst study cases with mucoepidermoid carcinoma, a $\chi^2$ test of linear trend indicated no significant effect of side of tumour and preferred side of calling for regular phone users ($\chi^2 = 0.115$, $p = 0.734$) (Table 5).

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*Table 3*. Collective result of multivariate analysis of correlation between risk of mucoepidermoid carcinoma and use of cellular phone[#].

| | *B* | S.E. | Wald | Sig. | OR[†] | 95% CI OR[†] Lower | Upper |
|---|---|---|---|---|---|---|---|
| **Frequency of use[*] X1** | | | | | | | |
| X1 = 0 (never or rarely) | | | | | 1.000 | | |
| X1 = 1 (regular use) | 0.314 | 0.373 | 0.710 | 0.400 | 1.369 | 0.638 | 2.101 |
| **Duration since the first use of a cellular phone to the time of diagnosis (years)[§] X2** | | | 28.251 | 0.000 | | | |
| X2 = 0 (never or rarely) | | | | | 1.000 | | |
| X2 = 1 (0–6) | 0.226 | 0.402 | 0.315 | 0.574 | 1.253 | 0.465 | 2.041 |
| X2 = 2 (7–8) | 2.977 | 1.097 | 7.360 | 0.007 | 19.629 | 17.478 | 21.779 |
| X2 = 3 (9–10) | 1.855 | 0.866 | 4.585 | 0.032 | 6.389 | 4.692 | 8.087 |
| X2 = 4 (>10) | 1.998 | 0.570 | 12.298 | 0.000 | 7.373 | 2.414 | 22.520 |
| **Calculated duration of cellular phone use (years)[§] X3** | | | 29.215 | 0.000 | | | |
| X3 = 0 (never or rarely) | | | | | 1.000 | | |
| X3 = 1 (0–6) | 0.232 | 0.402 | 0.333 | 0.564 | 1.261 | 0.473 | 2.049 |
| X3 = 2 (7–8) | 2.402 | 0.846 | 8.061 | 0.005 | 11.050 | 9.391 | 12.708 |
| X3 = 3 (9–10) | 2.370 | 1.100 | 4.645 | 0.031 | 10.699 | 8.544 | 12.855 |
| X3 = 4 (>10) | 1.991 | 0.570 | 12.216 | 0.000 | 7.325 | 2.398 | 22.377 |
| **Average daily use (hours)[¶] X4** | | | 18.112 | 0.000 | | | |
| X4 = 0 (never or rarely) | | | | | 1.000 | | |
| X4 = 1 (0.5 h) | 0.015 | 0.392 | 0.001 | 0.969 | 1.015 | 0.246 | 1.784 |
| X4 = 2 (0.5 h $< x \leqq$ 2.5 h) | 1.567 | 0.614 | 6.514 | 0.011 | 4.790 | 3.587 | 5.993 |
| X4 = 3 (>2.5 h) | 2.544 | 0.871 | 8.529 | 0.003 | 12.733 | 2.309 | 70.221 |
| **Average daily longest time of a single call (hours)[¶] X5** | | | 5.039 | 0.080 | | | |
| X5 = 0 (never or rarely) | | | | | 1.000 | | |
| X5 = 1 (<0.5 h) | 0.006 | 0.390 | 0.000 | 0.988 | 1.006 | 0.469 | 2.159 |
| X5 = 2 (0.5 h $< x \leqq$ 2.5 h) | 1.027 | 0.525 | 3.819 | 0.051 | 2.792 | 1.762 | 3.821 |
| **Average daily no. of calls[¶] X6** | | | 5.841 | 0.120 | | | |
| X6 = 0 (never or rarely) | | | | | 1.000 | | |
| X6 = 1 (0–8) | 0.001 | 0.382 | 0.000 | 0.997 | 1.001 | 0.253 | 1.750 |
| X6 = 2 (9–10) | 1.974 | 1.017 | 3.769 | 0.052 | 7.200 | 5.207 | 9.193 |
| X6 = 3 (>10) | 1.084 | 0.781 | 1.926 | 0.165 | 2.955 | 1.425 | 4.485 |
| **No. of calls since first use[¶] X7** | | | 11.369 | 0.010 | | | |
| X7 = 0 (never or rarely) | | | | | 1.000 | | |
| X7 = 1 (≤24,000) | 0.230 | 0.372 | 0.382 | 0.537 | 1.258 | 0.607 | 2.607 |
| X7 = 2 (24,001–42,000) | 2.472 | 1.060 | 5.445 | 0.020 | 11.851 | 9.774 | 13.928 |
| X7 = 3 (>42,000) | 2.119 | 1.070 | 3.918 | 0.048 | 8.322 | 6.224 | 10.420 |
| **Time of calls since first use (hours)[¶] X8** | | | 7.078 | 0.069 | | | |
| X8 = 0 (never or rarely) | | | | | 1.000 | | |
| X8 (≤1350) | 0.063 | 0.384 | 0.027 | 0.869 | 1.065 | 0.502 | 2.261 |
| X8 (1351–4320) | 0.939 | 0.611 | 2.363 | 0.124 | 2.557 | 1.360 | 3.754 |
| X8 (>4320) | 1.351 | 0.683 | 3.913 | 0.048 | 3.860 | 2.522 | 5.198 |
| **Preferred side of calling X9** | | | 9.391 | 0.025 | | | |
| X9 = 0 (never or rarely) | | | | | 1.000 | | |
| X9 = 1 (ipsilateral) | 0.371 | 0.434 | 0.732 | 0.392 | 1.449 | 0.619 | 3.391 |
| X9 = 2 (contralateral) | 0.239 | 0.490 | 0.238 | 0.625 | 1.270 | 0.310 | 2.230 |
| X9 = 3 (bilateral) | −0.950 | 0.532 | 3.188 | 0.074 | 0.387 | 0.136 | 1.097 |

[#] Collective result of multivariate non-conditional logistic regression analysis; X1–X9 represented corresponding variates, any two of which was not simultaneously analysed in multivariate logistic regression; all covariates except occupation, most of which are blank in case group, were included in the final statistical model.

[†] OR, odds ratio; 95% CI, 95% confidence interval.

[*] Regular use was defined as at least one call per week for 6 months or more before initial diagnosis time.

[§] Duration classification based on median and quartiles amongst controls who are regular users as well as long term exposure in the literature: data divided in to ≤median, >median to ≤third quartile, >third quartile to ≤10 years, >10 years.

[¶] Classification based on median and quartiles amongst controls who are regular users: data divided in to ≤median, >median to ≤third quartile, >third quartile.

## Discussion

Cellular phones transmit and receive radiation mainly in the frequency range 800–1800 MHz. When tissues are exposed to a radiofrequency field, the response is related to the absorption rate of energy deposited per unit mass, measured as the specific absorption rate (SAR) and expressed in units of watts per kilogramme (W/kg). Electromagnetic radiation from cellular phones is partially absorbed by human tissues, and the SAR differs for different types of tissues. In particular, the head and hands have most contact with cellular phones, and previous studies have reported that they absorb about 40% of the electromagnetic energy from cellular phones[3]. In addition, electromagnetic radiation decreases with distance from the source, and it is well-established that the parotid gland absorbs significant microwave energy from cellular phones. This absorbed energy may be associated

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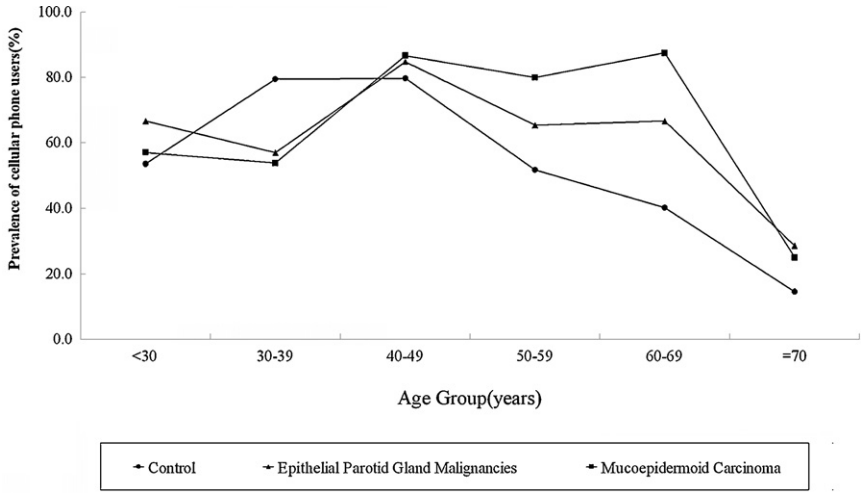


*Fig. 1.* Prevalence of cellular phone users with epithelial parotid gland malignancies, mucoepidermoid carcinoma and controls in each age group.

with thermal effects and/or non-thermal effects.

Four previous studies have indicated an association between cellular phone use and parotid gland tumours[2,8,14,17]. Yet, given the small sample sizes, use of different statistical designs, and various sources of possible bias, the association of cellular phone use and parotid gland tumours remains controversial. Three earlier reports, which did not have long-term use data, concluded that there was no elevated risk of parotid gland tumours from cellular phone use[2,8,14]. A 2008 study[17] reported significant positive associations between high cumulative exposure to cellular phones and ipsilateral tumours, rural or mixed rural/urban residence, and parotid gland tumours.

As of June of 2010, two studies have compared the type of cellular phone and risk of parotid gland tumours[2,8]. Both concluded that cellular phones did not increase the risk of tumours, in contrast to other studies of intracranial tumours in cellular phone users[1,3,6,7,9,12,13,15,20,21,23]. Both of these studies had small sample sizes and did not consider other potentially carcinogenic factors, which may have led to bias. In the present study, most regular users did not know their cellular phone type (analogue or digital), so cellular phone type was not considered in this pilot study.

The authors found that frequency of cellular phone use was not significantly associated with parotid gland malignancy. This may be because young people in the control group were more likely to be frequent users of cellular phones, and epithelial parotid gland malignancy depends on total exposure over many years.

The authors found general indications of a dose–response relationship between cellular phone use and parotid gland malignancy. In particular, duration of use prior to diagnosis, average daily number of calls, average daily duration of cellular phone usage, number of calls since first use, and total time of usage were positively associated with parotid gland malignancy. Nevertheless, the contradictory results of the univariate and multivariate analyses resulted from interactions amongst covariates, according to four exposure categories of parameters of epithelial parotid gland malignancies. The authors found no significant relationship between average daily duration of the longest single call and parotid gland malignancy. This suggests that long-term single exposures do not increase the risk of cancer.

Based on the assumption that there is a dose–response relationship between local EMF exposure and parotid gland malignancy, the location of the tumour should be associated with side of cellular phone usage or hand-free device. The authors found no significant association between preferred side of calling and location of epithelial parotid gland malignancy or mucoepidermoid carcinoma. This indicates that a definitive conclusion about the effect of cellular phone usage and parotid gland malignancy cannot be made.

Covariates such as female gender, advanced age, married status, more education, higher monthly income, and smoking were associated with increased risk of epithelial parotid gland malignancy, especially mucoepidermoid carcinoma. These results are consistent with previous studies of the epidemiology of epithelial parotid gland malignancies and mucoepidermoid carcinoma[17,18]. These results were also expected based on common sense.

People with more education, greater monthly income, married status, and/or mobile are usually more likely to use cellular phones. Smoking is a well-known factor for numerous types of cancer. The

*Table 4.* Side of tumour and preferred side of calling for regular phone users amongst the study cases of epithelial parotid gland malignancies*.

| | Preferred side of calling | | |
|---|---|---|---|
| Side of tumour | Left | Right | Both |
| Left | 13 | 12 | 23 |
| Right | 13 | 8 | 21 |
| Both | 0 | 0 | 1 |
| Total | 13 | 12 | 23 |

* $\chi^2$ test of linear trend: $\chi^2 = 0.036$, $p = 0.850$. There is no significant linear trend between side of tumour and preferred side of calling for regular phone users amongst the study cases of epithelial parotid gland malignancies.

*Table 5.* Side of tumour and preferred side of calling for regular phone users amongst the study cases of mucoepidermoid carcinoma*.

| | Preferred side of calling | | |
|---|---|---|---|
| Side of tumour | Left | Right | Both |
| Left | 6 | 10 | 3 |
| Right | 13 | 5 | 7 |
| Both | 0 | 0 | 0 |
| Total | 19 | 15 | 10 |

* $\chi^2$ test of linear trend: $\chi^2 = 0.115$, $p = 0.734$. There is no significant correlation or linear trend between side of tumour and preferred side of calling for regular phone users amongst the study cases of mucoepidermoid carcinoma.

recent study[17] which reported a possibly increased risk of malignant tumours due to cellular phone usage needs to be confirmed by larger studies. The authors found that rural residence was inversely associated with risk of epithelial parotid gland malignancy, especially mucoepidermoid carcinoma. This result is inconsistent with a recent study of an Israeli population[17], possibly due to differences in the study populations or because of different developing models in the telecommunication industry. The lower rate of parotid gland malignancy in the present rural subjects may be because rural residents in China tend to have lower incomes than urban residents and cannot afford cellular phones.

The authors identified a positive association between long-term and heavy use of cellular phones and epithelial parotid gland malignancy and mucoepidermoid carcinoma (a sub-type of epithelial parotid gland malignancy). This study design cannot exclude the possibility of recall bias or selection bias. Exposure (regular use) was defined as at least one call per week for 6 months or more prior to diagnosis. Epithelial parotid gland malignancies are not likely to be induced by such a short exposure time, so this may have led to misclassification bias. The authors suggest that additional large-scale studies, especially those with a prospective design, be performed to reduce the sources of bias and to confirm the significance of the present results.

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## Competing interests

None declared.

## Ethical approval

Not required.

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