

Imperial College
London

Airwave Health Monitoring
Pilot Report

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1. Background

The aim of the Airwave Health Monitoring Programme is to investigate any possible health impact on Police personnel related to the use of Airwave, the new communications system for the Police in England, Wales and Scotland. The programme addresses needs raised in the report by the National Radiological Protection Board's Advisory Group on Non-ionizing Radiation on "Possible health effects from TETRA" (AGNIR 2001).

The specific objectives of the research programme are as follows:

- a) To pilot among police personnel within two police forces (West Midlands and Lancashire) the necessary procedures and mechanisms to administrate a health questionnaire, health screening and TETRA data collection for long-term health monitoring (see objective (3)).
- b) To conduct an electroencephalogram and cognitive study to examine the relationship between TETRA use and psychological wellbeing, or cognitive/neurophysiologic function. The study will be based on TETRA exposure (high vs. low) and symptoms (symptomatic vs. asymptomatic) in three samples of Police personnel (50 in each) recruited from the initial pilot.
- c) Following the pilot phase, to conduct long-term health monitoring of the whole Police Force (England, Wales and Scotland) via procedures developed during the pilot.

2. Headline summary

Part (a) (above) has been completed. Key outcomes from the pilot phase are as follows:

- Enrolment health questionnaire (EHQ) designed and rolled out among designated pilot Forces (West Midlands and Lancashire)
- In addition, South Wales Force included in pilot phase
- Roll-out of EHQ currently in progress in Leicestershire Force
- 4,511 Police enrolled in programme to date
- 40% enrolment response rate
- Returned EHQs electronically scanned and stored on private network at Imperial
- Quality assurance checks performed
- 3,186 health screens requested
- 71% screening response rate (overall)
- Agreement with PITO to obtain national Airwave call record data every month
- Electroencephalogram and cognitive study – volunteers booked to start in first quarter of 2006
- Independent Ethics Governance Committee (EGC) established

3. Enrolment Health Questionnaires (EHQ)

During the Pilot phase, the EHQ was rolled out to potential participants in Lancashire and West Midlands. South Wales Force was also included in the pilot. The purpose of the questionnaire was to: (a) secure consent thereby allowing the researchers to track participant's health in the future and (b) provide the opportunity to sign up for health screening.

Questionnaire Versions

Although only one generic questionnaire was developed, we implemented it in three different versions during the pilot. This reflected our growing knowledge of what works with this cohort, and what does not. A brief history of the three versions is below:

- **Version 1.0** was the original 28-page questionnaire that covered a wide range of subjects from general health issues to specific points relating to the use of the Airwave radio. Although this version was relatively comprehensive, it proved to be unpopular with participants, principally because of its size.
- **Version 1.1** cut down the original questionnaire to 8 pages, removing several sections about general health and merging some of the Airwave questions. It resulted in a better response rate than Version 1.0. The response rate improved from 20 to 40%.
- **Version 1.2** was a slightly modified version of 1.1 that posed essentially the same set of questions as its predecessor, but added extra contact information.

Analysis of EHQs

EHQ data have been loaded onto the Imperial servers and reports created for health screen requests. Tables below indicate the volumes of completed questionnaires received and numbers of health screens conducted from the beginning of the programme until December 2005.

Table (1): Lancashire Force

		Airwave user status		Total
		Yes	No	
<i>Health screen requested</i>	Yes	924	816	1,740
	No	260	210	470
	<i>Total</i>	1,184	1,026	2,210

Table (2): West Midlands Force

The following figures are for all responses in West Midlands, including the initial Command Units targeted by the pilot.

		Airwave user status		Total
		Yes	No	
<i>Health screen requested</i>	Yes	510	88	598
	No	246	37	283
	<i>Total</i>	756	125	881

Table (3): South Wales Force

		Airwave user status		Total
		Yes	No	
<i>Health screen requested</i>	Yes	838	10	848
	No	569	3	572
	<i>Total</i>	1,407	13	1,420

Table 4: Response rate by Force

	Lancashire	West Midlands***	South Wales	Grand Total
Total contacted	5,500	1,068	4,000	10,568
Total returning EHQ*	2,210 (40%)	466 (43%)	1,420 (36%)	4,096 (39%)
Health screening**	1,740 (79%)	315 (68%)	848 (60%)	2,903 (71%)

* % in brackets = Total returning EHQ / total contacted x 100

** % in brackets = Total health screens / total returning EHQ x 100

*** Figures in West Midlands here refer to the original sample of 1,068 personnel from command units K1, K2, Force Traffic Unit, Air Operations, Firearms, and dog unit.

Reliability of scanning process

Quality assurance checks were performed to test the reliability of scanning answers from the EHQ. A detailed internal report has been written, but the key finding is that the quality of scanned data was good. Occasionally, there were questionnaires where selected boxes were crossed out and another chosen instead. The scanning process made the correct selection in every example found. It also succeeded in translating what were ambiguous letters and numbers from poor hand-writing.

Future Plans for EHQ

Although the EHQ was successful in enrolling Police personnel in the programme, decreasing its size further may improve response rates. Therefore, the questionnaire has been split into two separate formats:

- A new EHQ with a single page of questions about general health and Airwave use, plus consent to join the programme (currently being trialled in Leicestershire).
- A new questionnaire will be completed by participants when they attend health screening. It will incorporate questions from the original EHQ + others relating to the health screen itself.

4. Sickness

Sickness reported by cohort members is an end-point of the programme and must therefore be measured in some form. However, based on the pilot, we can conclude that obtaining reliable

data on employment and sickness is likely to be difficult. The main problem is that there are approximately 43 Forces, each of which seems to have its own method of recording sick leave, and no standard form of data interchange. The recent implementation of standard statutory performance indicators (SPIs) means that indicators such as number of hours sickness absence per officer (e.g. SPI 13 a and b) *should* be available. This requirement will be specified when Forces are contacted during the continued rollout of the programme.

5. Tracing and flagging individuals

The ability to trace health events of individual cohort members is central to the programme, and it is achieved in two stages. Firstly, NHS numbers for consenting individuals based on name, date of birth and address are obtained using the NHS tracing service. Secondly, the NHS number is used to flag individuals notified with serious illness at the Office of National Statistics (ONS). The first stage has been successfully tested during the pilot. The second stage is currently being tested. There appear to be no unforeseen reasons why such a strategy cannot be implemented.

6. Confidentiality and consent

Each person on the research team has undergone Home Office security clearance. Premises and security procedures used in the programme have also been checked by the National Crime Squad/SOCA. Individually identifiable data collected in the programme are handled in strictest confidence by the Research Team and are not available to any third party including the Home Office, or any Police Force. When the Research Team makes public the results of the study in any form, including within the scientific and medical literature, it will not be possible to identify any individual participant in the programme.

A multi-stage process has been adapted for enrolling participants in the programme. Firstly, written consent is required in the main enrolment questionnaire. This is vital, as otherwise, we are not able to enter the person into the study – the consent allows the researchers to check participant's health in the future via medical records. Secondly, at the health screen, consent is required for measuring, storing and analyzing data related to weight, height, blood pressure, ECG (trace) and lung function. Separate consent is required for collecting, storing and analyzing biological samples (blood and urine). All biological samples collected are barcode labeled to allow precise tracking of samples and protection of participants' identities. Information linking the barcode to each participant is kept confidentially at the Department of Epidemiology and Public Health, Imperial College.

NHS Research Ethics approval has been obtained and in addition, an independent Ethics and Governance Committee (EGC) has been appointed to advise the Airwave Study Steering Committee on ethical aspects of the conduct of the study, and on ethical aspects of research projects which intend to use the Airwave dataset and sample collection. The EGC consists of 4 expert members, and lay members appointed by the Police Federation and UNISON.

7. Health Screening

The pilot phase has been successful in screening ca.3,000 individuals. The systems and methods used in the pilot are currently being further developed to improve overall service efficiency with a projected re-launch date during the first quarter of 2006.

Issues & Goals in Delivering Health Screening

Measures of health that are collected manually by the nurse are entered onto a laptop application designed for the purpose. HTML forms were built to collect the data that the nurse obtains from the examination. The forms run on a standard browser, but unlike normal use, the source files are stored locally rather than on a remote website. This means that the laptop can be “offline” during the screen. On completion of each clinic, the data is saved using the “post” method, which results in an email being created and queued locally on the machine.

For the nurse, this method involves loading the form (which is the default page), entering the participant’s details and pressing a “submit” button. The form has extensive error checking (e.g. to check that measured values are within the typical range). At the end of the day, or whenever convenient, the nurse connects the PC to a telephone line, establishes a point-to-point connection to a Mailserver run by the Airwave Programme at Imperial and uploads the results. For security reasons, the Mailserver is connected to a modem but has no other network connections. Once received at Imperial, the mail is saved onto disk and merged into a spreadsheet application designed for the health-screening feedback. Macros written using the Excel VBA language are used to validate the data and prepare it in a form for feeding back to participants. The feedback process itself is implemented using mail-merge into a Microsoft Word document.

Data Security

The transmission and storage mechanism is secure and protected against most types of data loss. The results are stored in the email client’s “Sent Items” box after having been uploaded to Imperial; so, if data are lost in transit they can be easily recovered. If the mail-item is accidentally deleted from the Outbox before transmission, it will be retained in Deleted Items indefinitely. To protect against loss of data through loss or failure of the PC itself, the completed forms can be printed after each session. Finally, the emails themselves are stored on an NTFS-encrypted disk. Therefore, in the worse case scenario whereby a PC is lost or stolen, the data are protected by password against intrusion.

Managing ECGs and blood sample results

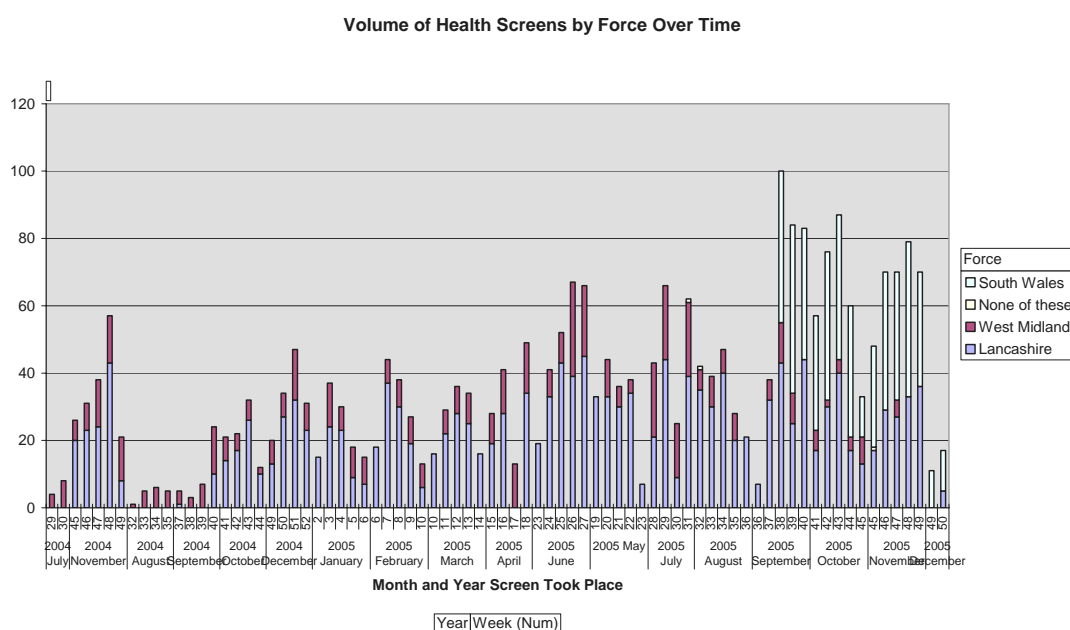
The ECG data are stored on the dedicated ECG machines and transmitted in batches to Glasgow CARE. Analysis is carried out at Glasgow and results returned to Imperial in summary form within two weeks, and in detailed form once a month. Only the summary information is required for feedback to the participant, and this is entered manually into the feedback system.

Blood samples collected at the clinic are analyzed by Imperial College. It should be noted that no identifiable information is stored at the lab and all blood and urine samples stored are barcoded to protect the anonymity of participants. Nurse laptop results are then integrated with ECG results and blood analyses to produce a single confidential report for feedback to each participant (home address is used) and their GP (if requested).

Appointments scheduling

Standardized procedures have been adopted (where possible) to establish an efficient health screening programme. This involves the following stages: setting up a contract with a nursing organization; training nurses; setting up screening venue(s) and purchasing equipment; setting up interface meetings between nursing company and Police HR; security vetting of

nursing staff; establishing screening list from completed enrolment questionnaires (data held on the Private Network at Imperial). The participant contact process has been piloted several ways: (a) Police Human Resources set up appointments; (b) Nurses contact participants and arrange appointments; (c) Participants arrange appointments. The preferred approach is that Human Resources make the appointments and advise the participant that they are expected to attend. This seems to result in a lower non-attendance (NA) rate than if the participant makes their own arrangement. NA rates in Lancashire were $\leq 7\%$. During the course of the programme, a significant number of people (260 in Lancashire) were recruited in the programme at a later stage, via the health screen. In such cases, the nurses have been advised to provide enrolment questionnaires to ensure these participants are correctly enrolled in the long-term programme. The figure below reports the volume of screens conducted by Force during the pilot period:



8. Analysis of CDRs

The plan for the Pilot was that CDRs would be collected from each Force on a month-by-month basis. The Airwave Health Programme is founded on a need to link the measured TETRA exposure of each cohort user over the 15-year life of the Programme. The only practical method of achieving this is to collect CDRs that define this usage and link them to members of the cohort. CDRs are collected by the Network Operator, Airwave O2, and provided to each Force monthly.

In the contract for this Programme, it was anticipated that each CDR would contain a data field – the ISSI – that embeds the user's Collar Number within it. The study team would collect CDRs from the forces each month and match them to the cohort, thereby building up a profile of usage over a long period. This has proven to be only partly achievable, the problems being centred around the logistics of obtaining data from each Force, and linkage.

Briefly:

Obtaining CDRs

Although CDRs were obtained from Lancashire Constabulary from 2001 through till September 2004 on CD (directly from the Force), it has proven to be impractical to collect CDRs from every Force each month. Instead, Imperial have secured from PITO an agreement to send us in a single monthly package the whole country's Airwave CDRs on DVD. This was implemented during the Pilot and data from May till October 2005 have already been received, with historical data from January 2005 expected in early 2006.

CDR Linkage

Simple ISSI-based linkage to collar number has been implemented by Lancashire and South Wales. For personal handsets, the Collar Number of the user is embedded directly in the ISSI Number field in the CDR, thus allowing the researchers to determine which participant is incurring Airwave exposure. This has been verified for Lancashire by a Manchester University study carried out by Martie van Tongeren, David While and Simon Mann: *Investigation of Airwave Patterns of Use amongst Police Officers of Lancashire Constabulary*.

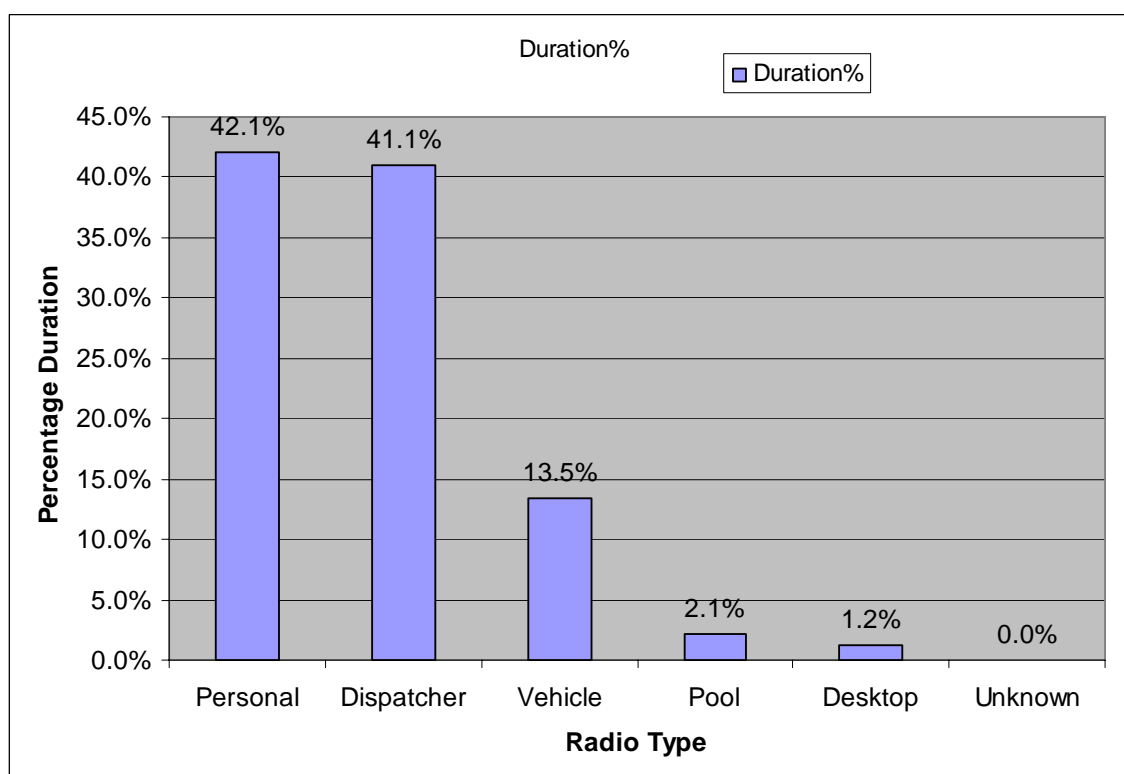
Although only hand-held terminals can be linked in this way, this contributes a substantial proportion of the usage (see figure below), and it's considered unlikely that dispatcher terminals or vehicle terminals would present significant risk as the antennae are physically some distance from the user. Further research is currently investigating TETRA exposure from vehicle terminals (principally Phil Chadwick at MCL). The progress and results from this research will be monitored closely.

Non ISSI-based Linkage

In West Midlands, however, Airwave terminals are assigned dynamically to individuals, breaking the direct link between ISSI and Collar Number. Although there seem to be systems in development that will enable us to link West Midlands CDRs using data from its inventory management systems, this has yet to be implemented. In the medium term, it may be possible to link individuals to CDRs by their logon identifier, and when this becomes available Imperial will seek to take advantage of it. In the short to medium term, however, the national rollout plan must be influenced by the availability of linkable CDRs, preferring those Forces where linkage is understood to those where it is not.

Usage and Analysis of CDRs

Analysis has been carried out on CDRs from Lancashire and South Wales to determine profiles of usage. This was done partly to check that we could analyse CDRs in the way we expect, and partly to identify potential volunteers for the high and low exposure cohorts of the neuro-cognitive study. Basic analyses on CDRs have been performed to verify that the pattern of usage of individual handsets over the course of 24-hour segments accords with likely shift patterns. Further analyses will be performed during the main roll-out to check CDR data against actual shift rosters. For the main study, we will build long term aggregates of exposure by study participants.

Lancashire CDRs by Terminal Type (2004)**9. National roll-out of programme**

National roll-out of the programme involves two main components:

(a) Enrolment in the long-term health monitoring programme via the enrolment health questionnaire (EHQ) and (b) organization of health screens.

(a) Enrolment: We aim to enrol all Forces in England, Wales and Scotland within the next 2.5 years. A draft study implementation document has been written and will be finalized and published in the first quarter of 2006. Its purpose will be to act as a planning tool when contacting new forces with a view to rolling out the EHQ and/or health screening. Currently, Lancashire and South Wales Forces have completed enrolment. Leicestershire and West Midlands are ongoing. The next phase will involve contacting the following Forces: Lothian and Borders; Staffordshire; Gwent; West Yorkshire; Greater Manchester; National Crime Squad, Cheshire and Merseyside.

(b) Screening: We estimate that the whole process for enrolling an average sized Force using the EHQ is approximately 60 days (in total). In contrast, the time for conducting and completing health screening in an average sized Force is approximately 50 weeks. Therefore, while we aim to enrol (a) and screen (b) in tandem where possible, for most Forces it will not be feasible to maintain a contiguous link between enrolment and screening – i.e. there will be a significant time delay between enrolment (via the questionnaire) and screening. One way of helping to alleviate this situation (to some extent) will be to organize regional health screening venues that will provide the opportunity for individuals to sign into the health screening programme earlier than planned (if this is requested).

10. Electroencephalogram (EEG) and cognitive study

The primary aim of this part of the Programme is to determine whether Airwave has any significant effect on the psychological wellbeing, or cognitive/ neuro-physiological function of users. Possible acute as well as acute-on-chronic effects will be explored.

Participants are being selected according to their degree of Airwave exposure as assessed from Airwave records, and according to whether or not they report adverse symptoms, based on results of the initial pilot.

Three groups of participants will be defined:

- i. High exposure, asymptomatic
- ii. Low exposure, asymptomatic
- iii. Symptomatic

Effects will be determined by provocation tests using a blinded randomized design, that is, the participants will be assessed both with and without Airwave exposure in an order unknown to the participant or experimenters.

All participants for the asymptomatic groups will be serving Police personnel from the Forces included in the pilot study. For the symptomatic group, Police are being recruited from the same sources but self-referrers from other Forces are also included. High and low levels of exposure have been defined from analysis of TETRA records from Airwave O2, also in the pilot study. Similarly, the definitions of '*symptomatic*' and '*asymptomatic*' will be determined from the symptom reports obtained from the Pilot phase.

Technical issues

Using a phantom head (glass-fibre head shape filled with a sucrose and salt solution that has permittivity and conductivity values comparable to a human head), our first assessment of the available EEG recording system's behaviour in presence of an Airwave signal showed that although the carrier wave frequency is well outside the bandwidth of the system, variation in the envelope of the signal caused by the 17.6Hz modulation was detected, along with higher harmonics (at 35.2Hz, 70.4Hz and upwards) and appeared as interference at these frequencies in the recordings. This report thus outlines the main methods that have been tried to reduce the problem of interference between the Airwave handset and the EEG recording system, grouped according to the critical areas where interference might be introduced to the recording system.

a) At the electrode/scalp interface:

Different commercially available electrodes have now been tested and we found that silver/silver chloride (Ag/AgCl) sintered electrodes were giving the best results.

b) The lead between the electrode and the pre-amplifier:

Several types of ferrite suppressor, a widely used technique for reducing both incoming and outgoing RF were tested; we found that a ferrite sleeve placed just outside the pre-amplifier proved to be the most effective (reducing the interference by approximately 50%). We have also made different recording leads from different types of commercially available coaxial cables, and found a further reduction in interference levels.

c) At the pre-amplifier itself:

Pre-amplification of the EEG signal is performed in a headbox positioned within <1m of the participant's head. The standard headbox is plastic and offers no effective protection from the RF signal. To overcome this problem, we built a metal box which encloses the headbox and acts as a Faraday cage. The use of the metal box made a significant improvement in reducing interference levels.

Furthermore, following advice from Roger Blackwell at the National Radiation Protection Board (NRPB), we have investigated the use of pi-network feed-through filters. The use of these low-pass filters, aimed particularly at eliminating high frequency RF interference, required further re-designing of the headbox shielding and connections. However, the pi-filters plus the extra design work further reduced the interference to no more than the background noise level.

Conclusions

We have now solved the technical problems related to reducing the interference level between the Airwave radio and EEG machine. Having started with an interference level of $\sim 3\mu\text{V}$, by adding ferrite sleeves and pi-filters to a redesigned shielded headbox, and using coaxial screened recording leads, interference has now been reduced to $\sim 50\text{nV}$; a reduction of $>80\%$ ($\sim 16\text{dB}$). Having solved these technical problems, recruitment of Police personnel started in December 2005. We have received a good response from the Police and the study commences with participants at the end of January 2006.