

the current knowledge of the health effects of mobile phones and their base stations on human beings, we conducted a search of the English literature since 1966 on Medline using "mobile phone" and "cellular phone" as key words and summarized the findings.

### **Health Effects of Exposures to Very-low-frequency (50-60 Hz) Radiation and Magnetic Fields**

Epidemiological studies of health effects of very-low-frequency radiation and magnetic fields are not conclusive. Wertheimer and Leeper<sup>5</sup> found that magnetic fields of high voltage electric cables were related to some childhood cancers after adjusting for the possible effects of street congestion, social class, and family structure. However, they applied the "wire coding" as a surrogate measurement of the exposure and did not measure the exposure level directly. Martha et al.<sup>6</sup> conducted a study on childhood leukemia using direct measurements of current in the former homes of participants but failed to find an association. In addition to sampling variations, we believe differences in study results might also be attributable to potential information biases in the Wertheimer and Leeper study, because in the study by Martha et al., measurements of EMF were conducted without the knowledge of the disease status (blinding). Matilainen et al.<sup>7</sup> and Juutilainen et al.<sup>8</sup> found significant statistical associations between EMF and abortions during early pregnancy. However, Robert<sup>9</sup> conducted a study in France and found that residents living within 500 m of high voltage wires had no increased risk of birth defects. In 1996, he repeated the same study in the same place and found the same results. These study results are not suitable to be applied directly to higher EMFs, such as those of mobile phones and their base stations.

### **Health Effects of Mobile Phones**

The mobile phone communication systems in Taiwan use the GSM900 and GSM1800, and the communication frequencies are between 800 and 2000 MHz. The emission power of a mobile phone is generally below 1000 mW, but sometimes the maximum power can reach 6 W.<sup>10</sup> When one uses a mobile phone, the

device is close to the ear and may introduce a thermal effect, which comes from the energy of the electromagnetic waves and the heat originating from the mobile phone. It is unknown, however, whether this energy can damage the brain.

In fact, even in the US, mobile phones were not widely used until the 1980s. As a result of the literature review, we found the following possible health effects caused by mobile phones:

#### **I. Interference with medical apparatus**

When an operating mobile phone is very close to a patient with an implanted pacemaker, its electromagnetic waves may interfere with the apparatus and cause asystole. Digital cellular phones (DCPs) generate strong, amplitude-modulated fields with pulse repetition rates near the physiological range that might be sensed by an ICD (implantable cardiac defibrillator) as arrhythmia. DCPs with time division multiple access (TDMA) pulsed-amplitude modulation caused the most prominent effect, i.e. high-voltage firing or inhibition of pacing output of an ICD. Bassen et al.<sup>11</sup> conducted an *in vitro* study on the potential of cellular telephones to interfere with representative models of commonly used ICDs and found electromagnetic interferences (EMIs) in varying degrees from all DCPs. When a TDMA11-Hz DCP was placed within 2.3 cm of ICDs, inhibition of pacer output occurred in one model of ICD, and high-voltage firing occurred in two other models. For the most sensitive model, inhibition followed by firing occurred at distances up to 5.8 cm. When a TDMA-50 Hz mobile phone was placed at the minimum test distance of 2.3 cm, inhibition followed by firing was observed in one model of ICDs. EMIs occurred most frequently when the lower portion of the monopole antenna of the cellular phone was placed over the ICD header. Fetter et al.<sup>12</sup> conducted clinical tests in 41 patients using the AT&T 6650 digital telephone with the NADC/TDMA-50 technology to examine the antenna-generated far field and the analog/digital cellular telephone near field. None of the ICDs tested were affected by over-sensing of the EMI field of cellular telephones. The *in vitro* antenna-