Cordless telephone use: implications for mobile phone research

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Cordless and mobile (cellular) telephone use has increased substantially in recent years causing concerns about possible health effects. This has led to much epidemiological research, but the usual focus is on mobile telephone radiofrequency (RF) exposure only despite cordless RF being very similar. Access to and use of cordless phones were included in the Mobile Radiofrequency Phone Exposed Users Study (MoRPhEUS) of 317 Year 7 students recruited from Melbourne, Australia. Participants completed an exposure questionnaire—87% had a cordless phone at home and 77% owned a mobile phone. There was a statistically significant positive relationship ($r = 0.38$, $p < 0.01$) between cordless and mobile phone use. Taken together, this increases total RF exposure and its ratio in high-to-low mobile users. Therefore, the design and analysis of future epidemiological telecommunication studies need to assess cordless phone exposure to accurately evaluate total RF telephone exposure effects.

Introduction

In the last ten years, there has been a substantial increase in the prevalence of wireless technology and its accompanying radiofrequency (RF) emissions. These emissions are often referred to as microwaves, and comprise the shorter wavelengths/higher frequencies of the RF range.

Cordless telephones have become normal household appliances, while concurrently the use of mobile (cellular) phones has become integral to everyday life. This has led to many people being exposed to background RF radiation 24 h a day from transmitters both outside and inside their schools, workplaces and homes.

Cordless phones put a base station inside the user's home and are often the strongest source of RF in the home.[1] Transmissions of the base and handset are most commonly digital and employ several frequency bands, usually 900 MHz, 1.8–1.9 GHz, 2.4 GHz, and 5.6 or 5.8 GHz.[2a,b] While some 900 MHz models are still analogue with digital features, most use digital enhanced cordless telecommunication (DECT). The more recent cordless phones operate on the two highest frequency bands using digital spread spectrum (DSS).

Standards currently used in most countries to regulate human exposure to RF were not designed for and do not consider short-range transmitters inside buildings nor the possibility of close proximity to people.[3] If a person sleeps or works half a metre away from a cordless phone base, his/her on-going background exposure can be more than 100 times greater than that from a nearby mobile base station (following from Kühn *et al.*[3]), and within adjacent rooms the electric field has been shown to be around the 95th percentile of fields encountered near cellular base stations in residential areas.[4]

Near-field exposure from cordless and mobile handsets is additional to this. During calls, DECT handsets have a time-averaged 10 mW output power delivered in bursts at the maximum transmit power of 250 mW.[5] DSS phones in the US are permitted 100 mW output power, operating at a transmit power of up to 1 W.[6] This is the same transmit power as for 900 MHz mobile phones.[7]

For most portable telephone models, output power does not vary with distance from the base. On the other hand, mobile phones adjust their power output according to the clarity of signal by using adaptive power control (APC). This means the output power varies considerably according to phone type, the

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Environmental impact

Humans utilise most electro-magnetic frequencies occurring naturally in our environment. Radio frequencies (RFs) are barely represented among these and pulse-modulated ones typically emitted by wireless phones are not represented at all. Most of the world's population is now exposed to these. While far-field effects of RF are well understood, research on biological interaction from near-field pulsed RF transmission is less well developed. Since pulsed RF environmental exposure is so recent and pervasive, it is important that epidemiological research is designed to accurately assess possible health effects. This paper suggests that research focussing solely on mobile phone use and disregarding cordless-portable phone exposure will reduce the chance of doing so and may give false reassurance of wireless phone safety.

network provider, and a variety of conditions including network user-load, obstacles, handover between cells, and proximity to a base station.[7] While the phone is establishing a connection and sending text messages (SMS) it functions on or near full power. At other times, APC may scale the time-averaged maximum output power from 250 mW at 1800 MHz or 125 mW at 900 MHz down to as low as 1–2 mW according to conditions.[7]

Other sources have measured time-averaged output power of mobile calls variously at below 1 mW for 3 min in suburban areas,[8] and, most recently, at 128 mW (900 MHz) or 63 mW (1800 MHz) for calls longer than 1 min averaged across all locations.[9] This multicentre study found that output power decreased with increasing call duration. However, it only accounted for exposure during speech; as APC reduces power output when the caller is listening, this study almost certainly overestimated actual mean exposure.

This means that, averaged over the course of conversation, a cordless DECT handset can expose the user to a higher RF output than would a mobile handset with consistently good reception. Thus exposure to cordless phone bases and handsets may make a considerable difference to total RF energy exposure from telephones, and for those living in good mobile reception areas the exposure from cordless phones is likely to be comparatively more substantial.

Due to considerable debate about whether cordless phone use should be assessed in epidemiological studies,[10–12] such as the forthcoming Mobi-Kids study,[13] it is important to find out whether treating those with only cordless phones as 'unexposed' is likely to bias associations between wireless phone use and cancer incidence. As well as establishing the extent of cordless phone use generally, we also need to know whether there is a correlation between mobile and cordless phone use since a positive correlation would have a compounding effect on total RF exposure. This means that if health effects exist, the risk ratio for the high user group would be increased.

We examined the proportion of an adolescent sample with cordless telephones at home, and the proportion of these that did not own a mobile phone, and asked how prevalent was cordless phone use in this sample and whether it was related to their mobile phone use.

Methods

Sample

The current analysis draws on data collected for the Mobile Radiofrequency Phone Exposed Users Study (MoRPhEUS), the methods of which are described in detail elsewhere.[14] Briefly, a cross-sectional clustered study was conducted during 2005/2006. We recruited 13 government, 4 Catholic and 3 independent secondary schools from around Melbourne, Australia. The numbers of schools were chosen to represent the proportions of secondary students attending each sector in the state of Victoria. At each school, one Year 7 homeroom class (typical age 12 to 13 years) was selected at random to participate. Parents or guardians of children in the selected class were sent information packages, explaining the study.

Questionnaires were completed by participating children and their parents. Exposures to mobile and cordless telephones were assessed with a modified version of the Interphone questionnaire.[15]

Ethics

MoRPhEUS was approved by the Standing Committee on Ethics in Research Involving Humans at Monash University, the Department of Education & Training, the Catholic Education Office and the principals of all participating schools. Children and their parents/guardians gave written informed consent.

Statistical analysis

Data analysis was performed using SPSS version 15.0.[16] Calls made and received per week were totalled, using the arithmetic mean when a range was given. Cordless and mobile total calls were each then log transformed, with an offset of 1 to include valid zeroes; this achieved normal distributions. Independent sample t-tests, Pearson (r) and Spearman's rank (ρ) correlations were used for analysis. All p values were two tailed and $p < 0.05$ was considered statistically significant.

Results

Of the 479 students invited, 317 (66%) participated in the study. We recruited 145 (46%) boys and 172 (54%) girls. The median age was 13 (range 11–14) years. A large majority (274 or 87%) of the 317 students had a cordless phone at home, and 243 (77%) owned their own mobile phones, although 252 (80%) currently used a mobile. All but 10 (3.2%) reported having access to one or other type of phone. Age was normally distributed, but the reported number of calls per week on both types of phone were right skewed (Fig. 1). Of the 74 (23%) participants who did not own a mobile phone, 62 (84%) had a cordless phone at home and 22 (33%) of them used it more than the median of the entire group. Ten (3%) of those with a cordless telephone at home reported not using it.

Looking at the whole sample, the reported total number of calls on cordless phones was a little lower than that on mobile phones, with the respective medians and interquartile ranges

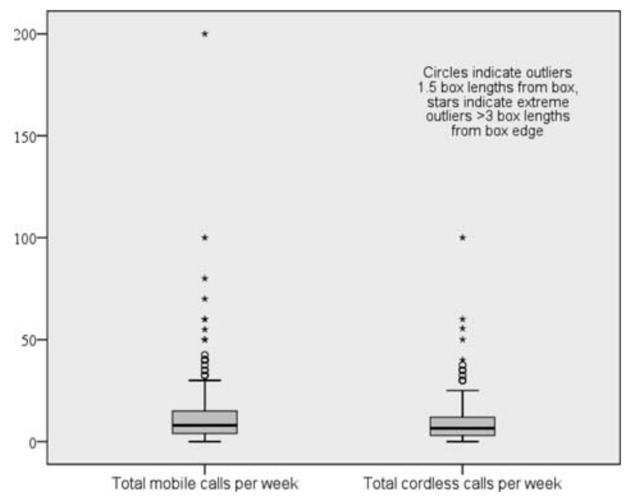

Fig. 1 Box plots of total mobile and cordless phone calls per week.

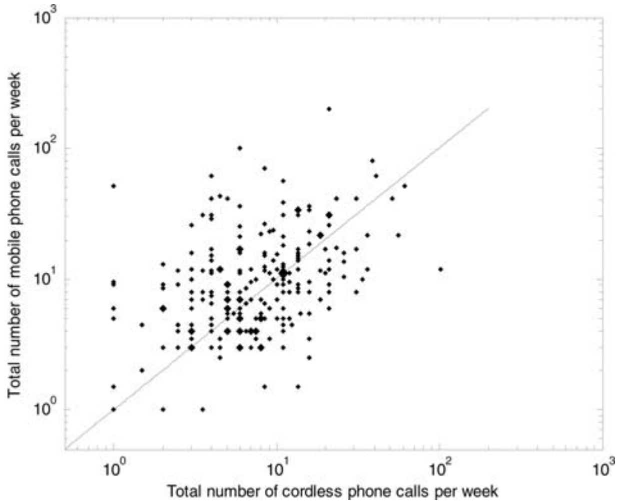

Fig. 2 Scatterplot of total weekly cordless and mobile calls using log transformed data. The symbol size is proportional to the number of replicated points.

(IQRs) being 6 (IQR 3–11) and 8 (IQR 4–15). The reported extent of cordless phone use was not related to age ($\rho = -0.027$, $p = 0.7$) and there was no significant difference in use between males and females ($t = -0.283$, $p = 0.6$).

The Pearson correlation between the total number of calls reported on cordless and mobile phones was 0.38 ($p < 0.01$). This positive association is apparent in the scatterplot (Fig. 2).

Discussion

MoRPhEUS is one of very few epidemiological studies to consider access to and use of cordless phones, especially among young people. We found that a large majority of adolescents had cordless phones at home and one fifth had a cordless but did not own a mobile. Almost all of them used either cordless or mobile phones. There was a positive association between the uses of the two phone types.

A Swedish study of 7 to 14 year olds[11] found a similar proportion of students had cordless phones at home (83.8% of the 1423 respondents compared with 87% here). In that study, use of both phone types increased rapidly with age. The German MobilEe study[17] asked participants for estimates of time spent on both phone types. Specific results for this were not given as this was not their main focus, although they recorded that adolescents used DECT phones more than children. The MoRPhEUS study had a narrow age range (97% aged 12 or 13), which perhaps explains the lack of association between age and use.

We explored whether access to a cordless phone would reduce an adolescent's use of a mobile phone. Perceived reasons for this possibility were that cordless phones are generally cheaper to use, afford the same privacy if desired, and are less likely to be regarded as a health threat due to lack of media focus on cordless phones in Australia. However, this expected negative relationship was not confirmed. On the contrary, there was a moderate positive relationship between adolescents' number of cordless and mobile phone calls. In another study of adolescents aged 15 to 19[18] it was similarly found that regular mobile phone use was associated with regular cordless phone use, although this was assessed in reported call duration rather than the number of calls. In the German MobilEe study adolescents reported a longer daily use of cordless phones than mobile phones (S. Thomas, personal communication, 17, September 2009).

Söderqvist *et al.*[19] also reported a significant positive association between regular mobile use (defined as talking $\geq$2 min a day) and cordless use in 7 to 14 year olds. This result is not directly comparable either as they also assessed participants' reported call duration. Duration tends to be overestimated and is recalled less accurately than the number of calls,[20,21] particularly by those with short to medium call durations.[22]

Estimation tendencies are different when reporting the number (rather than length) of mobile phone calls. The latter study[22] compared the number and duration of actual and recalled calls over periods of 24 h and 3 days. They found a significant difference ($p = 0.001$) between recall accuracy of the number of calls by high and low users, with high users tending to underestimate and low users tending to overestimate. If these findings apply to the current study, the significance of the correlation between cordless and mobile calls may be stronger than reported here, as it would increase the actual range of calls made and received.

The very high proportion of adolescents who have a cordless phone at home indicates that many people have a higher level of total RF exposure from telephones than considered by most mobile phone studies to date. The largest of these is the 13-country Interphone study which treated those who used cordless but not mobile phones as unexposed.[23]

The statistically significant positive correlation found between the use of the two types of telephone alters the ratio of RF exposure between high and low mobile users. Furthermore if generally applicable, the 33% of those who do not have a mobile, but use a cordless more than average, would potentially confound the interpretation of mobile phone studies that do not consider cordless phone exposure. This could lead to incorrect and under-estimation of RF exposure when cordless-portable use is not included. Ultimately this would affect the conclusions drawn about the severity or existence of health effects.

Strengths of the MoRPhEUS study relevant to the current analysis lie in cluster sampling across all school sectors and a high participation rate providing a representative sample.[14] The main limitation was the reliance on self-reporting of exposure. Reliability of estimation is known to be affected by the time-span over which participants are asked to recall information. Timotijevic *et al.* found an increased tendency to underestimate call numbers after three days compared to one day.[22] It is not clear how this interacts with the effects of recall on high or low numbers of calls, or whether recalling an average week, as in the current study, is more or less reliable than recalling the last three days. Differences in age or sex appear not to play a part.[20]

Conclusions

This study found that a large majority of Australian adolescents have a cordless telephone at home, and almost 20% have a cordless phone at home but do not own a mobile phone. Cordless telephones are single-cell mobile phones whose bases emit RF at all times, and whose handsets have a very comparable type of emissions to mobile phones, but without the ability to adjust output according to need. For these reasons, extended proximity to the base or use of the handset can appreciably increase total RF exposure. We also found a statistically significant positive relationship between the extent of cordless and mobile phone use. When taken into consideration, this changes the ratio of total RF exposure of high users compared to low users. We conclude therefore that when designing and analysing epidemiological mobile phone studies, it is important to also assess cordless phone handset and base exposure in order to accurately evaluate total RF telephone exposure effects.

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