FOR REFERENCE ONLY

HSE
Health & Safety Executive

Hand-transmitted vibration: Occupational exposures and their health effects in Great Britain

Prepared by
the **Medical Research Council Environmental Epidemiology Unit** and
the **Institute of Sound and Vibration Research**
for the Health and Safety Executive

CONTRACT RESEARCH REPORT

232/1999

HSE
Health & Safety
Executive

Hand-transmitted vibration: Occupational exposures and their health effects in Great Britain

K T Palmer MA, BMBCh, FFOM, MRCGP,
D Coggon MA, PhD, DM, FRCP, FFOM,
H E Bendall MSc and
B Pannett MSc, MRSC, CChem
Medical Research Council
Environmental Epidemiology Unit
University of Southampton
Southampton General Hospital
Southampton S016 6YD

M J Griffin BSc, PhD and
B M Haward BSc, MSc, MErgS
Institute of Sound and Vibration Research
University of Southampton
Highfield
Southampton SO17 1BJ

HEALTH AN...
SHEFFIELD
21 SEP
COPY 399153-1001

This report and the work it describes were funded by the Health and Safety Executive (HSE). Its contents, including any opinions and/or conclusions expressed, are those of the authors alone and do not necessarily reflect HSE policy.

HSE BOOKS

© Crown copyright 1999
Applications for reproduction should be made in writing to:
Copyright Unit, Her Majesty's Stationery Office,
St Clements House, 2-16 Colegate, Norwich NR3 1BQ

First published 1999

ISBN 0 7176 2476 5

All rights reserved. No part of this publication may be reproduced, stored in a retrieval system, or transmitted in any form or by any means (electronic, mechanical, photocopying, recording or otherwise) without the prior written permission of the copyright owner.

Foreword

This document is one of four reports presenting the findings of a research project to estimate the number and distribution of workers in Great Britain exposed to hand-transmitted and whole-body vibration.

Hand-transmitted vibration: Occupational exposures and their health effects in Great Britain CRR232/1999 HSE Books ISBN 0 7176 2476 5

Whole-body vibration: Occupational exposures and their health effects in Great Britain CRR233/1999 HSE Books ISBN 0 7176 2477 3

Hand-transmitted vibration: Evaluation of some common sources of exposure in Great Britain CRR234/1999 HSE Books ISBN 0 7176 2480 3

Whole-body vibration: Evaluation of some common sources of exposure in Great Britain CRR235/1999 HSE Books ISBN 0 7176 2481 1

The findings from a postal questionnaire survey of occupational exposure to hand-transmitted and whole-body vibration are presented in CRR232/1999 and CRR233/1999 respectively. Each report provides information on the extent of vibration exposure and estimates the prevalence rate ratios for symptoms commonly associated with hand-transmitted or whole-body vibration.

Workplace visits, including measurement of vibration exposures for selected tools and equipment, were carried out to verify the responses from the questionnaires. These findings are presented separately for hand-transmitted and whole-body vibration in reports CRR234/1999 and CRR235/1999.

Hand-transmitted Vibration: Occupational Exposures and their Health Effects in Great Britain

Keith T Palmer MA, BMBCh, FFOM, MRCGP
David N Coggon MA, PhD, DM, FRCP, FFOM
Holly E Bendall MSc
Samantha D Kellingray MSc
Brian Pannett MSc, MRSC, CChem
MRC Environmental Epidemiology Unit
University of Southampton
Southampton General Hospital
Southampton
SO16 6YD

M J Griffin BSc, PhD
B M Haward BSc, MSc, MErgS
Institute of Sound and Vibration Research
University of Southampton
Highfield
Southampton SO17 1BJ

SUMMARY

A postal survey was conducted to estimate the prevalence of occupational exposure to hand-transmitted vibration (HTV) in Great Britain and to explore its association with finger blanching and sensorineural symptoms in the upper limbs. The aims were:

a) To estimate the number of workers in Great Britain currently employed in processes that entail significant exposure to HTV.

b) To identify the occupations and the industrial sectors where exposures arise.

c) To estimate the approximate extent of work exposure to HTV in occupations and industries where exposure is likely to be significant.

d) To estimate the prevalence and prevalence rate ratios for symptoms attributable to HTV by occupation.

e) To examine factors that might interact with HTV in causing health effects.

In addition, a series of workplace visits were made to determine the accuracy of self-reports of exposure.

Methods

In the postal survey the study sample comprised 21,201 men and women of working age who were selected at random from the age-sex registers of 34 general practices across Britain, and a further 993 men and women from HM Armed Services selected at random from pay records for serving members in the UK. Following a small number of exclusions, 22,415 questionnaires were mailed in two tranches, divided between the summer of 1997 and the following winter. Usable responses were obtained from 12,907 subjects (response rate 61% among eligible subjects). Among other items the questionnaire asked about exposure to sources of HTV at work and in leisure, and about symptoms of finger blanching and of tingling and numbness in the upper limbs. In addition data were obtained from the latest national census on the numbers of men and women by occupation and industry in Great Britain in 1991. Census information was applied to the questionnaire data to provide estimates of exposure frequency in the whole population.

In the workplace study, 116 users of hand-powered tools and 63 other workers with exposure to whole-body vibration were observed at work over a one-hour period. A comparison was made between the sources and durations of exposures to HTV reported by the workers and those directly observed. Subjects also completed an account of their exposures in the past week (identical to that used in the postal survey), and an attempt was made to ascertain the plausibility of these accounts by careful inquiry and inspection of tool inventories.

Findings on exposure

The population estimates indicate that in a one week period some 4.2 million men and 667,000 women in Great Britain are exposed to HTV at work, and that personal daily vibration exposures, as estimated from self-reported durations of vibratory tool use, exceed a suggested action level equivalent to 2.8 ms^{-2} for 8 hours (A(8) > 2.8 ms^{-2} r.m.s.) in some 1.2 million men and 44,000 women.

Nationally, exposure among men was most common in metal-working production and maintenance fitters, carpenters and joiners, electricians and electrical maintenance fitters, motor mechanics and autoengineers, plumbers and heating and ventilating engineers, and builders and building contractors (the craft and related occupations major group of Standard Occupational Coding (SOC) 90). The most commonly used tools were hammer drills, hand-held portable grinders and jig saws. Multiple tool use was common among exposed men. High estimated A(8) values (>5 ms^{-2} r.m.s.) arose most often in bricklayers and masons, gardeners and groundsmen, carpenters and joiners, electricians and electrical maintenance fitters, and builders and building contractors. The highest median A(8) values were seen in builders and building contractors, followed by welding trades, and then by carpenters and joiners.

Among women, the most common exposure source was floor polishers and the most commonly exposed occupation was domestic worker or cleaner. High personal vibration exposures appear to be uncommon in women.

Observations in the workplace confirmed that workers are generally accurate in reporting the sources of their exposure, although they sometimes confuse pairs of tools, omit to report exposures or provide descriptions of exposure that may be misleading. They tended systematically to overestimate their exposure durations: in 104 comparisons, the median ratio of reported to observed exposure duration was 2.5 (IQR 1.6-5.9). Such a scale of over-reporting would lead on average to an implied A(8) exposure magnitude 60% too high, although there was wide individual variation in the accuracy of self-estimates. Reports tended to be more accurate when fewer tools were used and in a more continuous fashion.

Findings on health

Clear excesses of finger blanching and sensorineural complaint were seen among men and women with exposure to HTV - including leisure time users of powered vibratory hand-held tools. In comparison with subjects who had never been exposed during work or leisure, the lifetime prevalence rate ratio (PR) of cold-induced finger blanching in men who had only been exposed at work was 1.97 (95% CI 1.67-2.32); while in men who had been exposed at work *and* in leisure the PR was 2.53 (95% CI 2.06-3.07). More marked excesses were seen when a stricter definition of Raynaud's phenomenon was used (cold-induced blanching with a clear edge), and for risk of troublesome and extensive disease. A similar pattern was seen in women, but the risks were lower.

In men, associations were also apparent for exposure in a previous job (PR for cold-induced blanching 2.86, 95% CI 2.19-3.72) and exposure in the past week (PR 2.01, 95% CI 1.60-2.52). Among current users, a self-reported $A(8) > 2.8\ ms^{-2}$ was associated with a PR of 2.42 (95% CI 1.76-3.29) for cold-induced blanching and 3.04 (95% CI 1.80-5.09) for troublesome blanching. Excess risks (PRs from 1.89 to 3.37) were found in many of the occupations identified as having noteworthy exposure, including carpenters and joiners, electricians and electrical maintenance fitters, motor mechanics, builders and building contractors, bricklayers and masons, and gardeners and groundsmen.

Similar patterns and risk estimates were found for complaints of tingling/numbness in the fingers, and for such symptoms in the upper limbs, disturbing sleep in the past week. Sensory symptoms in the fingers were associated with lifetime and current exposure to HTV, even in subjects who did not experience blanching.

The cross-sectional nature of this survey and the frequency of multiple tool use preclude definite attribution of risk to individual hand-powered tools. But the health analyses were compatible with independent risks from many tools which are common in Britain and which have not been examined in previous surveys of vibration exposure and health risk.

A total of 670,000 men and 104,000 women in Great Britain were estimated to have cold-induced finger blanching attributable to HTV exposure. For a stricter case definition (cold-induced blanching with a clear edge between normal and affected skin), the attributable numbers were 255,000 and 33,000 respectively.

Conclusions

a) It is estimated that some 4.2 million men and 667,000 women in Great Britain are exposed to HTV at work in a one-week period. Personal daily vibration exposures exceed a suggested action level equivalent to 2.8 ms^{-2} for 8 hours (A(8) > 2.8 ms^{-2} r.m.s.) in some 1.2 million men and 44,000 women.

b) High estimated doses (A(8) > 5 ms^{-2} r.m.s.) arose most often in bricklayers and masons, gardeners and groundsmen, carpenters and joiners, electricians and electrical maintenance fitters, and builders and building contractors. High median A(8) values were seen particularly in builders and building contractors, welding trades, and carpenters and joiners.

c) Excess risks of cold-induced finger blanching were found in all of these occupations, and in workers with an estimated A(8) > 2.8 ms^{-2} in the past week.

d) Exposure to HTV is surprisingly prevalent and vibration-induced white finger is a common cause of Raynaud's phenomenon in men.

e) Many vibratory tools that are common in Britain have been overlooked in previous surveys of vibration exposure and health, highlighting an important avenue for future research.

f) Workers tend to systematically overestimate the duration that they are exposed to HTV. The importance of this source of error in the research used to evolve safety standards is unclear.

g) Further research is warranted on exposure-response relationships given these concerns, the high frequency of exposure, the evidence on public health risk and the practical issues of enforcement and compliance. The relation between exposure and disease would best be examined in a prospective inquiry, looking at incident disease in high-risk industries and occupations.

CONTENTS

BACKGROUND

Exposure to hand-transmitted vibration (HTV) has been linked with a number of health effects, the best known being Raynaud's phenomenon secondary to vibrating tool use - 'vibration-induced white finger' (VWF)[1,2]. Sensorineural impairment in the fingers[2,3] and carpal tunnel syndrome[4-6] are other well-recognised associations in vibratory tool users, while osteoarthritis of the wrist or elbow and musculoskeletal disorders of the upper limb[7-11] may also occur. The term 'hand-arm vibration syndrome' (HAVS) has been used to collectively define the disorders thought to be associated with exposure to HTV[12].

From the public viewpoint it is important to determine the extent of disease caused by HTV and to identify the common, important exposures that are linked with health risks. Ideally these should be known by occupation, by industry and by tool type, providing sufficient detail to target future control initiatives. Information on the extent of exposures is required to determine national priorities, and to provide the impetus for manufacturers to develop new and safer tools, and for managers, health and safety professionals, and legislators to press for them.

One major national survey of occupational exposure to hand-transmitted vibration, undertaken by the Health and Safety Executive (HSE) in the 1980s, suggested that more than 400,000 British workers were exposed on a weekly basis to the potentially injurious effects of vibration[13], but several obvious limitations to the data were acknowledged. Sampling was based on a narrowly selected list of industries and a restricted range of exposure patterns (emphasis was placed on tools and occupations covered by U.K. statutory reporting arrangements); no detailed information was collected by occupation and tool type; for practical reasons establishments were sampled rather than employees; the exposure histories of workers were obtained by proxy, by questioning their managers; and some important working groups had not been included (later on there were supplementary surveys in railway, mine and quarry workers[14,15] which raised the estimated number of exposed workers to nearly 500,000). Practical difficulties were encountered in obtaining a head count in some of the sectors, notably in the building industry, and the sample, which was restricted to premises registered with HSE, almost certainly under-represented the small employer and the self-employed business person.

These surveys also omitted to collect health data. The impetus for protecting exposed workers comes principally from evidence of health impairment, and the planning of sensible control measures hinges on identifying the common, important exposures that are instrumental in disease occurrence. But here too the picture is incomplete. National information on vibration-related health complaints derives principally from compensation claims made under the State Industrial Injuries Scheme and employers' statutory reports under the Reporting of Injuries, Diseases and Dangerous Occurrences Regulations; but these schemes rely on awareness and willingness to report, and are further distorted by rules of restricted eligibility. They are widely considered to underestimate the incidence of disease, but to an uncertain extent: many exposures have not been systematically studied and the attributable number of cases of disease in Great Britain is not known.

In recognition of the need for more information, HSE commissioned this study, which involved two separate but related investigations:

a) A *postal survey* which collected information on the frequency and extent of exposures and of relevant symptoms in a large community-based sample. (Some of the limitations of earlier studies were addressed by sampling from the community.) Responses were assessed by occupation and industry, and prevalence estimates for the country as a whole were derived using census information on occupational and industrial populations nationally. The association between exposure and health complaints was also determined.

b) A series of *observational visits* to establishments where exposures to HTV occurred on a regular basis, undertaken to assess the validity of exposure data from the postal survey and to determine its limits. In this study, assessment was based on a comparison of self-reports of exposure with direct observations and information supplied by employers.

OBJECTIVES

The aims of the postal survey were:

a) To estimate the number of workers in Great Britain currently employed in processes that entail significant exposure to hand-transmitted vibration.

b) To identify the occupations and the industrial sectors where the exposures arise.

c) To estimate the approximate extent of work exposure to hand-transmitted vibration in occupations and industries where exposure is likely to be significant.

d) To estimate the prevalence and prevalence rate ratios for symptoms attributable to hand-transmitted vibration by occupation.

e) To examine factors that might interact with hand-transmitted vibration in causing the health effects.

In addition, the methods allowed several other objectives of interest to be pursued:

a) To determine the commonest sources of exposure to HTV in Great Britain.

b) To identify new, potentially important pockets of exposure that might be risk-conferring.

c) To estimate the attributable number of cases of VWF in Great Britain.

d) To assess the contribution of leisure-time exposures to HTV in causing health effects.

The aims of the workplace visit programme were:

a) To determine how accurately workers recount the sources of HTV to which they are exposed.

b) To quantify the errors in their assessment of daily exposure times and to identify the principal sources of error and bias.

The opportunity was also taken to determine the vibration characteristics of some sources of exposure that are common in Great Britain. (These findings are presented in a separate report entitled *Hand-transmitted vibration: Evaluation of some common sources of exposure in Great Britain*).

FORMAT OF THIS REPORT

The methods and findings of these investigations are described below, beginning with details of the postal survey, which is followed by an account of the observational visits programme. The entire body of work is then reviewed with recommendations for further action. As an aid to interpretation, the key findings are represented graphically in the text; but more detailed information is also provided in tables that follows the main text (pages 72-110). Concluding appendices provide extra details of the questionnaire and method, and of the prevalence of exposure by region and according to a comprehensive listing of occupations and industries.

POSTAL SURVEY

METHODS

Sample selection

In 1997-98 a postal questionnaire was mailed to a sample of 21,422 men and women from the patient lists of 34 general practices and to 993 members of HM Armed Services.

The practices were chosen to ensure a broad geographical coverage of Great Britain and to ensure that industries with known exposure to vibration were adequately represented in the sample (- that is, to include industries of known concern but with a restricted geographical distribution). The Royal College of General Practitioners and the Primary Care Rheumatology Society were contacted to discover whether GPs who had an interest in research were practising in the selected areas. Candidate practices were approached and recruited. In a few locations where practices could not be enlisted in this way, practices were identified from names in the Medical Directory. The locations of the practices that participated are listed in Table 1, together with the industries they were chosen to represent. Prior approval was obtained from the Local Research Ethics Committee in each area (30 committees in total). Each practice supplied the research team with a computer disc containing the names and contact details of all men and women aged 16-64 on their age-sex register.

To permit an examination of seasonal differences in the reporting of exposure and health, the mailing was split into two tranches during different calendar periods. In the summer of 1997, 1 in 8 samples of men and women in the relevant age range were randomly selected from the patient lists of 18 of the practices. A similar procedure was adopted in the following winter for the remaining practices, except that the sampling fraction was varied to include a higher proportion of men (1 in 6 men as compared with 1 in 12 women). The provisional mailing lists were vetted by the general practitioners concerned and a small number of subjects (1%) were excluded on their advice, generally because of terminal illness or recent bereavement. The remainder was sent a postal questionnaire with covering letters from the study team and GP. The first mailing was conducted in the third week of May and first week of June 1997 (11,965 subjects), and the second in the last week of January 1998 (9,236 subjects). Non-responders were sent a single reminder after about five weeks.

Members of HM armed forces were unlikely to be included in these mailings, as primary care cover for the services is provided by military doctors rather than civilian practitioners. To ensure their representation in the sample, a separate armed forces mailing was conducted in January 1998. The sampling frame was restricted to members of the armed forces currently resident in Great Britain, and a simple random sample of men and women aged 16-64 was taken from each service, using central pay records for serving members as an enumeration list. Nine hundred and ninety-three names were selected altogether, divided between the services in proportion to their estimated national head counts, with the sampling fraction set accordingly. This resulted in questionnaires being mailed to 297 subjects from the Royal Air Force, 220 subjects from the Navy and 476 subjects from the Army. For this mailing, a covering letter was provided by the Director General Medical Services (in lieu of the general practitioner), but the procedure was otherwise similar to that employed in the principal mailings.

Study questionnaire

The questionnaire (Appendix A) was developed following consultation with health and safety professionals, vibration specialists, trades unions, trades associations and members of a former working group of the Faculty of Occupational Medicine. It underwent several rounds of field testing and refinement, the details of which have been published[16].

In the context of this report, the questionnaire contained items on: current occupation and industry; exposures to HTV at work in the previous 7 days (sources and durations of exposure); first exposure to HTV; leisure exposure to HTV; upper limb numbness and tingling in the previous 7 days and previous 12 months; and symptoms of finger blanching (extent, frequency, precipitants, date of onset). Questions were also included on a number of other occupational exposures that might be relevant to the symptoms of interest (cold store work, work outdoors, lifting, digging, shovelling and keyboard work), as well as questions that permitted an assessment of potential reporting biases (for example, 'dummy' health outcomes, to gauge generalised over-reporting of symptoms; and mood and mental health questions, to identify psychological variables that may affect propensity to report symptoms).

Data processing

All questionnaire returns were double-entered on to computer. A cross-comparison of duplicate entries was used to identify data entry errors, and then a set of checks was performed to detect inconsistencies, and improbable or impossible values for variables. The main procedures performed are summarised in Appendix B.

Coding

Most responses in the questionnaire were of the 'yes/no' variety; but open response questions required formal coding to permit further analysis. The occupations of respondents were coded to the latest revision of the Standardised Occupational Classification (SOC90)[17] and industries were coded according to the Standard Industrial Classification Scheme (SIC 92)[18].

Information on current exposure to HTV was obtained principally from a question about use in the past week of a closed list of named tools and machines (Question 11), namely:

Floor polisher	Rock drill	Nibbling machine
Nut runner	Tamper	Clinching and flanging tool
Impact wrench	Scabbler	Concrete vibrothickener
Impact screwdriver	Stone-working hammer	Nailing or stapling gun
Jig saw	Rotary burring tool	Pedestal grinder
Circular Saw	engraving pen	Pedestal linisher
Chain saw	Hammer drill	Hand-held portable grinder
Hand-guided mower	Riveting hammer or dolly	Hand-held polisher
Hand-held hedge trimmer	Chipping hammer	Hand-held sander
Brush saw	Scaling hammer	Shoe pounding-up machine
Barking machine	Caulking hammer	Vibratory roller
Stump grinder	Rammer	
Concrete breaker (road breaker)	Needle gun	

However, descriptions of exposure were provided by 561 subjects in response to an open question about other sources of occupational exposure to HTV in the past week (Question 13). These were reviewed independently by a vibration specialist (MJG), an occupational hygienist (BP) and an occupational physician (KP), to decide whether responses represented substantive exposures, and if so whether they belonged to the pre-defined list, or whether new categories should be created to accommodate them. Differences of opinion were resolved by consensus. This resulted in a few reports being classified as non-significant, and eleven new response categories being created to add to the existing tool families, namely:

Metal drill	Strimmer	Jet wash
Surgical tool	Screw driver	Router
Disc cutter	Metal saw	Miscellaneous
Hair clipper	Planer/planing tool	

One hundred and thirty-six openly worded responses were not classifiable, and these were coded as not exposed in past week.

Those who had ridden on a motor cycle in the past week during the course of their work, were also classified as occupationally exposed.

Information was also collected on previous occupational and recreational exposures, and the sources involved. Question 27 asked about occupational exposure to HTV for more than an hour per week in any previous job; while Question 28 inquired about regular leisure time exposure to HTV for more than an hour per week. Positive replies to these questions were vetted independently by the vibration specialist and occupational physician to confirm that the sources of exposure described were substantive. All of the coded responses were used to define a baseline category of never exposed to HTV in work *or* leisure (*'a lifetime non-user'*) and three additional lifetime or 'ever' exposure categories:

a) never exposed to HTV occupationally, but exposed at some time during leisure (*'a leisure-only user'*);

b) exposed to HTV occupationally at some time past or present, but never in leisure (*'a work-only user'*); and

c) exposed to HTV at some time, both occupationally *and* in leisure (*'a work and leisure-time user'*).

All coding decisions on exposure were made blind to information on health status.

Health variables

The principal health analyses of this report concern Raynaud's phenomenon and sensorineural complaints of the upper limbs. Several alternative definitions of these health variables were explored:

Raynaud's phenomenon

Three definitions:

- attacks in which fingers suddenly become cold and numb and at the same time turn white or pale ('yes' to question 38);
- similar attacks which were cold-induced ('yes' to questions 38 *and* 41a);
- cold-induced attacks in which a clear edge demarcated normal from affected skin ('yes' to questions 38 *and* 41a *and* 42).

Sensorineural symptoms

Tingling or numbness lasting at least three minutes (a) during the past week and (b) the past year, affecting the:

- fingers/thumbs ('yes' to question 35a);
- other parts of the hand(s) ('yes' to question 35b);
- other parts of the arm(s) ('yes' to question 35c);
- any of the above, disturbing sleep ('yes' to question 35d and any of 35a, 35b or 35c).

Several of these items have been tested and used in other investigations. Definitions of Raynaud's phenomenon have varied between community surveys[19-23], but the first of the chosen definitions had been used in an earlier community investigation of Raynaud's phenomenon, and was then reported to have a predictive value of 80% as judged at medical interview[19]; the second is generally regarded as even more specific[22]. In the study's development stage we further tested the repeatability and validity of these questions in a sample of rheumatology outpatients and general practice patients, including 18 subjects with Raynaud's phenomenon[24]. They were found to have good to excellent repeatability (kappa coefficient (κ) for question 38 = 0.90 in 61 pairs; κ for question 41a = 0.70 in 24 pairs), and to have a high sensitivity (94%-100%) and specificity (75-78%).

The sensorineural questions were selected as potentially representing the diffuse digital polyneuropathy and the peripheral nerve entrapment of HAVS. In the absence of a clinical examination and electrophysiological testing the predictive value of these items is likely to be more limited: exposure to HTV commonly causes transient sensory disturbance in healthy individuals, while the reported predictive value of nocturnal arm symptoms in carpal tunnel syndrome is around 40-60%[25,26]. However, to improve the specificity, a threshold for symptom reporting was imposed (a minimum duration of at least three minutes); and to examine the extent to which complaints were explained by recent exposure a comparison was made between current and former users of tools (described below). Nocturnal parasthesiae that disturb sleep may in any case be a more specific complaint in subjects with HAVS.[4-6,27,28] The sensorineural items were also pre-tested in a sample of rheumatology outpatients and patients from general practice, including nine patients with carpal tunnel syndrome[24]. They were found to have good repeatability ($\kappa = 0.63$ in 65 pairs for finger symptoms in the past week and 0.67 in 45 pairs for symptoms in the hand or arm disturbing sleep); while in patients with carpal tunnel syndrome the sensitivity of the question on sleep disturbance was 75% and the specificity was 60% as compared with rheumatologist's opinion.

Categorisation of other exposures and risk factors

Several personal and occupational factors were considered as potential confounders of these health outcomes, including: age, sex, smoking history, location of practice, physical occupational activities and co-reporting of stress, depression and anxiety.

Age and sex were included in all analyses because of strong existing evidence of their association both with Raynaud's phenomenon and with exposure[19-23,29-36]. The other factors were investigated because of a *priori* concerns or evidence from the literature of a possible association. Smoking has been reported to cause acute digital vasoconstriction[37], and an association has sometimes reported with smoking[34,38] and coronary heart disease[34,35,39] in studies of Raynaud's phenomenon. Attacks of blanching are provoked by cold, and may be more common in temperate and cold climates[32,35]. They can also be provoked by emotion, and a relation has been proposed between job stressors and the prevalence of complaint[36]. Occupational lifting has been reported to have an independent effect[36], although this has seldom been explored. Finally, those who frequently complain of tiredness, stress and depression may be more likely than others to report trouble with somatic symptoms such as cold sensitivity of the digits and upper limb pains.

Exploratory analyses, including pairwise frequency counts, and χ^2 tests of association were first conducted to determine how these factors covaried. The associations between the physical occupational exposures reported in the questionnaire (question 9) were examined; and similar analyses were conducted for psychological risk factors such as headaches, low mood and feelings of constant tiredness and stress (question 53), after first collapsing the response categories to create dichotomous variables ('frequently suffer' versus 'occasionally or never suffer'). Occupational lifting was found to be strongly correlated with digging and shovelling, and frequent tiredness with stress and low spirits, so these five variables were collapsed into two new ones - lifting weights $\geq$ 20 lbs (10 Kg) in an average day; and frequently feeling tired or stressed. The other physical factors were retained in later analyses.

Location of general practice was also considered as a possible factor of adjustment, but the age-standardised prevalence of cold-induced finger blanching and sensorineural complaint showed no systematic differences by latitude or practice type (urban vs rural), and no further adjustment was considered necessary.

ANALYSIS

National estimates

The study sample was selected at random from practice lists, but the locations of the general practices were chosen to ensure that occupations of known concern were represented and to maximise the amount of information about job content in geographically localised industries. To derive estimates for the population of Great Britain, and to allow for the possibility of differential sampling and response rates between occupations, account was taken of the relative frequency of occupations (or in some analyses industries) as compared with the national population. Tables from the latest available (1991) National Census[40] were specially commissioned from the Office of National Statistics to provide the estimated national populations by occupation and industry in working-aged men and women, coded on the same basis as for the sample. Thereafter, in most analyses, the numbers in the sample with exposure in each occupation were multiplied by the relative numbers in that occupation in the national population as compared with the sample:

$$\text{Estimated national number with exposure within an occupation} = \text{number within the occupation exposed in the sample} \times \frac{\text{number belonging to the occupation in the population}}{\text{number belonging to the occupation in the sample}}$$

Some analyses looked at the numbers exposed within an industry, and in these calculations the numbers within an industry were used instead as the multiplying factors. The limits of this approach are discussed later.

Personal vibration exposures

Dominant axis frequency-weighted vibration accelerations (a_{hw} values) were assigned to each tool family from published and other sources of information. Further details are provided in Appendix C. Average personal daily vibration exposures (A(8)) for the past week were then estimated in current users by assuming the time dependency in ISO 5349, 1986[41] and summing the partial doses arising from each source, as follows:

$$A_i = a_{hwi}\left[\frac{t_i}{5 \times 480}\right]^{\frac{1}{2}}$$

where:

A_i is the average 8-hour equivalent magnitude for *i*th tool

a_{hwi} is the worst-axis frequency-weighted acceleration for the *i*th tool

t_i is total duration of exposure in minutes over the whole week.

And for several tools used in combination:

$$A(8) = \left[\sum_{i=1}^{i=n} A_i^2\right]^{\frac{1}{2}}$$

where:

n is the number of tools

A(8) is the average 8-hour equivalent magnitude (personal daily vibration dose) for all *n* tools combined

A_i is as above

These expressions assume that the daily exposure durations in the past week were sufficiently similar on each day for the average to approximate the likely risk.

For a few of tools, representative a_{hw} values could not be assigned with confidence; and in a substantial minority of cases estimates of the duration of exposure were missing. In such cases total dose could not be calculated, but for subjects who were exposed to more than one source of HTV sufficient information often existed to estimate the *minimum* A(8).

Risk estimates and attributable numbers

All statistical analyses were carried out using STATA, Release 5[42]. Odds ratios and 95% confidence intervals (95% CI)) for Raynaud's phenomenon and sensorineural complaints of the upper limbs were obtained from multiple logistic regression models with appropriate adjustment for the potential confounding effects of other occupational activities and personal factors. Prevalence rate ratios (PRs) and 95% CI were obtained by converting the odds ratios and 95% CI according to a formula proposed by Zochetti *et al*[43] .

Estimates were derived for the proportion of disease and the numbers of cases attributable to exposure, using the following formulae:

$$\text{Attributable proportion } (a_p) = \frac{p(R-1)}{1+p(R-1)}$$

where:

R = PR of Raynaud's phenomenon in those ever exposed to HTV compared with those never exposed

p = standardised estimate of the prevalence of ever being exposed to HTV in the population of Great Britain

$$\text{Attributable number} \cong a_p n$$

where:

a_p is as above

n = standardised estimate of the number of cases of Raynaud's phenomenon in the population of Great Britain

For the purposes of these calculations, the standardised estimates of the prevalence of exposure and number of cases were derived by using the occupational distribution of adults in the population of Great Britain (according to 1991 census) as the standard.

RESULTS

Questionnaire distribution and returns

Tables 1 - 4 provide information on the study sample and the patterns of response. Altogether, 22,415 subjects were provisionally selected to receive a questionnaire, but 221 of these (fewer than 1%) were excluded on general practitioners' advice, so that 22,194 questionnaires were mailed. One thousand and twenty-eight questionnaires (4.6%) were returned as 'address unknown', 'moved away' or 'deceased', and 56 questionnaires were subsequently excluded because their particulars (of date of birth and sex) implied that they were completed by someone other than the intended recipient. This meant that 12,907 usable questionnaires were received, leading to an overall response rate of 61% among subjects who could be contacted.

The response rate varied between general practices (Table 1), being lowest in Lambeth (39%) and highest in Devon (74.6%), but exceeding 65% in 16 of the 34 centres. The response rates in the armed services were: 61% for the Army, 65% for the Navy and 73% for the RAF.

The response rate was higher in women than men (69% as compared with 55%), and higher in older age bands than younger ones (Table 2), but was similar between the summer and winter mailings.

The employment status of respondents is described in Table 3. Seventy-three per cent of respondents were in a paid job or self-employed in the week preceding completion of the questionnaire (79% of men and 65% of women). The majority of these respondents (9,084 out of 9,368) were at work in that week. Five hundred and thirty-one respondents (4% of those making a usable return) held a second job in the same week, but only 37 men and eight women reported using hand-held vibratory tools during this work, and so analyses that concerned current exposure were confined to the main job held in the week preceding completion of the questionnaire.

Table 4 compares the frequency of occupations in the sample with that of the 1991 National Census[40] and two recent random sample community surveys of occupational ill health and working conditions[44,45]. The occupational mix was generally similar, except that the sampling design led to over-representation of the defence sector, and there was some under-representation of managers and construction workers.*

* Residual differences were accounted for in the analysis by the method of scaling, described previously.

Estimates of exposure

Frequency of occupational exposure to hand-transmitted vibration

42.6 % of all male respondents (2,945 men) reported having had exposure to HTV at some stage in their career ('ever' exposure); 1,727 of these men reported exposure to a source of HTV in the week preceding completion of the questionnaire (31.5% of those in employment). The corresponding population estimates for working-aged men in the past week were: 20.5% (95% CI 19.7-21.3%) for all subjects, or 31.9% (95% CI 30.7-33.1%) for men who were at work.

Among women, all categories of exposure were less common: 7.9% of the sample (475) had been exposed in one or other employment; and 3.7% (225 women) had been exposed in the past week. In the national population, 2.9% (95% CI 2.6-3.3%) of all women and 6.4% (95% CI 5.6-7.2%) of working women were estimated to be exposed in the past week.

Tables 5 and 6 present further details, including the estimated numbers in Great Britain who were exposed to a source of HTV in the past week. The principal data are presented separately by occupation, by industry and by sex; and have been ranked according to the estimated number of exposed subjects in the national population.

For all occupations combined, it was estimated that 4,207,500 men (95%CI 4,043,700-4,371,300) in Great Britain were exposed to a source of HTV in the past week (Table 5). The occupations which contributed the largest estimated numbers of exposed men were those belonging to group 5 of SOC 90 (the craft and related occupations major group). These included: metal working production and maintenance fitters (298,600 men exposed 95%CI 272,000-324,400), carpenters and joiners (254,400, 95%CI 242,200-266,700), electricians and electrical maintenance fitters (193,700, 95% CI 176,800-210,600), motor mechanics and auto-engineers (157,300, 95%CI 138,900-175,600), plumbers and heating and ventilating engineers (140,800, 95%CI 127,000-154,600) and builders and building contractors (131,400, 95%CI 119,200-143,700). These six leading occupational unit groups accounted for 28% of the estimated men with exposure nationally.

The industries which contributed the largest estimated numbers of exposed men were: construction (979,500 men exposed, 95%CI 907,100-1,052,000), motor vehicle maintenance and repair (276,900, 95%CI 233,800-320,000), agriculture (219,200, 95%CI 194,500-243,900), manufacture of fabricated metal products other than machinery and equipment (218,500, 95%CI 184,800-252,100) and defence (162,300, 95%CI 123,100-201,500) (Table 6). These five industries accounted for 49% of the estimated men with exposure nationally.

The estimated number of women with weekly exposure in Great Britain was 666,600, (95%CI 582,300-750,900). The occupation with the largest estimated number of exposed women was cleaner or domestic worker (240,800, 95%CI 193,200-288,500), followed by hairdresser (11,800, 95%CI 3,900-19,800). The education sector gave rise to the biggest estimated number of exposed women by industry (111,100, 95%CI 83,100-139,000).

Most common sources of hand-transmitted vibration

Table 7 lists the hand-held powered tools most commonly used in the previous week by respondents, and the estimated number of users of these tools in Great Britain. Among employed men in the sample, the most common exposure sources were: hammer drill (11.9%), hand-held portable grinder (10.9%) and jig saw (7.5%). The national estimates for these tools imply that these are very common exposures (e.g. more than 1.7 million users of hammer drills, and more than 1.5 million users of hand-held portable grinders). Among women, floor polishers were used most often, followed by nailing and stapling guns.

Eighty-one men and eight women from the sample reported occupational use of a motorcycle in the previous week.

Occupational patterns of exposure

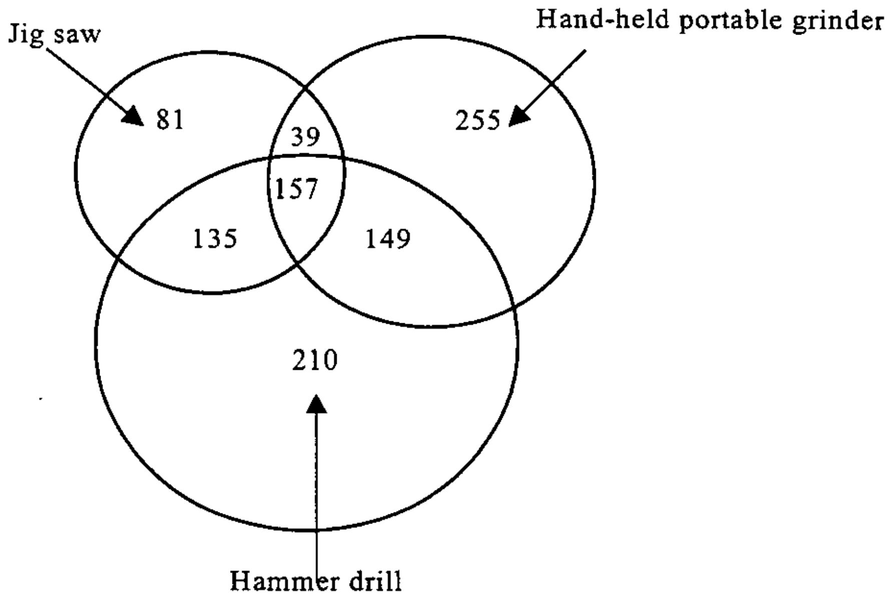
Exposure to several sources of HTV was comparatively common (Table 8). A total of 1,218 men (22% of employed men in the sample) were exposed to two or more sources of HTV in the week prior to completion of the questionnaire. A significant minority of them (301 men) reported using six or more tools in the previous week, leading to a population estimate of 784,400 (95%CI 698,500-870,300) for this variety of exposure.

Figure 1 illustrates the overlap among men for the three most common sources of exposure in the sample. A substantial proportion of hammer drill users also used hand-held portable grinders and jig saws. The degree of overlap was such that although 1,663 tools were used when counted separately, exposures were incurred by 1,026 men. Most of these men had

Contents

exposure to other sources too. In women, by contrast, exposure to more than one source of HTV was uncommon (only 39 subjects among 3,878 employed respondents).

Figure 1
Overlap in the use of three common vibratory tools in the past week among male respondents



The distribution of tool type by occupation is illustrated in Table 9, for occupations which contributed most to national estimates of exposure frequency and tools which were most commonly reported (- that is, occupations from Table 5 and sources from Table 7). The data indicate that some exposure sources, such as hammer drills and hand-held grinders, are prevalent across a range of occupations. However, they also identify some occupations in which selected exposures are exceptionally prevalent (e.g. jig saws, hammer drills and circular saws in carpenters and joiners, and hand-guided mowers in gardeners and groundsmen), presumably due to specific job requirements.

An attempt was made to define the common combinations of exposure by looking at the pairwise association of sources for men with two exposure sources; but no more than 40 subjects were found sharing a unique combination of two or more tools.

Durations of exposure

Table 10 presents respondents' estimates of the time they were exposed to common sources of HTV in the week preceding completion of their questionnaire. Median usage times ranged from 0.5 to 2.3 hours in men, but were longer in women who used floor polishers (3.4 hours).

The summary measures disguise variations between individuals and between sources: for example, 12.3% of hammer drill users reported being exposed for 15 minutes or less over the whole week, but 4.4% of them reported being exposed for more than ten hours; 1% of pedestal grinder users estimated their exposure to be more than 10 hours over the week, as compared with 7.6% of men who used nailing and stapling guns and 6.3% of men who used hand-guided mowers. A significant minority (a fifth to a half, depending on the source) failed to report an exposure time.

Personal daily vibration exposures in the past week

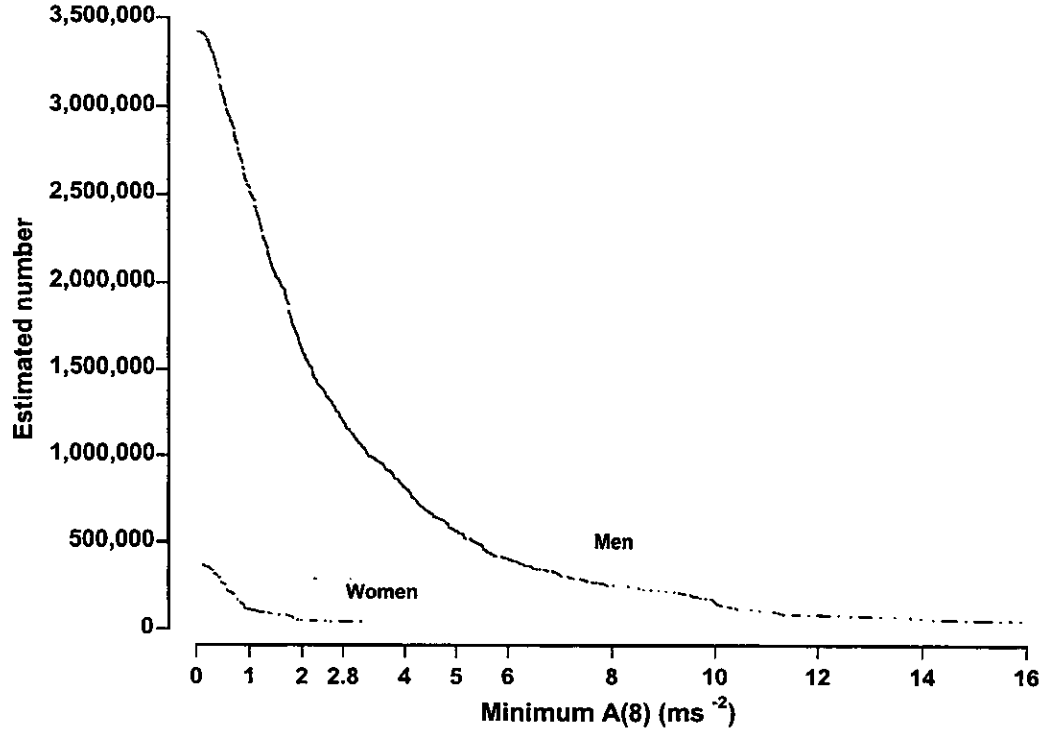
In employed men from the sample who supplied full information, 3.4% of the exposures exceeded a suggested HSE A(8) action level of 2.8 ms^{-2} r.m.s., 1.4% of these being above 5 ms^{-2} r.m.s. (Table 11).

Some exposure information was missing for 1,023 of the 1,727 male tool users, but in many cases partial exposure information was available, and this indicated that a further 260 men had a *minimum* A(8) >2.8ms^{-2}. The effect of including this information was to increase substantially the minimum estimate of the number of men in the population exceeding this action level to 1,198,200, (95%CI 1,092,000-1,304,400). Among women in the sample, these levels of exposure were uncommon (only 9 of 3,878 employed respondents had a minimum estimated A(8) > 2.8ms^{-2}).

Figure 2 presents further details in the form of a cumulative frequency curve showing the estimated numbers in the population exceeding estimated values of A(8) in the past week. Curves are drawn separately for men and women, and are minimum estimates, as in some cases exposure information was missing. They clearly illustrate the lesser exposures of women.

Contents

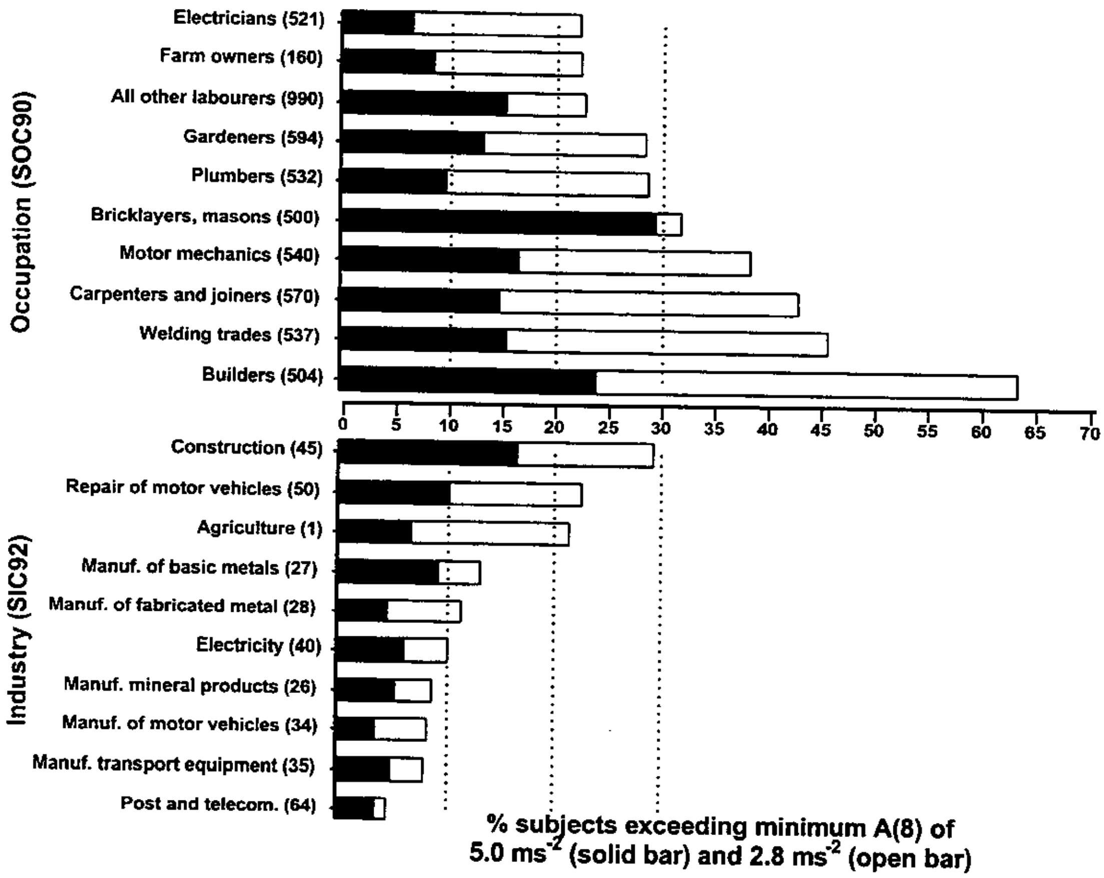
Figure 2
Estimated number of men and women in Great Britain with indicated minimum A(8) exceedences in past week (see also table 11)



In certain occupations and industries the likelihood of a high estimated daily A(8) was greater than in others. Figure 3 and Table 12 present prevalence estimates for A(8) values of interest in the occupations and industries where exceedance was common. Analysis is confined to occupations with more than 30 respondents and industries with more than 60 respondents; and minimum proportions are presented, as exposure information was sometimes missing. High values (A(8) values >5 ms^{-2} r.m.s.) were most often seen in the construction crafts (bricklayers and masons; builders and building contractors; carpenters and joiners; plumbers; electricians and fitters), and in motor mechanics and agricultural and horticultural workers (gardeners, groundsmen and farm owners).

Contents

Figure 3
Occupations (SOC90) and industries (SIC92) in which substantial minimum A(8) values most commonly arose among employed men (see also table 12)

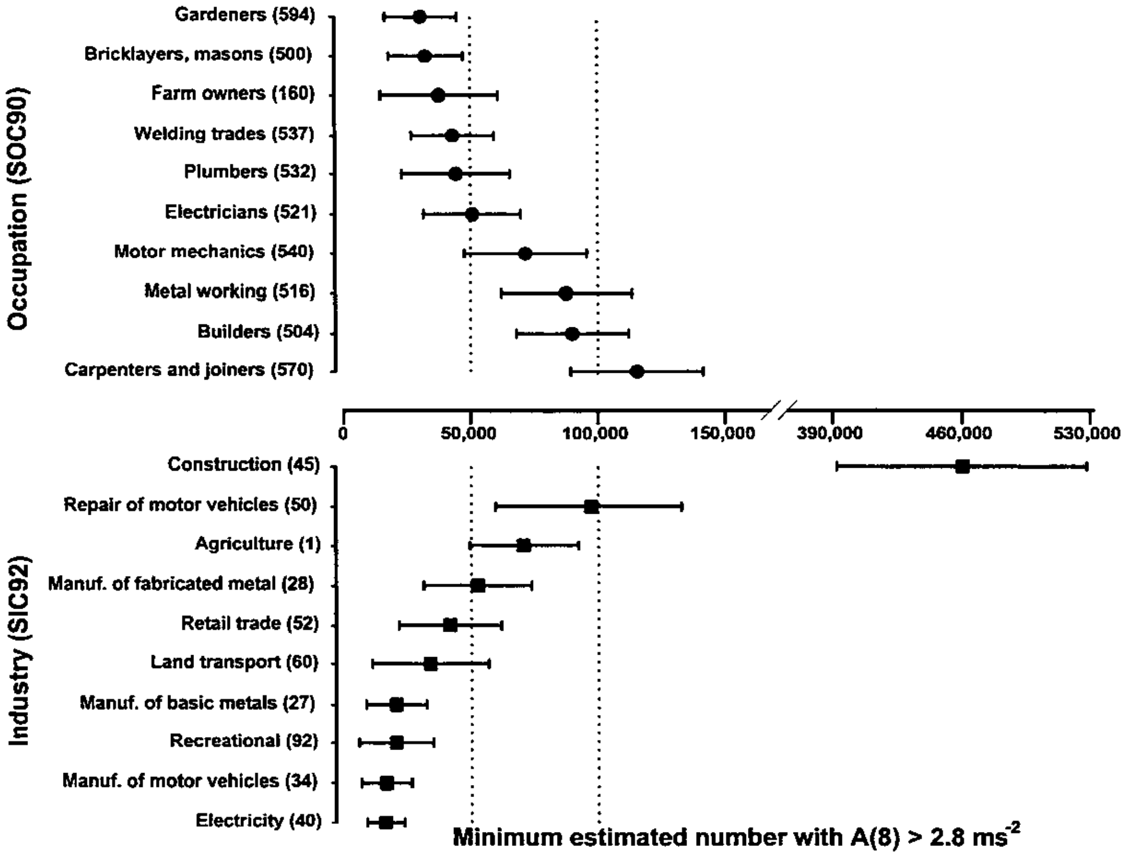


These trades also contributed the largest numbers to national estimates of the frequency of substantive exposure (minimum A(8)>2.8 ms^{-2}) (Figure 4; Tables 13 and 14),* with some 115,000 carpenters and joiners, 90,000 builders and building contractors, 88,000 maintenance fitters and 72,000 motor mechanics estimated to receive daily exposures above this threshold.

---

* *Supplementary analyses by a more comprehensive listing of occupational group (SOC 90), by two-digit SIC 92 industry code, and by region are presented in Appendix D and Appendix E.*

Figure 4
Minimum estimated number of men in Great Britain with A(8) > $2.8ms^{-2}$ in past week by occupation and industry (see also tables 13 and 14)



For men, the median and interquartile ranges of A(8) from all occupational sources combined were plotted by occupation (Figure 5). The highest median value occurred in builders and building contractors, followed by welding trades and then carpenters and joiners. A wide spread of values was estimated for some occupations, notably for bricklayers and masons.

Figure 5
Median and interquartile range of minimum estimated A(8) in the past week by occupation* in men with substantial exposure

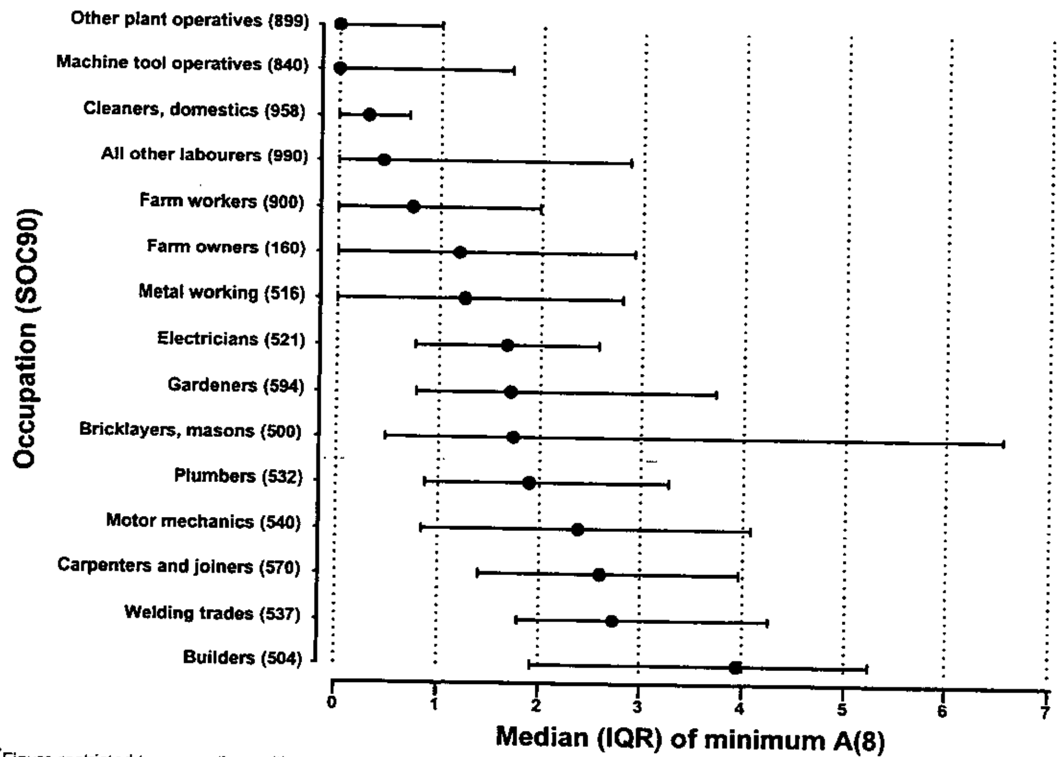


*Figure restricted to occupations with ≥ 30 male subjects with minimum A(8) data available
All other occupations with ≥ 30 subjects with appropriate data have median (IQR) = 0 (0 - 0)

Occupational exposure to HTV and current employment status

Among men who reported having a paid job in the past week, 913 (16.6%) described themselves as being self-employed. Men in this category were more likely to have used hand-held powered tools in the past week (47.8%) than all men in work (31.5%), and more commonly belonged to one of the trades with substantive exposure: for example, 92% of farm owners and managers were self-employed, as were 79% of builders and building contractors, 55% of plumbers and heating and ventilating engineers, 40% of carpenters and joiners, 39% of bricklayers and masons, and 28% of gardeners and groundsmen.

Leisure-time exposure to HTV

13.9% of men (964) and 3.2% of women (189) reported ever regularly using hand-held vibratory tools outside work for an hour or more per week (Question 29). The most commonly reported sources were: hand-guided mowers (334 reports), hand-held sanders (297), hammer drills (207), jig saws (197), hand-held hedge trimmers (153) and hand-held portable grinders (125). One hundred and two subjects reported using chain saws to this extent in their leisure time.

Finger blanching

Prevalence and personal risk factors for Raynaud's phenomenon in the sample

Table 15 records the prevalence of Raynaud's phenomenon in men and women according to three alternative definitions of disease, and the personal risk factors that influence them. The data in this table are based on the whole sample, including the non-employed, and are independent of exposure status.

The prevalence in men varied by definition with an overall prevalence of 13.0% (95% CI 12.2-13.8%) for blanching attacks; 10.6% (95% CI 9.9-11.3%) for cold-induced blanching attacks, and 4.1% (95% CI 3.9-4.3%) for cold attacks associated with a clear edge. In women, the corresponding prevalences were: 15.6% (95% CI 14.7-16.5%) for blanching attacks; 13.4% (95% CI 12.5-14.2%) for cold-induced blanching, and 5.3% (95% CI 4.7-5.9%) for cold attacks with a clear edge.

For all definitions and in both sexes, the prevalence was found to rise with age, and independent associations were found with complaints of feeling frequently tired or stressed and having frequent headaches. A significant association was also found with a history of ever having been a smoker in men, but not in women.

The frequency of attacks, extent of blanching and frequency of troublesome attacks in subjects with symptoms is detailed in Table 16. The pattern proved to be similar, irrespective of case definition. Around two-thirds of symptomatic respondents reported fewer than 10 attacks in the past year; and only 5 – 11% reported more than 50 attacks. About a third of patients had disease affecting eight or more digits, and a quarter had blanching in 15 or more phalanges. Forty per cent reported interference with activities, a fifth to a quarter had taken their complaint to a doctor and about half had suffered attacks in the summer months. There were no significant differences on χ^2 testing in the pattern, extent and frequency of disease between male and female complainants.

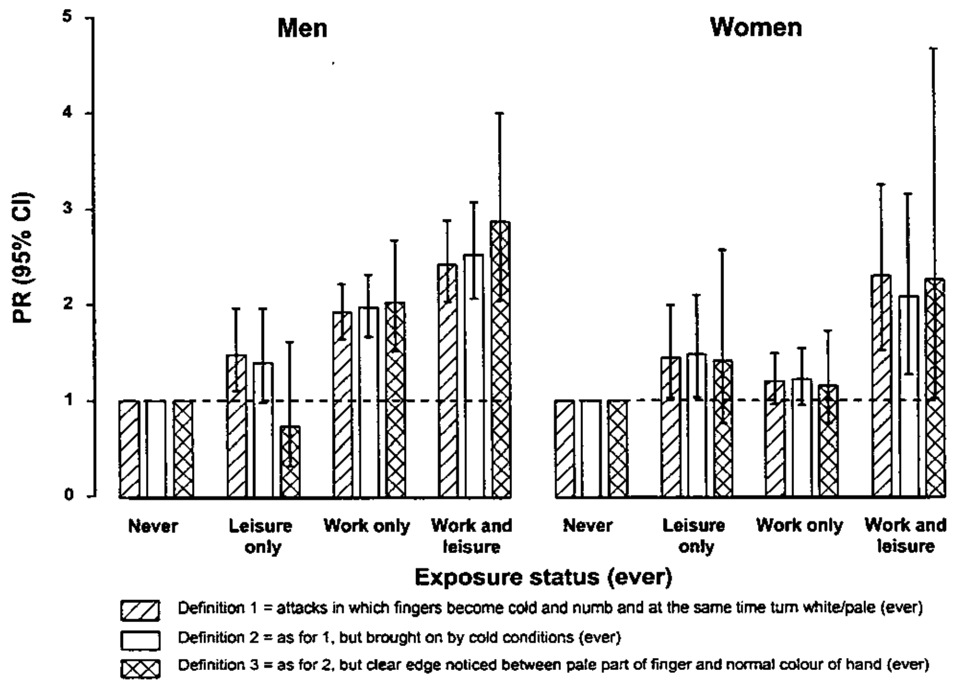
Relation between finger blanching and lifetime exposure to vibration

The relation between lifetime history of exposure to HTV and Raynaud's phenomenon (three alternative definitions) was examined with exposures classified into the four groups: never in leisure and never in work (the baseline group); ever in leisure but never at work; ever at work but never in leisure; and ever at work and also in leisure. Analysis was based on the whole sample, and the prevalence rate ratios were adjusted for age, smoking status and complaints of frequent headaches and frequent tiredness or stress.

Exposure to leisure-time and occupational sources of vibration were both associated with finger blanching (Figure 6 and Table 17). The relation was evident in both sexes, but stronger in men than women. Risk ratios became somewhat greater and the confidence intervals somewhat wider as the definition of Raynaud's phenomenon became more specific, but similar patterns were apparent for all definitions. PRs of around 1.4 - 1.5 were observed in men and women exposed to HTV only in their leisure-time; for work-only exposures, the PR in men was 1.9-2.0, but lower (around 1.2) in women; and the highest risks were seen in people who reported both categories of exposure, varying from 2.08 (95%CI 1.27 - 3.16) in women with cold-induced blanching attacks to 2.87 (95%CI 2.04 - 4.00) in men with clear-edged attacks. Most of the associations in men and several in women were significant at the 5% level.

Further analyses were restricted to a single definition of Raynaud's phenomenon – namely cold-induced finger blanching. This was selected because of the essential similarity of risk estimates and patterns of disease for all three definitions, the general acceptability of this definition, and the need to preserve sufficient numbers for subgroup analyses.

Figure 6
Relation between lifetime exposure to hand-transmitted vibration and the risk of Raynaud's phenomenon according to three definitions of disease (see also table 17)



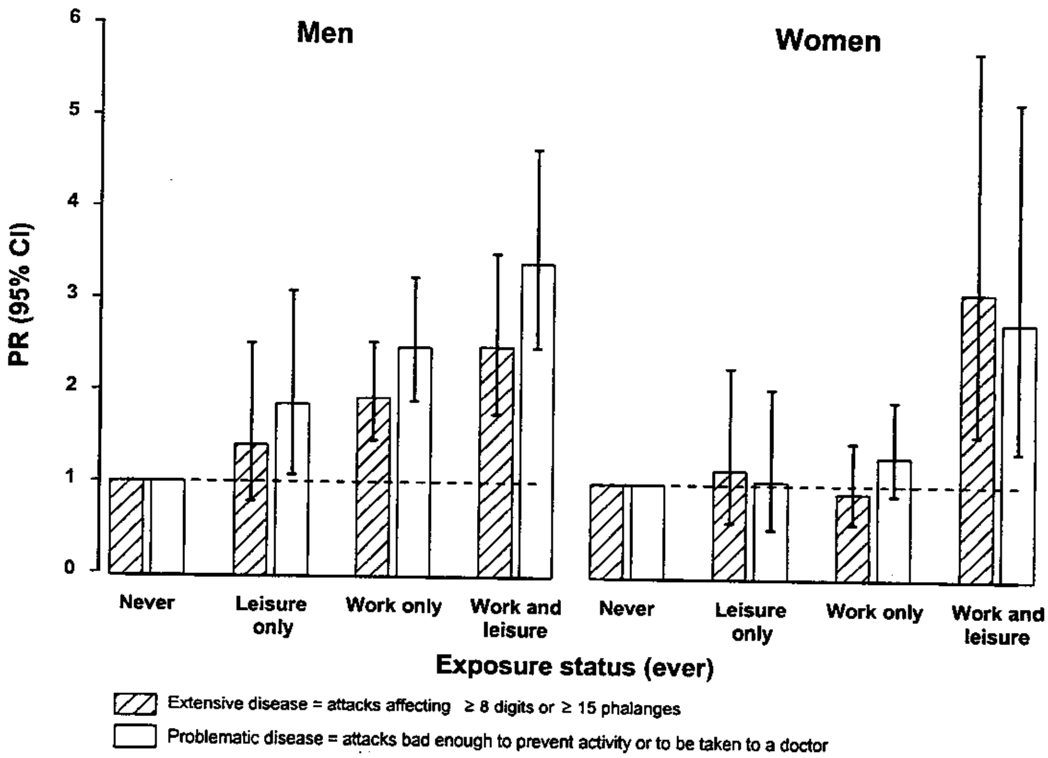
The data from Table 16 were used to define two categories of severe disease:

a) *extensive disease* - disease affecting eight or more digits or 15 or more phalanges (about 40% of cases); and

b) *troublesome disease* - disease which had prevented activity or had been taken to a doctor (also 40% of cases).

Figure 7 and Table 18 examine the relation between these categories of severe cold-induced blanching and lifetime exposure to HTV. In general, similar patterns and risk estimates were observed in the subgroups, although larger risk estimates were observed for troublesome disease than for blanching attacks as a whole. The highest risks were again seen in men, and in those who used hand-held vibratory tools both in work and in their leisure. In men, the PR for troublesome disease varied among occupational users from 2.46 (95% CI 1.88 - 3.23) in work-only users to 3.39 (95% CI 2.46 - 4.64) in work and leisure users; and the PR for extensive disease varied from 1.91 (95% CI 1.45 - 2.52) in work-only users to 2.47 (95% CI 1.73 - 3.49) for work and leisure users. In women, the risk for both categories of severe disease was increased about three-fold in those who had both work and leisure exposure.

Figure 7
Relation between exposure to hand-transmitted vibration and the risk of extensive and troublesome cold-induced finger blanching (see also table 18)



Prevalence and risk factors for Raynaud's phenomenon in current workers

Further analyses focused on those employed and at work in the previous week, as this group supplied the most detailed information on exposure to vibration.

To identify other potential occupational risk factors, the relation was next explored between disease frequency and work activities in employed men who had *never* been exposed to HTV (Table 19). The factors considered were physical components of an average working day in the present job – namely: work outdoors or in a cold store; lifting weights more than 20 lbs (10 Kg) by hand; work with hands above shoulder height for more than an hour; use of a keyboard for more than four hours; and riding on a heavy industrial vehicle* in the past week.

**The questionnaire also inquired about exposure to whole-body vibration in the past week. This group included workers who had driven or ridden on rock crushers, concrete production machinery, tractors, loaders, excavators, bulldozers, graders, scrapers, dumpers, road rollers, mowers, off road forestry vehicles, armoured vehicles, forklift trucks, mobile cranes, lorries, helicopters, planes, high-speed boats, hoists/lifts, ambulances, boats, off road cars/vans, quad bikes, fire engines, milk floats or conveyor belts in the past week.*

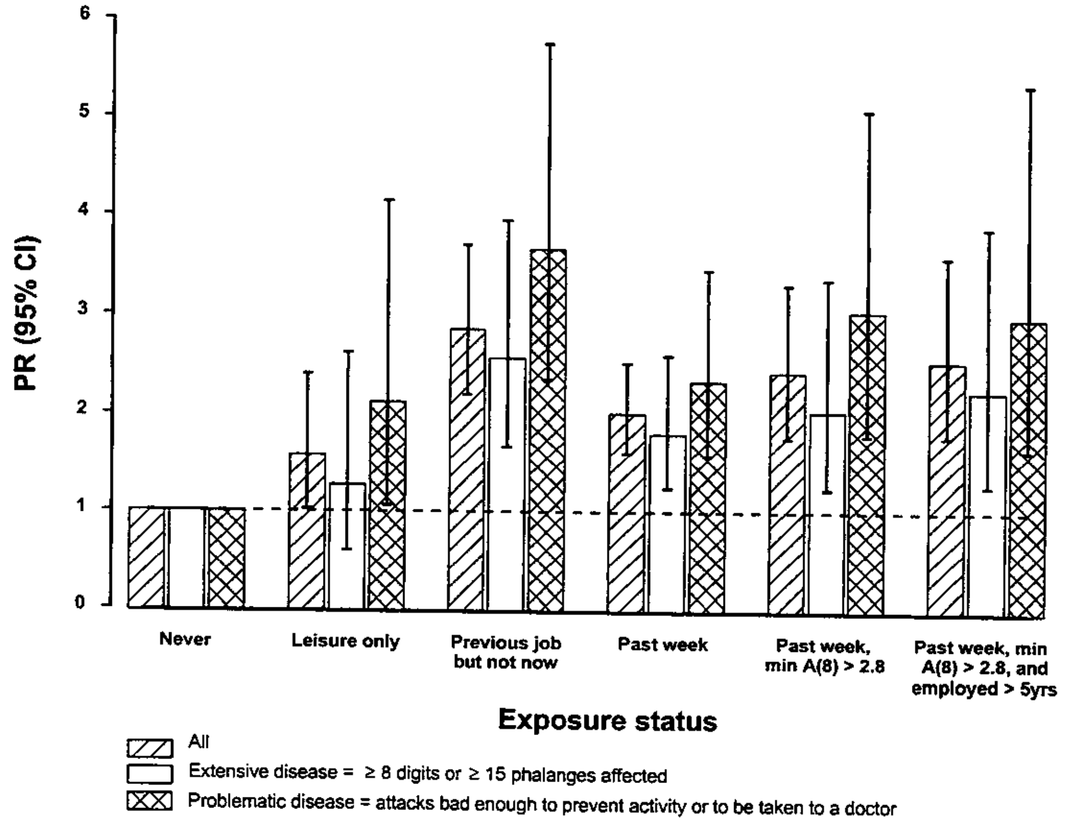
A possible association was found with lifting weights in men (PR 1.42, 95% CI 0.98 - 2.07 for cold-induced attacks, with similar risk estimates for alternative definitions of Raynaud's phenomenon); but no association was found with the other physical factors, including exposure to whole-body vibration. In women, potential associations were found with outdoor and cold store work (PR 1.44, 95% CI 1.00 - 2.01), work with hands above shoulder height (PR 1.73, 95% CI 1.13 - 2.54) and riding on a heavy industrial vehicle in the past week (PR 1.24, 95% CI 0.66 - 2.19), but these were based on small numbers with exposure, and as the principal interest of later analyses was health effects in men, lifting weights was taken forwards as a factor of adjustment alongside age, smoking status, headaches and tiredness/stress.

To confirm that the relation between lifetime exposure to HTV and risk of cold-induced finger blanching was unaltered by the new factors of adjustment, and by focusing on workers rather than the whole sample, the analyses of Table 17 were repeated in employed subjects (Table 20). The risk estimates for occupational exposure were still significantly elevated.

Pairwise risk estimates were then derived in relation to the baseline of never exposed for workers exposed in a previous job (but not currently); workers exposed in the past week; workers substantially exposed in the past week (defined as minimum daily A(8) > 2.8 ms^{-2} r.m.s.); and substantially exposed workers employed for more than five years in their present job (Figure 8 and Table 20). Higher risk estimates were seen for exposure in an earlier job than for exposure in the past week - e.g. PR for cold-induced blanching: 2.86, 95% CI 2.19 - 3.72 (past job) vs. 2.01, 95%CI 1.60 - 2.52 (past week); PR for troublesome blanching: 3.68, 95% CI 2.34 - 5.78 (past job) vs. 2.33, 95% CI 1.57 - 3.46 (past week). And higher risk estimates were also observed for men with substantial exposure in the past week than for all men with current exposure - e.g. PR for cold-induced blanching: 2.42, 95% CI 1.76 - 3.30 (daily A(8) > 2.8 ms^{-2}, past week) vs. 2.01, 95% CI 1.60 - 2.52 (any exposure in the past week); PR for troublesome blanching: 3.04, 95%CI 1.79 - 5.09 (daily A(8) > 2.8ms^{-2}, past week) vs. 2.33, 95% CI 1.57 - 3.46 (any exposure in the past week).

Among men with a minimum A(8) > 2.8 ms^{-2} in the past week, similar risks were found in those employed for more than and fewer than five years. (60% of currently exposed men had been employed more than five years.)

Figure 8
Relation between exposure to hand-transmitted vibration and risk of cold-induced finger blanching in employed men (see also table 20)



Population attributable risks for finger blanching

As explained in the methods section, population estimates of the lifetime prevalence of exposure to HTV (from all sources combined) were determined after standardisation for occupation. (For this purpose people without an occupation were treated as a separate occupational category.) Estimates of the number of cases of finger blanching in Great Britain were similarly derived after standardisation for occupation. Relative risk estimates (ever vs. never exposed to HTV) were obtained for each of the three definitions of Raynaud's phenomenon after adjustment for age, smoking, frequent headaches, frequent tiredness and stress and lifting weights $\geq$ 20 lbs in an average work day (this categorical variable was set as zero in the non-employed). The proportion and numbers of cases attributable to HTV in the population were then estimated using the formulae described in the methods section. Attributable proportions and numbers were similarly determined for the two definitions of severe Raynaud's phenomenon (extensive and troublesome disease); and for disease potentially severe enough to merit a DSS assessment for compensation under the British state industrial injuries scheme.*

For men with cold-induced finger blanching, the attributable fraction from all sources of vibration was estimated to be 29%, corresponding to a population attributable number of 673,500. For the stricter definition of cold-induced blanching with a clear edge, the attributable proportion was unchanged, but the attributable number fell to 255,500. In women, the attributable proportion from vibration was much smaller (3%), leading to an attributable number of 104,100 for cold-induced blanching, or 33,300 when attacks were associated with a clearly defined edge.

Assuming the definition of cold-induced finger blanching, the attributable number of cases of extensive disease was estimated to be 222,300 in men and 20,300 in women; the corresponding numbers for troublesome blanching were 459,100 and 44,100 respectively. Finally, the estimated number of attributable cases among current workers of disease severe enough to potentially merit an assessment for state compensation purposes was 268,000 for men and 33,400 for women.

Sensorineural complaints

Prevalence and personal risk factors for sensorineural complaints in the sample

The questionnaire collected information on eight categories of sensorineural complaint across two prevalence periods: numbness/ tingling lasting at least three minutes in the past week and past year in: the fingers, hand, arm, or upper limb disturbing sleep. In exploratory analyses independent associations were found in both sexes between each of the definitions and age, smoking history and complaints of frequent tiredness, stress and headaches. The strongest associations were observed for symptoms disturbing sleep, followed by finger symptoms, and these two complaints were selected for later analysis because of *a priori* interest in digital neuropathy and median nerve compression. It was further considered that

---

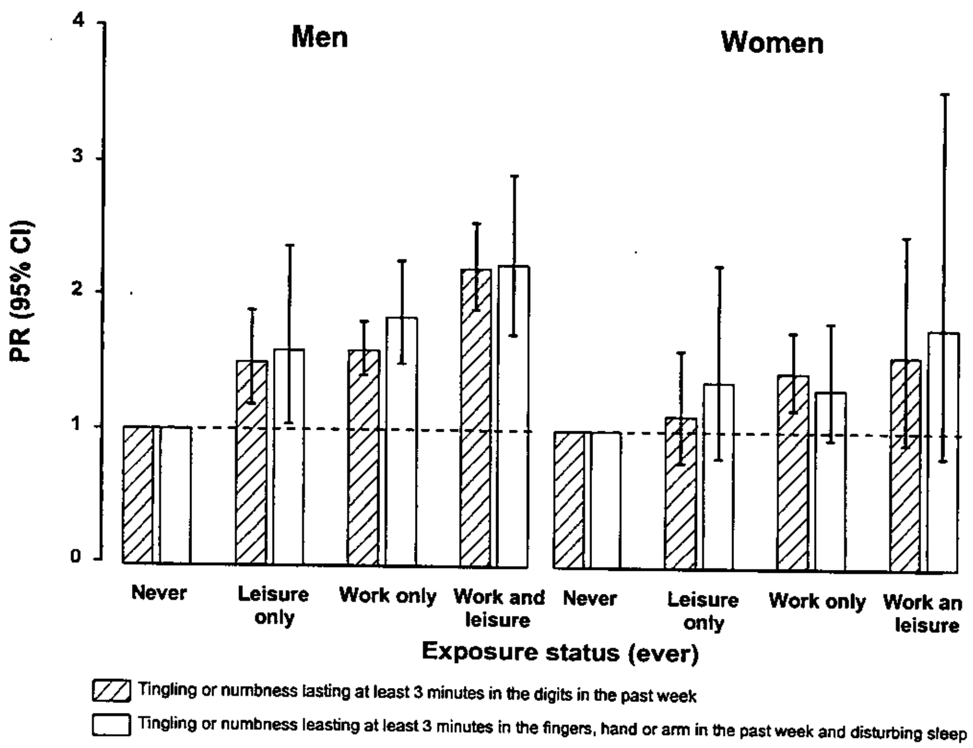
**This was defined as cold-induced blanching affecting the distal and middle phalanges of three digits on either hand, with attacks in the summer as well as the winter, and attacks in the past year. Analysis was confined to current workers, but took no account of the DSS eligibility restrictions in relation to occupation and exposure. In practice, not all workers with such complaints would qualify for an assessment.*

recall would be more reliable for symptoms occurring in the past week. Table 21 presents the mutually adjusted associations with age, smoking and psychological variables for these two categories of complaint in men and women from the entire sample. These were found to be related to reporting of symptoms.

Relation between sensorineural symptoms and lifetime exposure to vibration

After adjustment for these factors, a clear relation was seen with lifetime history of exposure to hand-powered vibratory tools (Figure 9 and Table 22), similar to that observed for finger blanching. Associations were apparent for both types of complaint and in both sexes (though the associations were weaker in women); and again there was evidence of a relation with leisure-time and occupational exposure to vibration. Risk estimates of about 1.5 were found in men who had only used tools in their leisure time, and 1.6-2.2 in men who had occupational exposure. As with finger blanching, the highest risk estimates were found in men and women with lifetime exposures to both sources of vibration. The associations in men were all significant at the 5% level.

Figure 9
Relation between lifetime exposure to hand-transmitted vibration and the risk of sensorineural complaints in the past week (see also table 22)



Contents

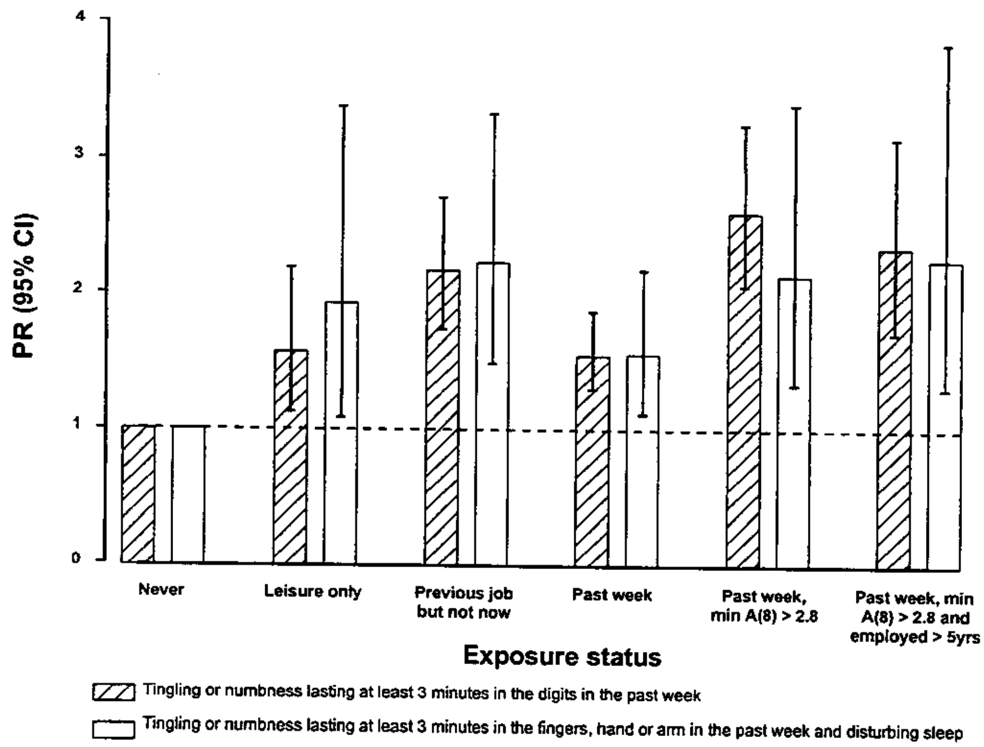
Prevalence and risk factors for sensorineural symptoms in current workers

Table 23 examines the relation between sensorineural symptoms in the past week and physical ingredients of an average working day in employed subjects who had never been exposed to HTV. Potential associations were identified with outdoor and cold store work, lifting weights, and work with hands above shoulder height; but there were no associations with use of a keyboard for $\geq$ 4 hours/day or exposure to whole-body vibration in the previous week. Hence, in further analyses of employed workers, cold work, lifting and work with hands above shoulder height were included as factors of adjustment alongside age, smoking and psychological complaints.

To confirm that the relation between lifetime exposure to HTV and risk of sensorineural symptoms was unaltered by the new factors of adjustment, and by focusing on workers rather than the whole sample, the analyses of Table 22 were repeated in employed subjects (Table 24). The risk estimates for occupational exposure were still significantly elevated, the strongest associations being with symptoms disturbing sleep rather than symptoms in the fingers.

Pairwise risk estimates were derived in relation to the baseline of never exposed for: workers exposed in a previous job (but not currently); workers exposed in the past week; workers substantially exposed in the past week (minimum daily A(8) > 2.8 ms^{-2} r.m.s.); and substantially exposed workers employed for more than five years in their present job (Figure 10 and Table 24). Higher risk estimates were seen for exposure in an earlier job than for exposure to HTV in the past week - e.g. PR for symptoms in the fingers: 2.17, 95%CI 1.73-2.71 (past job) vs. 1.55, 95%CI 1.29-1.86 (past week); PR for symptoms disturbing sleep: 2.23, 95%CI 1.49-3.33 (past job) vs. 1.56, 95%CI 1.11-2.18 (past week). And higher risk estimates were also observed for men with substantial exposure in the past week than for other current users - e.g. PR for symptoms in the fingers: 2.60, 95%CI 2.06-3.26 (daily A(8) > 2.8 ms^{-2} r.m.s., past week) vs. 1.55, 95%CI 1.29-1.86 (any exposure in past week); PR for symptoms disturbing sleep: 2.14, 95%CI 1.33-3.41 (daily A(8) > 2.8 ms^{-2} r.m.s., past week) vs. 1.56, 95%CI 1.11-2.18 (any exposure in past week). Length of employment had little effect on risk estimates in the current job.

Figure 10
Relation between exposure to hand-transmitted vibration and the risk of sensorineural complaints in the past week in employed men (see also table 24)



Relation between finger blanching and sensorineural complaints

Sensorineural and vascular complaints appeared to bear a similar relation to exposure, but attacks of blanching may cause numbness and their resolution may cause parasthesiae. To assess whether or not these effects arise independently, the extent of overlap was examined according to exposure status (Table 25), and the prevalence of sensorineural complaint stratified by blanching and exposure status (Table 26). Associations between exposure to HTV and sensorineural symptoms were found, even in the absence of blanching. Similar patterns were seen in men and women, and in association with exposure during leisure and in a former employment, as well as current occupation. These data suggest that sensorineural complaints in the fingers do not arise solely or principally as a result of blanching.

Risk from individual tools

As discussed later, the capacity of this study to examine risk by individual tool type is limited by the cross-sectional nature of the exposure information on named sources and the multiplicity of tool use. However, 60% of workers had been in their current job for more than

Contents

5 years and only 9.9% reported their exposure in the past week to be atypical, and on the basis that current exposure may be a rough guide to the past, a series of exploratory analyses were conducted of risk according to tools used in the past week. Risk was examined in users of several tools, adjusted for the effects of other tools used in the same week; and also in men exposed to a single source of vibration in the previous week.* The risks of finger blanching and sensorineural complaint were examined separately.

Table 27 presents an analysis based on all working men which compares the risks of cold-induced finger blanching from each of a number of common tools, before and after mutual adjustment for other tools used in the past week. When no account was taken of other sources of exposure, all of the common tools appeared to be associated with a significant risk of blanching. After adjustment for other sources of exposure to HTV in the past week, the risks mostly persisted, although the associations only remained statistically significant at the 5% level for hand-guided mowers, metal drills, concrete breakers and chain saws. In some cases, the risk estimate for blanching increased upon adjustment (e.g. hand-held sanders, mowers, metal drills and chipping hammers), but in the case of jig saws, circular saws and impact wrenches it disappeared. In users of a single tool (Table 28) excess risks of cold-induced blanching were similarly observed with exposure to a number of sources, including floor polishers, metal drills engraving pens, nailing guns, hand-guided mowers and hand-held portable grinders. However, the numbers were small and the confidence intervals surrounding the risk estimates were wide.

For sensorineural complaints (Table 29), significant associations were found between all of the common vibratory tools and sensorineural symptoms in the fingers in the past week (PRs 1.46 - 2.17) when no account was taken of multiple exposures. After adjustment for use of other tools in the same week, the risks from concrete breakers (PR 3.43, 95%CI 1.69-6.21) and hand-guided mowers (PR 1.98, 95%CI 1.08-3.42) were still significantly elevated, and those from jig saws (PR 2.29, 95%CI 0.85-5.59), hand-held sanders (PR 1.83, 95%CI 0.73-4.13) and impact screwdrivers (PR 2.17, 95%CI 0.77-5.21) all increased. Apparent associations with use of the hammer drill, hand-held grinder, circular saw, impact wrench and chipping hammer disappeared.

**The vibratory tools chosen for analysis were those previously determined to be most common nationally (Table 7). However, a crude excess of finger blanching was also seen in users of many other tools from the questionnaire.*

Associations were also seen between exposure to a number of common sources of HTV and sensory symptoms disturbing sleep, though the picture was mixed. Significant associations were found for use of the metal drill, concrete breaker, impact screwdriver and hammer drill, but after adjustment for other tools used in the past week the only significant association was with use of the concrete breaker (PR 4.64, 95%CI 1.67-12.11). In a few other cases the risk persisted or increased after adjustment - namely: hand-held sander (PR 2.11 95%CI 0.49-8.45), metal drill (PR 2.19, 95%CI 0.77-5.89), impact wrench (PR 1.49, 95%CI 0.20-9.83) and circular saw (PR 1.48, 95%CI 0.20-10.07).

Among users of a single tool, significantly elevated risks were found for floor polishers in men (PR 1.94 for finger symptoms; and 3.37 for symptoms disturbing sleep) and nailing and stapling guns in women (PR 2.53 for finger symptoms) (Table 30). Elevated risks were also found for a number of other sources, including hand-guided mowers, metal drills and motor-cycles, though these did not reach statistical significance.

Risk by current occupation

Finally, in Table 31 the risks of cold-induced finger blanching are presented by current occupation, for jobs where exposures commonly exceeded a self-estimated A(8) >2.8 ms^{-2} r.m.s.*. In men, significant excess risks were seen in carpenters and joiners (PR 2.66, 95%CI 1.39-5.00), electricians and electrical maintenance fitters (PR 2.28, 95%CI 1.41-4.47), motor mechanics (PR 3.23, 95%CI 1.49-6.67) and builders and building contractors (PR 3.37, 95%CI 1.42-7.38); elevated risks were also seen in bricklayers and masons (PR 2.37, 95%CI 0.87-5.96), gardeners and groundsmen (PR 1.89, 95%CI 0.65-5.08) and metal working production and maintenance fitters (PR 1.52, 95%CI 0.77-2.94). In a number of occupations slightly higher risks were found among those employed for more than five years. Among women, no excess risk was seen in cleaners, domestic workers or hairdressers.

**These estimates were not adjusted for occupational lifting, as this proved to be very strongly correlated with exposure in these professions. The independent risk from lifting in non exposed men was 1.42 (Table 23), so these values may represent a small over-estimate.*

WORKPLACE VISITS

METHOD

More than 30 premises were visited, including a plant where motor vehicles were manufactured, another where mattresses were assembled, a metal working shop in a shipbuilder's yard, three farming and horticultural estates, two retail warehouses, a haulage depot, a joinery, the works and gardens departments in a local authority and a university, and depots involved in the maintenance of aircraft, buses, police vehicles and fire engines.

The visit programme followed an interim analysis of the first postal mailing and was informed by it. A list of exposure sources was first assembled, based on the frequency of use and evidence of potential health risk. Vibratory tools with the greatest national estimated numbers of users formed the basis for a provisional list, namely:

hammer drill	hand-held portable grinder
jig saw	circular saw
hand-held sander	hand-guided mower
pedestal grinder	impact screwdriver
impact wrench	floor polisher

Workplaces in which these tools were in use were identified, and in discussion with managers the departments in which exposures of interest occurred were identified. Tool users were selected for assessment in each workplace on the basis of availability, and with no overall limit (range 3-22 workers). Each worker was asked to complete a questionnaire identical to the exposure section of the postal questionnaire - providing details of occupation and hand-powered vibratory tools used in the previous week. An attempt was later made to verify, through interviews with line managers and by inspecting tool inventories, that the tools described as being used could actually have been used; and to identify any tools that had been reported but which could not have been used, or any that had been incorrectly described.

Workers were next observed over a one-hour period during representative activities that involved use of the hand-held powered tools, and a record made of the sources and the durations of exposure. In each case the hand-tool contact time was directly measured using a

Contents

stopwatch for the time when the switch was on or the power engaged (representing the true interval that vibration entered the hand). The worker was asked after the observation period to complete a second proforma, similar to the first but describing the exposures that had been incurred during the time he (she) was observed.

Proformas were completed immediately after the observation period, or at the earliest available work break. A record was made of when they were completed and whether or not the worker regarded the observation period as 'typical of the job'.

Openly worded descriptions of exposure sources were coded on the same basis as for the principal survey - independently by an occupational physician and a specialist in vibration research, with any disagreements resolved by consensus. Coding was performed blind to the information collected by direct observation.

Additionally, a series of visits were made to workplaces where exposures to whole-body vibration (WBV) were incurred. As for HTV, the visits were planned to sample exposures that were common nationally, and these occurred in drivers of vans, buses, lorries, tractors, fork-lift trucks and ride-on mowers. The same questionnaires were employed as used in the HTV assessments, and again a direct comparison was made between observed and reported exposures. For all subjects, the opportunity existed to report (and/or observe) exposure to HTV as well as WBV (- in some cases both types of exposure were observed), so the findings from both sets of visits were incorporated into the present analysis.

ANALYSIS

a) Reports of exposure in the previous week were compared with the inventories of tools available for use as the 'gold standard'. Frequency counts were determined of the reports considered to be feasible and those considered unlikely, and so the proportion of plausible exposures was ascertained, overall and by tool type.
b) For the observation period, a similar comparison was made between the sources reported as used and those observed in use. Contingency tables were drawn up, both overall and for each of the 38 pre-defined tool categories in the questionnaire. The sensitivity and specificity of the questionnaire were calculated in relation to: (a) being classified as a user of any of these tools ; and (b) use of each specific tool from the list.

Contents

c) Scatter plots were drawn comparing workers' reports of exposure times in the observation period with the times that were measured, and median (interquartile) ratios of observed to reported exposure time were calculated, overall and for several commonly observed tools.

RESULTS

Participants

One hundred and sixty-six male and 13 female workers were approached in total (median age – 40 years, range 16-63 years) and all agreed to participate. These comprised 116 workers selected primarily for their exposure to HTV and 63 selected primarily because of their exposure to WBV. Occupations in the former group included: motor assembly workers (17), cleaners (13), metal plate workers and shipwrights (12), gardeners and groundsmen (11), motor mechanics (9), mattress makers (8), carpenters and joiners (7), woodworking machinists (5) and metal working and maintenance fitters (5); occupations in the latter group included drivers of lift trucks (25), goods vehicles (10), buses (9) and vans (7).

Ninety-three per cent of forms (166) were completed within an hour, and eight others within three hours of the observation period. In five others the time of completion was not recorded. On inquiry, 114 of the 116 workers seen in connection with vibratory tool use reported that the observation period had been 'typical' of their job. Two others did not specify.

Reported exposures in the past week

One hundred and twenty-five subjects reported exposure to HTV in the past week, and in 121 of these cases (97%), the exposure status was confirmed as feasible (Table 32). Altogether, 393 sources of exposure were reported (2.2 per subject on average), and in 260 of these reports (66%) inquiry confirmed the possibility of these exposures. The feasibility of exposure accounts varied by tool type, from 19% to 100%, but generally exceeded 80%. It was particularly high for hand-guided mowers (100%), impact screwdrivers (93%), hand-held sanders (87%), floor polishers, nut runners and hammer drills (all 86%); intermediate for impact wrenches (62%), and poor for riveting hammers (19%).

The entire accounts (positive and negative reports) of 75 subjects (42%) were confirmed as reasonable after inquiry and inspection of tool inventories. In a further 52 subjects (29%), one or more exposures were reported that did not appear feasible. In 90 subjects some exposures that appeared feasible were not reported, although no evidence exists that these were true errors of omission. The possible causes of error were explored in the observational part of the investigation (below).

Exposures in the observation period

Sources

The powered tools most commonly observed in use were: hammer drills (30), nailing and stapling guns (24), impact screwdrivers (18), nut runners (15), portable grinders (14), floor polishers (13) and jig saws (13).

One hundred and thirteen subjects were observed using hand-powered tools in the workplace, among whom 69 people used a single tool, 31 used two tools, 8 used three, and 5 used five. This compared with 110 people who reported exposure (Table 33). The sensitivity of the questionnaire items to detect exposure was 96% (i.e. it detected nearly all persons with genuine exposure); and its specificity was 98% (i.e. nearly everyone classified as non-exposed was truly so). All but one person who claimed to use hand-held vibratory tools was observed using at least one such tool (i.e. the positive predictive value in this sample of being a vibratory tool user having reported such an exposure was 99%). Among the 69 subjects who reported no exposure, one person was observed using a hand-held vibratory tool (negative predictive value 94%).

When specific sources were considered, 179 separate reports of exposure were recorded as compared with 180 observed exposures. The specificity of reports by tool type was 93-100% for all subjects (and even higher among those with any exposure to HTV). The sensitivity varied by tool type, from 39% for impact screwdrivers to 100% for circular saws, floor polishers and hand-guided mowers.

For the last two of these sources all reports were confirmed by direct observation. In other cases there was evidence of some misclassification between particular pairs of tools: eight of 10 subjects reporting exclusive exposure to the riveting hammer were actually using nailing and stapling guns; in three instances where hand-held sanders were reported as used, only portable grinders had been observed; and eight of 29 subjects who only used a hammer drill

Contents

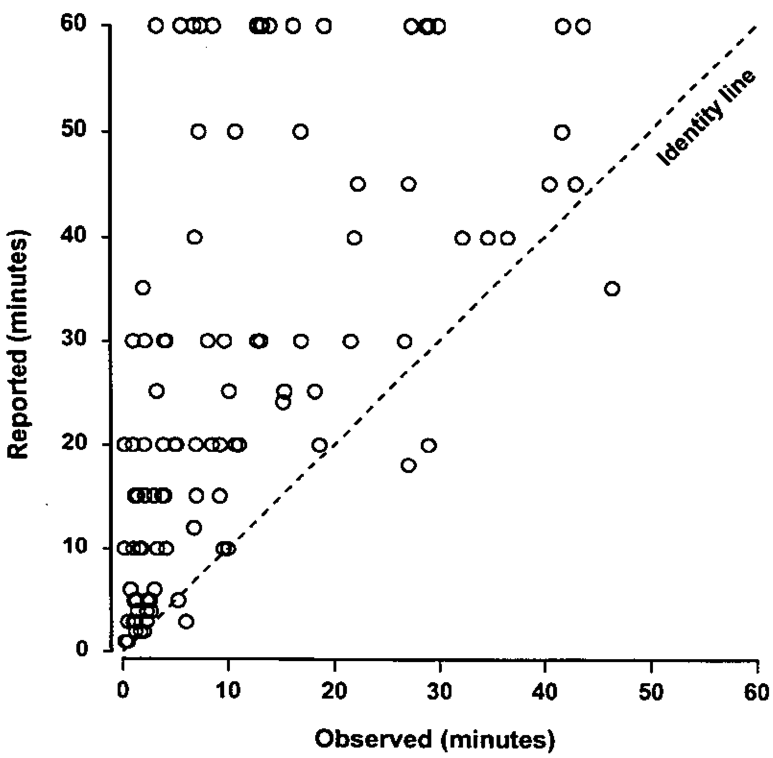
reported using a riveting hammer with or without another tool. Another source of error lay in the inadequate description of some tools by subjects: in five subjects observed using a hammer drill their various reports of using a 'drill', an 'air drill', a 'portable drill' and a 'hand-held drilling machine' led to them being misclassified as non-exposed.

The entire accounts (positive and negative reports) of 131 subjects (73.2%) were confirmed by observation (Table 34). In a further 13 subjects (7.3%), an exposure was reported that was not observed; in 13 subjects (7.3%) an exposure was observed that was not reported; and in 22 others (12.3%) elements both of over-reporting and under-reporting were observed. The errors became more common the greater the number of tools actually used (Table 35).

Durations of exposure

Figure 11 compares the reported exposure times from all sources of HTV with the times observed. The plot illustrates the strong general tendency to over-report exposure times; the wide scatter of reported times for similar periods of true exposure; and the evident tendency to round estimates up or down to the nearest whole multiple of five or ten minutes (digit preference). In a few instances times were reported that were longer than the period of observation, illustrating the difficulties subjects had in comprehending instructions and the line of inquiry.

Figure 11
Reported versus observed exposure times for sources of hand-transmitted vibration



Contents

The ratio of reported to observed times by tool type is presented in Table 36, as median and interquartile values. The median number of repetitions (times each tool type was used in the observation period) is also recorded. The degree of over-reporting varied by tool type, from a median of 1.2-fold (IQR 0.8-2.0) for hand-guided mowers up to 6.3-fold (IQR 3.4-7.6) for hand-held sanders. The median value for all tools was 2.5 (IQR 1.6-5.9). The three lowest ratios arose for sources of exposure with the smallest median number of repetitions.

The ratio of reported to observed times fell as the true period of observation increased - from a median ratio of 5.8 (IQR 2.7-11.7) among 24 subjects truly exposed for ≤ 2 minutes over the hour to 1.2 (IQR 1.1-1.2) among nine subjects exposed for more than 30 minutes of exposure. The opportunity for over-reporting also fell as the true period of exposure got closer to the period of observation: the last column of Table 36 illustrates the maximum theoretical range of over-reporting possible in each time band. The data suggest that this constraint may have accounted for a part but not all of the effect.

DISCUSSION

This national survey of exposure indicates that in a given week approximately 20% of all working-aged men (4.2 million men) and 3% of all working-aged women (667,000 women) are exposed to hand-transmitted vibration at work. It further estimates, based on self-reports of exposure times, that the daily A(8) in 5.8% of working-aged men (1.2 million), and 0.2% of working-aged women (44,000) exceeds the suggested action level of 2.8 ms^{-2} r.m.s. The occupations and industries contributing most to national estimates of exposure prevalence have been identified, as well as those in which individuals with high levels of exposure are to be expected; and the commonest hand-held vibratory tools in use, and the common exposure patterns have been described.

The data also provide an estimate of the lifetime frequency of occupational and leisure-time exposures, and indicate that these too are very prevalent: 42% of men and 8% of women from the sample had worked in jobs with exposure to HTV at some stage; and 14% of men and 3% of women had regularly used powered tools outside work for more than an hour per week.

The findings further imply that vibration is a common cause of Raynaud's phenomenon in British men, and that many more cases of VWF exist nationally than previously estimated; while the sensorineural data supplement the picture, by providing an indication of the additional numbers with neurological complaints. Excess risks of finger blanching were found in many occupations where exposures have been estimated to be common and substantial.

POTENTIAL BIASES AND LIMITATIONS

Before considering the public health implications of the study, however, it is necessary to reflect on some of its potential biases and limitations. On the exposure side these include the validity of self-reported exposures and the potential for misclassification and quantitative errors; the representativeness of exposure histories; the assumptions inherent in extrapolating from a sample to the population; and possible response and reporting biases.

On the health side, the principal concern, in a study which manifestly concerned vibration and health, is that risk might have been overestimated if subjects with exposure and disease participated preferentially (response bias), or if subjects were more likely to recall exposure in the presence of disease than without it (reporting bias). Estimation of the attributable numbers requires information on the prevalence of exposure, its risk, and the frequency of disease in the population, and so may be affected by several sources of error or bias. These issues are discussed in the commentary that follows.

Exposure

Misclassification of sources of exposure

Three principal sources of error need to be considered: lapses of memory; failures of recognition or representation; and confusion between leisure-time and occupational exposures.

Errors of recall are more likely for earlier career exposures than exposures in the past week, and these are most likely to be omissions, leading to underestimation of the frequency of lifetime exposure. Even so, some workers may have reported tools as being used in the past week which were not, but which they did sometimes use in their job. Such errors, if common, would lead to an overestimate of the number of weekly tool users, the number of tools used in the past week and the personal daily vibration dose; but not the numbers with exposure in the current job.

Information on current sources of exposure came either from closed questions about a pre-defined list of tools or from an openly worded section evaluated by a panel of vibration specialists. All of these reports are likely to represent substantive sources of exposure, but error might arise in the closed list if respondents failed to recognise a tool name or confused it with another that they had used; and in the open response section if they described tools in an ambiguous or misleading way. Such errors could lead to an over- or under-estimate of the frequency of exposure. (As an example of the former, users of ordinary drills might report instead that they had used a hammer drill; as an example of the latter, they could have failed to recognise the tool as a hammer drill and reported only the use of a drill in the open response section - which would be misclassified as non-exposed to HTV.)

Another possibility is that recreational activities were sometimes reported as if they were occupational. This risk might be expected to be higher for some tools, such as hand-guided mowers, than for others.

One test of these concerns is to examine the face validity of common sources of occupational and recreational exposure. This was done for users of hammer drills, hand-held portable grinders and jig saws (the three commonest sources of exposure) and for users of hand-guided mowers, hedge trimmers and strimmers (three exposures that are may arise recreationally as well as occupationally). Exposures in the former group largely arose from occupations where use was expected or considered plausible, lending support to the data. Thus, 71% of men who reported using a hammer drill came from the occupational groupings of metal processing, electrical processing, other processing and construction (HSE occupational groups 18, 19, 21 and 23); 69% of men who used hand-held portable grinders and 67% of jig saw users came from these same professions. However, only 31% of men who used a hand-guided mower, 35% of men who used a hedge trimmer and 61% of men who used a strimmer came from the farming, fishing or forestry industry; and only 19-35% of these exposures were specifically in gardeners. So a possible bias due to the false reporting of leisure-time exposures cannot be discounted in the case of gardening equipment.

An independent test of the accuracy in reporting sources of exposure was conducted during the observational workplace visits (Tables 32-34). Accounts of exposure in the past week were generally confirmed as plausible on careful inquiry, while in the observation period the questions used to determine overall exposure status had a high predictive value in this sample with no false positive classifications and few false negatives. The questionnaire items on exposure to particular tools had a high sensitivity and specificity. Some misclassifications arose at the level of individual tools, because of confusion of tool names or inadequate descriptions: as a result, use of the hammer drill, nailing gun and portable grinder were under-reported and use of the riveting hammer and sander were over-reported. However, three-quarters of subjects made no errors or omissions of reporting at all. Among the remainder elements of over- and under-reporting were equally represented over the many items tested. The data suggest that false reporting of exposure sources is not a large source of error, but becomes smaller as fewer tools are used.

Representativeness of exposure histories

The questionnaire collected information at two limited calendar periods. The responses included people who were employed but absent from work (e.g. those who were sick or on holiday); and encompassed a variety of exposure patterns, some typical and some less representative. Short cycle variations and periods of atypical exposure might be expected to even out in a large sample, and do in any case contribute to the broad picture of national exposure, which is dynamic rather than static. But estimates in occupations with strong seasonal differences in vibratory tool use, such as farming and construction, could convey a misleading impression of the annual exposure picture. In practice however, these effects are likely to be small: only 9.9% of men and 5.8% of women with exposure in the past week reported their exposure to be atypical of the job*; and a cross-comparison of responses within occupations between summer and winter mailings identified only minor differences at different calendar periods in the proportions in commonly exposed occupations and in those directly reporting exposure and substantial exposure (Table 37).

Response biases

The response rate in the study was 60%, with higher participation rates in older subjects and in women than in men. White-collar workers were also slightly over-represented in the sample. To compensate for over- or under-sampling and a difference in response rates by occupation, estimates were standardised according to the occupational profile of the 1991 National Census. However, differential response rates might still have influenced the estimates of prevalence of exposure if these were related to the type and extent of exposure. In particular, an overestimate might have arisen if older men used tools less often the younger men, or responders within a profession were more commonly exposed than their peers who did not respond (e.g. because they were more interested in the survey and therefore more likely to make a return).

To test the first of these possibilities, the frequency of current exposure to HTV was compared in younger and older male responders (Table 38). The likelihood of reporting

---

**171 men reported that exposure was atypical, among whom 80 provided further usable particulars: 49 men said they used tools less often ordinarily, and 31 more often. Managers, teachers and HGV drivers mainly belonged to the former group (12 vs 2), whereas farm, forestry and construction workers tended to belong to the latter group (22 vs 14). Only 13 women described their exposure as atypical.*

exposure, overall and in several commonly exposed occupations, showed no consistent relation with age, so this appears unlikely to be a major source of bias.

The second possibility, that respondents tend to over-represent the frequency of exposure in their profession, was explored by comparing the prevalence of exposure in willing responders (people who responded at the first invitation) and reluctant responders (those who required a reminder) (Table 39). If exposed subjects had a greater interest in the survey than others, the frequency of exposure might be expected to be higher in the former group than the latter. In the event, only minor differences were apparent between these two groups, providing no evidence of a response bias.

Extrapolating to the population

Figures based on a sample can only provide an estimate of the true value for the whole population. The sample appears to have adequately represented occupations in the general population (Table 4), but in any case the method of scaling takes account of residual differences in occupational frequencies between the sample and the population estimates. One inevitable limitation is that the numbers by occupation in Great Britain today probably vary from those of the 1991 National Census. In most cases the differences are likely to be unimportant, but in shrinking industries (like coal mining) fewer workers will be exposed than these data imply.

Underlying the survey is an implicit assumption that members of a particular occupation are representative of that occupation in terms of exposure. In using occupational (or industrial) frequency as the scaling factor two further simplifying assumptions are made - that there is little heterogeneity between industries within an occupation (and vice versa), and that any geographical variation in exposure within occupations and industries is adequately represented in the broad geographical sampling base, or unimportant as a source of error. In practice, heterogeneity exists within the sample and in the national population, but given the small numbers of exposed people in the various occupation-industry combinations (no more than 71 in any one combination) the validity of these assumptions cannot be readily tested. However, the overall estimates of exposure, particularly those for larger occupational groups, are unlikely to be seriously biased, and these should provide an adequate basis for decision making.

Contents

The aggregated estimates, by virtue of their large sample size, have narrow 95% confidence intervals, but in many cases population estimates have been derived from small sample sizes within an occupation or industry. This represents a limit on precision and results in some relatively wide confidence intervals in the data that have been presented for some groups.

Quantitative information on exposure

Personal estimates of exposure are subject to several potential sources of error and bias - in a_{hw} assignment, in self-assessment of exposure times, and in the method of dose calculation. The task of a_{hw} assignment was based on a qualitative appraisal of the available data. Generally, several sources of information were consulted for each exposure source, but a different choice could have been made. One value was ascribed to each family of tools, but quite wide variation exists within a family and between tools of the same type in different stages of ageing, repair or design modification. In a few cases a paucity of dependable data prevented any value being assigned, and missing exposure details required the calculation of minimum rather than absolute A(8) values. Personal daily vibration exposure was calculated according to a widely promulgated method of dose summation, but there is some general uncertainty about the best method[46]. Finally, reliance was placed on self-estimates of the duration of daily exposures - an approach traditionally assumed to be adequate, but seldom tested. These limitations are not particular to this investigation, but general to the field of inquiry.

The accuracy of quantitative self-estimates of exposure was tested in the observational visits. Several systematic errors were found, particularly when exposures were brief, intermittent and from many different sources. The bias was towards overestimation of the exposure time. The spread of estimates was wide in some instances, and there was evidence of rounding errors and digit preference. In some cases there was confusion with length of time taken to complete the job (although the difference from hand-tool contact time was carefully stressed); in others the task may have been perceived as too difficult, discouraging meaningful attempts at estimation. Self-estimates of duration of exposure were more accurate when tools were used in a more nearly continuous fashion.

The observational data themselves may contain some sources of imprecision - relatively few occupations and exposure sources were sampled, and the true duration of exposure was based on a stopwatch measurement of the time vibration entered the hand - which may be less precise for short duration intermittent exposures. But measurement and sampling errors were probably small in relation to the size of effect discovered.

The effect of overestimating exposure duration may not be so great as first appears. Dose and risk are assumed to be proportional to the *square root* of the daily exposure time in hours: roughly speaking, the observational data suggest a 2.5-fold over-reporting of exposure time, but this would translate into a dose (A(8)) only 60% too high.* Furthermore, the errors may not be large in relation to other sources of error in dose estimation such as a_{hw} assignment (where the interquartile range of published values often varies by four or five-fold).

Nevertheless, tables that contain quantitative estimates of exposure must be regarded as indicative rather than definitive. One important issue in interpretation is whether similar biases may have existed in the epidemiological studies that promulgated suggested action levels. This is discussed more fully below, but these data can probably be related to standards and exposure limits developed on a similar basis. Furthermore, health effects have been demonstrated at and below a self-reported A(8) of $2.8ms^{-2}$ r.m.s. and excess risks were discovered in many occupations estimated by these means to be significantly exposed. Workers with high self-estimated exposures were found to be 'at risk', and to this extent the data inform policy.

Health estimates

Response and reporting biases

The possibility of bias was investigated in several ways. Firstly, a comparison was made between the risk estimates in 'willing' and 'reluctant' respondents. If there were substantial response bias, a higher frequency of disease might be expected in people who responded to the first letter of invitation (willing respondents) than those who answered only after a reminder (reluctant ones). The prevalence of cold-induced finger blanching and sensorineural symptoms was similar in the two groups, and provided no evidence of such an effect (Table 39).

**We have not attempted to apply a simple multiple to correct for this effect in the data from the postal survey in view of the small number of direct observations, the variation between individuals and tool types, and the other sources of error in dose estimation.*

Secondly, to test the specificity of association, whole-body vibration was used an alternative measure of exposure; and low back pain was explored as an alternative measure of health. Any bias which was related to vibration *per se* might result in elevated risks of health complaints for whole-body as well as hand-transmitted vibration. But in current riders of industrial vehicles who had never been exposed to HTV the risks of blanching and sensorineural complaint were not elevated (PR for cold-induced finger blanching 1.07, 95%CI 0.68-1.68; PR for sensorineural symptoms in the fingers in the past week 0.89, 95%CI 0.62-1.28; and PR for upper limb sensory symptoms disturbing sleep in the past week 0.93, 95%CI 0.50-1.70*).

Similarly, any general tendency in vibration-exposed workers to over-report symptoms might result in excess risks for symptoms outside the upper limb, but no excess of low back pain was seen in current users of hand-held powered tools (PR for low back pain in the past year 1.06, 95% CI 1.00-1.12; and PR for low back pain in the past year making it difficult or impossible to put on socks or shoes 1.03, 95% CI 0.93-1.14#).

Finally, alternative definitions of finger blanching were used to examine how the risk estimate was altered by varying the specificity of case definition. If response biases were substantial, the risk estimate might be expected to fall as the case definition became more specific. The opposite pattern was observed (Table 17), a finding that implies that bias was probably not substantial.

COMPARISON WITH OTHER STUDIES

Exposure

This study indicates that exposure to HTV is far more common than estimated by Kyriakides[13] and Bednall[14,15]. There are a number of possible reasons for this, but the most important appears to be that previous sampling was selective as to industry and source of exposure. No data were collected in the previous studies from at least 28 of the 38 industries

---

**Risk estimates were mutually adjusted for age (in 5 bands), smoking, frequent headaches, frequent tiredness/stress, cold work, lifting weights, work with hands above shoulder height and use of a keyboard for more than 4 hrs/day.*

#Risk estimates were adjusted as above, and also work out of doors/in a cold store and estimated personal daily dose of whole body vibration (eVDVT from all sources combined, in tertiles).

in the SIC-92 2-digit code groups where we have found exposure; within an industry, often only restricted aspects of exposure were assessed (e.g. only chain saws in agriculture and forestry); and many of the tools in our questionnaire were omitted or incompletely surveyed (including floor polishers, nut runners, impact screwdrivers, jig saws, circular saws, hand-guided mowers, hand-held hedge trimmers, brush saws, barking machines, stump grinders, tampers, scabblers, hammer drills, needle guns, nibbling machines, motorcycle handlebars and nailing and stapling guns). The emphasis appears to have been on sources reported to cause health problems and exposures that were explicitly reportable and compensatable under statutory rules. However, HSE has always advised that other hand-powered tools may produce hazardous levels of vibration, and many additional sources now appear in the Industrial Injuries Advisory Committee's revised list of compensatable exposures, given disease of sufficient severity[47]. These extra tools alone may account for an estimated additional 1.5 million users nationally. Finally, differences also arise because we have sampled more completely from small businesses and the self-employed, where the proportion of exposed workers is higher.

While this survey was being conducted, another independent estimate of community exposure was reported in the Office of National Statistics' Omnibus survey[45]. A questionnaire on self-reported working conditions was administered to a sample of adults in private British households, selected from a national post code address file. Face to face interviews were conducted in August and October 1995. A question on exposure to HTV was posed as part of a much wider survey of economic activity which had no particular focus on vibratory tool use, blue collar work or work-related illness. A comprehensive definition of exposure was employed (*'the use of power tools which transmitted vibration to the hands'*) but no pre-defined check list of substantive exposure sources, as employed here. Nonetheless, a very similar estimate of exposure was obtained. Among 2,230 employed individuals, 27% of men (95%CI 24%-30%) and 7% of women (95%CI 5%-9%) reported using hand-held powered tools in their job. A more detailed comparison between the present survey and this Self-reported Working Conditions Survey shows striking similarities in the respective estimates of exposure frequency by occupation (Table 40).

Hence, estimates which were collected independently, during different calendar periods, by different methods, and in a different context, show a high degree of agreement. In the context of this study, this provides reassurance about the representativeness of exposure information and suggests that response and sampling biases have not caused important errors in the numbers estimated to be exposed.

Health

National estimates of the incidence of disease attributable to HTV come principally from compensation claims under the DSS Industrial Injuries Benefit Scheme and employers' statutory reports under the Reporting of Injuries, Diseases and Dangerous Occurrences (RIDDOR) Regulations. In 1996/7 232 cases of HAVS were reported under RIDDOR and in 1995/6 3016 claims of VWF were assessed by Special Medical Boards in consideration of State Benefit[48].

Unfortunately, these sources do not provide an adequate basis for determining the true prevalence of complaint, or of the distribution of illness by occupation, industry or tool type. Under-reporting arises under the RIDDOR regulations because many employers are unaware of the requirement to report and many employees do not present their complaints to a doctor. Also, many general physicians fail to recognise the occupational basis of the illness presenting to them, and those that do are not required to notify their patient's employer (indeed, considerations of medical confidentiality make it more likely that they would not).

DSS statistics reflect awareness and willingness to lodge a claim on the part of the individual and other particulars of the scheme, more than the incidence of disease. The influence of local knowledge is reflected in widely disparate rates of new assessment between industries. In 1995, for example, 45% of all claims came from coal miners[48] who represented around 0.1% of British industry[40]. The scheme also has a restricted eligibility: only disease of sufficient severity, arising from use of a qualifying tool in a qualifying occupation, may be assessed; and the self-employed cannot be considered.

To gain a more complete picture of work-related health complaints, HSE commissioned trailers to the Labour Force Surveys of 1990 and 1995. The Labour Force Survey (LFS) is a rolling survey of private households in Great Britain, conducted by Office of National Statistics to collect data on individuals' economic activity. In 1990 a sample of respondents were asked additionally to identify the worst work-related disease they had suffered (if any) in the past 12 months, and to record the doctor's diagnosis, or to describe the problem in their own words. Fifteen respondents were considered to have VWF, leading to a national estimate of 7,300 cases[49], but this number appeared incongruously low when compared with the preceding five years of state benefit claims, and a revised estimate of 20,000 was made, extrapolating from industry-based surveys of exposure and disease[50]. In 1995 respondents to the second LFS were allowed to volunteer information on several work-related complaints, and the estimated number of VWF cases was revised upwards to 36,000[44].

Neither LFS inquired directly about symptoms of cold-induced finger blanching, and the accuracy of the derived estimate hinges on whether VWF is well recognised by sufferers or not. It is known, for example, that people only occasionally present symptoms of blanching to a physician[19,20,22], and it appears plausible, especially in outdoor work, that an association between pale numb fingers and occupational exposures might go unrecognised. In some cases, because of intermittence or regression of symptoms, the attacks may not have occurred in the previous 12 months. The execution of the study during a temperate period of the year could have hampered recall of symptoms, although our data (Table 37) do not provide evidence of any strong seasonal differences in the reporting of blanching.

The prevalence of Raynaud's phenomenon in British men has been reported previously to lie in the range of 5-16%[19,22]. The LFS data imply therefore that no more than 5% of disease in workers arises secondary to vibratory tool use. Clinical experience suggests that this may be a substantial underestimate (- according to Coffman, HTV is probably the commonest cause of Raynaud's phenomenon in men[51]), but the proportion of disease attributable to vibratory tool use has never been formally estimated in British community surveys.

Elsewhere a few international studies have considered the problem. Maricq *et al* investigated a multi-stage probability sample of households in South Carolina using an interview-administered questionnaire[20]. The case definition was based on a history of unusual sensitivity of the fingertips or toes to cold together with unusual colour changes of pallor or cyanosis. The crude odds ratio (OR) for cold sensitivity was 1.9 – 2 in men and 1.4 in women with current exposure to hand-held vibratory tools; while the prevalence of the exposure was around a third in men and under 3% in women.

In a second multi-centre investigation in Charleston, Toulouse, Nyons, Grenoble and Tarantaise, the OR of Raynaud's phenomenon in lifetime users of vibratory tools was estimated to be 1.93 (95% CI 1.07 – 3.49) after adjustment for sex, climate, education, age, body mass index, cardiovascular disease and family history[32].

Harada *et al* assessed the prevalence of Raynaud's phenomenon in four thousand residents of the Ehime prefecture in Japan who attended periodic health examinations[30]. The diagnosis was based on clinical opinion supported by a positive identification of blanching in a set of hand photographs. Among 30 of the 61 male cases (49% of affected men) the presumed cause was exposure to HTV; in women, two of 49 cases (4%) were ascribed to this cause.

International differences may exist in the extent of exposure and the likelihood of blanching attacks[32,35], but this small literature is consistent with our own estimates of risk, which imply a higher attributable proportion than previously suggested among British men.

Our data indicate, therefore, that exposure to HTV is far more common than previously supposed; that health effects are commoner too (including attributable cases of more severe blanching), and that these findings are unlikely to be heavily influenced by biases and errors. The findings are consistent with a small alternative literature - in particular the estimates of exposure frequency by occupation are close to those recently obtained by an independent community survey. One source of error, previously suspected and now confirmed, lies in self-estimates of exposure time, which are systematically biased upwards.

DISCUSSION POINTS

Attributable numbers

Although the risk estimate was not altered much by varying the definition of disease, the prevalence of disease in the population, and hence the estimated numbers attributable to HTV varied by more than two-fold, depending on whether or not a clearly demarcated edge of blanching was required in the case definition.

Two of the three definitions that were explored represented subsets of a higher level definition (those with cold-induced blanching were a subset of those with blanching; and the 'clear edge' group were a subset of those with cold blanching), but the relation between these

Contents

groups is not well understood. Lewis, as a result of his historic experiments in the 1930s referred to a biological continuum in which "the transition from normal subjects to those in whom the obstruction becomes complete (and that are properly called cases of Raynaud's disease) is not abrupt but quite gradual"[52]. But another possibility is that the difference lies solely in people's self-awareness and articulation of symptoms, as blanching is sometimes reported to be patchy and mottled, rather than discrete and uniform. For this reason three estimates have been presented.

In trying to gauge the true prevalence of Raynaud's phenomenon and vibration-related blanching, one approach might be to validate the case definition against clinical opinion, or objective tests of finger blood flow and sensorineural disturbance. Survey questions have been assessed against the former criterion, but so far not against the latter. In Leppart's community survey of women from Sweden[21], 80% of those who reported 'cold and white fingers' were verified as having Raynaud's phenomenon at a clinical interview. In another community study, a similar predictive value was reported by Heslop *et al*[19] using the first study definition of 'attacks in which fingers suddenly became cold and numb and at the same time turned white'. Finally, the questions we used were pre-tested in a sample of rheumatology patients, including sufferers from Raynaud's phenomenon and were found to have a sensitivity of 94%-100% and a specificity of 75-78%, when compared with the diagnosis at clinic[24].

Under-researched tools

The data identify some sources of exposure as common in Britain that have been omitted from earlier inquiries. What strength of evidence exists that tools such as floor polishers, metal drills, impact screwdrivers, circular saws, jig saws and hand-guided mowers are associated with health risks?

At present this appears to rest almost entirely on the measured levels of vibration in a selection of these tools. This has led to proposals for some of these tools to be included in parts 2-17 of ISO 8662[53]; for vibration type tests to demonstrate tool safety standards under CEN/TC231/WG 2 (N99 March 1994); and to such sources being included in the Industrial Injuries Advisory Committee's recent list of compensatable exposures[47]. By contrast, there have been few reports of adverse health effects arising from these sources. A search of the

EMBASE (Excerpta Medica) database, 1980-98 and MEDLINE (National Library of Medicine, USA) database, 1966-98 failed to identify any articles in which key words such as 'mower', 'circular saw', 'jig saw', 'impact screwdriver', 'nut runner' and 'floor polisher' were used in conjunction with search criteria for Raynaud's Phenomenon and VWF; and little or no published information on health risks from these sources or from metal drills and hammer drills could be discovered in ISVR's international library of vibration research.

Such exposures appear to have been overlooked hitherto in health inquiries, and are worthy of formal study. This cross-sectional study's capacity to determine the risk attributable to individual tools was limited by two main factors:

a) It was not possible to establish a lifetime history of exposure to named tools in a postal questionnaire. Instead, information was sought on named tools used in the past week. The risk-conferring exposures are likely to be chronic and cumulative, and respondents could have incurred higher or lower exposures at earlier stages in their employment history.
b) Multiple tool use was common in the sample (Table 8), making attribution of risk by tool type uncertain.

Exposures in the past week were generally reported to be typical of the current job and 60% of male tools users had been employed for more than five years in this job, providing some basis for regarding contemporary exposure as a proxy for the longer term pattern, but the data that relate risk to tool type should be viewed as exploratory rather than indicative. The analyses in Tables 27 and 29 adjust for other tools used in the past week: persistent risks are unlikely therefore to be accounted for by this particular factor; and risks were seen in single users of several unusual tools (Tables 28 and 30). Hence, we were not able to exclude a possible independent risk from several under-researched but common sources of exposure, and further targeted investigation is warranted.

Exposure times and the dose-response relationship

Little attempt has been made in the past to verify workers' accounts of their exposure histories. This is surprising given the evident difficulties in quantitative estimation - which include the need to remember and name several different sources of exposure; to comprehend the difference between hand-tool contact time and the time taken to complete the task and to distinguish these events; and to recall intermittent and irregularly spaced exposures over the course of a particular week. The magnitude of errors, their direction and the parameters that influence them are reported here. These indicate that substantial overestimates can arise, depending on the tool and the pattern of use. Errors are largest for brief, intermittent and multi-source exposures.

In the context of this national survey it is clear that people are quite good at reporting their exposure sources but not their exposure durations. The tables which present A(8) values contain estimates of the numbers above HSE action levels defined conventionally using self-reported exposure times, and for exposure defined in this way and according to these methods there is evidence of an excess risk. This should form a basis for setting preventive policy in groups with high self-estimated levels of exposure, but the findings of the observational visits need to be confirmed and studied in a wider range of settings and they carry a number of implications that extend beyond this report.

One point of concern is that the investigations that have influenced currently proposed safety standards may have contained similar errors. To what extent is unclear. Much of the information came from the forestry industry where studies focused on the chain saw, a tool that is used fairly continuously; but data on other tools including pedestal grinders, hand-held grinders, rock drills, chipping hammers, and caulking guns were also considered[54, 55]. The basic relationships are considered to apply to workers who operate a power tool all day long on a near daily basis. This allows interpretations that differ in the assumed duration of daily exposure to vibration by factors as great as those measured during the observations in this study. A degree of over-estimation of exposure time may therefore have biased dose estimation in the investigations used to propose the ISO standards. Later attempts to compare observations with the dose-response model may have been affected by a similar bias, the size of which will vary from industry to industry. Departures from the predicted risk in some jobs have sometimes been taken as evidence against the method of frequency weighting applied in estimating the magnitude of vibration, but they may also reflect different biases in the estimation of exposure duration that occur between tools and occupations.

A related concern is that health effects may have arisen at a lower threshold than allowed for in current safety standards. This is important and needs to be tested. If true, one practical consequence would be that a safety target set according to objectively determined exposure times would not confer the anticipated degree of protection; and in enforcement policy, a practical dilemma would arise in balancing the desire for objectivity of risk assessment with standards promulgated on a less secure basis.

A relation has often been found between cumulative exposure in self-estimated hours of exposure and risk of VWF[56-59]. How could such a finding arise if estimates of exposure time are flawed? There are several possible explanations:

a) In the derivation of cumulative dose according to current standards such as ISO 5349, more weight is given to magnitude of vibration and exposure times longer than a day than hours within a day (the first two factors are assumed to be directly proportion to dose, while the latter bears a square root relation).
b) Furthermore, self-estimated exposure time in hours tends to be correlated with that in years[58], and workers are quite accurate in dating the duration of their employment[60]; so years of exposure may provide the basis for the association.
c) Another possibility is that workers err in their absolute estimates of exposure, but not so much as to alter their relative ranking, and they tend to be correctly placed in tertiles of daily exposure time or dose.

Frequency of exposure and disease

The scale of exposure to HTV is large, and raises significant public health concerns, particularly when allied with the health data. Clearly the strategic need to limit exposures at source is emphasised - and the data provide evidence concerning the occupations, industries and tools that should be the priorities for corrective action. But there are many logistic issues.

In some instances, technical solutions exist that enable vibration levels to be reduced substantially at source[61], but in other situations the only present recourse is to limit exposure times, perhaps to seemingly unrealistic levels. (For many common sources the action limit of $2.8 ms^{-2}$ r.m.s. would be exceeded after quite brief objectively determined daily exposure times[61], and in multiple tool users this might result in an even shorter allowable interval per tool, depending on the pattern of use.)

Multiple tool use is common in Britain and all of these exposures may be problematic. The data do not distinguish in multiple tool users particular patterns that are risk-conferring, and so all sources may need to be regarded as contributing to the total risk. (Indeed, the evidence suggests that exposures away from work matter too, and that workers with occupational and leisure-time exposures should be encouraged to limit their exposure to each of these sources). The idea that all exposures may need to be controlled contrasts with the current approaches to state compensation - which ascribe risk to individual named tools, and takes no account of combination use – but corresponds to HSE guidance which emphasises the need to assess risk from all sources of high-magnitude vibration.

Health surveillance

HSE recommends a programme of preventive measures and health surveillance at an A(8) of $2.8ms^{-2}$ r.m.s. and would enforce this under the Management Regulations[62]. (ISO and BS tables predict at this threshold that 10% of the workforce might be expected to develop finger blanching over an eight year period[63]). Elsewhere, HSE advises, because of the uncertainty about the dose-response relation, that it would be prudent to conduct health surveillance on all regularly exposed workers, and that risk control measures should be contemplated whenever tingling arises in the fingers following exposure[61]. Our data are compatible with this advice: health effects were seen at and below self-estimated exposures of $2.8ms^{-2}$ r.m.s. (see Appendix F) and at true levels likely to be lower again. But the data do indicate the enormous scale of the problem. Providing health surveillance for more than a million men in Britain poses a considerable challenge in relation to the supply of competent practitioners. Services would need to be based on a screening filter that was simple and pragmatic (for example, a short questionnaire or interview with an occupational health nurse), with further inquiry and investigation reserved for people with a relatively high prior probability of disease. Facilities for objective testing are scarce and expensive, and may in many instances need to be reserved for cases of enforced career change or legal dispute.

Problems of risk assessment, risk control and monitoring are likely to be more acute among small businessmen, as they are often self-employed and lack a sophisticated health and safety infrastructure within their companies.

If many cases arise in workers who do not have access to occupational health services, family doctors also need better information. In the survey only about a quarter of men with blanching saw a doctor about this, and only about quarter of those who did could recall a diagnosis of 'Raynaud's phenomenon', 'white finger', 'dead finger' or 'VWF'. General practitioners need to know that this problem is common, and about sources of further advice.

The data raise other important practical questions about occupational placement. Given the scale of complaint, what should be the threshold be for job change? If a low threshold were set, would it be practical for so many people to be relocated or to avoid further exposure? Only limited information exists on the natural history of complaint at present. This suggests that vascular symptoms may be capable of slow improvement, given sufficient curtailment of exposure, but that neurological symptoms do not improve[64-67]. However, the studies that provide this view are small and potentially subject to selection biases; and information on the rate of progression and remission, and the factors that influence it, is limited. In providing advice on placement, it would appear desirable to know more about natural history and the continuing risks of exposure, and this information is best collected in the context of a prospective study.

Contents

CONCLUSIONS

a) It is estimated that some 4.2 million men and 667,000 women in Great Britain are exposed to HTV at work in a one-week period. Personal daily vibration exposures exceed a suggested action level equivalent to 2.8 ms^{-2} for 8 hours ($A(8) > 2.8$ ms^{-2} r.m.s.) in some 1.2 million men and 44,000 women.

b) High estimated doses ($A(8) > 5$ ms^{-2} r.m.s.) arose most often in bricklayers and masons, gardeners and groundsmen, carpenters and joiners, electricians and electrical maintenance fitters, and builders and building contractors. The highest median A(8) values were seen in builders and building contractors, followed by welding trades, and then by carpenters and joiners.

c) Excess risks of cold-induced finger blanching were found in all of these occupations, and in workers with an estimated $A(8) > 2.8$ ms^{-2} in the past week.

d) The findings in this report may have been influenced by response bias, but those on exposure are consistent with estimates from a recent independent survey, those on health are consistent with a small international literature, and an internal examination of the data has not revealed any evidence of substantial biases.

e) Exposure to HTV is surprisingly prevalent and vibration-induced white finger is a common cause of Raynaud's phenomenon in men.

f) Many tools which are common in Britain have been overlooked in previous surveys of vibration exposure and health. These may confer health risks, but the evidence on this is limited at present.

g) Workers, though fairly accurate in describing the sources of their vibration exposure, tend to systematically over-estimate their exposure durations - leading on average to an approximate 60% increase in the implied exposure dose. The importance of this source of error in the research used to evolve safety standards is unclear.

h) Even after allowance for this bias, many men in Britain are likely to have substantial levels of exposure.

i) The scale of exposure and symptom reporting is large and suggests the need for targeted action on the sources of exposure. Preventive measures and health surveillance are justified for many men in Britain, but there are significant logistic problems, especially in the self-employed and in small businesses.

RECOMMENDATIONS FOR FURTHER WORK

a) This study is limited in its reliance on self-reported estimates of exposure and health. Before translating the findings into public health policy it would be helpful to verify them in industries where exposures and health complaints are predicted to be prevalent.

b) Several sources of exposure have been identified which are common in Britain, but which have been overlooked in health inquires. These health risks should be assessed formally through targeted investigation.

c) This study was also limited in the level of detail that could be collected on lifetime exposure patterns; and in its cross-sectional nature which makes it difficult to examine dose-response effects and the contribution of individual tools. An examination of the dose-response relationship would appear justified, as the observational data cast further doubt on the scientific basis of the standard proposed in the draft European Physical Agents Directive, and thereby raise practical dilemmas in enforcement and compliance. Studies of exposure and response have all been cross-sectional and have attracted many criticisms[46]: the question is better addressed through prospective inquiry looking at incident complaints in high risk industries and occupations. Prospective investigation would also provide information on the natural history of disease, which could aid decisions of placement and career counselling. Such a study seems justified, given the high prevalence of exposure and the evidence on public health risk.

ACKNOWLEDGEMENTS

We are grateful to the thirty-four general practices, to H M Armed Services and to the Royal College of General Practitioners and the Primary Care Rheumatology Society for their help in the postal survey, and to the employers who assisted us in the workplace observational study. Many staff in the MRC Unit at Southampton helped in the mailing and in data handling. We are particularly indebted to Ian Bowes and Vanessa Cox for their role in the collection and processing of the data, and to Denise Gould and Sue McIntosh for their work in preparing this manuscript.

REFERENCES

1. Lorigia G. Il Lavorco co i martelli pneumatici? *Boll Inspett Lavoro* 1911;**2**: 35-60
2. Taylor W, Pelmear PL. *Vibration White Finger in Industry*. London: Academic Press, 1975.
3. Alaranta H, Seppalainen AM. Neuropathy and the automatic analysis of electro-myographic signals from vibration-exposed workers. *Scand J Work Environ Health* 1977;**3**:128-134.
4. Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. *Am J Ind Med* 1987;**11**:343-358.
5. Koskimies K, Farkkila M, Pyykko I, *et al*. Carpal tunnel syndrome in vibration disease. *Br J Ind Med* 1990;**47**:411-416.
6. Wieslander G, Norback D, Gothe CJ, Juhlin L. Carpal tunnel syndrome (CTS) and exposure to vibration, repetitive wrist movements, and heavy manual work: a case-referent study. *Br J Ind Med* 1989;**46**:43-47.
7. Gemne G, Saraste H. Bone and joint pathology in workers using hand-held vibrating tools. *Scand J Work Environ Health* 1987;**13**:290-300.
8. Yuguchi M. Roentgenological studies of elbow joints in patients suffering from vibration disease. *J Science of Labour* 1990;**66**:6-18.
9. Malchaire J, Maldague B, Huberlant JM, Croquet F. Bone and joint changes in the wrists and elbows and their association with hand and arm vibration exposure. *Ann Occup Hyg* 1986;**30**:461-486.
10. Sakakibara H, Suzuki H, Momoi Y, Yamada S. Elbow joint disorders in relation to vibration exposure and age in stone quarry workers. *Int Arch Occup Environ Health* 1993;**65**:9-12.
11. Bovenzi M, Zadini A, Franzinelli A, Borgogni F. Occupational musculoskeletal disorders in the neck and upper limbs of forestry workers exposed to hand-arm vibration. *Ergonomics* 1991;**34**:547-562.
12. Faculty of Occupational Medicine of the Royal College of Physicians. *Hand-transmitted vibration: clinical effects and pathophysiology, Part 1: Report of a working party*. London: RCP 1993, Appendix A2.
13. Kyriakides K. Survey of exposure to hand-arm vibration in Great Britain. Research Paper 26. London: HMSO, 1988.

14. Bednall AW. *Survey of exposure to hand-arm vibration in Great Britain: mines and quarries. Research Paper 29.* London: HMSO, 1991.

15. Bednall AW. *Survey of exposure to hand-arm vibration in Great Britain: railway maintenance.* Research Paper 35. London: HMSO, 1992.

16. Palmer K, Coggon D, Griffin, Pannett B. The development of a self-administered questionnaire to assess exposures to hand-transmitted and whole body vibration and their health effects. *J Sound Vib* 1998; **215:** 653-686.

17. Office of Population Censuses and Surveys. *Standard Occupational Classification 1990.* London: HMSO, 1990.

18. Office of National Statistics. *Indexes to the Standard Industrial Classification of Economic Activities 1992.* London: HMSO, 1993.

19. Heslop J, Coggon D, Acheson ED. The prevalence of intermittent digital ischaemia (Raynaud's Phenomenon) in a general practice. *J Royal Coll Gen Practrs* 1983;**33**:85-89.

20. Maricq HR, Weinrich MC, Keil JE, LeRoy EC. Prevalence of Raynaud phenomenon in the general population: a preliminary study by questionnaire. *J Chronic Dis* 1986;**39**:423-427.

21. Leppert J, Aberg H, Ringqvist I, Sorensson S. Raynaud's phenomenon in a female population: prevalence and association with other conditions. *Angiology* 1987;**38**:871-877.

22. Silman A, Holligan S, Brennan P, Maddison P. Prevalence of symptoms of Raynaud's phenomenon in general practice. *Br Med J* 1990;**301**: 590-592.

23. Weinrich MC, Maricq HR, Keil JE, McGrgor AR, Diat F. Prevalence of Raynaud phenomenon in the adult population of South Carolina. *J Clin Epidemiol* 1990;**43**: 1343-1349.

24. Palmer K, Smith G, Kellingray S, Cooper C. Repeatability and validity of an upper limb and neck discomfort questionnaire: the utility of the standardised Nordic questionnaire. *Occup Med* (1999);(in press).

25. De Krom MCTFM, Knipschild PG, Kester ADM, Thijs CT, Boekkooi PF, Spaans F. Carpal tunnel syndrome: prevalence in the general population. *J Clin Epidemiol* 1992;**45**: 373-6.

26. De Krom MCTFM, Knipschild PG, Kester ADM, Spaans F. Efficacy of provocative tests for diagnosis of carpal tunnel syndrome. *Lancet* 1990;**335**: 393-5.

27. Stewart AM, Goda DF. Vibration Syndrome. *Brit J Ind* 1970;**27**:19-27.

28. Bovenzi M, Petronio L, Marino F. Epidemiological survey of shipyard workers exposed to hand-arm vibration. *Int Arch Occup Environ Health* 1980;**46**:251-266.

29. Iwata H, Makimo S, Miyashita K. Prevalence of Raynaud's phenomenon in individuals not using vibrating tools. *Jpn J Ind Health* 1987;**29**:500-503.

30. Harada N, Ueda A, Takegata S. Prevalence of Raynaud's phenomenon in Japanese males and females. *J Clin Epidemiol* 1991;**44**:649-655.

31. Keil JE, Maricq HR, Weinrich MC, McGregor AR, Diat F. Demographic, social and clinical correlates of Raynaud phenomenon. *Int J Epidemiol* 1991;**19**:221-224.

32. Maricq HR, Carpentier PH, Weinrich MC, Keil JE, Franco A, Drouet P, Poncot OCM, *et al.* Geographic variation in the prevalence of Raynaud's phenomenon: Charleston, SC, USA, vs Tarentaise, Savoie, France. *J Rheumatol* 1993;**20**:70-76.

33. Riera G, Vilardell M, Vaque J, Fonollosa V, Bermejo B. Prevalence of Raynaud's phenomenon in a healthy Spanish population. *J Rheumatol* 1993;**20**:66-69.

34. Valter I, Maricq HR. Prevalence of Raynaud Phenomenon in Tartu and Tartumaa, Southern Estonia. *Scand J Rheumatol* 1997;**26**:117-124.

35. Maricq HR, Carpentier PH, Weinrich MC, Keil JE, Palesch Y, Biro C, Vionnet-Fuasset M, *et al.* Geographic variation in the prevalence of Raynaud's phenomenon: A 5 region comparison. *J Rheumatol* 1997;**24**:879-889.

36. Kaminski M, Bourgine M, Zins M, Touranchet A, Verger C. Risk factors for Raynaud's phenomenon among workers in poultry slaughterhouses and canning factories. *Int J Epidemiol* 1997;**26**:371-380.

37. Goodfield MJD, Hume A, Rowell NR. The acute effects of cigarette smoking on cutaneous blood flow in smoking and non-smoking subjects with and without Raynaud's phenomenon. *Br J Rheumatol* 1990;**29**:89-91.

38. Letz R, Cherniack MG, Gerr F, Hershman D, Pace P. A cross sectional epidemiological survey of shipyard workers exposed to hand-arm vibration. *Br J Ind Med* 1992;**49**:53-62.

39. Brand FN, Larson MG, Kannel WB, McGuirk JM. The occurrence of Raynaud's phenomenon in a general population: The Framingham Study. *Vascular Medicine* 1997;**2**:296-301.

40. Office of Population Censuses and Surveys. *Census 1991: Economic Activity Report.* London:HMSO, 1993.

41. International Organisation for Standardisation. *Mechanical vibration - guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration.* Geneva: ISO,1986: 5349.

42. StataCorp. 1997. Stata Statistical Software: Release 5.0 College Station, TX: Stata Corporation.

43. Zocchetti C, Consonni D, Bertazzi PA. Relationship between prevalence rate ratios and odds ratios in cross-sectional studies. *Intern J Epidemiol* 1997; **26**:220-223.

44. Jones JR, Hodgson JT, Clegg TA, Elliott RC. *Self-reported Work-Related Illness in 1995. Results from a household survey*. London: HSE Books HMSO, 1998.

45. Jones JR, Hodgson JT, Osman J. *Self-reported Working Conditions*. Health and Safety Executive, HMSO, London, 1995.

46. Griffin MJ. Measurement, evaluation, and assessment of occupational exposures to hand-transmitted vibration. *Occup Environ Med* 1997;**54**: 73-89.

47. Department of Social Security. *Hand Arm Vibration Syndrome (Vascular and Neurological Components Involving the Fingers and Thumb)*. London: HMSO, 1995.

48. Health and Safety Commission. *Health and Safety Statistics 1996/7*. London: HMSO, 1997.

49. Hodgson JT, Jones JR, Elliott RC, Osman J. *Self-reported Work-related Illness*. London: HMSO, 1993.

50. Benn T. Estimation of the prevalence of hand-arm vibration syndrome in Great Britain *Proceedings of the Institute of Acoustics* 1993;**15**:463-470.

51. Coffman JD. *Raynaud's phenomenon*. London: Oxford University Press, 1989.

52. Lewis T. Raynaud's disease, with special reference to the nature of the malady. *Brit Med J* 1932;136-8.

53. International Organisation for Standardisation. *Measurement of vibrations in hand-powered tools - Parts 2-17*. Geneva: ISO/DIS 8662/2-17.

54. Brammer AJ. Relations between vibration exposure and the development of the vibration syndrome. In: Brammer AJ, Taylor W, eds. *Vibration Effects on the Hand and Arm in Industry*. New York: Wiley, 1982. p283-290.

55. Brammer AJ. Threshold limit for hand-arm vibration exposure throughout the workday. In: Brammer AJ, Taylor W, eds. *Vibration Effects on the Hand and Arm in Industry*. New York: Wiley, 1982. p291-301.

56. Matsumoto K, Itoh N, Kasamatsu T, Nirotashi I. A study of subjective symptoms based on total operating time of chain saw. *Jap J Ind Health* 1977;**19**:22-28.

57. Miyashita K, Shiomi S, Itch N, Kasamatsu T, Iwata H. Epidemiological study of vibration syndrome in response to total hand-tool operating time. *Br J Ind Med* 1983;**40**:92-98.

58. Tominaga Y. Dose-response relation for the vibration syndrome. In: Brammer AJ, Taylor W, eds. *Vibration Effects on the Hand and Arm in Industry.* New York: Wiley, 1982.

59. Palmer KT, Crane G, Inskip H. Symptoms of hand-arm vibration syndrome in gas distribution operatives. *Occup Environ Med* 1998; **55:** 716-721.

60. Correa-Villasenor A, Batutista L, Rothman N, et al. Job histories obtained by interview from semiconductor manufacturing workers: a reliability study. *Am J Epidemiol* 1991;**134**:737-738.

61. Health and Safety Executive. *Vibration solutions - practical ways to reduce the risk of hand-arm vibration injury. London:* HSE Books HMSO, 1997.

62. Health and Safety Executive. *Hand-arm vibration HS(G) 88.* London:HMSO, 1994.

63. International Organisation for Standardisation. *Mechanical vibration - guidelines for the measurement and the assessment of human exposure to hand-transmitted vibration.* Geneva: ISO:5349. 1986

64. Riddle HFV, Taylor W. Vibration-induced white finger among chain sawyers nine years after the introduction of anti-vibration measures. In: Brammer AJ, Taylor W, eds. *Vibration Effects on the Hand and Arm in Industry.* New York: John Wiley & Sons, 1982. p169-172.

65. Hursh HJ. Vibration-induced white finger - reversible or not? A preliminary report. In: Brammer AJ, Taylor W, eds. *Vibration Effects on the Hand and Arm in Industry.* New York: John Wiley & Sons, 1982. p156-167.

66. Pyykko I, Korhonen O, Farkkila M, Starck J, Aatola A. A longitudinal study of vibration syndrome among Finnish forest workers. In: Brammer AJ, Taylor W, eds. *Vibration Effect on the Hand and Arm in Industry.* New York: John Wiley and Sons, 1982. p157-167.

67. Futatsuka M, Ueno T, Sakurai T. Follow up study of vibration induced white finger in chain saw operators. *Brit J Ind Med* 1985;**42**:267-271.

Contents

Table 1
Questionnaire distribution and response rates, overall and by centre (a) - 1997 mailing

Location of general practice	Industry	Numbers selected	Numbers vetted out#	Numbers mailed	Numbers not contactable≠	Numbers returned‡	% Response rate+
Devon	Agriculture	398	2	396	15	278	73.0
Suffolk		516	7	509	29	315	65.6
Wolverhampton	Metal Manufacture	512	15	497	11	327	67.3
Middlesbrough		611	18	593	22	345	60.4
Sheffield		437	3	434	26	193	47.3
Glasgow	Ship Building	774	18	756	91	357	53.7
Newcastle		284	0	284	18	143	53.8
Stoke	Heavy Engineering	856	7	849	10	543	64.7
Leeds		912	25	887	18	572	65.8
Coventry	Coach & Vehicle Repair	929	0	929	45	596	67.4
Derby		1196	6	1190	42	722	62.9
Eastleigh		565	0	565	19	333	61.0
Selby	Coal mining	764	0	764	20	417	56.0
Caernarfon	Quarrying	458	2	456	11	282	63.4
Hexham	Forestry	627	0	627	16	432	70.7
Lyndhurst		386	7	379	19	227	63.1
Birkenhead	Ships Crews	724	7	717	34	445	65.2
Lambeth	Various	1133	0	1133	168	375	38.9
	Totals	**117**	**11965**	**614**	**614**	**6902**	**60.8**

Contents

(b) -1998 mailing

Location of general practice	Industry	Numbers selected	Numbers vetted out#	Numbers mailed	Numbers not contactable≠	Numbers returned‡	% Response rate+
Devon	Agriculture	139	5	134	8	94	74.6
Suffolk		371	8	363	41	213	66.1
Birmingham	Metal manufacturing	835	1	834	34	447	55.9
Port Talbot		704	10	694	12	395	57.9
Newcastle	Ship building	878	15	863	30	385	46.2
Leeds	Heavy engineering	332	0	332	12	215	67.2
Derby	Coach & vehicle repair	401	9	392	25	243	66.2
Mansfield	Coal mining	885	6	879	21	553	64.4
Selby		1062	21	1041	26	675	66.5
Aberdeen	Quarrying	342	7	335	22	208	66.5
Portland		874	5	869	27	565	67.1
Lochgilphead	Forestry	524	4	520	28	328	66.7
Hull	Ships crews	528	1	527	37	270	55.1
Kendal	Shoe making	639	4	635	20	416	67.6
Lewisham	Various	331	2	329	24	133	43.6
Bolton	Various	495	6	490	41	220	49.9
RAF	Armed service	297	0	297	0	216	72.7
Navy	Armed service	220	0	220	5	139	64.7
Army	Armed service	476	0	476	1	290	61.1
	Totals	**580**	**9754**	**10229**	**414**	**6005**	**61.2**

#Number excluded from the mailing on general practitioners' advice

≠Number of questionnaires returned as 'not known at this address', 'moved away' or 'deceased'

‡and confirmed (date of birth and sex consistent with the expectation)

+Among those who were mailed to, and not known to have moved away or deceased

Table 2
Returns and response rate by age and sex

Age Band (yrs)	All Subjects		Men		Women	
	No Returned	% Response	No Returned	% Response	No Returned	% Response
16 - 24	1601	50.6	814	43.4	787	61.0
25 - 34	2911	52.1	1516	45.2	1395	62.6
35 - 44	3033	62.9	1609	57.2	1424	70.8
45 - 54	2951	68.4	1652	64.2	1299	74.6
55 - 65+	2406	74.0	1317	71.2	1089	77.6
missing	5		5		0	
Total	**12907**	**61.0**	**6913**	**55.4**	**5994**	**69.0**

+*The responses include 33 men and 39 women who were 64 when the mailing list was assembled, but were 65 at the time the questionnaire was completed*

Table 3
Employment characteristics of the respondents

	All Subjects (n=12 907)		Men (n=6 913)		Women (n=5 994)	
	No	%	No	%	No	%
Employed in past week: in paid job (Q6) or self employed (Q8)	9368	72.6	5490	79.4	3878	64.7
At work in the past week (Q10)	9084	70.4	5364	77.6	3720	62.1
Second job held in past week (Q21)	531	4.1	274	4.0	257	4.3

Table 4

Occupational distribution of the study sample in relation to the 1991 Census, and two other surveys of occupational ill health

Occupational Groups*	National Census 1991[40] (%)	Labour Force Survey 1995[44] (%)	Survey of Working Conditions 1995[45] (%)	Current Survey 1997/8 (%)
Professional & related supporting management (1)	6.6	8.3	7.1	5.9
Teaching (2)	3.4	3.7	4.0	4.1
Nursing (3)	2.9	2.6	3.4	2.9
Other education & welfare (4)	2.8	3.4	3.2	3.7
Literary, artistic & sports (5)	1.4	1.8	1.5	1.1
Science & engineering (6)	5.2	5.4	6.0	4.9
Managerial (7)	10.6	10.4	9.5	8.5
Clerical (8)	11.4	11.1	11.5	10.5
Secretarial (9)	5.2	4.5	4.5	4.0
Selling (10)	6.4	7.2	6.9	6.1
Security & protective services (11)	2.4	2.2	2.1	8.7
Catering (12)	3.3	3.9	3.4	3.1
Care workers 13)	2.9	4.1	3.5	3.9
Hair & beauty (14)	0.7	0.6	1.1	1.0
Cleaners (15)	3.8	3.4	3.4	2.7
Other personal services (16)	0.8	0.9	1.1	1.0
Farming, fishing & forestry (17)	2.2	2.2	2.2	2.7
Metal processing (18)	6.5	5.0	4.7	5.2
Electrical processing (19)	2.0	2.0	1.5	1.9
Textile processing (20)	1.4	1.2	1.7	1.0
Other processing (21)	5.6	4.7	4.7	5.7
Repetitive assembly, inspection (22)	2.3	2.2	2.0	1.4
Construction (23)	4.0	3.2	2.7	2.3
Coal mining (24)	0.2	0.1	-	0.2
Road transport operatives (25)	2.9	2.9	3.9	2.5
Other transport & machinery operatives (26)	1.0	0.8	0.8	1.0
Material moving & storing (27)	1.6	1.8	1.6	1.4
Miscellaneous (28)	0.3	0.4	0.4	1.0

**As defined in* 'Self-Reported Working Conditions in 1995', *Appendix 2. Percentages are of those in employment.*

Contents

Table 5

Frequency of exposure to hand-transmitted vibration in the past week by occupation in the sample and estimated numbers with exposure in Great Britain*

Occupation+	Sample			Population of Great Britain	
	No.	No. with exposure	% exposed	Estimated no. exposed	(95% CI)
MEN					
All occupations	*5490*	*1727*	*31.5*	*4,207,500*	*(4,043,700 - 4,371,300)*
Metal working, production and maintenance fitters (516)	155	119	76.8	298,600	(272,000 - 324,400)
Carpenters and joiners (570)	103	97	94.2	254,400	(242,200 - 266,700)
Electricians and electrical maintenance fitters (521)	95	80	84.2	193,700	(176,800 - 210,600)
Motor mechanics, auto engineers (inc. road patrol engineers) (540)	55	46	83.6	157,300	(138,900 - 175,600)
Plumbers, heating and ventilating engineers and related trades (532)	42	38	90.5	140,800	(127,000 - 154,600)
Builders, building contractors (504)	38	35	92.1	131,400	(119,200 - 143,700)
Farm owners and managers, horticulturists (160)	36	25	69.4	118,800	(93,000 - 144,500)
Gardeners, groundsmen (594)	46	40	87.0	94,800	(84,200 - 105,400)
Bricklayers, masons (500)	41	34	83.0	85,300	(73,500 - 97,200)
Welding trades (537)	33	29	87.8	83,600	(73,000 - 94,200)
Production workers and maintenance managers (110)	94	18	19.1	75,100	(43, 900- 106, 300)
Managers & proprietors in service industries (179)	101	15	14.9	68,200	(36,400 - 100,100)
Machine tool operatives (inc CNC machine tool operatives) (840)	55	28	50.9	67,100	(49,700 - 84,500)
Cleaners, domestics (958)	30	19	63.3	64,500	(47,000 - 82,100)
Farm workers (900)	51	39	76.5	60,500	(51,300 - 69,700)
Drivers of road goods vehicles (872)	157	21	13.4	58,500	(35,200 - 81,800)
NCOs and other ranks, UK armed forces (600)	571	155	27.2	40,300	(34,900 - 45,700)
All other labourers and related workers (990)	53	31	58.5	39,200	(30,300 - 48,100)
Store keepers & warehousemen (441)	94	14	14.9	35,500	(18,400 - 52,700)
Other plant and machine operatives nec (899)	61	26	42.6	30,500	(21,600 - 39,400)
WOMEN					
All occupations	*3878*	*225*	*5.8*	*666,600*	*(582,300 - 750,900)*
Cleaners, domestics (958)	161	61	37.9	240,800	(193,200 - 288,500)
Hairdressers (660)	40	7	17.5	11800	(3,900 - 19,800)

**The population figures have been rounded to the nearest hundred. Analysis has been confined to occupations with at least 30 in the sample.*
+The numbers after each occupation refer to SOC 90 unit group codes
nec = not elsewhere classified

Table 6

Frequency of exposure to hand-transmitted vibration in the past week by industry: in the sample and estimated numbers with exposure in Great Britain

Industry[†]	Sample			Population of Great Britain	
	No.	No. with exposure	% exposed	Estimated no. exposed	(95% CI)
MEN					
All industries	*5490*	*1727*	*31.5*	*See table 5*	
Construction (45)	428	266	62.1	979,500	(907,100 - 1,052,000)
Sale, maintenance and repair of motor vehicles and motorcycles; retain sale of automotive fuel (50)	89	57	64.0	276,900	(233,800 - 320,000)
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52)	329	86	26.1	224,600	(183,800 - 265,400)
Agriculture, hunting and related service activities (1)	154	102	66.2	219,200	(194,500 - 243,900)
Manufacture of fabricated metal products, except machinery and equipment (28)	188	87	46.3	218,500	(184,800 - 252,100)
Public administration and defence; compulsory social security (75)	299	54	18.1	162,300	(123,100 - 201,500)
Wholesale trade and commission trades, except of motor vehicles and motorcycles (51)	60	12	20.0	119,500	(59,000 - 179,900)
Recreational, cultural and sporting activities (92)	94	37	39.4	108,800	(81,500 - 136,100)
Land transport; transport via pipelines (60)	137	25	18.2	106,500	(68,800 - 144,300)
Other business activities (74)	110	15	13.6	104,400	(55,300 - 153,600)
Education (80)	199	40	20.1	94,500	(68,300 - 120,700)
Manufacture of other transport equipment (35)	64	30	46.9	91,300	(67,500 - 115,100)
Hotels and restaurants (55)	108	25	23.1	87,300	(57,300 - 117,300)
Manufacture of motor vehicles, trailers and semi-trailers (34)	124	50	40.3	83,400	(65,600 - 101,300)
Manufacture of basic metals (27)	77	35	45.5	72,300	(54,600 - 90,000)
Health and social work (85)	208	35	16.8	67,300	(46,900 - 87,600)
Manufacture of food products and beverages (15)	102	20	19.6	59,600	(36,200 - 83,000)
Post and telecommunications (64)	94	15	16.0	54,000	(28,900 - 79,000)
Electricity, gas, steam and hot water supply (40)	170	54	31.8	51,900	(40,400 - 63,300)
WOMEN					
All industries	*3878*	*225*	*5.8*	*See table 5*	
Education (80)	482	54	11.2	111,100	(83,100 - 139,000)
Other service activities (93)	64	9	14.1	32,500	(12,800 - 52,100)

[†]The numbers in brackets are 2-digit SIC 92 code numbers

The population figures have been rounded to the nearest hundred. Analysis has been confined to industries with at least 60 in the sample.

Contents

Table 7
Most common sources of exposure to hand-transmitted vibration in the past week in the sample and estimated numbers with exposure in Great Britain*

Tool	Sample		Population of Great Britain	
	No.	% exposed	Estimated no. exposed	(95% CI)
<u>MEN</u>**				
Hammer drill	651	11.9	1,723,500	(1,600,100 - 1,846,900)
Hand-held portable grinder	600	10.9	1,560,000	(1,442,800 - 1,677,200)
Jig saw	412	7.5	1,066,500	(967,800 - 1,165,200)
Circular saw	348	6.3	926,500	(832,600 - 1,020,400)
Hand-held sander	298	5.4	803,600	(715,200 - 892,000)
Pedestal grinder	266	4.8	641,500	(566,300 - 716,700)
Impact wrench	233	4.2	540,700	(472,700 - 608,700)
Impact screwdriver	223	4.1	540,800	(471,300 - 610,300)
Hand-guided mower	176	3.2	478,000	(408,700 - 547,300)
Chipping hammer	170	3.1	418,200	(356,300 - 480,100)
Concrete breaker	166	3.0	470,400	(400,100 - 540,700)
Chain saw	165	3.0	405,400	(344,500 - 466,300)
Nailing or stapling gun	157	2.9	375,400	(317,500 - 433,300)
Metal drill	156	2.8	369,500	(312,300 - 426,700)
Unclassified	119	2.2	233,300	(191,800 - 274,800)
<u>WOMEN</u>+				
Floor polisher	81	2.1	278,000	(218,300 - 337,700)
Nailing or stapling gun	51	1.3	142,400	(103,600 - 181,200)

**The population figures have been rounded to the nearest hundred. The percentages refer to those in employment that used a given tool in the week.*
***All others less than 2.1% of male workers in the sample*
+*All others less than 0.5% of female workers in the sample*

Contents

Table 8

Number of sources of exposure to hand-transmitted vibration in the past week: observed frequencies in the sample and estimated frequencies in Great Britain*

No. of sources	Men				Women			
	Sample		Population of Great Britain		Sample		Population of Great Britain	
	No.	%	Estimated No.	(95% CI)	No.	%	Estimated No.	(95% CI)
0	3763	68.5	8,634,900	(8,472,800 - 8,797,000)	3653	94.2	9,408,400	(9,315,900 - 9,500,900)
1	509	9.3	1,130,700	(1,036,800 - 1,224,600)	186	4.8	525,200	(451,700 - 598,700)
2	320	5.8	757,800	(677,100 - 838,400)	16	0.4	58,100	(29,700 - 86,500)
3	289	5.3	762,400	(677,100 - 847,700)	7	0.2	12,900	(3,300 - 22,500)
4	177	3.2	421,700	(360,600 - 482,800)	5	0.1	38,500	(4,800 - 72,200)
5	131	2.4	350,300	(291,100 - 409,500)	4	0.1	19,500	(400 - 38,600)
≥6	301	5.5	784,400	(698,500 - 870,300)	7	0.2	12,300	(3,200 - 21,400)

**The population estimates have been rounded to the nearest hundred. All percentages refer to those in employment.*

Contents

Table 9
Prevalence of exposure to hand-transmitted vibration by occupation in respondents

Occupation*	No. (%) in occupation who used tool									
	No.	Hammer drill	Hand-held grinder	Jig saw	Circular saw	Hand-held sander	Pedestal grinder	Impact wrench	Impact screwdriver	Other commonly used tools
MEN										
Metal working, production and maintenance fitters (516)	155	52(33.6)	79(51.0)	20(12.9)	14(9.0)	15(10.0)	54(34.8)	34(21.9)	23(14.8)	Nut-runner 23 (14.8) Chipping hammer 21 (13.6)
Carpenters and joiners (570)	103	83(80.6)	31(30.1)	85(82.5)	81(78.6)	57(55.3)	13(12.6)	2(1.9)	17(16.5)	Nailing gun 21 (20.4) Chain saw 10 (9.7)
Electricians and electrical maintenance fitters (521)	95	65(68.4)	31(32.6)	27(28.4)	12(12.6)	3(3.2)	20(21.1)	797.4)	11(11.6)	Metal drill 10 (10.5)
Motor mechanics, auto engineers (inc. road patrol engineers) (540)	55	14(25.5)	35(63.6)	3(5.5)	2(3.6)	15(27.3)	14(25.5)	39(70.9)	20(36.4)	
Builders, building contractors (504)	38	29(76.3)	21(55.3)	20(52.6)	17(44.7)	10(26.3)	1(2.6)	0(0)	9(23.7)	Concrete breaker 15 (39.5) Chipping hammer 12 (31.6)
Plumbers, heating and ventilating engineers and related trades (532)	42	35(83.3)	18(42.9)	21(50.0)	19(45.2)	5(11.9)	3(7.1)	3(7.1)	6(14.3)	
Farm owners and managers, horticulturists (160)	36	7(19.4)	13(36.1)	3(8.3)	4(11.1)	2(5.6)	2(5.6)	2(5.6)	2(5.6)	Chain saw 19 (52.8)
Gardeners, groundsmen (594)	46	6(13.0)	5(10.9)	3(6.5)	1(2.2)	2(4.4)	2(4.4)	0(0)	0(0)	Hand-guided mower 34 (73.9) Hedge trimmer 22 (47.8)
Bricklayers, masons (500)	41	20(48.8)	14(34.2)	6(14.6)	8(19.5)	5(12.2)	0(0)	1(2.4)	1(2.4)	Concrete breaker 13 (31.7) Stone hammer 10 (24.4)
Welding trades (537)	33	6(18.2)	24(72.7)	3(9.1)	4(12.1)	11(33.3)	17(51.5)	5(15.2)	1(3.0)	Chipping hammer 31 (33.3)
Production workers and maintenance managers (110)	94	5(5.3)	7(7.5)	2(2.1)	4(4.3)	3(3.2)	3(3.2)	4(4.3)	1(1.1)	
Managers & proprietors in service industries (179)	101	2(2.0)	3(3.0)	3(3.0)	4(4.0)	3(3.0)	1(1.0)	3(3.0)	2(2.0)	
Machine tool operatives (inc CNC machine tool operatives) (840)	55	9(16.4)	18(32.7)	5(9.1)	2(3.6)	6(10.9)	20(36.4)	6(10.9)	2(3.6)	
Cleaners, domestics (958)	30	1(3.3)	0(0)	1(3.3)	0(0)	1(3.3)	0(0)	0(0)	0(0)	Floor polisher 15 (50)
WOMEN										
Cleaners, domestics (958)	161	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	0(0)	Floor polisher 56 (34.8)

**The numbers after each occupation refer to SOC 90 unit group codes*

Contents

Table 10

Duration of exposure to the most common vibratory tools among respondents who were exposed to hand-transmitted vibration in the past week

Sources	No. exposed	% of exposed subjects using the tool for [*n*] hours over the past week						Median time (IQR)* hours	
		≤0.25	>0.25- 1	>1 - 2.5	>2.5 - 10	>10	Missing		
MEN:									
Hammer drill	651	12.3	28.7	13.5	13.5	4.4	27.5	1.0	(0.4 - 2.5)
Hand-held portable grinder	600	13.5	26.7	13.5	14.3	3.2	28.8	1.0	(0.3 - 2.5)
Jig saw	412	13.8	31.3	13.6	11.2	2.7	27.4	1.0	(0.5 - 2.0)
Circular saw	348	13.5	25.0	12.4	15.5	3.7	29.9	1.0	(0.5 - 3.0)
Hand-held sander	298	6.0	19.8	15.1	15.1	4.0	39.9	2.0	(0.5 - 4.0)
Hand-guided mower	176	1.7	27.3	23.9	16.5	6.3	24.4	2.0	(1.0 - 3.0)
Pedestal grinder	266	25.9	36.1	8.9	5.6	1.0	22.9	0.5	(0.2 - 1.0)
Impact screwdriver	223	15.7	26.0	9.4	16.6	5.4	26.9	1.0	(0.4 - 3.3)
Impact wrench	233	14.2	26.6	12.5	18.0	3.9	24.9	1.0	(0.5 - 4.0)
Chipping hammer	170	7.1	22.4	11.2	15.3	5.3	38.8	1.5	(0.5 - 3.3)
Metal drill	156	8.3	12.8	5.8	12.2	5.8	55.1	1.5	(0.5 - 7.0)
Nailing or stapling gun	157	17.8	19.8	4.5	12.7	7.6	37.6	0.7	(0.3 - 4.0)
Concrete breaker	166	1.2	10.8	14.5	16.9	6.0	50.6	2.3	(1.3 - 6.7)
Chain saw	165	9.7	17.0	17.0	13.9	6.7	35.8	1.9	(0.8 - 3.5)
WOMEN:									
Floor polisher	81	2.5	9.9	18.5	45.7	4.9	18.5	3.4	(1.8 - 8.3)
Nailing or stapling gun	51	31.4	27.5	9.8	9.8	5.9	15.7	0.5	(0.1 - 2.0)
Hand-guided mower	20	0.0	45.0	25.0	0.0	0.0	30.0	1.0	(0.5 - 2.0)

**IQR = interquartile range*

Contents

Table 11

The estimated magnitude of daily vibration exposures to hand-transmitted vibration in the past week

Personal exposure level (A(8)) (ms^{-2} r.m.s.)	Men (n = 5490)				Women (n = 3878)			
	Sample		Population of Great Britain*		Sample		Population of Great Britain*	
	No.	%	Estimated No.	(95% CI)	No.	%	Estimated No.	(95% CI)
0	3763	68.5	8,634,900	(8,472,800 - 8,797,000)	3653	94.2	9,408,400	(9,315,900 - 9,500,900)
>0 - 1	237	4.3	567,600	(496,900 - 638,300)	74	1.9	243,200	(188,400 - 298,000)
>1 - 2.8	282	5.1	689,400	(611,100 - 767,700)	16	0.4	45,400	(23,300 - 67,600)
>2.8 - 5	108	2.0	282,200	(229,600 - 334,900)	3	0.1	31,900	(0 - 67,900)
>5	77	1.4	208,300	(162,100 - 254,500)	1	<0.1	4,300	(0 - 12,700)
missing≠	1023	18.6	2,459,800	(2,323,800 - 2,595,800)	131	3.4	341,700	(284,200 - 399,200)
minimum A(8)♣ >$2.8ms^{-2}$	445	8.1	1,198,200	(1,092,00 - 1,304,400)	9	0.2	43,900	(15,300 - 72,500)

**The population figures have been rounded to the nearest hundred*

≠Tool users for whom a_{hw} or exposure time information was missing

♣Includes individuals with partial exposure information (a_{hw} values and usage times for some but not all exposures)

Contents

Table 12

Occupations and industries in which substantial minimum daily A(8) values most commonly arose among male respondents*

Occupation[+]	% subjects exceeding A(8) of			Industry[‡]	% subjects exceeding A(8) of		
	$1 ms^{-2}$	$2.8 ms^{-2}$	$5.0 ms^{-2}$		$1 ms^{-2}$	$2.8 ms^{-2}$	$5.0 ms^{-2}$
All occupations	*17.9*	*8.1*	*3.7*	All industries	*17.9*	*8.1*	*3.7*
Bricklayers, masons (500)	56.1	31.7	29.3	Construction (45)	48.1	29.2	16.4
Builders, building contractors (504)	81.6	63.2	23.7	Sale, maintenance and repair of motor vehicles and motorcycles (50)	42.7	22.5	10.1
Motor mechanics, auto engineers (inc. road patrol engineers) (540)	67.3	38.2	16.4	Manufacture of basic metals (27)	36.4	13.0	9.1
Welding trades (537)	81.8	45.5	15.2	Agriculture, hunting and related service activities (1)	40.3	21.4	6.5
All other labourers and related workers (990)	34.0	22.6	15.1	Electricity, gas, steam and hot water supply (40)	22.9	10.0	5.9
Carpenters and joiners (570)	79.6	42.7	14.6	Manufacture of other non-metallic mineral products (26)	17.0	8.5	5.1
Gardeners, groundsmen (594)	63.1	28.3	13.0	Manufacture of other transport equipment (35)	25.0	7.8	4.7
Plumbers, heating and ventilating engineers and related trades (532)	69.0	28.6	9.5	Manufacture of fabricated metal products, except machinery and equipment (28)	32.4	11.2	4.3
Farm owners and managers, horticulturists (160)	47.2	22.2	8.3	Manufacture of motor vehicles, trailers and semi-trailers (34)	28.2	8.1	3.2
Electricians and electrical maintenance fitters (521)	62.1	22.1	6.3	Post and telecommunications (64)	10.6	4.3	3.2
Metal working, production and maintenance fitters (516)	55.5	22.6	5.2	Recreational, cultural and sporting activities (92)	21.3	7.4	3.2
Cleaners, domestics (958)	13.3	3.3	3.3	Other business activities (74)	5.5	3.6	2.7
Other plant and machine operatives nec (899)	24.6	8.2	3.3	Land transport; transport via pipelines (60)	10.2	5.8	2.2
Fork lift and mechanical truck drivers (887)	3.0	3.0	3.0	Retail trade, except of motor vehicles; repair of personal and household goods (52)	13.1	4.9	1.5
Civil, structural, municipal, mining and quarrying engineers (210)	7.9	5.6	2.6	Hotels and restaurants (55)	9.3	2.8	1.0
Drivers of road goods vehicles (872)	3.2	1.9	1.9	Public administration and defence; compulsory social security (75)	5.4	1.7	1.0

[+] The numbers in brackets refer to SOC 90 unit group codes
[‡] The numbers in brackets refer to 2-digit SIC 92 industry codes
nec = not elsewhere classified
[*] Analysis has been confined to occupations with at least 30 respondents and industries with at least 60 respondents

Contents

Table 13

Minimum frequency of exposure to hand-transmitted vibration (A(8) >2.8ms^{-2} r.m.s.) in the past week by occupation: number and percentage in the sample and estimated number in Great Britain*

Occupation+	Sample			Population of Great Britain	
	No.	Min no. with A(8) >2.8ms^{-2}	Min % with A(8) >2.8ms^{-2}	Estimated min. no. with A(8) >2.8ms^{-2}	(95% CI)
MEN					
All occupations	*5490*	*445*	*8.1*	*1,198,100*	*(1,092,000 - 1,304,200)*
Carpenters and joiners (570)	103	44	42.7	115,400	(89,600 - 141,200)
Builders, building contractors (504)	38	24	63.2	90,100	(68,200 - 112,000)
Metal working, production and maintenance fitters (516)	155	35	22.6	87,800	(62,200 - 113,400)
Motor mechanics, auto engineers (inc. road patrol engineers) (540)	55	21	38.2	71,800	(47,600 - 95,900)
Electricians and electrical maintenance fitters (521)	95	21	22.1	50,900	(31,700 - 70,000)
Plumbers, heating and ventilating engineers and related trades (532)	42	12	28.6	44,500	(23,200 - 65,700)
Welding trades (537)	33	15	45.5	43,200	(27,100 - 59,400)
Farm owners and managers, horticulturists (160)	36	8	22.2	38,000	(14,800 - 61,200)
Bricklayers, masons (500)	41	13	31.7	32,600	(18,000 - 47,300)
Gardeners, groundsmen (594)	46	13	28.3	30,800	(16,600- 45,000)
Machine tool operatives (inc CNC machine tool operatives) (840)	55	7	12.7	16,800	(5,200 - 28,400)
All other labourers and related workers (990)	53	12	22.6	15,200	(7,600 - 22,700)
WOMEN					
All occupations	*3878*	*9*	*0.2*	*43,900*	*(15,300 - 72,500)*

**The population figures have been rounded to the nearest hundred. Analysis has been confined to occupations with at least 30 in the sample.*
+The numbers after each occupation refer to SOC 90 unit group codes

Contents

Table 14

Minimum frequency of exposure to hand-transmitted vibration (A(8) >2.8 ms^{-2} r.m.s.) in the past week by industry: number and percentage in the sample and estimated number in Great Britain*

Industry‡	Sample			Population of Great Britain	
	No.	Min no. with A(8) >2.8ms^{-2}	Min % with A(8) >2.8ms^{-2}	Estimated min no. with A(8) >2.8ms^{-2}	(95% CI)
MEN					
All industries	*5490*	*445*	*8.1*	*See table 13*	
Construction (45)	428	125	29.2	460,300	(392,400 - 528,200)
Sale, maintenance and repair of motor vehicles and motorcycles; retain sale of automotive fuel (50)	89	20	22.5	97,200	(59,700 - 134,700)
Agriculture, hunting and related service activities (1)	154	33	21.4	70,900	(49,500 - 92,400)
Manufacture of fabricated metal products, except machinery and equipment (28)	188	21	11.1	52,700	(31,500 - 74,000)
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods (52)	329	16	4.9	41,800	(21,800 - 61,800)
Land transport; transport via pipelines (60)	137	8	5.8	34,100	(11,200 - 57,000)
Manufacture of basic metals (27)	77	10	13.0	20,700	(8,700 - 32,600)
Recreational, cultural and sporting activities (92)	94	7	7.4	20,600	(5,900 - 35,300)
Manufacture of motor vehicles, trailers and semi-trailers (34)	124	10	8.1	16,700	(6,800 - 26,600)
Electricity, gas, steam and hot water supply (40)	170	17	10.0	16,300	(9,000 - 23,700)
Manufacture of other transport equipment (35)	64	5	7.8	15,200	(2,400 - 28,000)
Public administration and defence; compulsory social security (75)	299	5	1.7	15,000	(2,000 - 28,100)
WOMEN					
All industries	*3878*	*9*	*0.2*	*See table 13*	

**The population figures have been rounded to the nearest hundred. Analysis has been confined to industries with at least 60 in the sample.*
‡The numbers in brackets are 2-digit SIC codes

Contents

Table 15
Relation between non-occupational factors and the prevalence and risk of Raynaud's phenomenon

	Definition 1*			Definition 2*			Definition 3*		
	No.+	No.(%) with RP	PR (95% CI)	No.+	No.(%) with RP	PR (95% CI)	No.+	No. (%) with RP	PR (95% CI)
MEN									
Age: 16 – 24	781	60 (7.7)	1.00	779	50 (6.4)	1.00	779	14 (1.8)	1.00
25 – 34	1482	31 (8.8)	1.02 (0.77 - 1.35)	1474	108 (7.3)	1.01 (0.74 - 1.38)	1474	31 (2.1)	0.99 (0.53 - 1.82)
35 – 44	1561	190 (12.2)	1.37 (1.05 - 1.77)	1542	146 (9.5)	1.27 (0.94 - 1.70)	1551	59 (3.8)	1.72 (0.98 - 3.02)
45 – 54	1581	239 (15.1)	1.65 (1.28 - 2.12)	1568	195 (12.4)	1.61 (1.21 - 2.14)	1568	82 (5.2)	2.24 (1.29 - 3.87)
55 – 65	1237	254 (20.5)	2.24 (1.75 - 2.85)	1227	215 (17.5)	2.27 (1.72 - 2.98)	1223	88 (7.2)	3.05 (1.77 - 5.23)
Ever smoking	3634	603 (16.6)	1.53 (1.33 - 1.75)	3598	500 (13.9)	1.58 (1.36 - 1.83)	3600	210 (5.8)	2.10 (1.60 - 2.74)
Frequent tiredness/stress	1886	403 (21.4)	2.00 (1.76 - 2.28)	1859	326 (17.5)	1.97 (1.71 - 2.28)	1861	136 (7.3)	2.18 (1.71 - 2.79)
Headache	640	139 (21.7)	1.37 (1.14 - 1.64)	630	113 (17.9)	1.38 (1.12 - 1.68)	631	51 (8.1)	1.59 (1.16 - 2.18)
WOMEN									
Age: 16 – 24	767	71 (9.3)	1.00	765	64 (8.4)	1.00	766	27 (3.5)	1.00
25 – 34	1365	161 (11.8)	1.25 (0.98 - 1.59)	1362	136 (10.0)	1.18 (0.90 - 1.54)	1361	66 (4.9)	1.37 (0.89 - 2.09)
35 – 44	1383	236 (17.1)	1.77 (1.41 - 2.21)	1371	201 (14.7)	1.70 (1.33 - 2.17)	1372	88 (6.4)	1.80 (1.19 - 2.71)
45 – 54	1240	255 (20.6)	2.11 (1.69 - 2.61)	1233	225 (18.3)	2.10 (1.65 - 2.65)	1228	77 (6.3)	1.75 (1.15 - 2.65)
55 – 65	1013	197 (19.5)	2.07 (1.65 - 2.58)	1004	160 (15.9)	1.89 (1.47 - 2.42)	1001	51 (5.1)	1.47 (0.94 - 2.28)
Ever smoking	2605	450 (17.3)	1.09 (0.97 - 1.23)	2587	375 (14.5)	1.05 (0.92 - 1.20)	2583	147 (5.7)	1.07 (0.86 - 1.33)
Frequent tiredness/stress	2162	440(20.4)	1.43 (1.26 - 1.62)	2142	356 (16.6)	1.31 (1.15 - 1.51)	2135	136 (6.4)	1.25 (0.99 - 1.57)
Headache	1162	243 (20.9)	1.31 (1.14 - 1.51)	1150	195 (17.0)	1.24 (1.06 - 1.45)	1144	75 (6.6)	1.20 (0.92 - 1.56)

**Definition 1 = attacks in which digits become cold and numb and at the same time turn white/pale (ever)*
Definition 2 = as per 1, but brought on by cold conditions (ever)
Definition 3 = as per 2, but clear edge noticed between pale part of finger and normal colour of hand (ever)
+Number of subjects with non-missing data
Analysis is based on the whole sample. The prevalence rate ratios (PR) are mutually adjusted.

Contents

Table 16

Extent and frequency of blanching, and its associated disability according to three definitions of Raynaud's phenomenon

	Definition 1*				Definition 2*				Definition 3*			
	Men		Women		Men		Women		Men		Women	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Attack frequency (per year):												
≤ 9	562	62.4	646	69.1	465	63.5	554	69.5	157	55.7	211	67.0
10 – 49	209	23.2	191	20.4	173	23.6	167	21.0	86	30.5	83	26.4
50+	77	8.6	64	6.8	57	7.8	52	6.5	32	11.4	17	5.4
missing	52	5.8	34	3.6	37	5.1	24	3.0	7	2.5	4	1.3
No. of digits:												
≤ 2	347	38.6	301	32.2	245	33.5	224	28.1	76	27.0	77	24.4
3 – 7	296	32.9	352	37.7	247	33.7	311	39.0	118	41.8	128	40.6
≥ 8	257	28.6	282	30.2	240	32.8	262	32.9	88	31.2	110	34.9
No. of phalanges:												
≤ 3	266	29.6	233	24.9	183	25.0	172	21.6	53	18.8	55	17.5
4 – 14	409	45.4	452	48.3	339	46.3	394	49.4	146	51.8	167	53.0
≥ 15	225	25.0	250	26.7	210	28.7	231	29.0	83	29.4	93	29.5
Attacks preventing activity≠ (ever):												
No	527	58.7	570	61.0	432	59.0	497	62.4	156	55.3	177	56.2
Yes	342	38.0	346	37.0	287	39.2	291	36.5	122	43.3	137	43.5
Missing	31	3.4	19	2.0	13	1.8	9	1.1	4	1.4	1	0.3
Attacks taken to a doctor (ever):												
No	683	75.9	694	74.2	575	78.6	613	76.9	207	73.4	230	73.0
Yes	179	19.9	212	22.7	138	18.9	167	21.0	68	24.1	81	25.7
Missing	38	4.2	29	3.1	19	2.6	17	2.1	7	2.5	4	1.3
Attacks in summer (ever):												
No	406	45.1	446	47.7	360	49.2	416	52.2	112	39.7	144	45.7
Yes	450	50.0	449	48.0	351	48.0	360	45.2	161	57.1	164	52.1
Missing	44	4.9	40	4.3	21	2.9	21	2.6	9	3.2	7	2.2

**Definition 1 = attacks in which digits become cold and numb and at the same time turn white/pale (ever)*
Definition 2 = as per 1, but brought on by cold conditions (ever). Definition 3 = as per 2, but clear edge noticed between pale part of finger and normal colour of hand (ever).
≠Attack so bad that the respondent was unable to carry on what he/she was doing. Analysis is based on those with Raynaud's phenomenon according to the relevant definition.

Contents

Table 17
Relation between lifetime exposure to hand-transmitted vibration and the risk of Raynaud's phenomenon (according to three definitions of disease)

Exposure status	Men					Women				
	No.+	No. (%) with RP		PR (95% CI)		No.+	No. (%) with RP		PR (95% CI)	
Definition 1*										
Never at work or leisure	3327	273	(8.2)	1.00		4828	705	(14.6)	1.00	
Leisure only (ever)	309	41	(13.3)	1.48	(1.10 - 1.96)	130	30	(23.1)	1.45	(1.03 - 1.99)
Work only (ever)	2130	360	(16.9)	1.92	(1.65 - 2.22)	385	74	(19.2)	1.20	(0.96 - 1.50)
Work and leisure (ever)	606	145	(23.9)	2.43	(2.03 - 2.88)	51	19	(37.3)	2.31	(1.53 - 3.26)
Definition 2*										
Never at work or leisure	3314	220	(6.6)	1.00		4812	611	(12.7)	1.00	
Leisure only (ever)	306	31	(10.1)	1.40	(0.98 - 1.96)	129	26	(20.2)	1.49	(1.03 - 2.10)
Work only (ever)	2107	296	(14.1)	1.97	(1.67 - 2.32)	380	63	(16.6)	1.22	(0.95 - 1.55)
Work and leisure (ever)	595	120	(20.2)	2.53	(2.06 - 3.07)	49	14	(28.6)	2.08	(1.27 - 3.16)
Definition 3*										
Never at work or leisure	3313	79	(2.4)	1.00		4806	243	(5.1)	1.00	
Leisure only (ever)	307	6	(2.0)	0.73	(0.32 - 1.62)	129	10	(7.8)	1.42	(0.76 - 2.58)
Work only (ever)	2110	115	(5.5)	2.02	(1.52 - 2.68)	380	24	(6.3)	1.15	(0.76 - 1.73)
Work and leisure (ever)	603	54	(9.0)	2.87	(2.04 - 4.00)	48	6	(12.5)	2.27	(1.02 - 4.68)

+Number of subjects with non-missing data
**Definition 1 = attacks in which digits become cold and numb and at the same time turn white/pale (ever)*
Definition 2 = as per 1, but brought on by cold conditions (ever)
Definition 3 = as per 2, but clear edge noticed between pale part of finger and normal colour of hand (ever)
Analysis is based on the whole sample
PR = prevalence rate ratios - adjusted for age, ever smoking, frequent tiredness or stress, and frequent headaches

Contents

Table 18

Relation between exposure to hand-transmitted vibration and the risk of severe cold-induced finger blanching

Exposure status and severity criterion	Men			Women		
	No.+	No. (%) with RP	PR (95% CI)	No.+	No. (%) with RP	PR (95% CI)
Extensive disease*:						
never exposed	3314	87 (2.6)	1.00	4812	236 (4.9)	1.00
leisure only (ever)	306	12 (3.9)	1.40 (0.78 - 2.50)	129	8 (6.2)	1.16 (0.58 - 2.27)
work only (ever)	2107	112 (5.3)	1.91 (1.45 - 2.52)	380	18 (4.7)	0.91 (0.57 - 1.46)
work and leisure (ever)	595	45 (7.6)	2.47 (1.73 - 3.49)	49	8 (16.3)	3.10 (1.55 - 5.74)
Troublesome disease#:						
never exposed	3314	81 (2.4)	1.00	4812	241 (5.0)	1.00
leisure only (ever)	306	15 (4.9)	1.84 (1.08 - 3.08)	129	8 (6.2)	1.04 (0.51 - 2.04)
work only (ever)	2107	139 (6.6)	2.46 (1.88 - 3.23)	380	29 (7.6)	1.31 (0.89 - 1.91)
work and leisure (ever)	595	61 (10.3)	3.39 (2.46 - 4.64)	49	8 (16.3)	2.77 (1.37 - 5.20)

+Number of subjects with non-missing data for age

**Blanching affecting ≥ 8 fingers or ≥ 15 phalanges*

#Attacks bad enough to prevent activity or to be taken to a doctor

Analysis is based on the whole sample

PR = prevalence rate ratios - adjusted for age, current smoking, frequent tiredness or stress and headaches

Contents

Table 19

Relation between physical occupational factors and the prevalence and risk of Raynaud's phenomenon in respondents never[ǂ] exposed to hand-transmitted vibration

	Definition 1*			Definition 2*			Definition 3*		
	No.+	No. (%) with RP	PR (95% CI)	No.+	No. (%) with RP	PR (95% CI)	No.+	No. (%) with RP	PR (95% CI)
MEN									
In average day:									
work outdoors or in a cold store	587	50 (6.3)	1.11 (0.77 - 1.59)	585	41 (7.0)	1.06 (0.71-1.58)	585	13 (2.2)	1.03 (0.50 - 2.11)
lifting wts ≥ 20 lbs	803	73 (9.1)	1.51 (1.07 - 2.11)	799	60 (7.5)	1.42 (0.98-2.07)	800	19 (2.4)	1.40 (0.71 - 2.75)
work with hands above shoulder height ≥ 1 hr	161	12 (7.5)	0.82 (0.44 - 1.49)	161	10 (6.2)	0.81 (0.41-1.57)	161	4 (2.5)	1.07 (0.36 - 3.15)
use of keyboard ≥ 4 hrs	695	34 (4.9)	0.74 (0.51 - 1.08)	695	28 (4.0)	0.71 (0.47-1.08)	695	9 (1.3)	0.73 (0.34 - 1.53)
In past week:									
rider of heavy industrial vehicle(s)†	407	30 (7.4)	0.96 (0.62 - 1.46)	405	27 (6.7)	1.07 (0.68-1.68)	405	8 (2.0)	1.03 (0.45 - 2.37)
WOMEN									
In average day:									
work outdoors or in a cold store	211	37 (17.5)	1.37 (0.98 - 1.88)	211	33 (15.6)	1.44 (1.00-2.01)	211	11 (5.2)	1.08 (0.57 - 2.03)
lifting wts ≥ 20 lbs	572	78 (13.6)	0.92 (0.72 - 1.18)	570	63 (11.1)	0.84 (0.63-1.10)	571	28 (4.9)	1.00 (0.65 - 1.53)
work with hands above shoulder height ≥ 1 hr	106	23 (21.7)	1.57 (1.05 - 2.26)	106	21 (19.8)	1.73 (1.13-2.54)	105	9 (8.6)	1.97 (0.99 - 3.75)
use of keyboard ≥ 4 hrs	1009	151 (15.0)	1.17 (0.97 - 1.42)	1008	131 (13.0)	1.17 (0.95-1.44)	1006	49 (4.9)	1.09 (0.77 - 1.55)
In past week:									
rider of heavy industrial vehicle(s)†	65	11 (16.9)	1.24 (0.64 - 1.99)	65	10 (15.4)	1.24 (0.66-2.19)	65	4 (6.2)	1.27 (0.46 - 3.32)

*For definitions see footnote to Table 15

†Driver or rider of a rock crusher, concrete production machinery, tractor, loader, excavator, bulldozer, grader, scraper, dumper, road roller, mower, off road forestry vehicle, armoured vehicle, forklift truck, mobile crane, lorry, helicopter, other aircraft, high speed boat, hoist/lift, ambulance, boat, off road car/van, quad bike, fire engine, milk float, conveyor belt or agricultural vehicle

ǂAnalysis is confined to respondents who were at work in the past week and have never been exposed to HTV at work or in their leisure

PR = prevalence rate ratios - are mutually adjusted and also adjusted for age, ever smoking and history of frequent tiredness or stress and headaches

Contents

Table 20

Relation between exposure to hand-transmitted vibration and risk of cold-induced finger blanching in employed men

Exposure status	Overall			Extensive disease*			Problematic disease#		
	No.+	No. (%) with RP	PR (95% CI)	No.+	No. (%) with RP	PR (95% CI)	No.+	No. (%) with RP	PR (95% CI)
Never exposed	2442	140 (5.7)	1.00	2442	58 (2.4)	1.00	2442	45 (1.8)	1.00
Leisure only (ever)	233	23 (9.9)	1.55 (1.02 - 2.28)	233	8 (3.4)	1.31 (0.63 - 2.66)	233	10 (4.3)	2.07 (1.06 - 3.93)
Work only (ever)	1803	229 (12.7)	1.87 (1.52 - 2.31)	1803	87 (4.8)	1.63 (1.15 - 2.30)	1803	91 (5.1)	2.10 (1.45 - 3.03)
Work and leisure (ever)	478	83 (17.4)	2.34 (1.81 - 2.99)	478	33 (6.9)	2.15 (1.40-3.28)	478	35 (7.3)	2.77 (1.78 - 4.27)
Never exposed	2442	140 (5.7)	1.00	2442	58 (2.4)	1.00	2442	45 (1.8)	1.00
Leisure only (ever)	233	23 (9.9)	1.57 (1.02 - 2.40)	233	8 (3.4)	1.26 (0.60 - 2.62)	233	10 (4.3)	2.11 (1.06 - 4.15)
Previous job but not now	517	114 (22.1)	2.86 (2.19 - 3.72)	517	45 (8.7)	2.57 (1.66 - 3.96)	517	50 (9.7)	3.68 (2.34 - 5.78)
Past week	1638	239 (14.6)	2.01 (1.60 - 2.52)	1638	92 (5.6)	1.80 (1.24 - 2.60)	1638	96 (5.9)	2.33 (1.57 - 3.46)
Past week, min A(8) >2.8	409	74 (18.1)	2.42 (1.76 - 3.30)	409	30 (7.3)	2.03 (1.23 - 3.36)	409	33 (8.1)	3.04 (1.79 - 5.09)
Past week, min A(8) >2.8 and employed >5 yrs	236	47 (19.9)	2.54 (1.77 - 3.60)	236	20 (8.5)	2.23 (1.26 - 3.90)	236	20 (8.5)	2.98 (1.63 - 5.36)

**Blanching affecting ≥ 8 fingers or ≥ 15 phalanges*
#Attacks bad enough to prevent activity or to be taken to a doctor
+Number of subjects with non-missing data
Analysis is confined to men at work in the past week. PRs adjusted for sex, ever smoking, frequent tiredness or stress, headaches and lifting wts ≥ 20 lbs in average day.

Contents

Table 21
Relation between non-occupational factors and the prevalence and risk of sensorineural symptoms

	Finger symptoms, past week*			Symptoms disturbing sleep, past week‡		
	No.+	No. (%) with symptoms	PR (95% CI)	No.+	No. (%) with symptoms	PR (95% CI)
MEN						
Age: 16 – 24	771	118 (15.3)	1.00	767	30 (3.9)	1.00
25 – 34	1466	192 (13.1)	0.75 (0.60 - 0.93)	1465	66 (4.5)	0.96 (0.63 - 1.45)
35 – 44	1545	241 (15.6)	0.87 (0.70 - 1.07)	1534	107 (7.0)	1.44 (0.98 - 2.12)
45 – 54	1543	300 (19.4)	1.06 (0.87 - 1.29)	1532	122 (8.0)	1.62 (1.11 - 2.37)
55 – 65	1217	280 (23.0)	1.29 (1.05 - 1.56)	1215	154 (12.7)	2.71 (1.88 - 3.90)
Ever smoking	3572	778 (21.8)	1.62 (1.44 - 1.83)	3549	339 (9.6)	1.58 (1.30 - 1.93)
Frequent tiredness/stress	1841	525 (28.5)	1.97 (1.76 - 2.20)	1835	266 (14.5)	2.70 (2.25 - 3.25)
Headache	624	212 (34.0)	1.76 (1.53 - 2.03)	622	115 (18.5)	2.15 (1.73 - 2.65)
WOMEN						
Age: 16 – 24	756	110 (14.6)	1.00	759	26 (3.4)	1.00
25 – 34	1333	163 (12.2)	0.83 (0.66 - 1.04)	1327	68 (5.1)	1.49 (0.97 - 2.26)
35 – 44	1358	215 (15.8)	1.06 (0.85 - 1.30)	1349	87 (6.5)	1.82 (1.20 - 2.73)
45 – 54	1198	249 (20.8)	1.38 (1.12 - 1.68)	1190	136 (11.4)	3.19 (2.17 - 4.69)
55 – 65	980	201 (20.5)	1.49 (1.20 - 1.82)	961	110 (11.5)	3.62 (2.45 - 5.32)
Ever smoking	2538	527 (20.8)	1.43 (1.27 - 1.61)	2518	242 (9.6)	1.42 (1.15 - 1.68)
Frequent tiredness/stress	2099	555 (26.4)	2.22 (1.96 - 2.51)	2077	275 (13.2)	2.64 (2.16 - 3.22)
Headache	1128	287 (25.4)	1.42 (1.24 - 1.62)	1118	156 (14.0)	1.87 (1.53 - 2.28)

Tingling or numbness lasting at least 3 minutes in the digits in the past week

‡*Tingling or numbness lasting at least 3 minutes in the digits, hand or arm in the past week and disturbing sleep*

+*Number of subjects with non-missing data*

Analysis is based on the whole sample with mutually adjusted prevalence rate ratios (PRs)

Contents

Table 22

Relation between lifetime exposure to hand-transmitted vibration and the risk of sensorineural symptoms in the past week

Symptom/Exposure status	Men			Women		
	No.[+]	No. (%) with symptoms	PR (95% CI)	No.[+]	No. (%) with symptoms	PR (95% CI)
Finger symptoms, past week*						
Never at work or leisure	3290	391 (11.9)	1.00	3284	149 (4.5)	1.00
Leisure only (ever)	308	60 (19.5)	1.50 (1.18 - 1.88)	303	24 (7.9)	1.11 (0.76 - 1.60)
Work only (ever)	2083	429 (20.6)	1.59 (1.40 - 1.80)	2074	193 (9.3)	1.43 (1.16 - 1.74)
Work and leisure (ever)	601	187 (31.1)	2.20 (1.89 - 2.54)	596	77 (12.9)	1.56 (0.91 - 2.47)
Symptoms disturbing sleep, past week*						
Never at work or leisure	4732	726 (15.3)	1.00	4712	325 (6.9)	1.00
Leisure only (ever)	125	26 (20.8)	1.59 (1.04 - 2.37)	124	15 (12.1)	1.36 (0.80 - 2.24)
Work only (ever)	370	93 (25.1)	1.83 (1.49 - 2.26)	363	41 (11.3)	1.31 (0.94 - 1.81)
Work and leisure (ever)	47	13 (27.7)	2.23 (1.71 - 2.90)	46	7 (15.2	1.77 (0.81 - 3.54)

[+]Number of subjects with non-missing data

**For definitions, see footnote to Table 21*

Analysis is based on the whole sample. Prevalence rate ratios (PRs) adjusted for age, ever smoking, frequent tiredness or stress, and frequent headaches.

Table 23

Relation between physical occupational factors and the prevalence and risk of sensorineural symptoms in respondents never exposed to hand-transmitted vibration

	Finger symptoms, past week*			Symptoms disturbing sleep, past week*		
	No.+	No. (%) with symptoms	PR (95% CI)	No.+	No. (%) with symptoms	PR (95% CI)
MEN						
In average day:						
work outdoors or in a cold store	580	67 (11.6)	0.99 (0.72 - 1.35)	577	29 (5.0)	1.41 (0.83 - 2.37)
lifting wts ≥20 lbs	789	108 (13.7)	1.76 (1.32 - 2.34)	789	41 (5.2)	2.19 (1.29 - 3.71)
work with hands above shoulder height ≥1 hr	157	25 (15.9)	1.34 (0.86 - 2.02)	156	10 (6.4)	1.45 (0.71 - 2.90)
use of keyboard ≥4 hrs	691	50 (7.2)	0.86 (0.63 - 1.18)	691	15 (2.2)	0.89 (0.49 - 1.58)
In past week:						
rider of heavy industrial vehicle(s)‡	403	42 (10.4)	0.89 (0.62 - 1.28)	402	16 (4.0)	0.93 (0.50 - 1.70)
WOMEN						
In average day:						
work outdoors or in a cold store	211	45 (21.3)	1.55 (1.13 - 2.08)	209	17 (8.1)	1.41 (0.82 - 2.39)
lifting wts ≥20 lbs	566	100 (17.7)	1.20 (0.95 - 1.51)	566	37 (6.5)	1.03 (0.69 - 1.52)
work with hands above shoulder height ≥1 hr	106	22 (20.8)	1.21 (0.77 - 1.82)	106	10 (9.4	1.43 (0.73 - 2.73)
use of keyboard ≥4 hrs	993	138 (13.9)	1.13 (0.92 - 1.39)	992	51 (5.1)	0.98 (0.69 - 1.38)
In past week:						
rider of heavy industrial vehicle(s)‡	65	15 (23.1)	1.49 (0.87 - 2.39)	64	9 (14.1)	2.48 (1.22 - 4.76)

For definitions, see footnote to Table 21

‡Driver or rider of rock crusher, concrete production machinery, tractor, loader, excavator, bulldozer, grader, scraper, dumper, road roller, mower, off road forestry vehicle, armoured vehicle, forklift truck, mobile crane, lorry, helicopter, other aircraft, highspeed boat, hoist/lift, ambulance, boat, off road car/van, quad bike, fire engine, milk float, conveyor belt or agricultural vehicle

Analysis is confined to respondents who were at work in the past week and who had never been exposed to hand-transmitted vibration in work or in leisure. PRs are mutually adjusted and also adjusted for age, ever smoking and history of frequent tiredness or stress and headaches.

Contents

Table 24
Relation between exposure to hand-transmitted vibration and risk of sensorineural symptoms in employed men

Exposure status	Finger symptoms, past week*			Symptoms disturbing sleep, past week*		
	No.+	No. (%) with symptoms	PR (95% CI)	No.+	No. (%) with symptoms	PR (95% CI)
Never exposed	2420	223 (9.2)	1.00	2413	72 (3.0)	1.00
Leisure only (ever)	234	36 (15.4)	1.50 (1.09 - 2.02)	233	14 (6.0)	1.81 (1.04 - 3.09)
Work only (ever)	1778	320 (18.0)	1.43 (1.20 - 1.69)	1772	120 (6.8)	1.63 (1.20 - 2.22)
Work and leisure (ever)	488	137 (28.1)	2.10 (1.72 - 2.54)	483	51 (10.6)	2.27 (1.58 - 3.24)
Never exposed	2420	223 (9.2)	1.00	2413	72 (3.0)	1.00
Leisure only (ever)	234	36 (15.4)	1.57 (1.12 - 2.19)	233	14 (6.0)	1.92 (1.08 - 3.38)
Previous job but not now	517	154 (29.8)	2.17 (1.73 - 2.71)	512	57 (11.1)	2.23 (1.49 - 3.33)
Past week	1627	348 (21.4)	1.55 (1.29 - 1.86)	1614	126 (7.8)	1.56 (1.11 - 2.18)
Past week, min A(8) >2.8	410	138 (33.7)	2.60 (2.06 - 3.26)	406	51 (12.6)	2.14 (1.33 - 3.41)
Past week, min A(8) >2.8 and employed >5 yrs	232	76 (32.8)	2.35 (1.71 - 3.17)	228	30 (13.2)	2.26 (1.30 - 3.87)

**For definitions, see footnote to Table 21*

+Number of subjects with non-missing data

Analysis is confined to men at work in the past week

PRs adjusted for age, ever smoking, frequent tiredness or stress, headaches, lifting wts ≥ 20 lbs in average day, work outdoors or in a refrigerated building and work with hands above shoulder height

Contents

Table 25

Relation between cold-induced finger blanching and numbness and tingling in the fingers in the past week

Exposure category	No.+	No. (%)							
		RP-ve/SN-ve		RP-ve/SN+ve		RP+ve/SN-ve		RP+ve/SN+ve	
MEN									
Overall	6566	5084	(77.4)	778	(11.8)	376	(5.7)	328	(5.0)
Never exposed to HTV	3328	2799	(84.1)	311	(9.3)	143	(4.3)	75	(2.3)
Ever exposed to HTV (work or leisure)	2979	2108	(70.8)	430	(14.4)	214	(7.2)	227	(7.6)
WOMEN									
Overall	5619	4188	(74.5)	664	(11.8)	511	(9.1)	256	(4.6)
Never exposed to HTV	4736	3605	(76.1)	531	(11.2)	413	(8.7)	187	(3.9)
Ever exposed to HTV (work or leisure)	539	350	(64.9)	89	(16.5)	62	(11.5)	38	(7.1)

+Number with non-missing data. RP = cold-induced finger blanching (ever). SN = numbness/tingling lasting at least 3 minutes in the past week in the digits. Analysis is based on the whole sample

Contents

Table 26

Prevalence of sensorineural symptoms in fingers and thumbs in past week in relation to cold-induced finger blanching and exposure status

Exposure category	No blanching		Blanching	
	No. SN-ve	No. (%) SN+ve	No. SN-ve	No. (%) SN+ve
MEN				
Never	2130	185 (8.0)	100	38 (27.5)
Leisure only	182	26 (12.5)	13	11 (45.8)
Previous job (not present)	317	83 (20.8)	44	65 (59.6)
Past week	1166	217 (15.7)	115	117 (50.4)
Past week, min A(8) >2.8 ms^{-2}	244	87 (26.3)	27	46 (63.0)
Past week, min A(8) >2.8 ms^{-2} and in job >5 years	143	39 (21.4)	12	34 (73.9)
WOMEN				
Never	2306	299 (11.5)	261	100 (27.7)
Leisure only	52	8 (13.3)	13	2 (13.3)
Previous job (now present)	13	6 (31.6)	1	3 (75.0)
Past week	143	34 (19.2)	18	14 (43.8)
Past week, min A(8) >2.8 ms^{-2}	5	1 (16.7)	2	0 (0.0)
Past week, min A(8) >2.8 ms^{-2} and in job >5 years	4	1 (20.0)	2	0 (0.0)

SN = numbness/tingling lasting at least 3 minutes in the past week in the digits
Analysis is for subjects at work in past week

Contents

Table 27

Frequency and risk of cold-induced finger blanching in men according to source of exposure in the past week

Source	No.*	No.+ve*	PR (95% CI)		PR adjusted for other tools† (95% CI)	
Never exposed to HTV•	2442	140	1.00		1.00	
Hammer drill	619	101	2.13	(1.60 - 2.83)	1.55	(0.84 - 2.82)
Hand-held portable grinder	574	88	2.03	(1.50 - 2.73)	1.93	(0.84 - 4.31)
Jig saw	389	63	2.07	(1.49 - 2.86)	1.11	(0.16 - 6.64)
Circular saw	328	61	2.47	(1.77 - 3.41)	0.78	(0.11 - 4.76)
Hand-held sander	286	52	2.26	(1.60 - 3.15)	2.50	(0.91 - 6.35)
Hand-guided mower	168	32	2.30	(1.52 - 3.41)	2.59	(1.34 - 4.78)
Pedestal grinder	260	39	1.93	(1.32 - 2.80)	2.00	(0.72 - 5.17)
Impact screwdriver	208	42	2.67	(1.84 - 3.83)	2.13	(0.51 - 1.92)
Metal drill	150	24	2.39	(1.53 - 3.65)	2.47	(1.15 - 4.97)
Impact wrench	222	37	2.24	(1.51 - 3.27)	0.95	(0.13 - 5.59)
Nailing/stapling gun	143	26	2.32	(1.49 - 3.52)	1.61	(0.50 - 4.61)
Chipping hammer	160	32	2.87	(1.92 - 4.22)	2.20	(0.51 - 7.75)
Concrete breaker	156	32	2.86	(1.89 - 4.23)	3.51	(1.50 - 7.46)
Chain saw	156	37	3.34	(2.28 - 4.81)	2.49	(1.00 - 5.62)
Any other tool	1638	239	2.01	(1.60 - 2.52)	2.04	(1.39 - 2.97)

**Number with non-missing information*

†Adjusted for use of other tools in the past week

•Never exposed at work or in leisure

Analysis is confined to men at work in the past week. All PRs adjusted for age, ever smoking, frequent tiredness or stress, and frequent headaches.

Contents

Table 28

Frequency and risk of cold-induced finger blanching in workers exposed to a single source of hand-transmitted vibration in the past week

Exposure source	No.+	No. (%) with blanching	PR (95% CI)
MEN			
Never exposed to HTV≠	2442	140 (5.7)	1.00
Hammer drill	73	7 (9.6)	1.36 (0.63 - 2.80)
Floor polisher	40	9 (22.5)	3.55 (1.82 - 6.35)
Metal drill	32	6 (18.8)	3.02 (1.32 - 6.13)
Motorcycle	32	4 (12.5)	1.96 (0.72 - 4.79)
Hand-held portable grinder	24	4 (16.7)	2.11 (0.74 - 5.26)
Nailing/stapling gun	24	3 (12.5)	1.86 (0.57 - 5.20)
Hand-guided mower	23	3 (13.0)	1.56 (0.47 - 4.56)
Engraving pen	20	3 (15.0)	2.59 (0.80 - 6.82)
WOMEN			
Never exposed to HTV≠	3007	365 (12.1)	1.00
Floor polisher	71	10 (14.1)	1.07 (0.58 - 1.88)
Nailing/stapling gun	38	7 (18.4)	1.49 (0.72 - 2.79)

+*Number of subjects with non-missing data*

≠*Never exposed at work or in leisure*

Analysis is confined to men and women at work in the past week. PRs adjusted for age, ever smoking, frequent tiredness or stress and frequent headaches.

Contents

Table 29
Frequency and risk of sensorineural symptoms in men according to source of exposure in the past week

Source	No.*	No.+ve	Finger symptoms, past week[#] PR (95% CI)		Finger symptoms, past week[#] Adjusted PR[‡] (95% CI)		Symptoms disturbing sleep, past week[#] PR(95% CI)		Symptoms disturbing sleep, past week[#] Adjusted PR[‡] (95% CI)	
Never exposed[≠]	2420	223	1.00		1.00		1.00		1.00	
Hammer drill	619	137	1.46	(1.12 - 1.89)	0.76	(0.40 - 1.40)	1.43	(1.00 - 1.97)	1.29	(0.54 - 3.03)
Hand-held portable grinder	574	136	1.55	(1.20 - 1.98)	0.88	(0.36 - 2.03)	1.29	(0.82 - 2.00)	0.89	(0.21 - 3.59)
Jig saw	388	91	1.64	(1.23 - 2.17)	2.29	(0.85 - 5.59)	1.45	(0.88 - 2.40)		-
Circular saw	329	80	1.67	(1.23 - 2.25)	0.87	(0.21 - 3.13)	1.42	(0.83 - 2.41)	1.48	(0.20 - 10.00)
Hand-held sander	282	72	1.72	(1.27 - 2.31)	1.83	(0.73 - 4.13)	1.49	(0.86 - 2.55)	2.11	(0.49 - 8.45)
Hand guided mower	167	47	1.99	(1.38 - 2.80)	1.98	(1.08 - 3.42)	1.21	(0.61 - 2.36)	1.17	(0.35 - 3.76)
Pedestal grinder	257	70	1.97	(1.46 - 2.63)	1.36	(0.50 - 3.31)	1.64	(0.96 - 2.77)		-
Impact screwdriver	206	59	1.81	(1.27 - 2.52)	2.17	(0.77 - 5.21)	1.81	(1.02 - 3.17)		-
Metal drill	149	28	1.46	(0.96 - 2.16)	1.27	(0.59 - 2.57)	2.39	(1.32 - 4.24)	2.19	(0.77 - 5.89)
Impact wrench	218	60	1.84	(1.31 - 2.53)	0.96	(0.23 - 3.31)	1.36	(0.74 - 2.45)	1.49	(0.20 - 9.83)
Nailing/stapling gun	145	38	1.79	(1.22 - 2.55)	1.35	(0.55 - 3.05)	1.77	(0.95 - 3.26)	0.70	(0.09 - 4.79)
Chipping hammer	161	45	1.96	(1.34 - 2.81)	0.54	(0.07 - 3.25)	1.77	(0.91 - 3.38)		-
Concrete breaker	158	46	2.17	(1.49 - 3.08)	3.43	(1.69 - 6.21)	1.95	(1.03 - 3.63)	4.64	(1.67 - 12.11)
Chain saw	156	50	1.99	(1.51 - 2.52)	1.78	(0.99 - 3.72)	1.73	(0.92 - 3.20)	1.30	(0.30 - 5.24)
Any other tool(s)	1627	348	1.55	(1.29 - 1.86)	1.55	(1.13 - 2.12)	1.56	(1.11 - 2.18)	1.53	(0.86 - 2.72)

**Number of subjects with non-missing data*

[#]For definitions, see footnote to Table 21

[‡]Adjusted for exposure to other tools in the table

[≠]Never in leisure or work

Analysis is confined to men at work in the past week. PRs are adjusted for age, ever smoking, frequent headaches, tiredness and stress, occupational lifting, work outdoors or in a refrigerated building, and work with hands above shoulder height.

Contents

Table 30

Frequency and risk of sensorineural symptoms in past week in workers exposed to a single source of hand-transmitted vibration in the past week

Source	Finger symptoms, past week*			Symptoms disturbing sleep, past week*		
	No.+	No. (%) with symptoms	PR (95% CI)	No.+	No. (%) with symptoms	PR (95% CI)
MEN						
Never exposed to HTV#	2420	223 (9.2)	1.00	2413	72 (3.0)	1.00
Hammer drill	71	5 (7.0)	0.51 (0.20 - 1.23)	71	3 (4.2)	0.80 (0.23 - 2.61)
Hand-guided mower	23	5 (21.7)	1.87 (0.73 - 4.10)	23	1 (4.3)	0.90 (0.11 - 6.08)
Nailing or stapling gun	24	5 (20.8)	1.67 (0.67 - 3.66)	22	1 (4.6)	0.85 (0.11 - 5.70)
Floor polisher	42	10 (23.8)	1.94 (1.01 - 3.46)	41	6 (14.6)	3.37 (1.39 - 7.62)
Metal drill	32	4 (12.5)	1.04 (0.38 - 2.59)	32	3 (9.4)	2.27 (0.68 - 6.85)
Engraving pen	21	4 (19.1)	1.67 (0.59 - 4.00)	21	0 -	- (-)
Hand-held portable grinder	24	1 (4.2)	0.29 (0.04 - 1.87)	23	0 -	- (-)
Motorcycle	31	5 (16.1)	1.53 (0.62 - 3.37)	31	2 (6.5)	1.82 (0.42 - 6.91)
WOMEN						
Never exposed to HTV#	2970	403 (13.6)	1.00	2969	160 (5.4)	1.00
Floor polisher	69	14 (20.3)	1.20 (0.70 - 1.98)	70	8 (11.4)	1.64 (0.78 - 3.28)
Nailing or stapling gun	37	13 (35.1)	2.53 (1.50 - 3.84)	36	1 (2.8)	0.43 (0.06 - 2.81)

**For definitions, see footnote to Table 21*

+Number of subjects with non-missing data

#Never exposed in work or in leisure

Analysis is confined to men and women at work in the past week. PRs are adjusted for age, ever smoking, frequent headaches, tiredness and stress, occupational lifting, work outdoors or in a refrigerated building, and work with hands above shoulder height.

Contents

Table 31
Frequency and risk of cold-induced finger blanching by occupation and by years in current occupation

Occupation	Overall					>5 years in current job				
	No.[+]	No. (%) with blanching		PR (95% CI)		No.[+]	No. (%) with blanching		PR (95% CI)	
MEN										
Occupations with no exposure to HTV[*]	498	25	5.0	1.00		269	14	5.2	1.00	
Metal working production and maintenance fitters (516)	149	13	8.7	1.52	(0.77 - 2.94)	104	11	10.6	1.65	(0.74 - 3.63)
Carpenters and joiners (570)	93	14	15.1	2.66	(1.39 - 5.00)	49	8	16.3	2.66	(1.11 - 6.15)
Electricians, electrical maintenance fitters (521)	89	12	13.5	2.28	(1.41 - 4.47)	53	8	15.1	2.36	(0.97 - 5.53)
Motor mechanics, auto engineers etc (540)	51	9	17.7	3.23	(1.49 - 6.67)	30	4	13.3	2.06	(0.62 - 6.24)
Builders, building contractors (504)	35	7	20.0	3.37	(1.42 - 7.38)	16	3	18.9	3.75	(1.01 - 11.44)
Farm owners and managers, horticulturists (160)	35	5	14.3	2.57	(0.98 - 6.20)	32	5	15.6	2.96	(1.08 - 7.59)
Gardeners, groundsmen (594)	41	4	9.8	1.89	(0.65 - 5.08)	20	1	5.00	0.81	(0.10 - 5.48)
Bricklayers, masons (500)	38	5	13.2	2.37	(0.87 - 5.96)	21	3	14.3	2.89	(0.80 - 9.07)
Other occupations in which exposure to HTV occurred[*]	3951	391	9.9	1.74	(1.17 - 2.59)	2265	237	10.5	1.76	(1.05 - 3.00)
WOMEN										
Occupations with no exposure to HTV[*]	1186	160	13.5	1.00		610	78	12.8	1.00	
Cleaners, domestics (958)	146	16	8.3	0.70	(0.42 - 1.15)	59	8	13.6	0.88	(0.43 - 1.73)
Hairdressers (660)	38	3	7.9	0.67	(0.22 - 1.86)	17	2	11.8	1.23	(0.30 - 3.76)
Other occupations in which exposure to HTV occurred[*]	2083	262	12.6	0.93	(0.77 - 1.12)	966	125	12.9	0.98	(0.75 - 1.28)

[+]Number of subjects with non-missing data

[*]No exposure in the past week

Analysis is confined to men and women at work in past week. PRs adjusted for age (in three bands, 16 - 34, 35 - 44, 45 - 65), ever smoking, frequently tired/stressed, and frequent headaches.

Contents

Table 32
Feasibility of self-reported exposures to hand-transmitted vibration in the past week, as determined by workplace inquiries

	Number Reported	Number confirmed as feasible		% Feasible
		Yes	No	
People:				
Any exposure to hand-transmitted vibration	*125*	*121*	*4*	*97*
Tools:				
All sources	*393*	*260*	*133*	*66*
Hand-held sander	30	26	4	87
Floor polisher	14	12	2	86
Nut runner	21	18	3	86
Impact wrench	21	13	8	62
Impact screwdriver	14	13	1	93
Jig saw	37	31	6	84
Circular saw	20	16	4	80
Hand-guided mower	13	13	0	100
Hammer drill	22	19	3	86
Riveting hammer or dolly	16	3	13	19
Nailing or stapling gun	16	13	3	81
Pedestal grinder	22	17	5	77
Hand-held portable grinder	35	26	9	74

Contents

Table 33

Agreement between self-reported exposures to hand-transmitted vibration and direct observations in the workplace: sources of exposure*

	Number observed	Number of reports	Sensitivity (%)	Specificity (%)
People:				
Any exposure to hand-transmitted vibration	*113*	*110*	*96*	*98*
Tools:				
All sources	*180*	*179*	*69*	*99*
Floor polisher	13	13	100	100
Nut runner	15	15	66	97
Impact wrench	7	13	71	95
Impact screwdriver	18	12	39	97
Jig saw	13	12	69	98
Circular saw	6	9	100	98
Hand-guided mower	10	10	100	100
Hammer drill	30	16	53	100
Riveting hammer or dolly	1	13	100	93
Nailing or stapling gun	24	17	58	98
Hand-held portable grinder	14	12	86	100
Hand-held sander	10	13	90	98

**Analysis is based on all subjects and on sources of exposure from the pre-defined list in the questionnaire (Q11)*

Contents

Table 34
Patterns of error and omission in reporting of sources of exposure to hand-transmitted vibration during the observation period

Number of sources observed in use	Number of subjects	All reports confirmed by observation		Exposures reported but not observed (false +ves)		Exposures observed but not reported (false -ves)		Under and over-reporting both observed (false +ves and false -ves)	
		No.	%	No.	%	No.	%	No.	%
0	66	65	98.5	1	1.5	0	0	0	0
1	69	56	81.2	8	11.6	2	2.9	3	4.3
2	31	10	32.3	4	12.9	8	25.8	9	29.0
≥3	13	0	0	0	0	3	23.1	10	76.9

Table 35
Relation between observed and reported exposure times for common hand-powered vibratory tools

Source	Number of people in whom tool* was observed	Median number of times tool was used	Reported: observed ratio of exposure times Median (IQR)
Impact screwdriver	7	10.0	4.00 (3.68 - 17.50)
Nut runner	8	10.0	2.96 (1.67 - 8.59)
Nailing or stapling gun	11	8.0	4.57 (2.29 - 6.91)
Hammer drill	6	8.0	2.66 (2.00 - 9.66)
Hand-held sander	8	7.5	6.31 (3.42 - 7.57)
Impact wrench	5	4.0	5.56 (3.00 - 10.00)
Jig saw	8	3.5	3.53 (1.83 - 8.22)
Hand-held portable grinder	11	2.5	2.08 (1.20 - 6.25)
Hand-guided mower	10	2.0	1.17 (0.75 - 2.00)
Floor polisher	13	1.0	1.63 (1.37 - 1.87)
All tools	*104*		*2.48 (1.64 - 5.89)*

**No. with non-missing information*
IQR - interquartile range

Contents

Table 36

Relation between reported and observed exposure durations

Observed exposure time (minutes)	Number of subjects*	Reported: observed ratio of exposure times		
		Median	(IQR)	Theoretical maximum
≤2	24	5.78	(2.70 - 11.69)	30 to ∞
>2 - 5	22	4.00	(2.08 - 7.18)	12 to 30
>5 - 15	30	2.98	(1.87 - 4.68)	4 to 12
>15 - 30	19	1.77	(1.37 - 2.08)	2 to 4
>30	9	1.15	(1.09 - 1.24)	1 to 2
All	*104*	*2.48*	*(1.64 - 5.89)*	*1 to ∞*

**Number with non-missing information*
IQR = interquartile range

Contents

Table 37

Comparison of exposure and health status between the summer (1997) and winter (1998) respondents

Men		Summer (n = 3079)		Winter (n = 3258)	
Age (y):	Mean (SD)	41.8	(13.3)	42.4	(13.1)
	Median (IQR)	42	(31 - 53)	43	(33 - 35)
		No.	*%*	*No.*	*%*
In work:		2388	77.6	2542	78.0
Occupational frequency⁺:					
Construction (23)		103	3.4	145	4.5
Metal processing (18)		216	7.0	256	7.9
Farming, fishing and agriculture (17)		78	2.5	121	3.7
Electrical processing (19)		95	3.1	85	2.6
Other processing (21)		188	6.1	262	8.0
Repetitive assembly, inspection (22)		37	1.2	52	1.6
Other transport & machinery operatives (26)		31	1.0	52	1.6
Security and protective services (11)		71	2.3	90	2.8
Other occupations with exposure		1490	48.4	1416	43.5
Exposure status*:					
Ever exposed to HTV (work or leisure)		1387	45.1	1503	46.1
Exposed in past week (work)		739	24.0	839	25.8
Min A(8) >2.8ms^{-2}, past week (work)		191	6.2	245	7.5
No. (%)* complaining of:					
Cold induced finger blanching (ever)		315	10.2	362	11.1
Numbness/tingling fingers, past week		500	16.2	580	17.8
Symptoms disturbing sleep, past week		214	7.0	253	7.8

Women		Summer (n = 3823)		Winter (n = 2102)	
Age (y):	Mean (SD)	40.4	(13.1)	41.0	(13.2)
	Median (IQR)	40	(30 - 51)	41	(30 - 52)
		No.	*%*	*No.*	*%*
In work:		2448	64.0	1363	64.8
Occupational frequency⁺:					
Farming, fishing and agriculture (17)		34	1.0	21	1.0
Other processing (21)		48	1.3	33	1.6
Repetitive assembly, inspection (22)		27	1.0	12	1.0
Hair and beauty (14)		32	1.0	23	1.1
Textile processing (20)		22	1.0	15	1.0
Security and protective services (11)		12	0.3	11	0.5
Cleaners (15)		119	3.1	74	3.5
Science and engineering (6)		39	1.0	20	1.0
Other occupations with exposure		2072	54.2	1128	53.7
Exposure status*:					
Ever exposed to HTV (work or leisure)		400	10.5	170	8.1
Exposed in past week (work)		156	4.1	65	3.1
Min A(8) >2.8ms^{-2}, past week (work)		6	<1.0	3	<1.0
No. (%)* complaining of:					
Cold induced finger blanching (ever)		508	13.3	282	13.4
Numbness/tingling fingers, past week		575	15.0	365	17.4
Symptoms disturbing sleep, past week		276	7.2	157	7.5

⁺*Percentage of each mailing within a given occupation*

**Percentage of responders in each of the respective mailings*

Table 38

Prevalence of occupational exposure to hand-transmitted vibration in the past week by occupation and by age*

Occupation‡	All ages		≤40 year-olds		>40 year-olds		PR for >40 vs ≤40 yrs (95% CI)
	No. in sample	% exposed	No. in sample	% exposed	No. in sample	% exposed	
ALL WORKERS							
All occupations	*9364*	*20.8*	*4730*	*20.8*	*4634*	*20.9*	*1.01 (0.93 - 1.09)*
MALE WORKERS							
All occupations	*5486*	*31.5*	*2719*	*31.9*	*1726*	*31.0*	*0.97 (0.90 - 1.05)*
Metal working, production and maintenance fitters (516)	155	76.8	61	82.0	94	73.4	0.90 (0.76 - 1.06)
Carpenters and joiners (570)	103	94.2	44	88.6	59	98.3	1.11 (0.99 - 1.23)
Electricians and electrical maintenance fitters (521)	95	84.2	42	90.5	53	79.2	0.88 (0.74 - 1.04)
Motor mechanics, auto engineers (inc. road patrol engineers) (540)	55	83.6	35	85.7	20	80.0	0.93 (0.72 - 1.21)
Plumbers, heating and ventilating engineers and related trades (532)	42	90.5	16	81.3	26	96.2	1.18 (0.92 - 1.52)
Builders, building contractors (504)	38	92.1	15	100.0	23	87.0	0.87 (0.74 - 1.02)
Farm owners and managers, horticulturists (160)	36	69.4	14	85.7	22	59.1	0.69 (0.46 - 1.04)
Gardeners, groundsmen (594)	46	87.0	20	90.0	26	84.6	0.94 (0.75 - 1.17)
Bricklayers, masons (500)	41	82.9	21	81	20	85	1.05 (0.80 - 1.39)
Welding trades (537)	33	87.9	14	85.7	19	89.5	1.04 (0.80 - 1.36)
Production workers and maintenance managers (110)	94	19.1	34	23.5	60	16.7	0.71 (0.31 - 1.62)
Managers & proprietors in service industries (179)	101	14.9	49	8.2	52	21.2	2.59 (0.88 - 7.60)
Machine tool operatives (inc CNC machine tool operatives) (840)	55	50.9	29	44.8	26	57.7	1.29 (0.76 - 2.17)
Cleaners, domestics (958)	30	63.3	14	57.1	15	73.3	1.28 (0.74 - 2.22)
Farm workers (900)	51	76.5	25	60.0	26	92.3	1.54 (1.10 - 2.16)
Drivers of road goods vehicles (872)	157	13.4	47	12.8	110	13.6	1.07 (0.44 - 2.58)
NCOs and other ranks, UK armed forces (600)	571	27.1	495	29.7	76	10.5	0.35 (0.18 - 0.69)
All other labourers and related workers (990)	53	58.5	26	53.8	27	63.0	1.17 (0.74 - 1.85)
Store keepers & warehousemen (441)	94	14.9	53	11.3	41	19.5	1.72 (0.65 - 4.58)
Other plant and machine operatives nec (899)	61	42.6	26	34.6	35	48.6	1.40 (0.75 - 2.63)
FEMALE WORKERS							
All occupations	*3878*	*5.8*	*2011*	*5.7*	*1867*	*5.9*	*1.03 (0.80 - 1.33)*
Cleaners, domestics (958)	161	37.9	60	35.0	101	39.6	1.13 (0.74 - 1.72)
Hairdressers (660)	40	17.5	31	19.4	9	11.1	0.57 (0.08 - 4.17)

**Excludes 4 male workers without age data*

‡The figures in brackets are SOC90 unit group codes nec = not elsewhere classified

Contents

Table 39
Demographic, health and exposure comparisons between early and late responders

	Men				Women			
	Responded to first letter (n = 5001)		Responded to reminder (n = 1912)		Responded to first letter (n = 4511)		Responded to reminder (n = 1483)	
Demographic features:								
Age (y): Mean (SD)	41.8	(13.0)	39.9	(13.2)	40.5	(13.2)	40.3	(13.0)
Median (IQR)	42	(32 - 52)	39	(29 - 51)	40	(30 - 52)	40	(30 - 51)
	No.	%	*No.*	%	*No.*	%	*No.*	%
In work:	3979	76.9	1511	79.0	2993	66.4	885	59.7
Exposure status (no. and %):								
Ever exposed to HTV (work or leisure)	2255	45.1	899	47.0	439	9.7	139	9.4
Exposed in past week (work)	1200	20.4	527	21.0	173	3.8	52	3.5
Min A(8) $>2.8ms^{-2}$, past week (work)	299	6.0	146	7.6	7	<1.0	2	<1.0
Health status (no. and %):								
Cold induced finger blanching (ever)	517	10.3	215	11.2	616	13.7	181	12.2
Numbness/tingling fingers, past week	824	16.5	335	17.5	728	16.1	220	14.8
Symptoms disturbing sleep, past week	342	6.8	146	7.6	327	7.3	107	7.2

Contents

Table 40

Proportion of workers with exposure to hand-transmitted vibration: study sample as compared with the HSE survey of Self-Reported Working Conditions 1995

Occupational groups+	Working conditions survey 1995[45]	Current Study					
		All		Men		Women	
	% exposed	No. in sample	% exposed	No.	% exposed	No.	% exposed
Construction (23)	76	250	78.4	248	79.0	2	0.0
Metal processing (18)	73	485	72.8	472	73.9	13	30.8
Electrical processing (19)	57	182	68.7	180	68.9	2	50.0
Farming, fishing & forestry (17)	53	254	62.6	199	74.4	55	20.0
Other processing (21)	42	531	44.3	450	50.0	81	12.3
Repetitive assembly, inspection (22)	40	128	38.3	89	43.8	39	25.6
Hair & beauty (14)	34	64	17.2	9	33.3	55	14.5
Other transport & machinery operatives (26)	29	84	29.8	83	30.1	1	0.0
Textile processing (20)	27	80	25.0	43	39.5	37	8.1
Security & protective services (11)	26	811	22.2	721	24.4	90	4.4
Cleaners (15)	25	251	44.2	58	72.4	193	35.8
Material moving & storing (27)	23	133	14.3	115	14.8	18	11.1
Science & engineering (06)	18	459	10.2	400	10.5	59	8.5
All occupations	*18*	*9368*	*20.8*	*5490*	*31.5*	*3878*	*5.8*
Managerial (07)	12	133	14.3	539	15.4	261	4.6
Teaching (02)	8	380	9.7	150	11.3	230	8.7
Road transport operatives (25)	8	233	10.3	225	10.7	8.0	0.0
Nursing (08)	7	272	3.3	27	11.1	245	2.4
Literary, artistic & sports (05)	5	100	16.0	57	22.8	43	7.0
Catering (12)	6	292	6.2	82	12.2	210	3.8
Selling (10)	5	568	6.7	225	13.3	343	2.3
Other education & welfare (04)	4	347	9.2	154	14.3	193	5.2
Care workers (13)	4	368	6.0	43	14.0	325	4.9
Clerical (08)	3	982	1.0	313	2.6	669	0.3
Professional & related supporting management (01)	2	550	1.6	330	2.4	220	0.5
Other personal services (16)	0	71	19.7	42	31.0	29	3.4
Secretarial (09)	0	377	0.8	21	9.5	356	0.3

+*As defined in 'Self-reported Working Conditions in 1995', HSE, Appendix 2*

Contents

APPENDIX A:

POSTAL QUESTIONNAIRE USED IN THE NATIONAL SURVEY OF VIBRATION

MRC

MEDICAL RESEARCH COUNCIL

National Survey of Health and Vibration

The answers given on this form are confidential.

You do not need to write your name on the form.

Replies will be seen by MRC staff ONLY.

Contents

YOURSELF

SECTION ONE **ABOUT YOURSELF**

1. Please fill in your date of birth

day month year

and your sex

male ☐ female ☐

2. How tall are you? _____ feet _____ inches

or _______ cm

3. Are you right or left handed?

Right ☐ Left ☐ Able to use both hands equally ☐

4. How would you best describe your racial origin?

European ☐ India/Pakistan ☐ Afro-caribbean ☐

South-east Asia ☐ Other ☐ ____________

5. Have you ever smoked regularly (i.e. at least once a day for a month or longer)?

No ☐ Yes ☐

If yes, how old were you when you first smoked regularly?

years

And do you still smoke regularly? No ☐ Yes ☐

If no, how old were you when you last smoked regularly?

years

6. Have you had a paid job during the past week? No ☐ Yes ☐

If no, please go to Section Four on page 14

If yes, please continue.

SECTION TWO MAIN JOB

7. What was your main OCCUPATION during the past week?	In what INDUSTRY did you carry out this occupation (e.g. farming, shipyard, car factory, shoe shop, hospital, insurance office)?
__________________	______________________________

On what date did you start this job? Date started ☐☐ month ☐☐ year

8. Are you self employed in this job? No ☐ Yes ☐

9. Does an **average working day** in the job involve any of the following?

Working outdoors for more than two hours (i.e. not in a building or enclosed vehicle)	No ☐	Yes ☐
Working in a refrigerated building or room (e.g. a coldstore)	No ☐	Yes ☐
Lifting or moving weights of 20 lbs (10 kg) or more by hand	No ☐	Yes ☐
Lifting or moving weights of 56 lbs (25 kg) or more by hand	No ☐	Yes ☐
Digging or shovelling	No ☐	Yes ☐
Working with your hands above shoulder height for more than one hour	No ☐	Yes ☐
Needing to shout most of the time to be heard by your colleagues	No ☐	Yes ☐
Use of a computer keyboard or typewriter for more than four hours	No ☐	Yes ☐
Work on a night shift.	No ☐	Yes ☐

10. Were you at work in the past week? No ☐ Yes ☐

If no, please go to Section Three on page 12. If yes, please continue.

11. During the past week, did you use any of the following powered tools or machines in the job? *(tick as many boxes as apply)*

Tool or machine		Tool or machine	
Floor polisher	☐	Stone-working hammer	☐
Nut runner	☐	Rotary hammer swager	☐
Impact wrench	☐	Rotary burring tool	☐
Impact screwdriver	☐	Engraving pen	☐
Jig saw	☐	Hammer drill	☐
Circular saw	☐	Riveting hammer or dolly	☐
Chain saw	☐	Chipping hammer	☐
Hand-guided mower	☐	Scaling hammer	☐
Hand-held hedge trimmer	☐	Caulking hammer	☐
Brush saw	☐	Rammer	☐
Barking machine	☐	Needle gun	☐
Stump grinder	☐	Nibbling machine	☐
Concrete breaker (road breaker)	☐	Clinching and flanging tool	☐
Rock Drill	☐	Concrete vibrothickener	☐
Tamper	☐	Nailing or stapling gun	☐
Scabbler	☐	Pedestal grinder	☐

Continued

Pedestal linisher	☐	Hand-held sander	☐
Hand-held portable grinder	☐	Shoe pounding-up machine	☐
Hand-held polisher	☐	Vibratory roller	☐

Or **None of these** ☐ (**If none**, go to question 13, page 6)

12. For those tools/machines that you have ticked in question 11, we would like to know the total number of hours (or minutes) you worked with them over <u>the whole week</u>.

Please only count the time that the tool was SWITCHED ON AND HELD. If you cannot give the exact time, please give your best estimate.

Write the name of the tool/machine below	Write the total time you used it over the whole week in the boxes below
1. ______	☐☐ hours ☐☐ mins
2. ______	☐☐ hours ☐☐ mins
3. ______	☐☐ hours ☐☐ mins
4. ______	☐☐ hours ☐☐ mins
5. ______	☐☐ hours ☐☐ mins
6. ______	☐☐ hours ☐☐ mins

Contents

13. During the past week did you use any other powered tools or machines in the job that vibrated your hands?

No ☐ (go to question 14)   Yes ☐ (continue below)

If yes, we would like to know which tools or machines, and the total number of hours (or minutes) you worked with them over the whole week.

Please only count the time that the tool was SWITCHED ON AND HELD. If you cannot give the exact time please give your best estimate.

Write the name of the tool/machine below	Write the total time you used it over the whole week	Describe the job that the tool/machine was used to do
1. ______	☐☐ hours ☐☐ mins	______
2. ______	☐☐ hours ☐☐ mins	______
3. ______	☐☐ hours ☐☐ mins	______
4. ______	☐☐ hours ☐☐ mins	______
5. ______	☐☐ hours ☐☐ mins	______
6. ______	☐☐ hours ☐☐ mins	______
7. ______	☐☐ hours ☐☐ mins	______
8. ______	☐☐ hours ☐☐ mins	______

14. **In your main job, do you __ever__ use other powered vibrating tools that you have not already told us about (e.g. tools used only occasionally or at certain times of the year)?**

No ☐ Yes ☐

If yes, which tools?

1 ______________________ 4 ______________________

2 ______________________ 5 ______________________

3 ______________________ 6 ______________________

15. **Was your use of powered vibrating tools/machines in the past week fairly typical of the current job?**

Not applicable (don't use them) ☐ No ☐ Yes ☐

If no, in what way was it unusual?

____

____

____

____

16. **During the past week did you drive, ride or stand on any of the following machines or vehicles in the job?** *(tick as many boxes as apply)*

Vehicle or machine		Vehicle or machine	
Car (other than going to and from work)	☐	Dumper	☐
Van (other than going to and from work)	☐	Other earth-moving machinery (specify) ______	☐
Bus or coach (other than going to and from work)	☐	Road Roller	☐
Train (other than going to and from work)	☐	Mower (seated)	☐
Motor cycle (other than going to and from work)	☐	Off road forestry vehicle	☐
Rock crusher	☐	Armoured vehicle	☐
Concrete production machinery	☐	Other off-road vehicle (specify) ______	☐
Tractor	☐	Lift truck/Forklift truck	☐
Loader	☐	Mobile crane	☐
Excavator	☐	Lorry	☐
Bulldozer	☐	Helicopter	☐
Grader	☐	Other aircraft	☐
Scraper	☐	Highspeedboat, hovercraft or hydrofoil	☐

Or **None of these** ☐ *(If none, go to question 18, page 10)*

17. **For those machines or vehicles that you have ticked in question 16, we would like to know the total number of hours (or minutes) that you drove/rode/stood on them <u>over the whole week</u>.**

Please only count the time that the ENGINE WAS RUNNING OR POWER ON. If you cannot give the exact time, please give your best estimate.

Write the name of the machine/vehicle below	Write the total time you drove/rode/stood on it over the whole week in the boxes below
1. ____________	☐☐ hours ☐☐ mins
2. ____________	☐☐ hours ☐☐ mins
3. ____________	☐☐ hours ☐☐ mins
4. ____________	☐☐ hours ☐☐ mins
5. ____________	☐☐ hours ☐☐ mins
6. ____________	☐☐ hours ☐☐ mins
7. ____________	☐☐ hours ☐☐ mins
8. ____________	☐☐ hours ☐☐ mins

18. **During the past week in your job did you drive/ride/sit or stand on any other vehicles or machines that caused vibration or frequent jolting or both?**

No ☐ (go to question 19) Yes ☐

If yes, **we would like to know which machines/vehicles, and how long in total you drove/rode/stood on them over the whole week.**

Please only count the time that the ENGINE WAS RUNNING OR POWER ON. If you cannot give the exact time, please give your best estimate.

Write the name of the vehicle/machine	Write the total time over the whole week	Describe the job the vehicle/machine was used to do
1. ______	☐☐ hours ☐☐ mins	______
2. ______	☐☐ hours ☐☐ mins	______
3. ______	☐☐ hours ☐☐ mins	______
4. ______	☐☐ hours ☐☐ mins	______
5. ______	☐☐ hours ☐☐ mins	______
6. ______	☐☐ hours ☐☐ mins	______

Contents

19. Was the time you spent over the past week riding/driving/standing on such machines typical of the job?

Not applicable ☐ No ☐ Yes ☐
(Don't ride or drive vehicle or machine)

If no, in what way was it unusual?

____

____

____

20. In your main job do you ever ride on/drive/stand on vehicles or machines (other than those you have already described) that cause vibration or frequent jolting that you can feel (e.g. vehicles only used occasionally or at certain times of the year)?

No ☐ Yes ☐

If yes, which vehicles/machines?

1. ______________ 4. ______________

2. ______________ 5. ______________

3. ______________ 6. ______________

SECTION THREE OTHER JOBS HELD

21. **Did you work at any other job during the past week?** No ☐ Yes ☐

If no, please move on to Section Four on page 14.

If yes, please continue

22. What was the other job?

Occupation ____________________ Industry ______________

23. Are you self-employed in this job? No ☐ Yes ☐

24. Does an **average working day** in the job involve any of the following?

Working outdoors for more than two hours (i.e. not in a building or enclosed vehicle)	No ☐	Yes ☐
Working in a refrigerated building or room (e.g. a coldstore)	No ☐	Yes ☐
Lifting or moving weights of 20 lbs (10 kg) or more by hand	No ☐	Yes ☐
Lifting or moving weights of 56 lbs (25 kg) or more by hand	No ☐	Yes ☐
Digging or shovelling	No ☐	Yes ☐
Working with your hands above shoulder height for more than one hour	No ☐	Yes ☐
Use of a computer keyboard or typewriter for more than four hours	No ☐	Yes ☐
Needing to shout most of the time to be heard by your colleagues?	No ☐	Yes ☐
Work on a night shift	No ☐	Yes ☐

25. During the past week did the job involve work with a powered tool or machine that made your hands vibrate?

No ☐ Yes ☐

If yes, we would like to know which tools and for how long (in hours or minutes) you worked with them over the whole week. Please only count the time that the tool was SWITCHED ON AND HELD.

Write the name of the tool/machine below	Write the total time you used it over the whole week in the boxes below
1. ______________	☐☐ hours ☐☐ mins
2. ______________	☐☐ hours ☐☐ mins
3. ______________	☐☐ hours ☐☐ mins
4. ______________	☐☐ hours ☐☐ mins

26. During the past week did the job involve driving/riding/standing on a vehicle/machine (such as those listed in question 16 page 8)?

No ☐ Yes ☐

If yes, We would like to know which machines or vehicles and for how long (in hours or minutes) you drove/rode/stood on them over the whole week. Please count only the time with THE ENGINE RUNNING OR POWER ON.

Write the name of the vehicle/machine below	Write the total time you drove/rode/stood on it over the whole week in the boxes below
1. ______________	☐☐ hours ☐☐ mins
2. ______________	☐☐ hours ☐☐ mins
3. ______________	☐☐ hours ☐☐ mins
4. ______________	☐☐ hours ☐☐ mins

SECTION FOUR EARLIER JOBS AND EXPOSURES

27. Other than in the work you have already told us about, have you EVER had a paid job which involved working with a powered tool or machine that made your hands vibrate for more than an hour a week?

No ☐ (go to question 29)

Yes ☐ (continue)

Approximately how old were you when you first did this work? ☐☐ years

28. What were the tools/machines you used at that time?
(Question 11 page 4 lists some possible tools)

1. ____________________
2. ____________________
3. ____________________
4. ____________________

And what was the job and industry?

Occupation	Industry (e.g. farming, shipyard, car factory etc.)

29. In your spare time (i.e. outside work), have you ever *regularly* used a tool or machine that made your hands vibrate, for more than an hour per week?

No ☐ (go to question 30)

Yes ☐ (continue)

Approximately how old were you when you first did this? ☐☐ years

And what were the tools or machines? (Question 11 page 4 lists some possible tools)

1. ____________________
2. ____________________
3. ____________________
4. ____________________

30. **In you spare time (i.e outside work and going to and from work), please estimate for the past week the total number of hours (or minutes) you spent driving or riding in the vehicles listed below. If you cannot give the exact time please give your best estimate.**

	Total time over week			Total time over week	
Car or van	☐☐ hours	☐☐ mins	Train	☐☐ hours	☐☐ mins
Bus or coach	☐☐ hours	☐☐ mins	Motorcycle	☐☐ hours	☐☐ mins

31. **How long altogether have you worked in noisy places where you had to shout to be heard?**

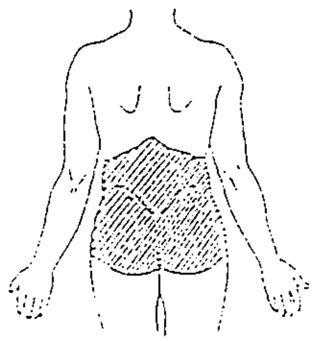
Never ☐ less than 12 months ☐ 1-5 years ☐

6-10 years ☐ More than 10 years ☐

SECTION FIVE HEALTH

32. **During the PAST 12 MONTHS, have you had back pain in the area shown in the diagram, which lasted for more than a day? (Do not include pain occurring only during pregnancy, during menstrual periods, or during the course of a feverish illness such as 'flu).**

No ☐ Yes ☐



If yes, did the pain spread down your leg to below your knee?

No ☐ Yes ☐

Did it make it difficult or impossible to put on socks, stockings or tights?

No difficulty ☐ Difficult but not impossible ☐ Impossible ☐

And have you had the pain during the past week?

No ☐ Yes ☐

Contents

33. PAIN IN THE PAST WEEK AND PAST YEAR:

Answer the questions below using the tick boxes - one tick for each question. Please answer these questions even if you have never had any trouble in these parts of your body.

During the **past week** have you had pain lasting a day or more in your:	During the **past 12 months** have you had pain lasting a day or more in your:	During the **past 12 months** have you been **prevented** from carrying out normal activities (eg. job, housework, hobbies) because of pain in your:
Knees No ☐ Yes ☐	**Knees** No ☐ Yes ☐	**Knees** No ☐ Yes ☐
Hips No ☐ Yes ☐	**Hips** No ☐ Yes ☐	**Hips** No ☐ Yes ☐
Shoulders No ☐ Yes ☐ right shoulder ☐ left shoulder ☐ both shoulders	**Shoulders** No ☐ Yes ☐ right shoulder ☐ left shoulder ☐ both shoulders	**Shoulders** No ☐ Yes ☐ right shoulder ☐ left shoulder ☐ both shoulders
Neck No ☐ Yes ☐	**Neck** No ☐ Yes ☐	**Neck** No ☐ Yes ☐
Wrists/hands No ☐ Yes ☐ right wrist/hand ☐ left wrist/hand ☐ both wrists/hands	**Wrists/hands** No ☐ Yes ☐ right wrist/hand ☐ left wrist/hand ☐ both wrists/hands	**Wrist/hands** No ☐ Yes ☐ right wrist/hand ☐ left wrist/hand ☐ both wrists/hands
Elbows No ☐ Yes ☐ right elbow ☐ left elbow ☐ both elbows	**Elbows** No ☐ Yes ☐ right elbow ☐ left elbow ☐ both elbows	**Elbows** No ☐ Yes ☐ right elbow ☐ left elbow ☐ both elbows

34. If you have had elbow pain in the last year, have you received an injection from a doctor to treat it?

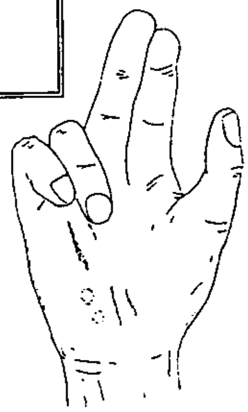
No ☐ Yes ☐ No elbow pain ☐

35. NUMBNESS OR "PINS AND NEEDLES" IN THE PAST WEEK AND PAST YEAR.

	In the past week have you had tingling or numbness that lasted at least three minutes in your:	In the past 12 months have you had tingling or numbness that lasted at least three minutes in your:
Fingers/thumbs?	No ☐ Yes ☐	No ☐ Yes ☐
Other parts of the hand(s)?	No ☐ Yes ☐	No ☐ Yes ☐
Other parts of the arm(s)?	No ☐ Yes ☐	No ☐ Yes ☐
If yes to any of the above, has the tingling or numbness disturbed your sleep?	(PAST WEEK) No ☐ Yes ☐	(PAST 12 MONTHS) No ☐ Yes ☐

36. Is your little finger (or little and ring finger) of either hand permanently bent as shown opposite so that you cannot straighten it, even with the other hand?

No ☐ Yes ☐

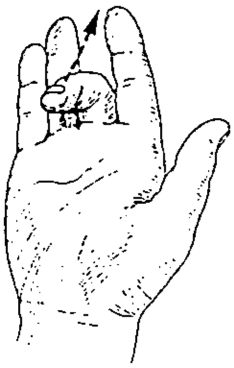


37. In the past year have you once or more had episodes when a finger or fingers have locked (got stuck), in the position shown in the diagram opposite and needed to be straightened using the other hand to help?

No ☐ Yes ☐

If yes, how many fingers have got locked or stuck?
(write a number in the boxes below)

Number in the right hand ☐ Number in the left hand ☐



38. Have you ever had attacks in which any or all of your fingers suddenly became cold and numb, and at the same time turned white or pale?

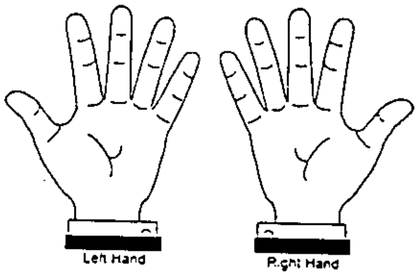
No ☐ Yes ☐

If no please move on to question 47. If yes please continue

39. Approximately how old were you when you first had one of these attacks?

☐☐ years

40. Which fingers/thumbs have gone white or pale? (Indicate by shading the parts that have gone pale on the diagram).



41. Have attacks ever been brought on by any of the following?

Cold conditions	No ☐	Yes ☐
Washing up	No ☐	Yes ☐
Use of a tool or machine	No ☐	Yes ☐

(**If yes**, which tools or machines?) ______________________________

____

42. During an attack, have you ever noticed a clear "edge" between the white or pale part of your finger and the normal colour of your hand?

No ☐ Yes ☐

43. Have you ever had an attack during the summer?

No ☐ Yes ☐

44. Have you ever had an attack so bad that you were unable to carry on with what you were doing at the time?

No ☐ Yes ☐

45. Have the attacks ever been bad enough for you to see a doctor about them?

No ☐ Yes ☐

If yes, what did the doctor say the problem was? ______________________________

____

46. How many attacks have you had during the past 12 months?

0 ☐ 1-9 ☐ 10 - 49 ☐ 50 - 99 ☐ 100+ ☐

47. Have you ever noticed that any of the following have also gone white or pale?

Toes	No ☐	Yes ☐
Ears	No ☐	Yes ☐
Nose	No ☐	Yes ☐

48. In the past week have you found it difficult to do any of the following activities? *(please tick).*

	No difficulty	Difficult but not impossible	Impossible
Turn a door knob or lever	☐	☐	☐
Open a tight jar lid	☐	☐	☐
Put on a jacket or pullover	☐	☐	☐
Fasten buttons	☐	☐	☐
Pour from a jug or teapot	☐	☐	☐

49. Do you use a hearing aid? No ☐ Yes ☐

(if you do, please answer the following questions as if not wearing the aid)

50. How well you can hear a person who is talking to you when he is sitting on your RIGHT SIDE in a quiet room? *(Please tick one box)*

Cannot hear him at all ☐ With great difficulty ☐ With moderate difficulty ☐

With slight difficulty ☐ With no difficulty ☐

51. How well you can hear a person who is talking to you when he is sitting on your LEFT SIDE in a quiet room? *(Please tick one box)*

Cannot hear him at all ☐ With great difficulty ☐ With moderate difficulty ☐

With slight difficulty ☐ With no difficulty ☐

52. During the past 12 months have you had noises in your head or ears (such as ringing, buzzing or whistling) which lasted longer than five minutes?

No, never ☐ Yes, but not most of the time ☐ Yes, most or all of the time ☐

53. OTHER HEALTH PROBLEMS:

How often do you suffer from the following?

Headaches	Never ☐	Occasionally ☐	Frequently ☐
Feeling constantly tired	Never ☐	Occasionally ☐	Frequently ☐
Feeling low in mood or spirits	Never ☐	Occasionally ☐	Frequently ☐
Feeling tired or under stress	Never ☐	Occasionally ☐	Frequently ☐

* *

You have finished. Thank you for completing the form. Please could you now post it back in the envelope provided? We are grateful for your help.

APPENDIX B:
PROCEDURES ADOPTED IN DATA CLEANING AND CODING

1. Sex and date of birth

In assembling the mailing lists a check was made of the dates of birth supplied. Subjects whose ages fell outside the study range (16-64 years) were excluded from the mailing.

A comparison was also made between the details of dates of birth and sex supplied by the respondents and those on the general practitioner's source file. Missing responses were made good by matching the questionnaire with the source file and substituting the expected values according to GP records. Where inconsistencies were detected between the two sources of information a number of conventions were adopted to determine eligibility for the study and the correct values of parameters. Thus, when the respondent was of the expected gender but their self-reported date of birth varied by only one digit from the GP's record, the value supplied by the subject was accepted as the true one; similarly, when the date of birth was as expected but the gender was not supplied, the expected gender was assumed. However, when the date of birth was very different from that expected, or the gender differed from that expected (and the first name was not common to both men and women), it was presumed that the questionnaire had been completed by a subject other than the selected one and the subject was treated as a non-responder.

2. Employment status

People were coded as *a worker/in employment* if: (a) they reported that they had had a paid job in the past week (Q6); or (b) that they were currently self-employed (Q8); or (c) that they had been at work in the past week (Q10). In the absence of one of these conditions, any exposure information supplied for the past week was set to missing. Workers were counted as *at work* in the past week if they answered 'yes' to Q10 and/or provided exposure information under Q11-13 or Q16-18.

3. Coding of exposure

The principal conventions adopted in coding of exposure have been described in the main text. In addition a number of other conventions were adopted:

Sources. Descriptions of the sources reported in Q12 (pre-defined list) and Q13 (open response section) were individually vetted to identify simple mis-spellings, abbreviations or common synonyms for tools, especially those belonging to the pre-defined list. Where sources and durations of exposure were reported in Q12 but omitted from Q11, exposure to a source from the closed list was deemed to have occurred and the Q11 value was changed from 'no' to 'yes'.

Durations of exposure. Where information was not supplied on the exposure time (Q12/Q13), the estimated A(8) was either set to 'missing' or a minimum value was calculated, depending on the other information supplied. Non-explicit information on duration of HTV exposure (e.g. 'only a few minutes over the whole week', 'or machines used during the week, not able to say') was treated as missing.

Suspected double reporting. Where identical sources and exposure times were reported in both the closed and open questions on HTV (Q12 and Q13), the information in Q13 was censored in case of double reporting.

Exceptional durations of exposure. Where individuals reported unusually prolonged periods of tool use during the past week (>60 hours), a check was made of their occupation and the nature of the reported exposures. Seven records were examined including those of a labourer, a tree surgeon and a locksmith - and these were accepted. One subject claimed a similar period of exposure to whole-body vibration; and two claimed more than 120 hours of exposure during the week: these three responses were coded as missing.

Representativeness of exposure. In Question 15, subjects were asked whether or not exposure to HTV in the past week was 'typical of the current job', and space was provided so they could describe any unusual features. Written responses were individually vetted to decide whether exposures were ordinarily more common or less common.

4. Coding of health outcomes

The principal conventions adopted in coding of the health outcomes have been described in the main text. In addition a number of other conventions were adopted. In particular when respondents reported that their blanching was cold-induced (Q41a) but omitted to record that they had had blanching attacks (Q38) the latter value was changed from missing to 'yes'.

Contents

In Question 40, subjects with blanching were asked to indicate the parts of the fingers and thumbs affected by shading a hand diagram. In coding their responses, the boundaries of a phalanx were defined by its external outline and its palmar creases: any shading within this area was counted as positive, and the number of affected phalanges was determined without any system of pattern-weighting.

In Question 45, subjects who had visited a doctor concerning their blanching were asked to record the doctor's opinion of the problem. A hand search was made of all the responses, in order to identify reports that might be compatible with Raynaud's phenomenon or VWF (e.g. terms such as 'Raynaud's', 'white finger', 'dead finger', 'blanching', 'VWF' and 'vibration-induced').

5. Coding of other workplace exposures and psychological factors

In Question 9, subjects were asked about ingredients of an average working day in the job - such as the need to lift weights, work in a cold store, or use a computer keyboard for more than four hours. Some respondents had difficulty in deciding upon their answer. By convention, when both the 'yes' and 'no' boxes were ticked, the information was treated as missing; and if neither was ticked but a description written, the replies were individually vetted. One common reply - 'sometimes' - was treated as a 'no' in coding.

In Question 53, subjects were asked about how often they suffered headaches and feelings of tiredness, low spirits and stress. The frequency of their symptoms was rated on a three-point scale ('never', 'occasionally', 'frequently'): where more than one box was ticked, the lesser frequency was assumed.

6. Other conventions

A few other conventions were adopted. These included checks for improbable heights and impossible or improbable dates for the commencement of smoking; and conventions similar to those described above for dealing with questions where too many boxes had been ticked. These had no direct impact on the data presented in this report, except for one item on the age at commencement of current occupation. Values were treated as missing if they indicated an age greater than the respondent's current age or younger than 10 years old. Incomplete information (e.g. missing day and month information) and impossible values (e.g. month > 12) were treated as missing.

Contents

APPENDIX C:

REPRESENTATIVE a_{hw} VALUES ASSIGNED TO SOURCES OF HAND-TRANSMITTED VIBRATION

Table C.1
Representative a_{hw} values assigned to sources of hand-transmitted vibration

Source	ms^{-2} r.m.s.	Source	ms^{-2} r.m.s.
Floor polisher	2.0	Rammer	32.5
Nut runner	6.1	Needle gun	16.0
Impact wrench	5.0	Nibbling machine	8.0
Impact screwdriver	4.0	Clinching and flanging tool	13.6
Jig saw	4.2	Concrete vibrothickener	3.5
Circular saw	1.7	Nailing or stapling gun	*
Chain saw	10.0	Pedestal grinder	12.0
Hand-guided mower	4.0	Pedestal linisher	4.0
Hand-held hedge trimmer	4.0	Hand-held portable grinder	5.3
Brush saw	7.0	Hand held polisher	3.5
Barking machine	15.0	Hand-held sander	6.0
Stump grinder	6.0	Shoe pounding-up machine	12.0
Concrete breaker (road breaker)	17.0	Vibratory roller	*
Rock drill	32.0	Metal drill	3.0
Tamper	12.0	Surgical tool	*
Scabbler	29.2	Disc cutter	3.1
Stone-working hammer	10.7	Hair clipper	*
Rotary hammer swager	16.7	Strimmer	8.0
Rotary burring tool	4.1	Screwdriver	1.0
Engraving pen	5.0	Metal saw	4.9
Hammer drill	11.0	Planer/planing tool	*
Riveting hammer or dolly	5.5	Jet wash	*
Chipping hammer	11.5	Router	2.1
Scaling hammer	21.4	Motor cycle handlebars	1.5
Caulking hammer	7.8	Miscellaneous	*
		Unclassified	*

These values, which represent dominant-axis values, have been assembled from a variety of sources, including:

1. Several confidential reports received by the Institute of Sound and Vibration Research, Southampton University.
2. Nelson C.M, Griffin MJ. *Vibration-induced white finger in dockyard employees.* ISVR Technical Report No. 170, Institute of Sound and Vibration Research, University of Southampton, 1989.

c) Nelson CM. Hand-transmitted vibration assessment - a comparison of results using single axis and triaxial methods. United Kingdom Group Meeting on Human Response to Vibration, ISVR, University of Southampton, 17th to 19th September 1997.

d) International Social Security Association (ISSA) *Vibration at Work*. International Section 'Research' Institut National de Recherche et de Securite (INRS), Paris, France 1989.

e) Griffin MJ. Measurement, evaluation, and assessment of occupational exposures to hand-transmitted vibration. *Occup Environ Med* 1997;**54**: 73-89.

f) Hewitt SM. Hand-transmitted vibration exposure in shipbuilding and ship repair. International Congress on Noise Control Engineering, Inter-Noise, Liverpool, United Kingdom, 30th July to 2nd August 1996, 1707-1712.

For each tool, several sources of information were generally consulted and a judgement taken on the quality of available data. Single values have been selected, but in practice variations are likely to exist in the true vibration magnitudes between tools that differ in their model type and source of manufacture; between similar tools when used for different tasks, or fitted with different accessories; and between tools from different eras of design (some older designs have been replaced with newer, low-vibration versions). To confirm the appropriateness of the choices made, a number of measurements were made on common sources of exposure and these are reported separately (in *Hand-transmitted vibration: Evaluation of some common sources of exposure in Great Britain*). In general, the median measured values approximated closely to the selected values.

For a few tools (marked with an asterisk in the table) it was not considered possible to assign a representative a_{hw}, either because of insufficient information, or because sources within a group were considered sufficiently dissimilar to negate the approach (such groups were created from smaller single user categories, and so contribute to the tool user tables but not to the A(8) tables). For nailing and stapling guns, which have transient impacts of low irregular frequency, the appropriate method of dose estimation is contentious, and so no partial A(8) values were calculated for these tools.

APPENDIX D:

ESTIMATED NUMBER OF MEN AND WOMEN IN GREAT BRITAIN BY OCCUPATION AND INDUSTRY WITH AN AVERAGE DAILY VIBRATION DOSE (A(8)) GREATER THAN 2.8 MS^{-2} R.M.S. IN THE PAST WEEK

The tables in this appendix provide a full listing of exposures to hand-transmitted vibration in the sample and estimated numbers exposed in the population of Great Britain. Separate tables are provided for men and women by occupation (down to minor groups in SOC 90) and by industry (to the 2-digit SIC 92-industry code). The population figures are estimates of the number of workers with a daily personal vibration dose >2.8 ms^{-2} (A(8)). They are minimum estimates, as in some cases exposure information was missing, and they have been rounded to the nearest hundred. It should be noted that for some occupational and industrial groups the numbers in the sample were small, resulting in wide confidence intervals for the population estimates.

Table D.1
Exposure to hand-transmitted vibration in the past week by minor occupational group (SOC 90) in men

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
10	General Managers and administrators in national and local government, large companies and organisations	26	0	0.0	0.0	0	(-)
11	Production managers in manufacturing, construction, mining and energy industries	129	27	20.9	0.8	4300	(0 - 12600)
12	Specialist managers	135	4	3.0	0.0	0	(-)
13	Financial institution and office managers, civil service executive officers	62	2	3.2	0.0	0	(-)
14	Managers in transport and storing	39	6	15.4	2.6	3300	(0 - 9600)
15	Protective service officers	14	4	28.6	0.0	0	(-)
16	Managers in farming, horticulture, forestry and fishing	50	32	64.0	26.0	46900	(25000 - 68900)

Contents

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
17	Managers and proprietors in service industries	168	30	17.9	1.8	13700	(0 - 29100)
19	Managers and administrators nec	133	18	13.5	0.0	0	(-)
20	Natural scientists	22	1	4.5	0.0	0	(-)
21	Engineers and technologists	163	15	9.2	2.5	10000	(300 - 19700)
22	Health professionals	67	13	19.4	0.0	0	(-)
23	Teaching professionals	157	18	11.5	0.0	0	(-)
24	Legal professionals	25	1	4.0	0.0	0	(-)
25	Business and financial professionals	65	0	0.0	0.0	0	(-)
26	Architects, town planners and surveyors	47	2	4.3	0.0	0	(-)
27	Librarians and related professionals	4	1	25.0	0.0	0	(-)
29	Professionals occupations nec	30	4	13.3	0.0	0	(-)
30	Scientific technicians	70	23	32.9	5.7	12700	(600 - 24700)
31	Draughtspersons, quantity and other surveyors	29	1	3.4	0.0	0	(-)
32	Computer analyst/programmers	59	0	0.0	0.0	0	(-)
33	Ship and aircraft officers, air traffic planners and controllers	9	0	0.0	0.0	0	(-)
34	Health associate professionals	35	3	8.6	0.0	0	(-)
35	Legal associate professionals	3	0	0.0	0.0	0	(-)
36	Business and financial associate professionals	50	1	2.0	0.0	0	(-)
37	Social welfare associate professionals	12	0	0.0	0.0	0	(-)
38	Literary, artistic and sports professionals	57	13	22.8	0.0	0	(-)
39	Associate professional and technical occupations nec	46	3	6.5	2.2	2100	(0 - 6300)
40	Administrative/clerical officers and assistants in civil service and local government	96	2	2.1	0.0	0	(-)
41	Numerical clerks and cashiers	78	1	1.3	1.3	3500	(0 - 0200)
42	Filing and records clerks	18	1	5.6	0.0	0	(-)
43	Clerks (not otherwise specified)	66	0	0.0	0.0	0	(-)
44	Stores and despatch clerks, storekeepers	98	14	14.3	1.0	2500	(0 - 7500)
45	Secretaries, personal assistants, typists, word processor operators	3	0	0.0	0.0	0	(-)
46	Receptionists, telephonists and related occupations	7	0	0.0	0.0	0	(-)
49	Clerical and secretarial occupations nec	11	2	18.2	0.0	0	(-)
50	Construction trades	166	125	75.3	30.7	181800	(140200 - 223300)

Contents

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
51	Metal machining, fitting and instrument making trades	185	138	74.6	20.5	118100	(84700 - 151600)
52	Electrical/electronic trades	174	120	69.0	17.2	75800	(51100 - 100500)
53	Metal forming, welding and related trades	105	94	89.5	38.1	136000	(102900 - 169200)
54	Vehicle trades	78	66	84.6	32.1	79700	(53900 - 105400)
55	Textiles, garments and related trades	34	13	38.2	5.9	5100	(0 - 12000)
56	Printing and related trades	23	3	13.0	0.0	0	(-)
57	Woodworking trades	124	118	95.2	41.1	129200	(102000 - 156400)
58	Food preparation trades	34	4	11.8	0.0	0	(-)
59	Other craft and related occupations nec	111	79	71.2	22.5	54500	(35700 - 73300)
60	NCOs and other ranks, armed forces	571	155	27.1	1.9	3100	(1300 - 5000)
61	Security and protective service occupations	140	17	12.1	0.7	2100	(0 - 6200)
62	Catering occupations	57	8	14.0	0.0	0	(-)
64	Health and related occupations	30	5	16.7	0.0	0	(-)
65	Childcare and related occupations	5	1	20.0	0.0	0	(-)
66	Hairdressers, beauticians and related occupations	9	3	33.3	0.0	0	(-)
67	Domestic staff and related occupations	28	23	82.1	10.7	7600	(0 - 15700)
69	Personal and protective service occupations nec	18	6	33.3	0.0	0	(-)
70	Buyers, brokers and related agents	15	0	0.0	0.0	0	(-)
71	Sales representatives	86	6	7.0	0.0	0	(-)
72	Sales assistants and check-out operators	106	18	17.0	0.0	0	(-)
73	Mobile, market and door-to-door salespersons and agents	25	5	20.0	0.0	0	(-)
79	Sales occupations nec	5	1	20.0	0.0	0	(-)
80	Food, drink and tobacco process operatives	35	5	14.3	0.0	0	(-)
81	Textiles and tannery process operatives	9	4	44.4	11.1	2500	(0 - 7100)
82	Chemicals, paper, plastics and related process operatives	72	19	26.4	5.6	8600	(400 - 16800)
83	Metal making and treating process operatives	24	9	37.5	4.2	1500	(0 - 4300)
84	Metal working process operatives	61	31	50.8	14.8	23900	(9500 - 38400)
85	Assemblers/lineworkers	38	24	63.2	10.5	8600	(600 - 16500)
86	Other routine process operatives	52	15	28.8	1.9	3400	(0 - 10000)
87	Road transport operatives	225	24	10.7	1.8	11400	(300 - 22500)
88	Other transport and machinery operatives	83	25	30.1	10.8	25000	(9600 - 40500)

Contents

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) $>2.8\ ms^{-2}$	Min no. with A(8) $>2.8\ ms^{-2}$	(95% CI)
89	Plant and machine operatives nec	138	77	55.8	26.8	81400	(59000 - 103800)
90	Other occupations in agriculture, forestry and fishing	98	72	73.5	17.3	21900	(12400 - 31400)
91	Other occupations in mining and manufacturing	55	33	60.0	23.6	31400	(16500 - 46300)
92	Other occupations in construction	34	30	88.2	47.1	89700	(57700 - 121700)
93	Other occupations in transport	21	3	14.3	0.0	0	(-)
94	Other occupations in communication	46	3	6.5	0.0	0	(-)
95	Other occupations in sales and services	91	30	33.0	3.3	7400	(0 - 15600)
99	Other occupations nec	53	31	58.5	22.6	16300	(8200 - 24400)
	Inadequately described	143	42	29.4	5.6		

nec = not elsewhere classified

Contents

Table D.2
Exposure to hand-transmitted vibration in the past week by minor occupational group (SOC 90) in women

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
10	General Managers and administrators in national and local government, large companies and organisations	22	0	0.0	0.0	0	(-)
11	Production managers in manufacturing, construction, mining and energy industries	15	1	6.7	0.0	0	(-)
12	Specialist managers	78	0	0.0	0.0	0	(-)
13	Financial institution and office managers, civil service executive officers	86	3	3.5	0.0	0	(-)
14	Managers in transport and storing	5	0	0.0	0.0	0	(-)
16	Managers in farming, horticulture, forestry and fishing	6	1	16.7	0.0	0	(-)
17	Managers and proprietors in service industries	124	8	6.5	0.8	4100	(0 - 12200)
19	Managers and administrators nec	59	1	1.7	0.0	0	(-)
20	Natural scientists	8	1	12.5	0.0	0	(-)
21	Engineers and technologists	9	0	0.0	0.0	0	(-)
22	Health professionals	43	3	7.0	0.0	0	(-)
23	Teaching professionals	245	20	8.2	0.0	0	(-)
24	Legal professionals	13	0	0.0	0.0	0	(-)
25	Business and financial professionals	31	0	0.0	0.0	0	(-)
26	Architects, town planners and surveyors	5	0	0.0	0.0	0	(-)
27	Librarians and related professionals	4	0	0.0	0.0	0	(-)
29	Professionals occupations nec	45	0	0.0	0.0	0	(-)
30	Scientific technicians	24	2	8.3	0.0	0	(-)
31	Draughtspersons, quantity and other surveyors	4	0	0.0	0.0	0	(-)
32	Computer analyst/programmers	6	0	0.0	0.0	0	(-)
34	Health associate professionals	267	11	4.1	0.0	0	(-)
35	Legal associate professionals	1	0	0.0	0.0	0	(-)
36	Business and financial associate professionals	34	1	2.9	0.0	0	(-)
37	Social welfare associate professionals	47	3	6.4	0.0	0	(-)
38	Literary, artistic and sports professionals	38	2	5.3	0.0	0	(-)

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
39	Associate professional and technical occupations nec	19	0	0.0	0.0	0	(-)
40	Administrative/clerical officers and assistants in civil service and local government	91	0	0.0	0.0	0	(-)
41	Numerical clerks and cashiers	227	0	0.0	0.0	0	(-)
42	Filing and records clerks	58	0	0.0	0.0	0	(-)
43	Clerks (not otherwise specified)	247	2	0.8	0.0	0	(-)
44	Stores and despatch clerks, storekeepers	17	2	11.8	5.9	3500	(0 - 10000)
45	Secretaries, personal assistants, typists, word processor operators	234	0	0.0	0.0	0	(-)
46	Receptionists, telephonists and related occupations	98	1	1.0	0.0	0	(-)
49	Clerical and secretarial occupations nec	25	0	0.0	0.0	0	(-)
50	Construction trades	1	0	0.0	0.0	0	(-)
51	Metal machining, fitting and instrument making trades	6	2	33.3	0.0	0	(-)
52	Electrical/electronic trades	2	1	50.0	0.0	0	(-)
54	Vehicle trades	3	2	66.7	0.0	0	(-)
55	Textiles, garments and related trades	30	3	10.0	3.3	6700	(0 - 19600)
56	Printing and related trades	8	1	12.5	12.5	5800	(0 - 16600)
57	Woodworking trades	2	2	100.0	0.0	0	(-)
58	Food preparation trades	8	0	0.0	0.0	0	(-)
59	Other craft and related occupations nec	25	1	4.0	0.0	0	(-)
60	NCOs and other ranks, armed forces	68	4	5.9	0.0	0	(-)
61	Security and protective service occupations	22	0	0.0	0.0	0	(-)
62	Catering occupations	129	3	2.3	0.0	0	(-)
63	Travel attendants and related occupations	10	1	10.0	0.0	0	(-)
64	Health and related occupations	166	4	2.4	0.0	0	(-)
65	Childcare and related occupations	172	11	6.4	0.0	0	(-)
66	Hairdressers, beauticians and related occupations	50	7	14.0	0.0	0	(-)
67	Domestic staff and related occupations	32	8	25.0	0.0	0	(-)
69	Personal and protective service occupations nec	15	0	0.0	0.0	0	(-)
70	Buyers, brokers and related agents	10	0	0.0	0.0	0	(-)
71	Sales representatives	35	0	0.0	0.0	0	(-)
72	Sales assistants and check-out operators	310	7	2.3	0.0	0	(-)

Minor Group Number	Minor Group Title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
73	Mobile, market and door-to-door salespersons and agents	9	0	0.0	0.0	0	(-)
79	Sales occupations nec	14	2	14.3	0.0	0	(-)
80	Food, drink and tobacco process operatives	13	0	0.0	0.0	0	(-)
81	Textiles and tannery process operatives	7	0	0.0	0.0	0	(-)
82	Chemicals, paper, plastics and related process operatives	2	0	0.0	0.0	0	(-)
84	Metal working process operatives	4	0	0.0	0.0	0	(-)
85	Assemblers/lineworkers	11	2	18.2	18.2	16100	(0 - 36200)
86	Other routine process operatives	31	10	32.3	0.0	0	(-)
87	Road transport operatives	8	0	0.0	0.0	0	(-)
88	Other transport and machinery operatives	1	0	0.0	0.0	0	(-)
89	Plant and machine operatives nec	21	4	19.0	4.8	2100	(0 - 6000)
90	Other occupations in agriculture, forestry and fishing	38	9	23.7	0.0	0	(-)
91	Other occupations in mining and manufacturing	14	3	21.4	0.0	0	(-)
93	Other occupations in transport	3	0	0.0	0.0	0	(-)
94	Other occupations in communication	13	0	0.0	0.0	0	(-)
95	Other occupations in sales and services	250	66	26.4	0.0	0	(-)
99	Other occupations nec	1	0	0.0	0.0	0	(-)
	Inadequately described	99	10	10.1	2.0		

nec = not elsewhere classified

Contents

Table D.3

Exposure to hand-transmitted vibration in the past week by 2-digit industry code (SIC 92) in men

Industry 2-digit code	Industry title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
1	Agriculture, hunting and related service activities	154	102	66.2	21.4	70900	(49500 - 92400)
2	Forestry, logging and related service activities	23	20	87.0	43.5	5800	(3100 - 8500)
5	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing	16	4	25.0	0.0	0	(-)
10	Mining of coal and lignite; extraction of peat	40	20	50.0	22.5	17500	(7500 - 27600)
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying	13	2	15.4	0.0	0	(-)
14	Other mining and quarrying	20	11	55.0	25.0	6300	(1500 - 11000)
15	Manufacture of food products and beverages	102	20	19.6	2.9	8900	(0 - 18900)
17	Manufacture of textiles	28	5	17.9	3.6	3900	(0 - 11500)
18	Manufacture of wearing apparel; dressing and dyeing of fur	7	2	28.6	0.0	0	(-)
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	22	4	18.2	4.5	1300	(0 - 3600)
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	20	11	55.0	25.0	29000	(7000 - 51000)
21	Manufacture of pulp, paper and paper products	29	6	20.7	3.4	3000	(0 - 8700)
22	Publishing, printing and reproduction of recorded media	66	10	15.2	0.0	0	(-)
23	Manufacture of coke, refined petroleum products and nuclear fuel	8	2	25.0	0.0	0	(-)
24	Manufacture of chemicals and chemical products	77	14	18.2	1.3	2800	(0 - 8200)
25	Manufacture of rubber and plastic products	32	11	34.4	9.4	13200	(0 - 27400)
26	Manufacture of other non-metallic mineral products	59	18	30.5	8.5	11600	(1900 - 21300)
27	Manufacture of basic metals	77	35	45.5	13.0	20700	(8700 - 32600)
28	Manufacture of fabricated metal products, except machinery and equipment	188	87	46.3	11.2	52700	(31500 - 74000)
29	Manufacture of machinery and equipment nec	32	18	56.3	12.5	40000	(3300 - 76600)
30	Manufacture of office machinery and computers	4	0	0.0	0.0	0	(-)
31	Manufacture of electrical machinery and apparatus nec	42	13	31.0	2.4	3900	(0 - 11400)
32	Manufacture of radio, television and communication equipment and apparatus	6	3	50.0	0.0	0	(-)

Industry 2-digit code	Industry title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
33	Manufacture of medical, precision and optical instruments, watches and clocks	7	1	14.3	14.3	12100	(0 - 34000)
34	Manufacture of motor vehicles, trailers and semi-trailers	124	50	40.3	8.1	16700	(6800 - 26600)
35	Manufacture of other transport equipment	64	30	46.9	7.8	15200	(2400 - 28000)
36	Manufacture of furniture; manufacturing nec	28	14	50.0	3.6	5700	(0 - 16700)
37	Recycling	2	0	0.0	0.0	0	(-)
40	Electricity, gas, steam and hot water supply	170	54	31.8	10.0	16300	(9000 - 23700)
41	Collection, purification and distribution of water	3	1	33.3	0.0	0	(-)
45	Construction	428	266	62.1	29.2	460300	(392400 - 528200)
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	89	57	64.0	22.5	97200	(59700 - 134700)
51	Wholesale trade and commission trades, except of motor vehicles and motorcycles	60	12	20.0	0.0	0	(-)
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	329	86	26.1	4.9	41800	(21800 - 61800)
55	Hotels and restaurants	108	25	23.1	2.8	10500	(0 - 22200)
60	Land transport; transport via pipelines	137	25	18.2	5.8	34100	(11200 - 57000)
61	Water transport	31	11	35.5	12.9	4200	(400 - 8100)
62	Air transport	20	9	45.0	10.0	4700	(0 - 10800)
63	Supporting and auxiliary transport activities; activities of travel agencies	58	9	15.5	1.7	2700	(0 - 8000)
64	Post and telecommunications	94	15	16.0	4.3	14400	(600 - 28200)
65	Financial intermediation, except insurance and pension funding	60	0	0.0	0.0	0	(-)
66	Insurance and pension funding, except compulsory social security	48	0	0.0	0.0	0	(-)
67	Activities auxiliary to financial intermediation	9	0	0.0	0.0	0	(-)
70	Real estate activities	24	10	41.7	12.5	15400	(0 - 31800)
71	Renting of machinery and equipment without operator and of personal and household goods	4	0	0.0	0.0	0	(-)
72	Computer and related activities	52	3	5.8	0.0	0	(-)
73	Research and development	4	1	25.0	0.0	0	(-)
74	Other business activities	110	15	13.6	3.6	27900	(1100 - 54600)
75	Public administration and defence; compulsory social security	299	54	18.1	1.7	15000	(2000 - 28100)

Contents

Industry 2-digit code	Industry title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
80	Education	199	40	20.1	1.5	7100	(0 - 15100)
85	Health and social work	208	35	16.8	1.4	5800	(0 - 12200)
90	Sewage and refuse disposal, sanitation and similar activities	15	7	46.7	13.3	10000	(0 - 22800)
91	Activities of membership organisations nec	15	5	33.3	0.0	0	(-)
92	Recreational, cultural and sporting activities	94	37	39.4	7.4	20600	(5900 - 35300)
93	Other service activities	38	16	42.1	21.1	15700	(6000 - 25400)
95	Private households with employed persons	1	1	100.0	0.0	0	(-)
	Inadequately described	1493	420	28.1	5.4		

nec = not elsewhere classified

Contents

Table D.4
Exposure to hand-transmitted vibration in the past week by 2-digit industry code (SIC 92) in women

Industry 2-digit code	Industry title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
1	Agriculture, hunting and related service activities	47	5	10.6	0.0	0	(-)
2	Forestry, logging and related service activities	4	1	25.0	0.0	0	(-)
5	Fishing, operation of fish hatcheries and fish farms; service activities incidental to fishing	3	0	0.0	0.0	0	(-)
10	Mining of coal and lignite; extraction of peat	2	0	0.0	0.0	0	(-)
11	Extraction of crude petroleum and natural gas; service activities incidental to oil and gas extraction excluding surveying	2	0	0.0	0.0	0	(-)
14	Other mining and quarrying	1	0	0.0	0.0	0	(-)
15	Manufacture of food products and beverages	46	2	4.3	0.0	0	(-)
16	Manufacture of tobacco products	1	0	0.0	0.0	0	(-)
17	Manufacture of textiles	16	2	12.5	0.0	0	(-)
18	Manufacture of wearing apparel; dressing and dyeing of fur	14	3	21.4	14.3	21300	(0 - 48700)
19	Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	1	0	0.0	0.0	0	(-)
20	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	2	0	0.0	0.0	0	(-)
21	Manufacture of pulp, paper and paper products	6	0	0.0	0.0	0	(-)
22	Publishing, printing and reproduction of recorded media	29	0	0.0	0.0	0	(-)
23	Manufacture of coke, refined petroleum products and nuclear fuel	1	0	0.0	0.0	0	(-)
24	Manufacture of chemicals and chemical products	12	0	0.0	0.0	0	(-)
25	Manufacture of rubber and plastic products	4	0	0.0	0.0	0	(-)
26	Manufacture of other non-metallic mineral products	21	1	4.8	0.0	0	(-)
27	Manufacture of basic metals	3	0	0.0	0.0	0	(-)
28	Manufacture of fabricated metal products, except machinery and equipment	29	1	3.4	3.4	3500	(0 - 10200)
29	Manufacture of machinery and equipment nec	6	0	0.0	0.0	0	(-)
31	Manufacture of electrical machinery and apparatus nec	16	4	25.0	6.3	4400	(0 - 12900)
32	Manufacture of radio, television and communication equipment and apparatus	3	0	0.0	0.0	0	(-)

Contents

Industry 2-digit code	Industry title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with $A(8) > 2.8\ ms^{-2}$	Min no. with $A(8) > 2.8\ ms^{-2}$	(95% CI)
33	Manufacture of medical, precision and optical instruments, watches and clocks	2	0	0.0	0.0	0	(-)
34	Manufacture of motor vehicles, trailers and semi-trailers	16	0	0.0	0.0	0	(-)
35	Manufacture of other transport equipment	9	0	0.0	0.0	0	(-)
36	Manufacture of furniture; manufacturing nec	6	2	33.3	0.0	0	(-)
37	Recycling	1	0	0.0	0.0	0	(-)
40	Electricity, gas, steam and hot water supply	27	2	7.4	0.0	0	(-)
41	Collection, purification and distribution of water	3	0	0.0	0.0	0	(-)
43	Clerks nec	1	0	0.0	0.0	0	(-)
45	Construction	33	1	3.0	0.0	0	(-)
50	Sale, maintenance and repair of motor vehicles and motorcycles; retail sale of automotive fuel	24	2	8.3	0.0	0	(-)
51	Wholesale trade and commission trades, except of motor vehicles and motorcycles	29	3	10.3	3.4	9900	(0 - 28900)
52	Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	459	13	2.8	0.2	3100	(0 - 9100)
55	Hotels and restaurants	154	5	3.2	0.0	0	(-)
60	Land transport; transport via pipelines	24	0	0.0	0.0	0	(-)
61	Water transport	3	0	0.0	0.0	0	(-)
62	Air transport	14	1	7.1	0.0	0	(-)
63	Supporting and auxiliary transport activities; activities of travel agencies	26	0	0.0	0.0	0	(-)
64	Post and telecommunications	46	0	0.0	0.0	0	(-)
65	Financial intermediation, except insurance and pension funding	95	0	0.0	0.0	0	(-)
66	Insurance and pension funding, except compulsory social security	59	0	0.0	0.0	0	(-)
67	Activities auxiliary to financial intermediation	12	0	0.0	0.0	0	(-)
70	Real estate activities	25	1	4.0	0.0	0	(-)
71	Renting of machinery and equipment without operator and of personal and household goods	3	0	0.0	0.0	0	(-)
72	Computer and related activities	8	0	0.0	0.0	0	(-)
73	Research and development	9	0	0.0	0.0	0	(-)
74	Other business activities	70	1	1.4	0.0	0	(-)

Industry 2-digit code	Industry title	Sample				Population of Great Britain	
		No	No exposed	% exposed	Min % with A(8) >2.8 ms^{-2}	Min no. with A(8) >2.8 ms^{-2}	(95% CI)
75	Public administration and defence; compulsory social security	178	6	3.4	0.0	0	(-)
80	Education	482	54	11.2	0.0	0	(-)
85	Health and social work	685	40	5.8	0.0	0	(-)
90	Sewage and refuse disposal, sanitation and similar activities	3	2	66.7	0.0	0	(-)
91	Activities of membership organisations nec	16	3	18.8	0.0	0	(-)
92	Recreational, cultural and sporting activities	75	4	5.3	0.0	0	(-)
93	Other service activities	64	9	14.1	0.0	0	(-)
95	Private households with employed persons	6	1	16.7	0.0	0	(-)
	Inadequately described	942	56	5.9	0.3		

nec = not elsewhere classified

Contents

APPENDIX E:

ESTIMATED NUMBERS OF MEN AND WOMEN IN GREAT BRITAIN BY OCCUPATION AND BY REGION WITH AN AVERAGE DAILY VIBRATION DOSE (A(8)) GREATER THAN 2.8 MS^{-2} R.M.S. IN THE PAST WEEK

Table E.1

Minimum frequency of exposure to a daily A(8) >2.8 ms^{-2} in men in the past week by occupation: estimated numbers and 95% confidence intervals for different regions of Great Britain

Country/Region	Leading Occupations	Min est no. with daily A(8) >2.8 ms^{-2}	(95 % CI)
National data:			
England	All occupations combined	1,015,100	(925,100 - 1,105,100)
	1. Carpenters and joiners (570)	96,300	(74,700 - 117,800)
	2. Builders, building contractors (504)	81,900	(62,000 - 101,700)
	3. Metal working, production and maintenance fitters (516)	75,100	(53,200 - 97,000)
	4. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	62,800	(41,700 - 83,900)
	5. Other building and civil engineering labourers nec (929)	52,500	(26,000 - 78,900)
Scotland	All occupations combined	110,500	(100,700 - 120,300)
	1. Carpenters and joiners (570)	13,700	(10,600 - 16,700)
	2. Other building and civil engineering labourers nec (929)	8,100	(4,000 - 12,200)
	3. Metal working, production and maintenance fitters (516)	7,200	(5,100 - 9,300)
	4. Construction and related operatives (896)	5,700	(3,800 - 7,600)
	5. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	5,500	(3,700 - 7,400)

Country/Region	Leading Occupations	Min est no. with daily A(8) >2.8 ms^{-2}	(95 % CI)
Wales	All occupations combined	65,200	(59,500 - 70,900)
	1. Builders, building contractors (504)	5,300	(4,000 - 6,600)
	2. Carpenters and joiners (570)	5,300	(4,100 - 6,500)
	3. Metal working, production and maintenance fitters (516)	4,800	(3,400 - 6,200)
	4. Farm owners and managers, horticulturists (160)	4,700	(1,800 - 7,600)
	5. Other building and civil engineering labourers nec (929)	4,500	(2,200 - 6,800)
HSE regions:			
Wales and West region	All occupations combined	200,100	(182,500 - 217,700)
	1. Builders, building contractors (504)	19,700	(14,900 - 24,400)
	2. Carpenters and joiners (570)	17,500	(13,600 - 21,400)
	3. Metal working, production and maintenance fitters (516)	13,700	(9,700 - 17,800)
	4. Farm owners and managers, horticulturists (160)	13,000	(5,000 - 20,900)
	5. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	11,600	(7,700 - 15,500)
Home Counties	All occupations combined	207,900	(189,500 - 226,300)
	1. Builders, building contractors (504)	19,600	(14,900 - 24,400)
	2. Carpenters and joiners (570)	19,500	(15,100 - 23,800)
	3. Metal working, production and maintenance fitters (516)	14,600	(10,400 - 18,900)
	4. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	13,300	(8,800 - 17,800)
	5. Other building and civil engineering labourers nec (929)	10,900	(5,400 - 16,400)
London and South East	All occupations combined	188,900	(172,000 - 205,800)
	1. Builders, building contractors (504)	20,400	(15,500 - 25,400)
	2. Carpenters and joiners (570)	19,000	(14,800 - 23,300)
	3. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	12,800	(8,500 - 17,100)
	4. Metal working, production and maintenance fitters (516)	12,300	(8,700 - 15,800)
	5. Construction and related operatives (896)	11,200	(7,500 - 15,000)
Midlands	All occupations combined	179,700	(163,800 - 195,600)
	1. Metal working, production and maintenance fitters (516)	15,100	(10,700 - 19,600)
	2. Carpenters and joiners (570)	15,000	(11,600 - 18,300)
	3. Builders, building contractors (504)	11,100	(8,400 - 13,800)
	4. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	10,800	(7,200 - 14,500)
	5. Welding trades (537)	8,900	(5,600 - 12,200)

Country/Region	Leading Occupations	Min est no. with daily A(8) >2.8 ms^{-2}	(95 % CI)
Yorkshire & North East	All occupations combined	164,400	(149,900 - 178,900)
	1. Carpenters and joiners (570)	16,000	(12,500 - 19,600)
	2. Metal working, production and maintenance fitters (516)	12,600	(8,900 - 16,200)
	3. Other building and civil engineering labourers nec (929)	9,600	(4,800 - 14,500)
	4. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	9,100	(6,000 - 12,100)
	5. Builders, building contractors (504)	8,100	(6,100 - 10,000)
North West region	All occupations combined	139,000	(126,700 - 151,300)
	1. Carpenters and joiners (570)	14,600	(11,300 - 17,900)
	2. Metal working, production and maintenance fitters (516)	11,600	(8,200 - 14,900)
	3. Motor mechanics, auto engineers (inc. road patrol engineers) (540)	8,600	(5,700 - 11,500)
	4. Builders, building contractors (504)	8,200	(6,200 - 10,200)
	5. Other building and civil engineering labourers nec (929)	7,300	(3, 600 - 11, 000)

nec = not elsewhere classified.

APPENDIX F:

SUPPLEMENTARY INFORMATION ON THE RELATION BETWEEN ESTIMATED DOSE (A(8)) IN THE PAST WEEK AND HEALTH COMPLAINTS

The data from the postal survey permitted an analysis of the relation between estimated average personal daily A(8) in the past week and symptom reports. It should be noted, however, that this cross-sectional study design is limited in its capacity to examine the precise form of the relationship, for two reasons:

1. Respondents only provided information on exposures in the past week: higher or lower exposures may have prevailed at other times.
2. In many cases exposure information was missing. The dose-response pattern could only be fully explored in workers who supplied complete information - a group who might not be typical of all exposed respondents.

Despite these limitations an exploratory analysis was conducted. Few exposed men reported that the last week was atypical, and more than 60% of tool users had been on their present job for more than five years, providing some basis for regarding the past week as a rough proxy of the longer-term exposure pattern. The effect of missing information was also assessed in workers with partial information for whom a *minimum* A(8) could be estimated.

Table F1 examines the relation of A(8) in the past week with finger blanching and troublesome finger blanching. Among subjects for whom full exposure information existed, there was evidence of an increased risk over baseline at all levels, but particularly for exposures > 5 ms^{-2} r.m.s, when the PR for blanching was 3.03 (95% CI 1.74-5.02) and that for troublesome blanching was 3.77 (95%CI 1.60-8.46). Higher risk estimates were obtained in the exposure band 1-2.8 ms^{-2} than in the next highest band (>2.8-5.0 ms^{-2}); but risk estimates in those with a *minimum* A(8) > 2.8 ms^{-2} were also greater than for the 2.8-5.0 ms^{-2} band. The probability of having incomplete information tends to increase as the number of sources of exposure increases, and perhaps also as the level of exposure and risk increase. This factor may distort the exposure-response relation, as evidenced by the pattern in subjects with full information, and so provide an explanation for these findings.

Contents

For sensorineural complaints a similar relation was seen with dose in the past week (Table F2). Among subjects who provided full exposure information, increasing risk was seen with increasing estimates of daily dose, particularly for symptoms felt in the fingers. When the highest exposure band was compared with the baseline of never exposed, the PR for symptoms in the fingers was 3.13 (95% CI 2.02-4.58); and the PR for symptoms disturbing sleep was 2.01 (95% CI 0.87-4.46).

Table F.1
Association between cold-induced finger blanching and magnitude of daily vibration exposure (A(8)) in the past week in employed men

A(8) level (ms^{-2})	All disease PR (95% CI)		Troublesome disease≠ PR (95% CI)	
Never exposed to HTV	1.00		1.00	
>0-1	1.66	(1.07 - 2.54)	0.80	(0.28 - 2.25)
>1-2.8	2.00	(1.39 - 2.87)	1.87	(0.96 - 3.60)
>2.8 - 5	1.54	(0.83 - 2.75)	1.51	(0.52 - 4.26)
>5	3.03	(1.74 - 5.02)	3.77	(1.60 - 8.46)
Missing	2.04	(1.58 - 2.63)	2.85	(1.85 - 4.37)
Minimum A(8) >2.8	2.42	(1.76 - 3.29)	3.04	(1.80 - 5.09)

≠Attacks preventing activity or taken to a doctor
Analysis is confined to men who were at work in the past week
PRs are adjusted for age, ever smoking, frequent headaches, tiredness, stress, and occupational lifting

Table F.2
Association between sensorineural symptoms and magnitude of daily vibration exposure (A(8)) in the past week in employed men

A(8) level (ms^{-2})	Symptoms in fingers+, past week PR (95% CI)		Symptoms disturbing sleep≠ PR (95% CI)	
Never exposed to HTV	1.00		1.00	
>0-1	1.21	(0.82 - 1.76)	0.87	(0.41 - 1.83)
>1-2.8	1.29	(0.92 - 1.79)	1.08	(0.59 - 1.97)
>2.8 - 5	1.92	(1.22 - 2.92)	1.39	(0.62 - 3.01)
>5	3.13	(2.02 - 4.58)	2.01	(0.87 - 4.46)
Missing	1.57	(1.27 - 1.94)	1.74	(1.20 - 2.52)
Minimum A(8) >2.8	2.32	(1.78 - 3.00)	2.14	(1.33 - 3.41)

+Tingling or numbness lasting at least 3 minutes in the digits in the past week
≠Tingling or numbness lasting at least 3 minutes in the fingers, hand or arm in the past week and disturbing sleep
Analysis is confined to men who were at work in the past week
PRs are adjusted for age, ever smoking, frequent headaches, tiredness and stress, occupational lifting and work outdoors or in a refrigerated building

In reading these tables the limits of study design should be borne in mind. The findings in Table F1, in particular, are compatible with increased risks at an $A(8) < 1\ ms^{-2}$, but they may also be explained by higher exposures in earlier work periods.

Contents

HSE BOOKS

MAIL ORDER
HSE priced and free publications are available from:
HSE Books
PO Box 1999
Sudbury
Suffolk CO10 2WA
Tel: 01787 881165
Fax: 01787 313995

RETAIL
HSE priced publications are available from good booksellers

HEALTH AND SAFETY ENQUIRIES
HSE InfoLine
Tel: 0541 545500
or write to:
HSE Information Centre
Broad Lane
Sheffield S3 7HQ

HSE home page on the World Wide Web:
http://www.open.gov.uk/hse/hsehome.htm

CRR 232

£37.50 net

ISBN 0-7176-2476-5

9 780717 624768

Contents