Institution: University of Southampton

Unit of Assessment: 15 General Engineering

Title of case study: 15-21 Hand-arm vibration syndrome: reducing risks to workers

1. Summary of the impact

Multidisciplinary research by the University of Southampton has been pivotal to tackling the problem of Hand-Arm Vibration Syndrome, HAVS, a major compensated industrial disease with more than 1.2 million workers at foreseeable risk in the UK and many millions with symptoms around the globe. Work by the Human Factors Research Unit, part of the University's Institute of Sound and Vibration Research, has had a major impact on understanding and controlling the disorder, shaping guidance that is used in national and international standards, governmental legislation, law courts and compensation schemes both nationally and internationally. The advances arising from the Southampton research are recognised by policymakers, industry, and peer groups.

2. Underpinning research

Phenomenal growth in the use of powered tools during the past 100 years has resulted in widespread exposure to hand-transmitted vibration and, consequently, the development of the 'hand-arm vibration syndrome', HAVS, a disease affecting blood vessels, nerves, muscles and joints of the hand, wrist and arm. Failure across industry, government, and the legal system to comprehend the complexities of the disease left workers at risk.

Recognising that a combination of engineering, epidemiological, experimental, and clinical studies was required, multidisciplinary research aimed at bringing HAVS under control has been conducted by the Human Factors Research Unit (HFRU), part of the University of Southampton's Institute of Sound and Vibration Research. Comprising 70 refereed journal publications, research led by Professor Michael Griffin (HFRU head: 1972 to present) has investigated the causes of HAVS and its consequences so as to improve vibratory tools, the diagnosis of disorders, and provide practical advice to industry and policymakers. Medical research included substantial collaboration with the University of Southampton MRC Lifecourse Epidemiology.

Early research at Southampton by Griffin and colleagues identified that hand-transmitted vibration caused both vascular and neurological disorders in the hands, with the disorders developing independently, and this is now widelty accepted **[3.1]**.

Together with the MRC Lifecourse Epidemiology Unit (Professor Coggon, 1980 – present; and Professor Palmer, 1994 – present), the HFRU undertook the largest survey (1997-1998) of the causes and consequences of exposure to hand-transmitted vibration, involving 12,907 participants. It was found that 4.2 million men and 667,000 women in Great Britain were exposed to hand-transmitted vibration at work and that 1.2 million men and 44,000 women had foreseeable risk of injury with exposures to vibration exceeding the Health and Safety Executive daily action level. The Southampton findings prompted a call for international action from policymakers.

In 2002, research for the HSE by Griffin and Lindsell (Research Assistant, 1995 – 2002) established reliable means of measuring vibration thresholds, thermal thresholds, and systolic blood pressures in the fingers and criteria for establishing abnormalities in vibration-exposed workers.

An epidemiological study of 1,200 dockyard workers completed in 2003 showed HAVS was related to the duration of exposure and that an improved vibration frequency weighting was needed to control the disorder **[3.2]**. HFRU psychophysical research showed for the first time (with Morioka in 2006) the dependence of frequency weightings on vibration magnitude **[3.3]**.

In the engineering field, methods of assessing exposures to hand-transmitted vibration were critically reviewed by Griffin (1997), who also assessed the vibration isolation efficiency of gloves

(Griffin, 1998) and later showed how contact conditions with a source of vibration had a great influence of the vibration modes (Concettoni and Griffin, 2009). All these studies challenged the frequency weighting and frequency range for predicting vibration disorders **[3.6]**.

Research in Southampton from 1995 to 2013 was key to the international development of methods for diagnosing HAVS, largely with PhD research in the Human Factors Research Unit. The First International Workshop on the diagnosis of disorders caused by hand-transmitted vibration was held in Southampton in 2002. The HFRU developed a set of CE-marked *HVLab* diagnostic tools, among them a tactile vibrometer, a thermal aesthesiometer, and a multi-channel plethysmograph (to measure finger blood pressure and finger blood flow). The Unit continues to improve on the established methods and equipment for measuring neurological and vascular dysfunction associated with HAVS **[3.4]**.

The multi-channel plethysmograph also made it possible to undertake unique experimental studies of the physiological response to vibration, revealing the mechanisms causing vibration-induced reductions in finger blood flow **[3.5]**.

3. References to the research (the best 3 are starred)

Example publications:

3.1. Griffin,M.J., Bovenzi,M. (2002) The diagnosis of disorders caused by hand-transmitted vibration: Southampton Workshop 2000. **International Archives of Occupational and Environmental Health**, 75, (1-2), 1-5.

3.2. *Griffin,M.J., Bovenzi,M., Nelson,C.M. (2003) Dose-response patterns for vibration-induced white finger. **Occupational and Environmental Medicine**, 60:16–26.

3.3. *Morioka,M., Griffin,M.J. (2006) Magnitude dependence of equivalent comfort contours for fore-and-aft, lateral and vertical hand-transmitted vibration. **Journal of Sound and Vibration** 295 633-648.

3.4. Griffin,M.J. (2008) Measurement, evaluation, and assessment of peripheral neurological disorders caused by hand-transmitted vibration. **International Archives of Occupational and Environmental Health,** 81(5), 559-573.

3.5. *Ye,Y., Griffin,M.J. (2011) Reductions in finger blood flow in males and females induced by 125-Hz vibration: association with vibration perception thresholds. **Journal of Applied Physiology**, 111, 1606-1613.

3.6. Griffin,M.J. (2012) Frequency-dependence of psychophysical and physiological responses to hand-transmitted vibration. **Industrial Health** 50, 354-369. [Invited paper at 12th International Hand-Arm Vibration Conference, Ottawa, June 2012].

4. Details of the impact

Southampton's long research into hand-arm vibration syndrome has influenced company practice around the world, demonstrated the need to tackle the disease and raised its profile on the policy agenda, provided health services with more effective diagnostic tools, and helped control the risks for millions of workers, of whom more than 1.2 million are at risk in the UK.

The EU Physical Agents (vibration) Directive (2002/44/EC) published in 2002 required member states to start implementing measures to control the risks of hand-transmitted vibration by 2005. With the Europe-wide policy legally binding for every employer in the European Union, Griffin led the preparation of the *EU Guide to Good Practice on Hand-Arm Vibration,* published in 22 languages by the European Commission **[5.1]**. The guide shows member countries how to implement the EU Physical Agents (vibration) Directive, and is also widely used outside the EU.

The HFRU has been in the vanguard of the development of standards related to on human

responses to vibration. Griffin is chair of the BSI sub-committee on human responses to vibration. The hand-transmitted vibration research of Professor Griffin is cited in ISO 5349-1:2001, ISO/DIS 10819:2011, ISO 13091-1:2001, ISO 14835-1:2005, ISO 14835-2:2005, ISO PD 12349:1997. These standards are the basis of the EU Physical Agents (vibration) Directive, the EU Machinery Safety Directive, and means of controlling exposures to hand-transmitted vibration and diagnosing disorders. They are in constant use by industry and government.

The *HVLab* instruments developed and produced in the ISVR are in use in England, Scotland, Northern Ireland, Italy, Sweden, Finland, USA, Japan, and South Africa to decide whether workers have HAVS, assess the adequacy of preventative measures, decide on the termination of work with vibratory tools, and assist courts in ruling on compensation. Initially, it was necessary to standardise the methodology and determine normal values for the measures – values that are now used to decide on future employment and the compensation of workers **[5.2]**. Having established their validity in fundamental research, the HFRU obtained certification to ISO 13485 so the *HVLab* instruments could be CE-marked and sold for diagnosis in hospitals by occupational health physicians **[5.3]**. The HFRU, which is also certified to ISO 9001, sells the specialist *HVLab* diagnostic instruments world-wide, including to hospitals in Japan with more stringent medical instrumentation standards **[5.4]**. More than 150 units have been sold in the past 10 years to the approximate value of £1.25 million (excluding accessories, upgrades, and servicing) with revenues used to fund related PhD research at the ISVR. The *HVLab* vibrometer and thermal aesthesiometer are in current use by the Department of Work and Pensions, DWP, at 41 sites run by Atos Healthcare across the UK to assess compensation of prescribed disease A11 in British workers **[5.5]**. Previously, *HVLab* instruments were used to decide on compensation for HAVS among more than ½ million coal miners **[5.6]**.

The range of *HVLab* instruments – vibrometer, thermal aesthesiometer, and plethysmograph – is also used in research centres that combine research with the clinical assessment of patients, including the UK Health and Safety Laboratory in Buxton, the Human Factors Research Unit, the University Hospital in Trieste (Italy), and Yamaguchi University School of Medicine (Japan). Such international collaboration with clinical researchers is needed to agree on diagnostic methods in an area where there are many affected workers but few UK experts. The specialised nature of the equipment and the current state of understanding mean that many involved in the diagnosis of HAVS require more support than is available from a solely commercial organisation, so the HFRU provides on-going training in the diagnosis of HAVS for users of the instrumentation and operates a telephone support system for nurses and physicians using *HVLab* equipment. The experience gained from users provides additional experience of industrial applications of the diagnostic methods, leading to improved techniques, developments of the relevant international standards (ISO 13091-1, ISO 14835-1, and ISO 14835-2), and advice to the government's Industrial Injuries Advisory Council on the appropriateness of the diagnostic methods.

Research at Southampton has increased awareness (within industry, policy, and legal circles) of the disease, leading to a considerable rise in the number of workers receiving compensation following the first significant HAVS compensation court case in the 1980s. Subsequent pressure from insurance companies – compensation for loss of earnings to highly skilled young workers can reach up to half a million pounds – has ensured employers set in place measures to reduce the likelihood of HAVS. Following some confusion in the courts, Griffin reviewed the alternative methods of deciding on compensation and defined a fairer means of deciding on employer negligence **[5.7]**.

HFRU research into vibration discomfort (with Morioka 1999 - 2013) led to the development of the only frequency weightings suitable for predicting the discomfort caused by hand-transmitted vibration over a range of vibration magnitudes. It was first used in US motorbike industry and is now used more widely in the transport industries where it remains the only available guidance.

Since its inception in 1972, the HFRU has played a leading role in the organisation and promotion

of the 'International Conference on Hand-Arm Vibration', which brings together industry, governments, and academia every four years. This is the only international forum for engineers, scientists, and medical researchers. In invited plenary presentations, the HFRU has raised the importance of HAVS in developing countries and was instrumental in the Chinese government offering to host the 2015 conference. In 2013, Griffin is advising a large group of Chinese companies that recently experienced an outbreak of the HAVS with major consequences to production. Efforts have also been made to raise the profile of the disease in Africa, collaborating with the University of Pretoria on studies in goldmines and advising local industry, in a country where awareness was very low. The HFRU's international efforts led to the Taylor Award by the International Advisory Committee on Hand-Arm Vibration at the International Conference on Hand-Arm Vibration in Ottawa in 2011 – recognising that the HFRU research had advanced understanding in such a way as to assist the prevention of the effects of hand-arm vibration, influencing tool design, anti-vibration devices and the recognition and diagnosis of the HAVS. The citation states: "*The Human Factors Research Unit has been at the forefront of research and development for almost half a century. Their contributions over the years to the understanding of human response to hand-arm vibration have been wide-ranging and comprehensive, and the excellence of their work has been acknowledged internationally. The impact of this leading centre for teaching, research and consultancy on hand-arm vibration is manifest world-wide*".

5. Sources to corroborate the impact

[5.1] Griffin,M.J., Howarth,H.V.C., Pitts,P.M., Fischer,S., Kaulbars,U., Donati,P.M. and Brereton,P.F. (2006) Guide to good practice on hand-arm vibration. Non-binding guide to good practice with a view to implementation of Directive 2002/44/EC on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (vibrations). Luxembourg, European Commission, 61pp. (Translated into 22 official languages of the EU: http://bookshop.europa.eu/is-bin/INTERSHOP.enfinity/WFS/EU-Bookshop-Site/en_GB/-/EUR/ViewPublication-Start?PublicationKey=KE7007108).

[5.2] Lindsell,C.J., Griffin,M.J. (2002) Normative data for vascular and neurological tests of the hand-arm vibration syndrome. Int. Arch Occup. Environ Health 75:43-54.

[5.3] http://www.hvlab.com/hvlab/diagnostic/index.html: *HVLab* Diagnostic instruments for disorders caused by hand-transmitted vibration.

[5.4] http://www.miyuki-net.co.jp/en/product/researchEquipment.shtml: Japanese agent selling *HVLab* diagnostic equipment in Japan.

[5.5] Provision of diagnostic equipment to Atos Health Care to provide diagnostic facility at 41 centres in UK for the DWP: Dr Colin Wigley: colin.wigley@atoshealthcare.com

[5.6] Lawson,I.J, and McGeoch,K.L. (2003) A medical assessment process for a large volume of medico-legal compensation claims for hand–arm vibration syndrome. Occupational Medicine, 53, 302-308.

[5.7] Griffin,M.J. (2008) Negligent exposures to hand-transmitted vibration. International Archives of Occupational and Environmental Health, 81 (5), 645-659.