A dosimetry study for a four member family inside an elevator, when a mobile phone is used, is carried out. Numerically accurate models of a 7th month pregnant woman, an adult male, an 8 years old male child and a 5 years old female child are used. Mobile phone is modelled in three talk positions, vertical, tilt and cheek while two cabin types are employed. As found, the averaged SAR values over 1g and 10g for the three no-phone user passengers are much lower than those of the phone user. Results depend on the relative position of the users, the position of the phone and the elevator cabin type. SAR values for the phone user are not affected from other passengers’ relative position.

Introduction
Numerous efforts have been carried out to determine hazards from the use of mobile phones. Attention of the scientists has been put, among others on determining the power absorption by humans when a phone is used in closed environment, like a car or an elevator cabin, especially for sensitive population groups such as pregnant women and children.

The whole-body Specific Absorption Rate (SAR) increases more drastically as compared to peak averaged over 10g or 1g SAR inside fully and partially enclosed metallic elevator cabins. This means that whole body exposure assessment might be equally significant with the peak averaged SAR values in the head [1]. As shown in [2] when a pregnant woman is using a phone inside an elevator, the averaged values of SAR are maximized at full metallic enclosure elevator cabin. Inside metallic enclosures, the averaged SAR values are increased as compared to free space [3, 4, 5]. Also the dosimetry values depend on the number of people inside metallic enclosures [6, 4]. Interestingly, as noted in [7], inside an elevator cabin, when all passengers are children, the power absorbed by no phone user child is higher as compared to a similar case of adult passengers.

In this paper, we investigate the effects of two different elevator cabins and two different configurations of persons on a family of 4 members, when a mobile phone is used. The mobile phone user is standing in the center of the cabin and is surrounded by a pregnant woman and two children.

The cell phone is placed at three different talk positions: vertical, tilt and cheek position (IEEE 1528 std and CENELEC EN 62209) [8], [9]. Two frequencies, 1000 MHz and 1650 MHz, are implemented. The numerical dosimetry simulations were carried out with SEMCAD-X [10].

Specific Absorption Rate (SAR) and Limits
The physical quantity used to determine the level of absorption of electromagnetic power by biological tissue per unit mass of tissue is Specific Absorption Rate (SAR).

The SAR can be calculated as:

\[
SAR = \frac{\sigma |E|^2}{\rho} \left[ \frac{W}{Kg} \right] \quad (Eq.1)
\]

where \( \sigma \) [S/m]: the electrical conductivity, \( \rho \) [kg/m³]: the mass density of tissue and \( E \): the effective value of the electric field. The whole body SAR can be calculated as:

\[
SAR_{wb} = \frac{P_{abs}}{m} \left[ \frac{W}{Kg} \right] \quad (Eq.2)
\]

where \( P_{abs} \) [W]: the absorbed power and \( m \) [kg]: the whole absorber mass.

Standards for safety levels with respect to human exposure to radiofrequency electromagnetic fields determine that maximum allowed peak spatial average SAR 1g is 1.6 W/kg, for 10g is 2.0 W/kg, and for Whole-Body is 0.08 W/kg [11], [12]. The above values are calculated for 6 minutes of exposure.

Models and Method
The mobile phone employed consists of 5 different materials, casing, screen, metal, antenna substrate, and air developed by the French ANR project Kidpocket [14]. Antenna is found at the low end of the phone, and operates at 1000 MHz and 1650 MHz.

According to the directive from Greek Regulations for Buildings [15], we used an elevator cabin of dimensions 1.10 x 1.40 x 2.10 m³ and 10 mm thick walls. Two different cases of enclosures are examined:
1. completely metallic model,
2. with an opening of 250 mm x 308 mm at the roof of the metallic enclosure, based on the directives for ventilation at elevators [16].
The human models used in our research are a numerically accurate anatomical model of a 34-year-old male (Duke), a 7th month pregnant woman (Pregnant II), a male 8 years old child (Dizzie), and a female 5 years old (Roberta) [13]. The phone user is a male human model, Duke, standing at the center of elevator cabin. The positioning point of the phone is chosen symmetrically to the horizontal axis of the phone and 5mm below its top edge (see Fig. 1 (a)). The reference power is 1 W for both 1000 MHz and 1650 MHz. The cell phone is placed in three different talk positions: vertical, tilt and cheek position (IEEE 1528 std and CENELEC EN 62209) [8, 9] (see Fig. 1(b, c, d)).

For roof opening cabin the remaining family members are placed at two different positions relative to Duke. One position is 5mm from the elevator walls for each (the longest distance from the phone user) denoted “far” (Fig.1 (e)), and the second is 5mm from Duke (the shortest distance from the phone user) denoted “close” (Fig.1 (f)). For free space and completely metallic cabin configurations, only “far” position is considered.

Results & Discussion

The averaged 10g SAR is presented at Fig. 2(a, b) for 1000 MHz and 1650 MHz, for the three no-phone-use passengers. Free space values are also presented. Cheek phone position creates the lowest values of SAR 10g (or SAR 1g – not shown here), at both operating frequencies for the three no-phone user passengers. At “close” roof opening configuration, the peak 10g averaged SAR has larger values than “far” configuration, for the pregnant woman at 1000 MHz; while at 1650 MHz has larger values for both pregnant woman and 8 years old Dizzie, more emphasized at tilt and vertical phone positions.

In general, pregnant woman has higher 10g SAR and whole body SARwb from Dizzie and Roberta children. Roberta has always the lowest maximum averaged SAR values when compared with the other passengers for each case, probably because of her position. For the full metal elevator cabin and tilt phone position configurations the highest whole body SAR values and power absorbed are found. The pregnant woman absorbs more power than the two children, but has lower SARwb due to higher mass.

In Fig. 3 (a) maximum 1g SAR values for 1000 MHz are presented for the cases of full metallic enclosure and roof opening for Duke. For reference free space results are also included. The “far” configuration is considered for the family case (denoted by Duke 4p) and obtained results are compared against the case when Duke is alone in the elevator [17] (denoted by Duke solo).

All peak SAR values found are higher for Duke 4p at cheek phone position, while at vertical position Duke-solo has higher value. The differences are smaller for SARwb and absorbed power for both operating cell phone frequencies (not shown here).

Finally, it has been calculated that the absorbed power by Duke is slightly affected by the relative position of the other family members (Fig.3 (b)).

Conclusion

We investigated the SAR values and the power absorbed for a family inside an elevator when one family member is using a mobile phone. From the obtained results we can see that the cheek phone position creates the maximum peak SAR values for the phone user and the tilt phone position creates the lowest peak averaged SAR values. The peak averaged SAR values over 1g (not shown) and 10g of mass for the three no-phone user passengers are much lower than the corresponding ones for the phone user. Still, they depend on the relative to the phone user position, the phone position and the elevator cabin type. In addition the absorbed power from the phone user is slightly affected from the presence and the position of the other passengers inside the elevator.

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References


Figures
Figure 1. (a) Numerical Mobile Phone model (105 x 28.5 x 10 mm\(^3\)) and positioning points on phone and human model (not in real scale). (b) mobile phone “vertical” position (c) “tilt” position and (d) “cheek” position, in relation with Duke, (e) “far” and (f) “close” positions of the human models inside the elevator cabin roof opening.
Figure 2. Graphic representation of SAR-10g [W/Kg] at “far” and “close” configurations, for 7th month pregnant, Dizzie and Roberta at free space, full metal and roof opening cabins for operating frequency of (a) 1000 MHz and (b) 1650 MHz, Pin = 1 W.
Figure 3. Graphic representation of (a) SAR 1g [W/Kg] for Duke with 3 other passengers inside the elevator cabin, “far” configuration, denoted with “Duke 4p” and Duke alone inside the elevator, denoted “Duke solo”, at operating frequency of 1000 MHz and Pin = 1 W, (b) power absorbed by Duke inside the roof opening elevator cabin with 3 other passengers inside, at two different positions “far” and “close”, at operating frequency of 1650 MHz and Pin = 1 W.

PA-129 [19:00]
Where is your phone? A survey of where adolescents and women aged 12-40 carry their mobile phone and related risk perception
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Smart phones are now owned by almost three quarters of US adolescents and young adults.¹ Exposure to radiofrequency electromagnetic fields (RF-EMF) from background data traffic during standby can be considerably higher than used to be the case. This is due to ongoing activity from applications running in the background on uplink and downlink. Very little is known about current mobile phone carrying habits of young women. This survey uses an online questionnaire. It asks participants about where they carry, store and hold their mobile phone under a variety of circumstances, and about related...