The Airwave Health Monitoring Study of police officers and staff in Great Britain: Rationale, design and methods

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A B S T R A C T

Background: The Airwave Health Monitoring Study was established to evaluate possible health risks associated with use of TETRA, a digital communication system used by police forces and other emergency services in Great Britain since 2001. The study has been broadened to investigate more generally the health of the work force.
Methods: From 2004, participants from each force who agreed to participate were enrolled either with an enrolment questionnaire or a comprehensive health screening performed locally. This includes questionnaire, 7-day food diaries, anthropometry, measurements of cardiovascular and cognitive function, blood chemistry, coagulation and haematology. Blood and urine samples are stored in vapour phase liquid nitrogen allowing long-term access for biochemical or genetic analysis. Access to the resource is via an access committee and a steering committee, including external scientific advisers as well as representatives of the police officers and staff.
Results: By the end of 2012, the study had recruited 42,112 participants, of whom 35,199 (83.6%) had attended the health screening. Almost two thirds of participants were men and 71% of them were a TETRA user. Being in lower ranks (constable/sergeant and staff) was associated with a worse cardio-metabolic risk profile compared to higher ranks (inspector or chief inspector, superintendent and above).
Conclusion: The Airwave Health Monitoring Study is the only large-scale cohort study of police employees worldwide. The specificities of this sample, such as its well-defined job hierarchy, make it a particularly valuable occupational cohort. Participants have consented to the use of their data and samples for future, currently unspecified, research purposes.

1. Introduction

Terrestrial Trunked Radio (TETRA) is a digital communication system adopted progressively by police forces and other emergency services in Great Britain since 2001. It uses a TETRA-based national network provided by Airwave Solutions Limited. TETRA differs from GSM (Global System for Mobile Communication) mobile phone technology in two important respects. First, the average output power of TETRA hand portables can, in some circumstances, exceed those from GSM900 and GSM1800 mobile phones. Second, TETRA transmission is pulsed at 17.6 Hz (1/56.7 ms) whereas mobile phones transmission is pulsed at 217 Hz (1/4.6 ms).

In 2000, the Independent Expert Group on Mobile Phones (Stewart Report) suggested that exposure to signal modulation at or around 16 Hz might have adverse effects on health (Independent Expert Group on Mobile Phones (IEGMP), 2000) based on experimental findings of increased calcium efflux from brain tissue (Bawin et al., 1975). While brief exposure to TETRA signals did not affect cognitive function or subjective symptoms in two double-blind randomised trials (Nieto-Hernandez et al., 2011; Riddervold et al., 2010), no human epidemiological or occupational study had yet explored the possible long-term health risks associated with TETRA use.

In response to recommendations of the Stewart Report, the Home Office iScotland commissioned Imperial College London in 2003 to investigate the feasibility of setting up a cohort study of the British police forces. This study would aim to evaluate possible health risks associated with the use of TETRA. A target sample size of at least 60,000 participants was set to give sufficient power to detect a wide range of health outcomes. To account for the period of latency between initial exposure and onset of disease, participants would be

followed up for at least 15–20 years. The Airwave Health Monitoring Study was launched in June 2004 with a pilot study in two forces, completed in 2006, before being rolled out nationally on a force by force basis. During the pilot, it was found that addition of a health screen boosted recruitment and gave an additional incentive for officers and staff to take part. The collection of extensive phenotypic data and the long-term storage of biological samples allow the investigation of research questions beyond the primary aim of the study. The Airwave Health Monitoring Study will therefore also investigate the health of the police force more generally.

2. Materials and methods

2.1. Inclusion procedure

The Airwave Health Monitoring Study is open to all 54 police forces in Great Britain, including police-related agencies that use Airwave and that are funded by the Home Office. In January 2012, a total of 259,283 people worked for police forces in Great Britain (155,892 police officers, 93,040 police staff, 7888 police community support officers and 2463 special constables) (Association of Chief Police Officers, 2012). The Airwave Health Monitoring Study aims to recruit over 60,000 participants by 2018. The study has ethical approval from the National Health Service Multi-site Research Ethics Committee (MREC/13/NW/0588).

Since the launch of the study in 2004, a total of 28 forces have so far agreed to participate. The study includes two phases. First, every employee receives the enrolment questionnaire via routine administration or the occupational health service. The second phase is a health screen performed locally by trained nurses using a standardised protocol (Fig. 1). Participants can attend the health screen irrespective of their participation in phase 1 and their Airwave usage. In phase 2, volunteers are recruited through general force-wide publicity (emails, wall posters, and articles in newsletters), word of mouth or direct contact if they request a health

screen on their enrolment questionnaire. Police employees who do not belong to one of the forces enrolled, but who are in close geographical vicinity to an Airwave clinic may also attend. Employees are allowed in-work (abstraction) time to attend the health screen which usually takes around 40–50 min. Results of biological and clinical measurements from the health screen are mailed to the participants and, with consent, to their general practitioner (GP), usually within two months of their appointment. More rapid referral is done where indicated, e.g. for high blood pressure or abnormal electrocardiogram (ECG) requiring urgent medical attention.

The time between the enrolment and the health screening phase is determined by logistical constraints and varies between 6 months and one or more years. Participants sign a consent form permitting use of their data and samples for future research (specific consents are given for long-term blood and urine sample storage).

As of 31 December 2012, data on 42,897 individuals were included in the database. Among those, 322 individuals had an invalid consent (0.7%), most often because they forgot to sign the consent form at the end of the enrolment questionnaire (317 out of 322). To date, only 3 participants have withdrawn from the study during follow-up (0.007%). In addition, a number of individuals could not be linked to National Health Service (NHS) records. This occurred when either individuals provided insufficient detail to be traceable in the enrolment questionnaire ($n=394$, 1%) or when they could not be uniquely identified. For example, the NHS Information Centre Medical Research Information Service (MRIS) and the General Register Office for Scotland (GROS), cannot identify individuals who do not update their details after changing name and address ($n=66$, 0.1%). (Numbers of linked participants may increase as participants update their details with the NHS.) Therefore, 42,112 participants with linkage to NHS number were considered enrolled as of 31 December 2012 (98.2% of the total number of individual records, 196,541 person years; median follow-up=4.9 years).

Once participants are flagged by the NHS, we are able to follow them for morbidity and mortality events throughout the lifetime of the study unless they leave the United Kingdom ($n=24$, 0.06%), enrol in the armed forces ($n=28$, 0.07%) or are not registered with a GP ($n=71$, 0.17%).

Some 16% of participants completed only phase 1, 58% completed only phase 2 and 26% completed both (Fig. 2). Excluding the pilot study, the cohort enrols on average 50% of police forces' employees once both phases are complete
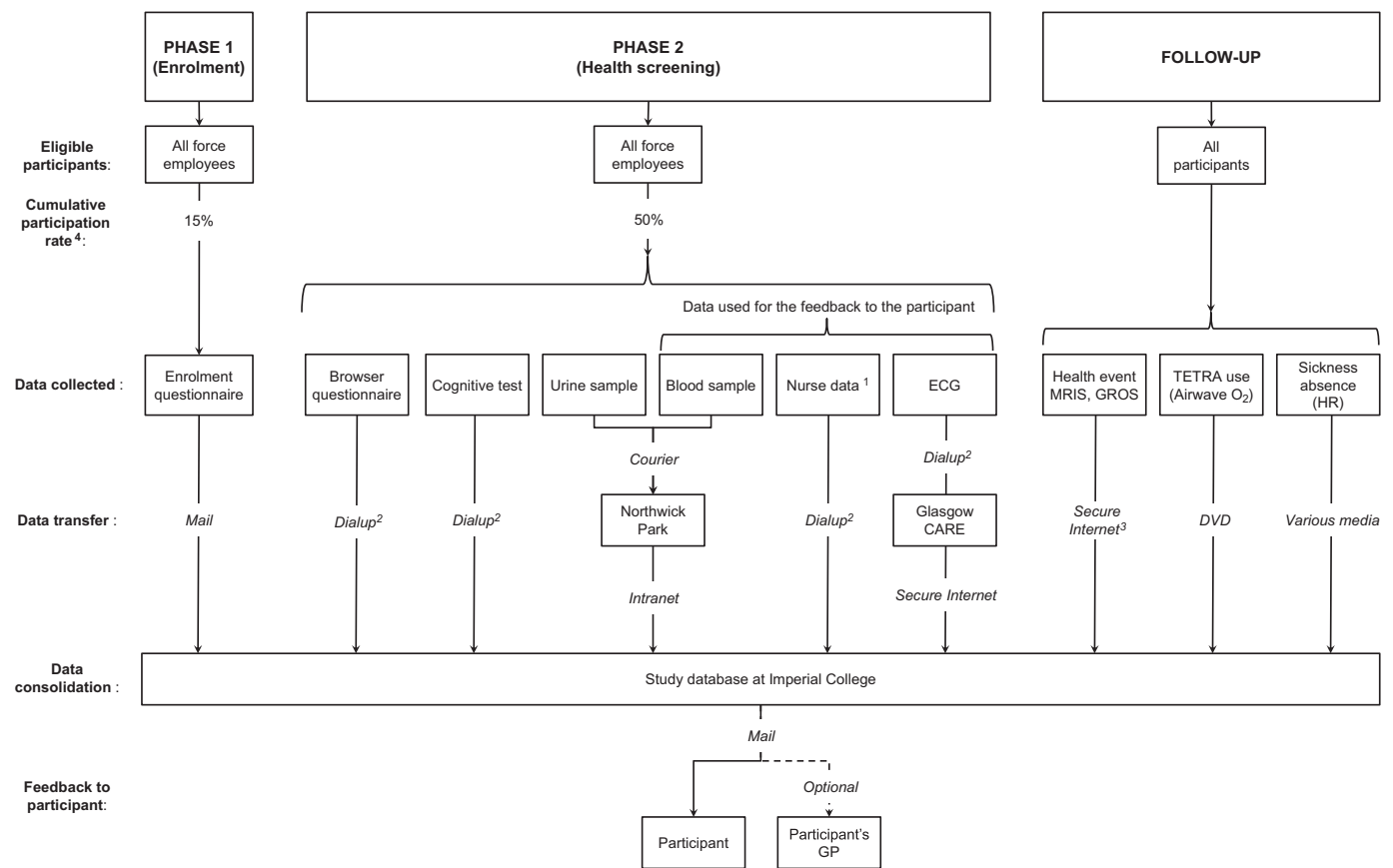
Fig. 1. Study design. [1]Nurse data include nurse interview and clinical measurements (blood pressure, anthropometric measurements, and arterial stiffness). [2]Internet access via telephone lines, [3]through MRIS/GROS website, and [4]excluding the 2 pilot forces. CARE: Computer Assisted Reporting of Electrocardiograms; ECG: electrocardiogram; GP: general practitioner; GROS: General Register Office for Scotland; HES: Hospital Episode Statistics; HR: Human Resource; MRIS: Medical Research Information Service; and TETRA: Terrestrial Trunked Radio.
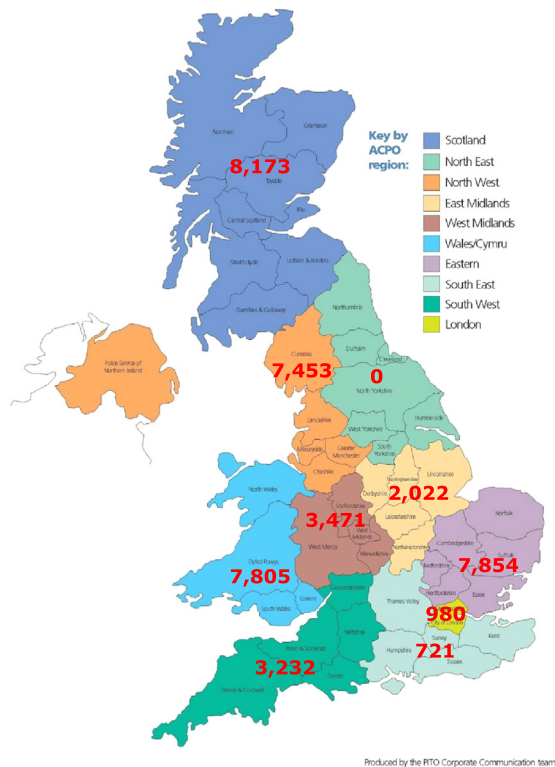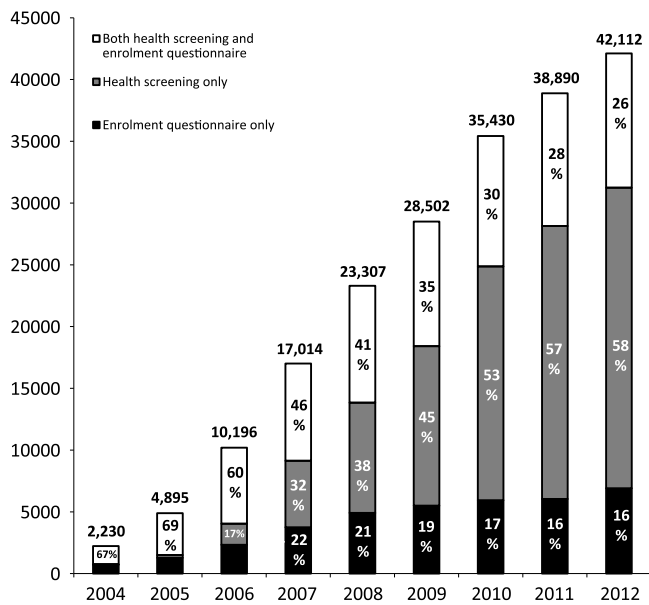
Fig. 2. (A) Cumulative enrolment from 2004 to 2012. (B) Enrolment per region by the end of 2012.

(Supplementary Table 1). In most forces, the percentage of men and the average age of participants were similar to those of the work force as a whole (Supplementary Table 1).

2.2. Questionnaire data

In phase 1, the participant fills in a short questionnaire including demographic, health and lifestyle information, and Airwave usage (Supplementary Table 2). Before the health screen, the participant is asked to complete a record of usage of the Airwave system (see below), and a seven-day food diary. At the health screen, the participant fills out an extensive questionnaire on a touchscreen computer, with questions on socio-economic status, work environment, Airwave usage, mobile phone usage, health and lifestyle (Supplementary Table 2). This questionnaire takes 10–30 min to complete.

2.3. Clinical measurements

During the health screen, the nurse measures blood pressure, arterial stiffness, weight, height, sitting height, waist and hip circumferences, body composition and performs an ECG. Details of each clinical measurement are provided in Supplementary Table 3.

2.4. Cognitive test

A cognitive test (taking 12 min) comprising six computerised tests is performed at the health screen on a self-access computer. These tests assess the four main cognitive domains: memory, processing speed, attention and executive function (Lezak et al., 2004). Details concerning the cognitive test are provided in Supplementary material.

2.5. Blood and urine samples

Blood and urine samples are obtained at the screening visit (with consent) and stored for future research use. Blood samples are spun at the clinics, stored in a thermoporter (Laminar Medica) and sent overnight from the clinics by courier to a dedicated laboratory for analysis. The blood samples are either analysed next day for haematology, coagulation and biochemistry tests or frozen for long-term storage. In addition, to date, 2016 participants have been genotyped using the Illumina Infinium HumanExome-12v1-1 BeadChip Array (Supplementary Tables 2 and 4); in 2013–2014, a total of 15,000 further participants are to be genotyped using the Illumina HumanCoreExome BeadChip Array.

Blood and urine samples are stored at -80 °C at the laboratory, before being transferred to a bio-repository facility at Hammersmith Hospital (London, United Kingdom) which is the primary long-term storage location for the samples. The samples are stored in vapour phase liquid nitrogen allowing long-term access for biochemical or genetic analysis. Samples for which consent has not been obtained for long-term storage are destroyed. All samples are stored in barcoded tubes. Supplementary Table 5 describes the amounts and types of biological material stored in the bio-repository.

The repeatability of health screening data (both clinical and biological) based on repeated visits for up to 310 participants to date is detailed in Supplementary material and Supplementary Table 6.

2.6. TETRA data

2.6.1. Reported TETRA usage

In both enrolment and clinic-based questionnaires, we ask participants to provide extensive information about their TETRA usage: year starting Airwave radio, usual usage for the different types/modes of radio, location of the radio, number of calls and minutes during the last shift for the different types/modes of radio, pool radio usage and working hours in operation room. Since July 2009, we have also been sending, to Airwave users only, a 7-day TETRA usage diary one week prior to the health screen for completion and return to the nurse on the day of their health screen.

2.6.2. Objective data on TETRA usage

Computerised records of Airwave use for individual police officers are being obtained from the network provider (Airwave O$_2$) for the duration of the study. All TETRA radios are assigned an Individual Short Subscriber Identity (ISSI) number. For some of the forces, this ISSI number can be linked to a police officer's collar number. Duration and number of base stations used for each individual call are obtained for personal radios. Among the 19 police forces that completed both phases of the study, as of 31 December 2012, ISSI numbers could be linked to collar numbers for 14 forces (Supplementary Table 1). In total 516 GB (zip format – 1.2 million files) of Airwave usage data have so far been obtained.

2.7. Data collection, storage and protection

Completed enrolment questionnaires are returned to the study team (via a self-addressed envelope attached to the questionnaire) for scanning into electronic format. Special arrangements are made for forces where greater security is required.

Health screening data are collected on a variety of devices for daily upload to the study team at Imperial College (Fig. 1). The participant is assigned a unique barcode that is used to link all the data collected during the screening. A pre-configured laptop accumulates all these data and uses a point-to-point dialup connection to upload results to the study database. For security reasons, the uploaded data accumulate on an off-network computer that is dedicated to this purpose. The data are then transferred periodically to the study database held on a private network, comprising computers that are dedicated to the study and used

Table 1
Descriptive statistics by gender [a].

	Women	Men	Total
N (%)	15,640 (37.1)	26,472 (62.9)	42,112
Age (years) (n=42,112)	38.5 (9.4)	40.9 (8.9)	40.0 (9.2)
Marital status (%) (n=30,729)			
Married	47.4	69.6	61.1
Cohabiting	20.8	14.7	17
Single	18.2	7.3	11.5
Divorced/separated	10.5	6.8	8.2
Other	3	1.5	2.1
White (%) (n=31,653)	97.5	96.5	96.9
Education (%) (n=31,636)			
Left school before taking GCSEs[b]	3.4	4.3	4
GCSE or equivalent[b]	27.9	32	30.5
Vocational qualifications	7.3	6.8	7
A levels or equivalent	31.6	32.4	32.1
Bachelor degree or equivalent	21.3	19	20.3
Postgraduate qualifications	7.4	5.4	6.2
Rank (%) (n=27,089)			
Police staff	50.1	16.6	29.3
Police Constable/Sergeant	43.8	71.3	60.8
Inspector/Chief Inspector	2.7	8.7	6.4
Other	3.4	3.4	3.4
Smoking status (%) (n=40,441)			
Non-smoker	65.2	68.7	67.4
Past smoker	21.9	21.6	21.7
Current smoker	12.9	9.7	10.9

[a] Means (SD) are presented for age and percentages are presented for all other variables; n refers to the number of participants for whom each variable is available.

[b] GCSE: General Certificate of Secondary Education.

exclusively by the study team. There are no external connections of the study database to any other network (including the Internet).

All data for each participant (i.e. enrolment questionnaire, health screening, blood results, event data, TETRA usage from Airwave O_2 and Human Resources data) are linked together and consolidated into an Oracle database. A feedback of the health screening results is mailed to participants (and to their GP with consent). Statistical analyses are performed on the private network using SAS version 9.3 (SAS, Cary, NC) and on the Imperial College High Performance Computing cluster for genetic and other computer intensive analyses.

2.8. Follow-up

Health outcome data are obtained by linking information on individual participants to national records on mortality, cancer incidence (MRIS and GROS) and hospitalisations through the Hospital Episode Statistics (English participants); the process of obtaining in-patient and out-patient hospitalisations for Welsh and Scottish participants is ongoing. We will also seek access to participants' GP records.

For the duration of a participant's police career, we obtain from some police forces (i) Human Resources (HR) records of absence from duty caused by sickness; (ii) HR records of dates and reason for leaving the employ of the force and (iii) computerised TETRA records which are used to estimate TETRA usage as well as shift patterns for TETRA users. By the end of 2012, 16 of 19 forces that completed phase 1 and 2 had provided HR data or computerised TETRA usage records (Supplementary Table 1). A follow-up questionnaire of all participants enrolled to date is planned for 2015.

3. Results

Almost two thirds of the participants are men (Table 1). Average age at enrolment was 40.9 years for men and 38.5 years for women; 96.9% of the sample is white. Overall, 11% of the study population were current smokers (Table 1), 23% were obese (body mass index ≥ 30 kg/m^2), and 38.8% of men and 14.2% of women had hypertension (Table 2). Almost three quarters of the cohort reported being Airwave users (Table 3a). Users were younger (38.8 vs. 43.1 years old on average) and more often men than non-users (71.2 vs. 42.1%). The majority of users were police officers (i.e. Police Constable/Sergeant or Inspector/Chief Inspector) whereas the majority of non-users were police staff. Users reported

working with Airwave for three and a half years on average. Personal radios were the most commonly used (95%) followed by car mounted radios (56%). Around three quarters of personal radio users reported using their radio a lot/all the time, including during their last shift (12 min of calls on average in the last shift) (Table 3b).

4. Discussion

The Airwave Health Monitoring study was designed to evaluate possible health risks associated with TETRA use. To improve exposure characterisation, extensive work is being done to estimate TETRA use from three different sources: reported previous day use from questionnaire, seven-day usage diary, and objective TETRA call records linked (where possible) to the individual. Various markers of exposure to TETRA signals including duration and frequency of calls, radio types and modes will be explored. These will be based on the extensive data collected both by questionnaire and through capture of computerised records of usage (where these can be reliably linked to the individual). As noted, health outcomes are being captured by linking information on individual participants to national records on mortality, cancer incidence and hospitalisations (and in the future GP records). Linkage to sickness absence data (by specific cause) from the HR departments of police forces is also being carried out for a sub-sample of the participants. In the short term, we will study the associations between TETRA use and sickness absence during follow-up. In the long term, we will estimate prospectively the associations between TETRA use and cancer incidence and other health outcome data.

Beyond studying the possible health risks associated with TETRA use, the particular population and the large amount of data available in the Airwave Health Monitoring Study make it well suited to explore various other research questions. These include social differentials between job ranks and assignments and the impact of stress and job strain on health, as well as the consequence of highly stressful events and shift working patterns specific to the police forces. The extensive questionnaire data, clinical and biological information, the linkage to health events and the long-term availability of biological samples will permit investigation of a wide range of research questions relevant to the police forces and to all men and women of working age.

The Airwave Health Monitoring Study has a number of important strengths. It is the only observational cohort worldwide that is evaluating the possible health effects of TETRA use, and is also the only large-scale cohort study of police employees worldwide. Only a few small cohort studies have been set up in the police forces of other countries including the United States (Fekedulegn et al., 2013; Franke et al., 1998; Kleinman et al., 2011), the Netherlands (van der Velden et al., 2013) and Israel (Amster et al., 2013). The Airwave Health Monitoring Study cohort includes both men and women from all regions of Great Britain. It recruits adults of working age, including large numbers of men in their 20–40s, who have been under-represented in other large cohort studies (Cohort Strategic Review Subgroup, 2014.) The link to routine data sources through the NHS, as well as sickness absence data, provides extensive information on the health of the cohort during follow-up. Contact with the police force administration that keep records of their employees' career development, and pension records for retired participants will facilitate maintaining contact with the cohort participants and mitigate against loss to follow-up.

The extent of TETRA usage information available is without precedent for a study of this size. In addition to two self-reported estimates (1-day use and seven day diary), objective TETRA computerised records will allow us to estimate cumulative usage

Table 2
Clinical and biological measurements by gender[a].

	Women	Men	Total
N (%)	13,239 (37.6)	21,960 (62.4)	35,199 (1 0 0)
BMI (kg/m^2) (n=35,117)	26.1 (4.8)	28.1 (3.7)	27.3 (4.3)
BMI < 25 kg/m^2 (%)	48.7	19.1	30.2
25 kg/m^2 ≤ BMI < 30 kg/m^2 (%)	33.9	54.6	46.8
BMI ≥ 30 kg/m^2 (%)	17.3	26.3	23.0
WC (cm) (n=34,846)	82.3 (11.6)	94.8 (9.8)	90.1 (12.1)
WC < 80/94 cm (W/M) (%)	47.1	48.0	47.7
80/94 cm ≤ WC < 88/102 cm (W/M) (%)	24.8	30.4	28.3
WC ≥ 88/102 cm (W/M) (%)	28.0	21.6	24.0
SBP (mmHg) (n=35,131)	123.1 (14.1)	136.2 (13.6)	131.3 (15.2)
DBP (mmHg) (n=35,131)	76.6 (9.6)	81.8 (10.0)	79.8 (10.1)
Hypertension[b] (%)	14.2	38.8	29.5
Total cholesterol (mmol/l) (n=34,875)	5.1 (1.0)	5.4 (1.1)	5.3 (1.0)
Total cholesterol ≥ 5 mmol/l (%)	54.0	66.5	61.8
HDL (mmol/l) (n=34,829)	1.7 (0.4)	1.3 (0.3)	1.5 (0.4)
HDL ≤ 0.9 (%)	0.6	4.7	3.2
Haemoglobin (g/dl) (n=34,713)	13.2 (1.0)	15.0 (1.0)	14.3 (1.3)
Haemoglobin < 11.5/13 g/dl (W/M) (%)	3.6	1.5	2.3
HbA1c (%) (n=34,708)	5.6 (0.5)	5.6 (0.6)	5.6 (0.6)
HbA1c < 6% (%)	80.7	84.9	83.4
6% ≤ HBA1C < 6.5% (%)	15.6	11.9	13.3
HbA1c ≥ 6.5% (%)	3.7	3.2	3.4
C-reactive protein (mg/l) (n=28,924)	2.3 (3.4)	1.7 (2.7)	1.9 (3.0)
C-reactive protein ≥ 3 mg/l (%)	21.5	12.4	15.9
Abnormal ECG[c] (n=35,159) (%)	1.3	3.8	2.8

[a] Means (SD) are presented for continuous variables and for categorical variables; n refers to the number of participants for whom each variable is available.

[b] Systolic blood pressure ≥ 140 mmHg or diastolic blood pressure ≥ 90 mmHg.

[c] As reported by Glasgow Computer Assisted Reporting of Electrocardiograms (CARE). BMI: body mass index, WC: waist circumference, SBP: systolic blood pressure, DBP: diastolic blood pressure, HDL: high-density lipoprotein, HbA1c: glycosylated haemoglobin, and ECG: electrocardiogram.

Table 3a
Descriptive statistics by Airwave usage, percentage or mean ± SD.

	Non-airwave user (n=11,713)	Airwave user (n=29,538)	Total (n=41,251)
Male (%)	42.1	71.2	63.0
Age (years)	43.1 ± 10.2	38.8 ± 8.5	40.0 ± 9.2
Education level (%)			
Left school before taking GCSEs [a]	4.2	2.6	3.1
GSCE or equivalent [a]	23.5	23.3	23.3
Vocational qualifications	5.2	5.4	5.4
A levels or equivalent	21.8	25.7	24.6
Bachelor degree or equivalent	15.7	15.5	15.5
Postgraduate qualifications	7.8	3.5	4.7
Missing	21.8	24.0	23.4
Rank (%)			
Police staff	45.2	8.9	19.2
Police Constable/ Sergeant	15.8	49.5	39.9
Inspector/Chief Inspector	3.1	4.7	4.2
Other	3.4	1.8	2.3
Missing	32.5	35.1	34.4
Smoking status (%)			
Non-smoker	63.6	67.0	66.0
Past smoker	24.1	20.2	21.3
Current smoker	10.8	10.6	10.7
Missing	1.6	2.2	2.0
Years of TETRA system usage	0.0 ± 0.3	3.6 ± 2.1	2.6 ± 2.4
Personal radio user (%)	0.0	95.0	68.0
Car mounted radio user (%)	0.0	56.1	40.2
Desk mounted radio user (%)	0.0	21.6	15.5
Body mounted radio user (%)	0.0	17.0	12.2
Motorcycle mounted radio user (%)	0.0	2.1	1.5
Other radio user (%)	0.0	4.1	2.9

[a] GCSE: General Certificate of Secondary Education.

Table 3b
Descriptive statistics, personal radio users, percentage or mean ± SD.

	Personal radio user (n=28,059)
Frequency of usage of the personal radio (%)	
All of the time	7.0
A lot of the time	68.6
Some of the time	24.4
Missing	0.0
Personal radio users who used their personal radio during their last shift (%)	73.5
Reported total duration of calls during the last shift (min)	12.4 ± 33.0
Reported total number of calls during the last shift	11.0 ± 20.1

(for participants where we are able to link the data), as well as changes in use during follow-up. After 20 years of follow-up, we will have 80% power (at 5% significance level) to detect a 12.4% increased risk of incident cancer (all causes) in the 25% participants with the highest TETRA usage compared to the rest of the population; power is substantially higher to investigate common events such as sickness absence and incident symptom reporting.

Limitations of the Airwave Health Monitoring Study are also related to its particular occupational setting. First, the police force population is not representative of the UK general population. Police forces are constituted predominantly of men: 63% in the Airwave cohort vs. 54% in the UK labour market (Office of National Statistics, 2013). In addition, only 3% of individuals are from ethnic minorities compared with 10% in the UK labour market (Office of National Statistics, 2013). This reduces our ability to examine associations in these specific sub-groups. The Airwave cohort is a working population which tends to be healthier than the general population. For example, the prevalence of current smokers is lower than in the general population: 11% current smokers in the cohort vs. 20% in the general population of Great Britain (Office for National Statistics, 2012). However, the prevalence of hypertension was higher in men (38.8% in the cohort vs. 22/26% iScotland/ Scotland) but lower in women (14.2% in the cohort vs. 18/22% in England/Scotland) (Townsend et al., 2012), and the prevalence of obesity (23%) was comparable to national rates (22–27%) (Health Survey for England, 2010; Scottish Health Survey, 2010; Welsh Health Survey, 2011). Second, each police force has its own local administration and data processing, which presents major logistical challenges for the research team. At the present time,

objective TETRA records cannot always be linked with their user, and sickness absence data have not been provided by all of the forces. Nonetheless a rich dataset has already been accrued on thousands of participants, with further enrolment underway at a rate currently of up to 5000 participants per year.

The study is overseen by a steering committee which represents the Home Office, the Imperial College research team, representatives of the forces and police officers including the Police Federation, and external scientific advisers. An access committee, also with Police Federation representation, reviews

and approves requests to access the data. The resource is part of the National Institute for Health Research Imperial BioResource within the Imperial College Healthcare NHS Trust and Imperial College Biomedical Research Centre. Research collaborations are welcome subject to ethics, access and steering committee approvals. More information can be found at http://www.police-health.org.uk/.

Ethics

The study has ethical approval from the National Health Service Multi-site Research Ethics Committee (MREC/13/NW/0588). Each participant provided informed written consent to participate in the study following procedures approved by the MREC.

Competing interests

There are no competing interests to declare.

Author's contributions

Paul Elliott is the principal investigator of the Airwave Health Monitoring Study and has primary responsibility for final content. Anne-Claire Vergnaud supervised the creation of the database extracts, analysed the data and helped to interpret the results. The manuscript was drafted by P.E. and A-C. Vergnaud. Deepa Singh and David Neasham were responsible for setting up the enrolment in each force and training clinic staff; D.N. also helped to develop the protocol; Jeanette Spear and Andy Heard developed and maintained the database; AH also managed the biological samples and repository.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.envres.2014.07.025.

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