ORIGINAL ARTICLE

Health response of two communities to military antennae in Cyprus

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Occup Environ Med 2007;**64**:402–408. doi: 10.1136/oem.2006.028894

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Accepted 19 January 2007
Published Online First 25 January 2007

Objectives: This study investigated concerns that have been raised about past and future health effects caused by high power transmissions of high frequency (7–30 MHz) radio waves from military antenna systems at Akrotiri, Cyprus.

Methods: A cross-sectional study of three villages (two exposed, one unexposed) collected longitudinal and short-term radiofrequency measurements. Health data were collected using questionnaires containing information on demographic factors, specific illnesses, general health (SF-36 well-being questionnaire), reproductive history, childhood illnesses, risk perception and mortality. Analysis was with SPSS v11.5 using cross tabulations of non-parametric data and tests for significance. Key health outcomes were subjected to logistic regression analysis.

Results: Field strengths within the two ''exposed'' villages were a maximum of 0.30 (Volts/Vm^{-1} metre) from the 17.6 MHz military transmissions and up to 1.4 Vm^{-1} from unspecified sources, mainly cell phone frequencies. The corresponding readings in the control village were <0.01 Vm^{-1}. Compared with the control village there were highly significant differences in the reporting of migraine (OR 2.7, $p<0.001$), headache (OR 3.7, $p<0.001$), and dizziness (OR 2.7, $p<0.001$). Residents of the exposed villages showed greater negative views of their health in all eight domains of the SF-36. There were also higher levels of perceived risk, particularly to noise and electromagnetic ''pollution''. All three villages reported higher values of risk perception than a UK population. There was no evidence of birth abnormalities or differences in gynaecological or obstetric history. Numbers of cancers were too small to show differences.

Conclusion: It was clear that even this close (1–3 km) to powerful transmissions, the dominant sources of radiofrequency fields were cell phone and national broadcast systems. There was no excess of cancer, birth defects or obstetric problems. There was heightened risk perception and a considerable excess of migraine, headache and dizziness, which appears to share a gradient with radiofrequency exposure. The authors report this association but suggest this is unlikely to be an effect of radiofrequency and more likely to be antenna visibility or aircraft noise.

The Akrotiri salt lake site is part of the UK Sovereign Base Areas Administration (SBAA) in Cyprus and contains a military air base and a large antenna array. The proposal to build a larger phased array (Pluto 2) to supplement the existing Pluto 1 antenna was greeted with demonstrations and media campaigns. The inhabitants expressed fears about cancer and childbirth problems, and cited concerns expressed in other countries that had led to restrictions outside the usually accepted International Commission on Non-Ionizing Radiation Protection (ICNIRP) levels[1] for radiofrequency exposure. Indeed the operational guidelines used at the time were National Radiological Protection Board (NRPB)[2] levels that were some five times higher than ICNIRP since the former did not distinguish public and occupational exposure differences. The public are to some extent confused because different countries have set different levels,[3] for ''precautionary'' reasons related to possible non-thermal effects. Thermal effects and their consequences are well established, and national guidelines, albeit at variance[3] with each other, have been set out to control these. However non-thermal effects have been seen to occur at low levels and probably represent no more than minor physiological responses.[4]

At a public meeting there was a call for a health survey to be linked to measurements of the fields from the military system. To meet these requirements the SBAA agreed to set up a monitoring antenna in Akrotiri village that relayed data to the Ministry of Telecommunications in Nicosia, and to commission this health survey (under the direction of the Ministry of Health, Cyprus) that began in June 2001. The survey consisted of two distinct elements: a health survey and a measurement survey.

METHODS

Subjects

A cross-sectional survey was conducted across three sites: the ''exposed'' sites of Akrotiri village and the smaller community of Asomatos, and the ''unexposed'' Pano Kyvides. This enabled comparisons to be made between the exposed communities and non-exposed village for both the electromagnetic field (EMF) profiles and health information collected. The spatial relationship of the villages and the antenna site is shown in figure 1.

Questionnaires

The prevalence of specific symptoms and diseases among the residents of all three communities was investigated using specifically designed questionnaires, a risk perception survey, and the collection of health and mortality data from available registry and other sources. Different questionnaires were used for age and gender specific issues:

1. The adult questionnaire comprised four sections. The first was concerned with basic demographic information. The second contained a list of 11 specific conditions or illnesses

Abbreviations: EMF, electromagnetic field; ICNIRP, International Commission on Non-Ionizing Radiation Protection; NRPB, National Radiological Protection Board; SMR, standardised mortality ratio

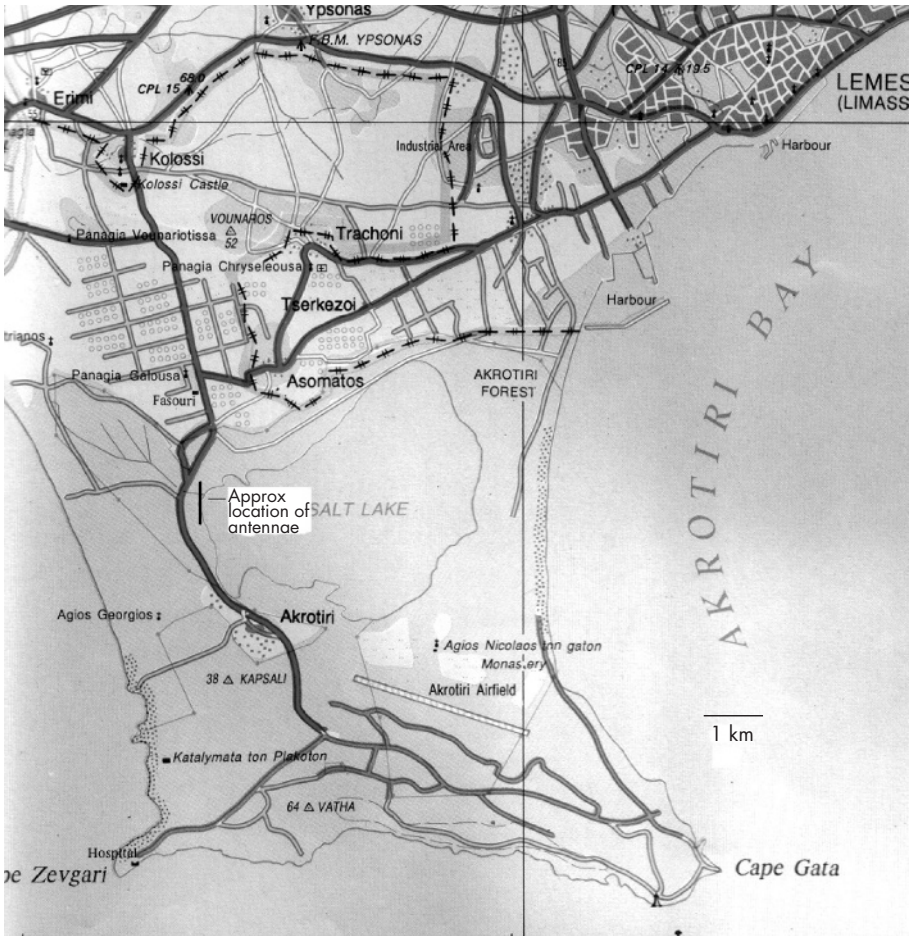

Figure 1 Location of antenna array in relation to Akrotiri and Asomatos. Note that the control village was approximately 15 km to the northeast of the antenna site (obtained from the Department of Land and Surveys, Cyprus).

under a general header ''Have you had any of the following conditions?'' and included, among others, migraine, headache and dizziness. Previous research[5–8] conducted on the health of populations living near broadcast media sites and electricity installations, provided an indication of the diagnoses and disease patterns of interest. This section went on to explore certain health behaviours such as smoking and mobile phone use, which may have a confounding effect on other responses. The third section used the SF-36 as a standard measure of health status. The SF-36 is a multipurpose, short-form health survey with only 36 questions. It yields an 8-scale profile of functional health and well-being scores as well as psychometrically-based physical and mental health summary measures and a preference-based health utility index.[9] Our version was a validated instrument in Greek obtained from the suppliers. Finally, the fourth section was concerned with an individual's relative perceptions of risk. A series of questions, previously developed at Bristol University, UK from a Swedish Occupational Health study and also used in the US,[10–12] was adapted for use with regard to proximity to military antennae. Respondents were invited to consider a series of situations and apply a ''risk category'' to each on a 5-point scale. The majority of items were identical to questions that had been used in the UK so that cultural comparisons would be possible.

2. The female questionnaire was an additional questionnaire for completion by all female residents of the communities aged 18–50 years. Previous research had suggested that electromagnetic field exposure may be associated with certain reproductive health effects,[13] and so this questionnaire was concerned with reproductive history including pregnancy, miscarriage, fetal loss and infertility.

3. The child questionnaire concerned the health of children under 16 years.

All questionnaires were translated into Greek and back translated into English.

Questionnaire data analysis

Analysis was carried out using a standard statistical package (SPSS v11.5). Most of the analyses were simple cross-tabulations for non-parametric data using the Pearson χ^2 test. Logistic regression analysis was used on four key outcome variables—migraine, headache, dizziness and depression. Models were developed incorporating all independent variables that had been shown to have an association with the particular outcome. This was assessed using the Pearson χ^2 statistic ($p<0.05$). These were entered in a stepwise way based on their level of association.

Mortality data collection

As official sources of mortality data were insufficient for our purpose, an alternative approach was used. Each family was asked to complete a questionnaire concerning family members (resident in the village) who had died within the previous 10 years. Details pertaining to the cause of death and the attending physician were requested. Data were then checked later against hospital records to confirm diagnosis. Because of the interest in brain tumours and leukaemia, special attention was paid to checking the cause of death and the site of specific cancers.

Table 1 Percentage of respondents reporting health problems or illnesses, percentage for each of the eight SF-36 domain scales and results of risk perception on a scale of 1 to 5

	Akrotiri (%)	Asomatos (%)	Pano Kyvides (%)		p Value
Condition					
Migraine	23.1	14.8	9.9		<0.001
Headache	51.3	35.1	22.2		<0.001
Dizziness	35.7	20.9	10.2		<0.001
Depression	10.2	9.7	3.9		0.002
Name of scale					
Physical functioning	75.7	70.7	80.9		<0.001
Role physical	71.4	71.5	81.0		0.001
Bodily pain	72.1	71.2	79.9		0.001
General health	55.2	56.9	59.6		0.025
Vitality	56.7	55.4	62.9		<0.001
Social functioning	72.3	70.8	82.4		<0.001
Role emotional	74.2	73.3	82.4		0.004
Mental health	64.6	63.1	73.6		<0.001
Risk perception statement	Score	Score	Score	Total	
Smoking	4.58	4.03	4.36	4.40	<0.001
Passive smoke	4.63	4.41	4.64	4.60	0.007
High alcohol consumption	4.64	4.55	4.62	4.62	0.515
Moderate alcohol consumption	3.54	3.15	2.36	3.01	<0.001
High fat diet	4.35	4.37	3.87	4.16	<0.001
Low fibre diet	3.80	3.72	3.51	3.67	0.001
Sedentary lifestyle	4.11	4.17	3.81	4.00	<0.001
Exposure to industrial chemicals	4.83	4.62	4.81	4.79	0.001
Living near nuclear power plant	4.85	4.75	4.87	4.84	0.104
Living near electric power station	4.45	4.55	4.24	4.39	0.001
Radioactive fallout from nuclear plant	4.88	4.86	4.85	4.87	0.802
Living near mobile phone transmitter	4.26	3.83	4.01	4.10	<0.001
Living near an overhead powerline	4.66	4.42	4.64	4.62	<0.001
Using a mobile phone	3.82	3.21	2.95	3.39	<0.001
EMF exposure overhead powerline	4.69	4.37	4.70	4.65	<0.001
EMFs from home appliances	2.37	2.68	2.13	2.31	<0.001
Living near a military antenna	4.85	4.62	4.62	4.73	<0.001
Exposure to noise	4.58	4.02	4.05	4.29	<0.001
Exposure to poor air quality	4.70	4.54	4.66	4.66	0.086
Driving twice legal limit of alcohol	4.81	4.82	4.86	4.83	0.383
Involved in RTA when sober	4.31	3.05	4.35	4.16	<0.001
Radiation exposure medical *x* ray	2.44	3.60	2.36	2.59	<0.001

EMF, electromagnetic field; RTA, road traffic accident.

Additionally, an estimate of the number of deaths was made from the cemeteries. Information on age and date of death was collected from the gravestones. These methods (though crude) provided the only possible mechanism for calculating standardised mortality ratios (SMRs) for all three sites.

Radiofrequency field measurements

Radiofrequency measurement was carried out using Delta T environmental multichannel loggers (Delta-T Devices Ltd, Cambridge, UK). Inside each of three loggers two radiofrequency amplifiers were connected to an antenna and signals approximately band-passed at below and above 100 MHz. The units were calibrated at 27 MHz (high frequency) and 900 MHz (ultra high frequency) with 1 Vm^{-1} signals. The outputs of the amplifiers were recorded every 10 min for maximum, average, and minimum signal for the high and ultra high frequency channels during the 10 min interval. One was sited on the upper floor of the Akrotiri community centre and later at the local bank, another at Asomatos Greek Orthodox Church behind the altar, and the third at Pano Kyvides medical centre. Measurements of the military Pluto antenna were undertaken on two occasions using a spectrum analyser, fed by a calibrated vehicle-mounted antenna, coupled to a computer and GPS. The military powered the antenna with 100 kW constant wave at 17.6 MHz and steered the beam either south towards Akrotiri or north to Asomatos whilst the vehicle was moved to key points in the village. Simultaneously a Narda handheld field meter (EMR 20C; Narda Safety Test Solutions, Pfullingen, Germany) was used to record the integrated field strength from all sources from 100 kHz to 3 GHz. Maximum operational power for that antenna was 500 kW. One limitation was that the constant wave transmission was available only after airfield operations, effectively at night, and subject to short notice cancellation.

RESULTS

Response rates

The estimates of the numbers of people living in each village were: 800 in Akrotiri, 350 in Asomatos and 1000 in Pano Kyvides. Questionnaires were distributed to all households, with an overall response rate of 87%. Individual village response rates were Akrotiri 87%, Asomatos 77% and Pano Kyvides 92%

Adult questionnaire: general personal information

There was no overall significant difference between villages when looking at age or gender ratio. The differences in marital status were of borderline significance. There were small differences in educational level that were just significant ($p = 0.048$) but there was no consistent pattern. There were significant differences in the number of years that adults had lived in each of three villages. For those who had lived in their village for >20 years the percentage for Akrotiri was 77.6%; for Pano Kyvides 72.9%; and for Asomatos 57.6%. There was no difference in smoking and mobile phone ownership between the three villages. On the question of frequency of mobile phone use there were significant differences ($p = 0.013$). The

percentage results for several times a day were 74.3% for Akrotiri, 68.9% for Asomatos and 81.1% for Pano Kyvides.

Adult questionnaire: health

There were significant differences by village for the seven conditions: migraine, headache, dizziness, depression, asthma, heart problems and other respiratory problems. No significant differences were found for diabetes, epilepsy, diseases of the nervous system, cancer or leukaemia. Asthma was present in 9.4% of adults in Asomatos compared with 3.2% in Akrotiri and 3.1% in Pano Kyvides. 7.2% experienced other breathing/lung problems in Akrotiri, compared with 5.6% in Asomatos and 2.9% in Pano Kyvides. There were significant differences in heart problems between the villages, with Asomatos showing 16.2% of the adult population compared with 10.5% in Akrotiri and 7.1% in Pano Kyvides.

There were highly significant differences by village for migraine, headache, dizziness and depression. Table 1 shows the percentage of adults complaining of those symptoms for each of the three villages. For migraine, headache and dizziness there was a marked gradient with Akrotiri having the highest figures and Pano Kyvides the lowest.

Further analysis was undertaken to describe the association of these conditions with other factors.

Migraine

Given the highly statistically significant association between village and migraine ($p<0.001$) logistic regression was carried out with migraine as the outcome variable. The reference district was Pano Kyvides and odds ratios were calculated for both Akrotiri and Asomatos against the reference village. The unadjusted odds ratio for Akrotiri was 2.73 ($p<0.001$, 95% CI 1.826 to 4.091). Initially the logistic regression model was developed by adding first one and then two independent variables in a stepwise way. Estimates were terminated at iteration number 5 because parameter estimates changed by less than 0.001.

In the final model (table 2) the average perceived risk score, age, smoking and mobile phone use were not significant. The variables that remained significant in the model ($p<0.05$) were two of the higher educational levels (adjusted odds ratio 3.26 95% CI 1.34 to 7.93; and adjusted odds ratio 2.38 CI 1.15 to 4.95), female gender (adjusted odds ratio 5.5 95% CI 3.35 to 9.03) and living in Akrotiri (adjusted odds ratio 3.32 95% CI 2.14 to 5.15). The Hosmer and Lemeshow goodness of fit test suggested a good match (χ^2 5.670, 8 df, significance level 0.684.). The full output from the logistic regression analysis is shown in table 2.

Table 2 Migraine: logistic regression analysis final table*

Education to university	Reference Odds ratio	95% CI lower	95% CI upper
No education	2.37	0.82	6.87
Education to age 12	3.26	1.34	7.93
Education to age 15	2.22	0.87	5.61
Education to age 18	2.38	1.15	4.95
Age group†	0.90	0.71	1.13
Gender (female)	5.50	3.35	9.03
Smoking	0.77	0.45	1.31
Mobile phone	1.02	0.62	1.67
Risk score (median used)	0.91	0.627	1.31
Village			
Village (1)	3.32	2.14	5.14
Village (2)	1.56	0.86	2.85

*All risk factors were considered within a single statistical model.
†Age was not significant as decades, nor as <40 vs 40 and over, which is shown here.

Headache

A logistic regression was carried out with the odds of experiencing headache in villages one and two against village three. It demonstrated significantly greater unadjusted odds of headache in Akrotiri (OR 3.69, $p<0.001$, 95% CI 2.71 to 5.00) and Asomatos (OR 1.89, $p<0.002$, 95% CI 1.26 to 2.85). Both gender and educational level stayed in the model. Gender showed an OR of 2.84 (95% CI 2.00 to 4.04). The adjusted OR for Akrotiri were 4.16 (95% CI 2.96 to 5.84) and for Asomatos 1.78 (95% CI 1.14 to 2.79). The Hosmer and Lemeshow goodness of fit test was χ^2 10.65, 8 df, significance level 0.222.

Dizziness

The adjusted odds ratios were significant for gender (OR 3.32, 95% CI 2.18 to 5.05); Akrotiri (OR 5.64, 95% CI 3.69 to 8.62) and Asomatos OR 2.37, 95% CI 1.37 to 4.12). The Hosmer and Lemeshow goodness of fit test was χ^2 15.77, 8 df, significance level 0.046.

Depression

The adjusted odds ratios were significant for gender (OR 3.00, 95% CI 1.54 to 5.84), Akrotiri OR 3.82, 95% CI 1.89 to 7.74) and Asomatos (OR 3.45, 95% CI 1.50 to 7.97). The Hosmer and Lemeshow goodness of fit test was χ^2 6.64, 8 df, significance level 0.595).

Adult questionnaire: SF-36

This section contained the 36 questions that comprise the validated health questionnaire, the SF-36. There are eight scales and each scale value is a number between 1 and 100. Table 1 gives the values of each scale by village and illustrates the extent of the differences in self-reported health between the villages. The similarity between Akrotiri and Asomatos contrasts with the results from the control village.

Adult questionnaire: risk perception

The final section of the adult questionnaire asked questions about risk perception. There were 22 questions and respondents were invited to select one of five comments: ''no possible harm''; ''low harm''; ''moderate harm''; ''high harm''; or ''extremely high harm''. Table 1 shows the mean score for each of the three villages, together with the total for all villages and the significance value of the differences between villages.

Computed perceived risk score

The average risk score for each subject was computed. Analysis showed that there was a significant difference between the villages (χ^2 80.67, 2 df, $p<0.001$. Residents in Akrotiri had the highest perception of risk across the whole range of risks.

Table 3 Incidence of reported conditions and infections in the three villages

	Akrotiri (%)	Asomatos (%)	Kyvides (%)	p Value
Condition				
Migraine	7.4	1.8	0	0.001
Headaches	12.9	10.7	2.8	0.001
Dizziness	7.1	5.6	1.9	0.045
Infections				
Lung or chest infections	11.8	18.2	5.5	0.006
High temperatures	78.6	61.0	65.7	0.009
Rubella (German measles)	6.7	21.1	12.4	0.013
Mumps	1.3	9.4	4.4	0.029
Tonsillitis	36.8	53.7	34.6	0.034
Measles	7.3	9.1	2.4	0.041

Table 4 Standardised mortality ratios using the different mortality data

	Akrotiri	Asomatos	Pano Kyvides
Questionnaire	0.97	1.01	1.50
Cemetery	1.37	1.53	1.60
National records	1.26	2.01	1.32

Residents in Asomatos were intermediate and those in Pano Kyvides showed the lowest perceived risk.

Female questionnaire

Eighty three per cent of women who completed this questionnaire had been pregnant. Miscarriages were reported by 35%, terminations of pregnancy by 17%, infant deaths by 12%, stillbirths by 4.6%, births of less than 2500 grams by 9.2% and births that arrived more than three weeks early by 9.7%. On average 8.1% of respondents reported problems with conception. Analysis of the female questionnaire indicated that there were no significant differences between villages with regard to pregnancy and childbirth.

Child questionnaire

The male:female ratio was 48.7:51.3 and the differences between villages was not statistically significant. There were no differences in the ages of the children between villages or in the number of abnormalities at birth: Akrotiri (4), Asomatos (6) and Pano Kyvides (8).

There were no significant differences for diabetes, asthma, other breathing and lung problems, epilepsy, depression, heart problems or cancer. There were, however, significant differences in relation to migraines, headaches and dizziness (table 3)

With regard to infections there were no differences between villages for head cold, chicken pox, pneumonia, meningitis, otitis media, skin infections, urinary tract infections and glandular fever. There were significant differences among the infections.

In five of the six infectious diseases where there were significant differences between villages, Asomatos had the highest percentage.

Qualitative data

Adult questionnaire

The majority of comments were provided by the residents of Akrotiri. The presence of the antennae dominated these responses. Comments also included reference to aircraft noise (because of the topography, noise was sudden and certainly startled researchers making readings in Asomatos), but the overwhelming majority of comments made reference to the antennae and the ''effect'' on health. The consensus of opinion recorded was that the antennae ''damaged'' health. The responses from both Akrotiri and Asomatos when viewed together suggested that these communities firmly believe that their health was being damaged by the antennae. Residents' perception of the risk involved was, in many ways, as important as the actual risk.

Female questionnaire

Women providing comments did not make any reference to the military antennae. This is very different from the other questionnaires that definitely associated health problems with exposure.

Child questionnaire

All the additional comments provided came from the exposed sites. The military antennae (perhaps unsurprisingly) were the concern of almost all the respondents. There was anxiety that the antennae were damaging the future health of the children living in the villages.

Mortality

Overall mortality and standardised mortality ratios

The Cyprus Ministry of Health has good information on age-specific death rates for all causes on a national basis, based on the 2001 population census. Death information is based on the three-year period from 2001 to 2003. The annualised age-specific death rates were applied to the census population for each village to provide an expected number of deaths: Akrotiri, 4.76; Asomatos, 1.78; and Pano Kyvides 3.92.

The calculation of the standardised mortality ratio (SMR) required information on the actual number of deaths. There were three different ways of calculating ''observed'' deaths: mortality questionnaires, cemetery information and national records.

There was a discrepancy between the three methods of calculating the SMR suggesting that we do not have any satisfactory method of determining the effect of any extraneous factor specific to location.

Results of the measurement study

The results of spot measurements in Akrotiri and Asomatos are summarised below and covered the limits and key points within the village. Readings were all in Vm^{-1} that can be converted to power density by the formula:

$$\frac{V^2}{377}\ Wm^{-1}$$

Field measurements of the radiofrequency during a 100 kW transmission were as follows: for Akrotiri in 12 different locations, the average broadband outdoor field strength (all sources, military, civil and broadcast) was 0.57 Vm^{-1} (SD 0.24, max 1.04, min 0.19), and for the military transmission at 17.6 MHz was 0.11 Vm^{-1} (SD 0.09, max 0.29, min 0.002).

For Asomatos in 14 locations, the average broadband was 0.46 Vm^{-1} (SD 0.32, max 1.38, min 0.10), and for the military transmission was 0.04 Vm^{-1} (SD 0.02, max 0.64, min 0.012).

Readings from the loggers, being inside buildings, were generally lower and did not exceed 1 Vm^{-1} at any time over the study period, consisting of a maximum of 0.57 Vm^{-1} from the high frequency transmissions and up to 0.9 Vm^{-1} very high frequency from unspecified sources, possibly nearby cell phone use. The average logger readings for all 10-min samples over the period in Akrotiri were 0.050 Vm^{-1} (there were long ''quiet'' periods) for high frequency and 0.110 Vm^{-1} for ultra high frequency, and 0.040 Vm^{-1} and 0.060 Vm^{-1} respectively in Asomatos. The corresponding readings in the control village were <0.01 Vm^{-1} for both high and ultra high frequency, and this was confirmed with the handheld meter. That village had no cell phone mast nearby and the nearest broadcast antenna was more than 10 km.

DISCUSSION

In common with many other countries, the population of Cyprus show concerns about exposure to EMFs. In most countries this is focused on cell phone masts and broadcast systems, leading to claims of hypersensitivity and other poorly defined health effects such as cancer and birth defects.[14] In 1999 the inhabitants of Akrotiri, in particular, voiced concerns

about the presence of large antenna arrays. These concerns escalated to extensive civil unrest, the imprisonment of a politician and an attack on a police station. Assurances from the Sovereign Base Area Administration (SBAA) that all transmissions met international guidelines for safety were not accepted by the local community.

Measurement in individual houses would have been desirable, but considered not feasible: the attenuation due to walls is highly variable necessitating personal data logging or multiple measurements, and this will differ for different frequencies. The military transmission on a particular frequency that could be tracked was only available when normal operations were shut down. This depended on field operations and ionospheric conditions, and for short times. This was incompatible with house-to-house appointments and measurement. Also the effect of raising awareness of radiofrequency exposure was considered undesirable. Although this resulted in a lack of accurate exposure assessment and an overestimate, exposure was in fact exceedingly low. The field measurements consisted of a set of longitudinal samples over two years taken at 10-min intervals, at central locations in all three villages. These were broadband, to include the military frequencies as well as broadcast and civilian communication frequencies. In addition, with the collaboration of the SBAA, limited high power measurements were made of the equipment of main public concern, namely the Pluto high frequency system covering 10–30 MHz. This enabled the contribution of the military system to public exposure to be assessed. The longitudinal measurements addressed the concerns of residents that there were no emissions of any extraordinary nature taking place while there was no surveillance. The questionnaire analysis has shown that the three villages were in fact reasonably well matched demographically and provided an appropriate basis for the comparison of exposed and unexposed populations.

The measurement study during military transmission confirmed an average value of 0.57 Vm^{-1} in Akrotiri and 0.46 in Asomatos. In Pano Kyvides the levels were <0.01 Vm^{-1}. The other sources were various broadcast antennae, in particular the cell phone mast in Akrotiri. It seems unlikely that the electromagnetic level was contributing to the neurological symptoms reported by those living close to the antenna.

A number of important issues emerged from the questionnaire results. Firstly, the responses to the adult health questionnaire provided significant differences between the villages (and not just between exposed and unexposed). In Akrotiri there was increased reporting of migraine, headache, dizziness and depression. A similar trend was noted in Asomatos although at lower levels. There is a consistent literature that cognitive and neurological effects are associated with EMF exposure. However, this is normally found at higher levels and higher frequencies and associated with mobile phone use, as covered in detail in the Stewart Report.[4] There are also reports of similar effects at lower levels, such as associated with mast exposure.[15 16] In particular the study by Hutter *et al*[15] shows remarkable similarities in the relative risk for headache and dizziness (vertigo) for those ''exposed'' compared with the ''unexposed'' population. The field strengths are also of similar magnitude.

The adult questionnaire was designed to explore general physical and mental health using a standard validated instrument (SF-36) and risk perception. The results showed significant differences between the two exposed villages and the unexposed. It is possible to compare the results from this study with other values from studies in Greece. One of these studies was in hospital staff, a healthy working population, by Tountas *et al* in 2003.[17] The values for that study were as follows (the figures in brackets are the results from Akrotiri): physical functioning, 84.2 (75.7); role physical, 75.7 (71.4); bodily pain, 74.4 (72.1), general health, 69.0 (55.2); vitality, 63.5 (56.7); social functioning, 69.5 (72.3); role emotional, 74.1 (74.2) and mental health, 66.6 (64.6). This perceived low health status may well have been causing distress and anxiety, which may in part explain the reported neurological symptoms. The risk perception sections of the questionnaire shows that Akrotiri respondents had a higher level of perceived risk than the other two villages. For example they showed a high level of concern for external and physical factors including noise and electromagnetic pollution.

Similar studies in the UK have produced a lower mean risk score (2.6) and lower values for all the 22 variables. Although it is not possible to compare the score between one question and another, this does indicate a particular bias in risk perception for Akrotiri (median 4.41) compared even with Asomatos (median 4.27), and Pano Kyvides (median 4.14). This is surprising, as Akrotiri and Asomatos are approximately equidistant from the antennae, although it has to be said that the antennae were more visible from Akrotiri because of the topography. However this result may also in part explain the observed symptoms. In comparison with the results found in the UK, all three villages scored highly, possibly reflecting a national difference. Furthermore, the analysis of the open comments provided in all three questionnaires demonstrated a heightened state of anxiety concerning the presence of the antennae. The consensus of opinion recorded was that the antennae ''damage health'', albeit in an unspecified manner.

Given the importance of the high levels of neurological symptoms reported in Akrotiri the information provided by the adult questionnaire gave the opportunity to analyse the relative importance of location (ie, village) in explaining this outcome. The logistic regression analysis confirmed the importance of village, but also the contribution made by several other key factors including gender and education.

The visibility of the antennae from each village and the amount of aircraft noise appears to be positively related to an

Main messages

- Health effects (within the WHO definition) can occur when there is perceived to be exposure to radiofrequency, and may be related to anxiety.
- Other factors which are associated, such as aircraft movement and noise, could be contributory.
- Actual radiofrequency exposure can be very low in spite of proximity to very high power systems.
- A cell phone base station is likely to be a dominant source because it is within the community.

Policy implications

- Consideration needs to be given to dissemination of information from a trusted source to allay anxiety.
- Visibility of sources of radiofrequency is likely to be as, if not more, important than actual exposure, and consideration of planning issues is required when deciding on location.
- Alternatively, consideration needs to be given to separating communities from perceived sources of threat.

increased reporting of health problems or illnesses (ie, migraine, headache, dizziness) and higher perceived risk scoring, with Akrotiri having the highest figures and Pano Kyvides having the lowest figures. These three symptoms reported are similar to those in many, if not all, of the studies of electrical hypersensitivity.[18–20] Hypersensitivity to EMFs has reportedly been associated with a general increase in sensitivity and anxiety, even though provocation experiments with EMFs have not been able to demonstrate an objective association.[21]

The findings from the female questionnaires do not provide evidence of any differences between exposed and unexposed sites in gynaecological and obstetric history. Miscarriage has been associated with exposure to high levels of EMFs in previous studies; however, this has not been found in this research.

No evidence of birth abnormalities was found in the child questionnaire, although this phenomenon is suggested by the wider literature.[14] There were, however, significant differences in the reporting of migraine, headache and dizziness, with exposed sites reporting increased incidence.

These present results are in accordance with a recently concluded study in the US on PAVE PAWS radar on Cape Cod. The local inhabitants were anxious about the health effects from the ultra high frequency radar system which, although in a higher frequency range than PLUTO and of higher power density, had many similarities in being a phased array and beamed at a low angle. A study carried out by the US National Academy of Sciences concluded that there was no evidence of a health hazard, in particular no increased cancer risk. However a recommendation of continued epidemiological studies has been made.[22]

In summary this study has established that the levels of EMF exposure in all three sites are comparable with many civilian urban situations (a thousand times lower than recommended guidelines), with the majority of exposure coming from broadcast or cell phone systems. We could find no evidence of increased cancer incidence, childhood illness or negative reproductive effects. The only health effects identified in the exposed sites were headaches, migraine, dizziness and depression. These symptoms are surprisingly similar to the results of Hutter *et al*[15] on subjective symptoms in subjects living near mobile phone base stations showing that, despite very low exposure to high frequency EMF, effects on well-being and performance cannot be ruled out and that the symptom of headache had the highest significant relation to measured power levels.

The results of the Akrotiri study do not exclude the possibility that proximity to EMF sources have an effect on well-being and health. However the field levels do not suggest any causal association. Part of the explanation could be heightened risk perception. Proximity to the antennae may also be associated with general pollution, including noise.

ACKNOWLEDGEMENTS

This work was funded through the Cyprus Ministry of Health. In particular we wish to thank the village leaders for their kindness and support, and the staff of the Ministry of Health for their help and guidance.

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