CHRC

Centre for Health Effects of Radiological and Chemical Agents

Annual Report 2018 - 2019

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Brunel University London

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Background

The British Government undertook a series of atmospheric nuclear weapons tests at various sites in Australia and the South Pacific between 1952 and 1958. Associated with these tests was an experimental programme in which radioactivity was dispersed into the environment, this programme ended in 1963 although operations continued through to 1967. Additionally, UK personnel participated in a series of American tests based at Christmas Island in 1962. It is estimated that over 20,000 UK servicemen participated in at least one of these British and American tests.

An ongoing concern within the nuclear test community has been whether veterans of these programmes could have received sufficient radiation exposure to adversely affect their health. This concern extends to whether they might also have passed on genetic alterations to their children, thereby potentially affecting their family's health.

Who are we?

The Centre for Health Effects of Radiological and Chemical Agents (CHRC) was established in September 2017, funded by the Nuclear Community Charity Fund (NCCF) through funds received by the Armed Forces Covenant Aged Veterans Fund and Brunel University London.

Figure 1: A number of CHRC staff, students and Advisory Board members.

Our purpose is the generation, promotion and integration of new, multi-disciplinary research that is particular to the British nuclear test veteran community, their genomic health and the impact of uncertainty on health more broadly. Our work is also investigating other scenarios in which people may be exposed to radiation and chemicals such as in the workplace or as a medical treatment.

Our aim is to build to become a credible, independent, evidence-based source of information for interested test veteran, scientific, health professional and political communities.

The CHRC will build to:

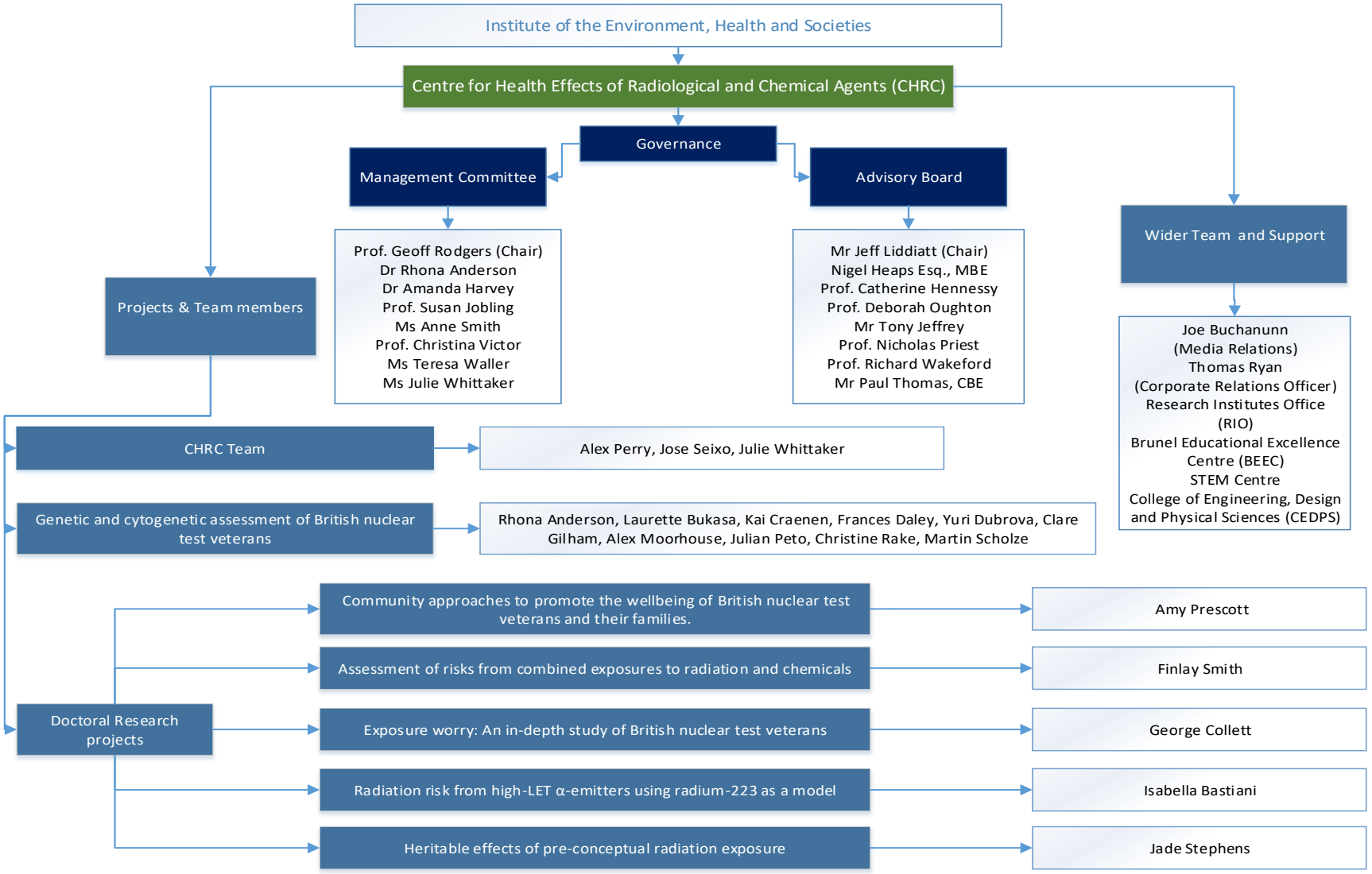
- act as a knowledge hub for scientific, health & wellbeing and, policy-related work
- deliver a programme of scientific research
- provide evidence-based information which is accessible to a broad audience
- enhance care and wellbeing through increased understanding

CHRC is being established in two phases. In Phase 1 the Centre is primarily acting as a research hub, generating new research and also reviewing what is currently understood. Phase 2 onwards will develop our research programme and also incorporate outreach, education and policy advising roles.

Phase 1 Implementation activities (Years 1-3; 2017-2020):

1. Establishing organisational structure and core personnel
2. Publishing review/s on the current state-of-the-science specific to the Centre's work and translating for lay audience
3. Identifying and prioritizing outstanding research needs in all discipline areas
4. Develop a research programme and delivery of core research in all discipline areas to help inform the nuclear community
5. Identify future care & wellbeing needs
6. Develop and begin delivery of educational material to inform all beneficiaries
7. Host networking & public engagement events
8. Establish a forward strategy for sustainable funding, research, translation and education.

CHRC Affiliates and Governance Bodies



Governance

CHRC Management Committee

Professor Geoff Rodgers: Vice-Provost Research

Dr Rhona Anderson: Director, CHRC

Dr Amanda Harvey: Division Lead (Biosciences), Department of Life Sciences

Professor Susan Jobling: Director, Institute of Environment, Health and Societies

Ms Anne Smith: Institute Manager (Institute of Environment Health and Societies)

Professor Christina Victor: Vice Dean Research (College of Health and Life Sciences)

Ms Teresa Waller: Director, Research Support and Development Office

Ms Julie Whittaker: Centre Manager, CHRC

CHRC Advisory Board

Mr Jeff Liddiatt (Chair): Treasurer of the Nuclear Community Charity Fund

Mr Nigel Heaps Esq., MBE: Director, BH Associates

Professor Catherine Hennessy: Professor of Ageing at University of Stirling

Professor Deborah Oughton: Professor in Environmental Chemistry and Head of the research school in Ecotoxicology at the Norwegian University of Life Sciences

Mr Tony Jeffrey: Chairman of the Nuclear Community Charity Fund

Professor Nicholas Priest: Visiting Professor at Middlesex University and Adjunct Professor at the Medical University of South Carolina, USA

Professor Richard Wakeford: Professor in Epidemiology, Manchester University and Dalton Nuclear Institute

Mr Paul R Thomas CBE: Chief Operating Officer (COO), Brunel University London

Staff at CHRC

Dr Rhona Anderson Director

Dr Rhona Anderson is a Reader in Radiation Biology in the Department of Life Sciences and, a member of the Institute of Environment, Health and Societies at Brunel University London. Rhona started her career as a clinical cytogeneticist before developing her research interests in radiation biology at the Medical Research Council Radiation and Genome Stability Unit, Harwell (1996-2005). She gained her PhD from Brunel University in 2004 before taking up a lectureship in 2005. She has held offices in the UK Association for Radiation Research, including acting as Chair (2012-14), was appointed Honorary Membership of Royal College of Radiology in 2017 and is currently serving as Councillor (at large) for the International Association for Radiation Research.

Professional staff

Julie Whittaker Centre Manager

Julie joined the CHRC in September 2017 at the start of the project, but has been working for Brunel University London since September 1999, when she joined the Department of Information Systems and Computing (DISC) as an administrator for undergraduate final year projects. Whilst in DISC Julie studied part time with the Open University and was awarded BSc Hons in Computer Science in 2010. During her time at Brunel Julie has taken on several secondments which has allowed her to gain knowledge in a wide range of research areas and activities.

Dr Alex Perry Communications and Engagement Officer

Dr Alex Perry joined the CHRC in November 2018 as a Communications and Engagement Officer. Alex holds a BSc and a Doctorate in chemistry from Southampton University. He worked as a post-doctoral researcher in the USA for 4 years and as a scientist in the pharmaceutical industry for 15 years. In 2017 Alex moved into the field of science communication and public engagement and obtained a Master's degree in this subject from Edinburgh University.

Research staff

Dr Kai Craenen - Postdoctoral Research Fellow (Nov 2018 - Sept 2019)

Dr Kai Craenen joined the CHRC as a postdoctoral fellow in November 2018. After gaining a BSc and an MSc in biochemistry and biotechnology from the University of Antwerp, Kai went on to complete a Doctorate in Biochemistry at the Catholic University of Leuven in Belgium and the Belgian Nuclear Research Centre SCK-CEN. He is the author of several scientific papers and has won a number of awards. Kai brings a highly multidisciplinary background to the CHRC, having worked in the fields of radiation biology, teratology, neuroscience, nutraceuticals and behavioural science.

Frances Daley - Research Assistant

Frances joined the Veterans Cytogenetic Project at Brunel University in August 2017 having moved from the Institute of Cancer Research Molecular Pathology department. Frances is a senior biomedical scientist and holds an MSc in Medical Molecular biology from the University of Westminster. She has accumulated vast experience working in a pharmaceutical, diagnostic and a research environments.

Alex Moorhouse - Postdoctoral Research Fellow

Dr Alex Moorhouse is a Postdoctoral Research Fellow based at the University of Leicester. Alex has gained degrees from the University of Exeter in bioinformatics and from UCL in human evolution. He has worked with a range of model organisms including Zebra fish, infectious yeast species of the genus *Candida*, the budding yeast *Saccharomyces cerevisiae* and mouse models of the malaria parasite *Plasmodium berghei*. Alex gained his PhD at the University of Aberdeen studying yeast genomics, population genetics and ancient DNA at the MRC Centre for Medical Mycology and Fungal Immunology with placement at the Australian Centre for Ancient DNA.

Jose Seixo - Research Technician

Jose joined the CHRC in November 2018 as a Research Technician. He has a MSc in Molecular and Cellular biology from the University of Porto and a BSc in Genetics and Biotechnology from the University of Trás-os-Montes and Alto Douro. Prior to joining the CHRC Jose worked at the Centre for Medical Genetics in Portugal in the field of human cytogenetics.

Doctoral students

Projects being carried out by our Doctoral Researchers are shown; delivering new research and building research capacity for the future.

George Collett supervised by Dr Wendy Martin, Dr Rhona Anderson, Dr Will Young and Professor Mary Gilhooly.

Exposure worry, ageing, and cognitive functioning: An in-depth study of British nuclear test veterans.

Start date: 8th Jan 2018 Funded by**:** CHRC

Isabella Bastiani supervised by Dr Rhona Anderson and Dr Liz Ainsbury.

Radiation risk from high LET alpha-emitters using radium-223 as a model.

Start Date: 1st Aug 2017 Funded by: Public Health England

Amy Prescott supervised by Professor Louise Mansfield, Dr Alistair John and Dr Rebecca Hings.

Sport, culture & wellbeing: community approaches to promote wellbeing among British nuclear test veterans and their families.

Start Date: 2nd October 2017 Funded by: CHRC

Finlay Smith supervised by Prof Andreas Kortenkamp and Dr Rhona Anderson.

Assessment of risks from combined exposures to radiation and chemicals.

Start Date: 8th Jan 2018 Funded by: CHRC

Jade Stephens supervised by Dr Rhona Anderson and Dr Joanna Bridger.

Pre-conceptional radiation exposure and transgenerational effects.

Start Date: 8th January 2018 Funded by: CHRC

CHRC multi-disciplinary research

The CHRC sits within the Institute of Environment, Health and Societies and, College of Health and Life Sciences at Brunel University London. Our work exploring the human health impact of radiological and chemical agents is organised as disciplinary projects (Figure 2) delivered in an environment that fosters interdisciplinary and inter-institutional collaboration. These can be grouped broadly as (1) Genetic markers of radiation exposure (2) Understanding health risks of exposures (3) Health and Wellbeing and, (4) Education and Engagement.

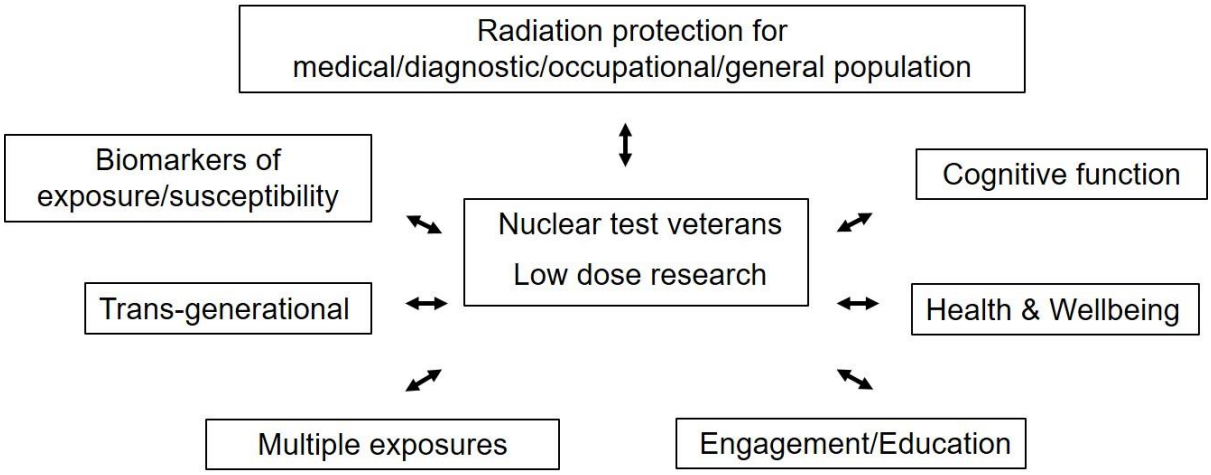


Figure 2: Current project areas exploring the human health impact of radiological and chemical agents.

The following section provides an overview of our current research activities, hypothesis and approaches to address these.

1. Genetic markers of radiation exposure

The major component of the research programme currently underway at the CHRC is a genetic and cytogenetic assessment of nuclear test veterans (NTV) and their families. This work is being carried out in collaboration with Professor Julian Petos' team from the London School of Hygiene and Tropical Medicine and Professor Yuri Dubrova at the University of Leicester and is funded by two project grants (Cytogenetic assessment of British nuclear test veterans and their families. Anderson RM (PI) and Peto J. £449,672, June 2016-Sept 2021 (Aged Veterans Fund) and Genetic and cytogenetic assessment of British nuclear test veterans and their families. Anderson RM (PI), Peto J and Dubrova Y. £826,027, Sept 2017-Aug 2020 (Aged Veterans Fund)).

Background

The British Government undertook a series of nuclear tests at various sites in the South Pacific between 1952 and 1958. Associated with these atmospheric tests was an experimental programme, conducted largely at Maralinga in Australia, in which radioactivity was dispersed into the environment. This programme ended in 1963 although clean-up operations continued through to 1967. According to official records the dose received by the majority of personnel was negligible, although a number of 'special groups' were identified as potentially liable to higher exposure. These estimates were based primarily on film badge measurements of external dose. There are no recorded measurements of internal contamination through inhalation or ingestion of radionuclides. Over the intervening decades, the question of adverse health effects in both the veterans and descendants of this testing programme remains an unresolved issue.

Aim of research

This research seeks to address whether a heritable genetic legacy could exist in families due to historical participation in various military operations during the British nuclear testing programme in the 1950s and 60s.

For this, we are undertaking a 'family trio' study that involves:

i. Recruitment of military veteran families
ii. Asking if there is any cytogenetic evidence of historical exposure of the test veterans
iii. Asking if there is any evidence of genetic anomalies in 1st generation children of test veterans

i. Recruitment of military veteran families

All necessary permissions and full HRA approval were obtained after a 17 month process allowing participant recruitment to start in January 2018. Our target is to recruit 50 nuclear test veteran family trios (veteran, child, child's mother) who had 'special group' status and/or who had participated in two or more Operations including the GRAPPLE series and Maralinga test sites. We are matching (on age and service) with veterans who served in the tropics at the same time but who are verified as not present at any test sites. After family consent is obtained, whole blood is sampled and shipped to Brunel University London and University of Leicester where it processed for cytogenetic and whole genome sequence analyses.

Since January 2018, we have sent ~3600 study invitations to GP practices and in return have reached our recruitment target for the number of eligible nuclear test veteran couples responding. Work continues to convert all eligible couples into fully consented families with the majority completed and in receipt of blood packs.

ii. Cytogenetic evidence of radiation exposure

Cytogenetic markers of historical and/or ongoing internal exposure in veterans

The potential health risks of exposure to ionising radiation can be estimated from individualised biological assessments of dose. Some prior knowledge as to the radiation quality and conditions of exposure are necessary if these estimates are to be robust however, as biological effect is influenced by linear energy transfer (LET) and dose-rate in addition to dose. In unknown or mixed dose exposure scenarios this may not always be the case. Current biological monitoring relies heavily on the quantification of chromosome aberrations that are detected using various means in the peripheral blood lymphocytes (PBL) and include reciprocal translocations and dicentrics. Indeed, the induction of simple reciprocal translocations and dicentrics by low-LET radiation such as γ-rays and their application as bio-dosimeters is very well characterized. Complex chromosome aberrations are defined as any exchange that involves three or more breaks in two or more chromosomes and are established as being strongly dependent on dose in the low-LET range but largely independent of dose after exposure to high-LET radiation. This has been shown for α-particles, neutrons and heavy ions.

24-colour chromosome karyotyping (multiplex-fluorescence in situ hybridisation (M-FISH)) is a cytogenetic technique that enables the detection and quantification of simple reciprocal translocation and dicentrics and, complex chromosome aberrations.

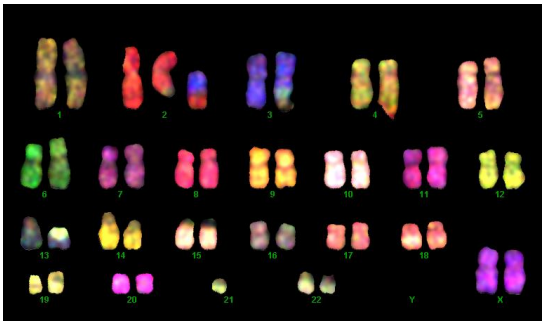


Figure 3: Representative M-FISH karyotype showing chromosomal abnormalities as colour changes.

Work is underway to analyse the occurrence of these different types of chromosome aberration in anonymised samples of veterans PBLs. Upon completion and de-coding to ascertain test and control status of the samples the observed frequencies within nuclear test veteran and control veteran groups will be statistically evaluated to look for any differences between the two veteran groups.

Cytogenetic markers of radiation-induced delayed effects in veterans and descendants

Radiation is known to destabilise the genome, whereby cellular descendants of irradiated cells express newly arising (non-clonal/sub-clonal) genetic alterations. The mechanisms and relevance to health risk of this radiation-induced genomic instability phenomenon continue to

be debated; however, its detection can be determined through the accumulation of newly arising or *de novo* chromosome and chromatid aberrations.

To test for evidence of radiation-induced genomic instability in veterans, chromatid-type aberrations and unstable chromosome type aberrations are being scored by staining with a dye called DAPI. This analysis is being followed by up as necessary be Giemsa staining to determine the frequency and type of abnormality. Upon completion and de-coding the observed frequencies within test veteran and control veteran groups will be statistically evaluated to look for any differences between the two veteran groups.

iii. Evidence of genetic anomalies in 1st generation children

Some studies have demonstrated that offspring of human and animal models exposed to high radiation doses of radiation show an increase in genomic instability. It has been hypothesized that germ cells of an exposed individual can develop a genetic memory, which leads to genomic instability in subsequence generations, termed as transgenerational genomic instability.

To test for evidence of trans-generational genomic instability in the descendants, chromatid-type and unstable chromosome type aberrations are being scored by Giemsa solid stain analysis. Upon completion and de-coding the observed frequencies within test and control groups will be statistically evaluated to look for any differences between the two descendant groups.

Whole genome sequence analysis to investigate mutation frequencies in germline

The lack of reliable approaches for monitoring germline mutation represents the main obstacle to evaluating the genetic risk of human exposure to mutagens. For this reason, germline mutation induction in mice has continued to be the main source of experimental data used to evaluate the genetic risk of human exposure to mutagens including radiation. In recent years, researchers have demonstrated the validity of whole genome sequencing approaches for the characterisation of mutagen signatures in the mammalian germline.

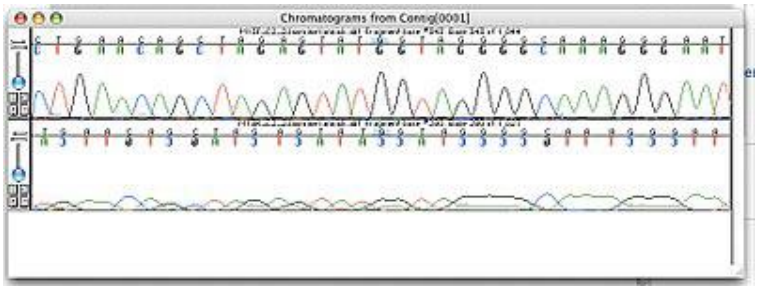


Figure 4: Representative image showing output from whole genome sequencing analysis for the detection of single nucleotide variants (SNVs), inDels and structural variants.

Using these approaches we are sequencing the genomes of 30 nuclear test veteran family trios and 30 control family trios (veteran, child, child's mother). The sequence data is being

interrogated to investigate if there are any significant differences in the frequency and spectra of *de novo* germline mutations in the 1st generation children of test veterans compared with those of the control family group. This analysis will also explore the potential for health consequences that may be attributable to paternal radiation exposure during participation in nuclear bomb tests.

All of the above work is being carried out by Laurette Bukassa[1], Kai Craenen, Frances Daley, Yuri Dubrova[2], Clare Gilham[1], Alex Moorhouse[2], Julian Peto[1], Christine Rake[1], Jose Seixo, Martin Scholze, Jade Stephens and Rhona Anderson.

[1] Department of Epidemiology and Population Health, London School of Hygiene and Tropical Medicine, London WC1E 7HT, UK.

[2] Department of Genetics and Genome Biology, University of Leicester, Leicester LE1 7RH, UK

2. Understanding health risks of exposures

Genomic instability and cancer risk

The genomic instability phenotype is recognised as an enabling characteristic of neoplasia facilitating the acquisition of the hallmarks of cancer. There is as yet no validated biomarker of cancer induced by ionising radiation, but the frequency of chromosome aberrations in PBLs has been reported to correlate with cancer incidence in human populations. We are exploring this in veterans and childrens samples to evaluate any occurrence of radiation-induced and/or transgenerational genomic instability observed with respect to age-expected norms and estimated risks for cancer.

Figure 5. Examples of chromatid type gaps and breaks (a and b) and a dicentric chromosome (c).

Pre-conceptional radiation exposure and transgenerational health

The adverse consequences of radiation exposure *in utero* are known but the heritable effects of parental radiation exposure pre-conception remain to be fully understood. The consensus within the radiation research community is that no epidemiological study has yet conclusively demonstrated a detrimental health effect in the offspring of radiation-exposed people, yet this

is tempered by some evidence from cellular and animal studies that support the presence of detrimental outcomes as a result of parental exposure to radiation.

One project underway examining this, is the G-band karyotypic analysis of descendant's samples to ascertain the chromosome constitution individuals are born with. Any identified abnormalities will be analysed in more detail to ascertain the origin (mother, father, *de novo*) and whether the abnormality is associated with any known clinical disorders.

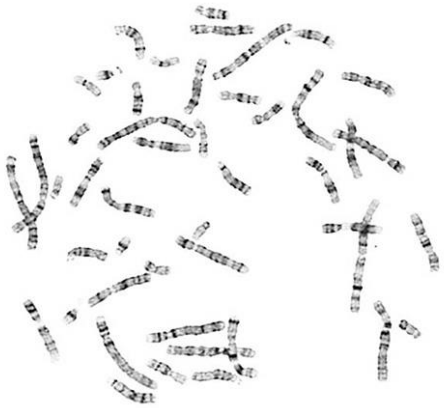



Figure 6: G-banding analysis used routinely to determine the chromosome constitution an individual is born with.

This work is being carried out by Jade Stephens as part of her Doctoral studies, supervised by Dr Rhona Anderson and Dr Joanna Bridger.

We are also undertaking a full systematic review of the published literature (PROSPERO registration CRD42019123237 and CRD42019123238). Specifically, we are asking whether there is sufficient evidence to support a transgenerational effect on morbidity, mortality, mutation and/or other heritable genetic change following parental pre-conceptional exposure in humans to ionising radiation. The study population are offspring, and/or members of subsequent generations, of a parent or parents who were exposed to ionising radiation prior to conception. Both human studies and mammalian animal systems published over the past 30 years are being sourced in accordance with guidelines from the Office of Health Assessment and Translation/National Toxicology Program. For this, we have constructed a Boolean search construct to search three databases, from which we have generated 2441 publications for review. Each of these papers were screened for eligibility using our pre-defined inclusion/exclusion criteria, resulting in 199 papers to be fully analysed. An additional 80 papers have also been identified from the reference lists of the eligible papers which are also being fully analysed as above. All relevant data has been extracted and we have completed our assessments on risk of bias and, strength and quality of evidence, for each individual paper. We are currently synthesizing all the evidence gathered using a narrative and quantitative approach.

This work is being undertaken by Jade Stephens, Alex Moorhouse, Kai Craenen, Ewald Schroder and Rhona Anderson.

Assessment of risks from combined exposures to radiation and chemicals.

Mixture toxicology deals with the concept that chemicals with similar chemical structures or similar biological effects can have a combined mixture effect that has greater toxicity than its components' individual toxicities. This suggests that mixtures of chemicals can present a risk even if each individual component is below its recommended 'safe' limit.

Mixture toxicity depends on:

- Exact mixture composition
- Whether toxicity is dose additive or independent
- Whether or not there are any synergies or antipathies in the interaction

Mixture effects are predicted using either Concentration (Dose) Addition (CA) for similar chemistry and routes of action, or via Independent Action (IA) principles for stochastic or dissimilar routes of action.

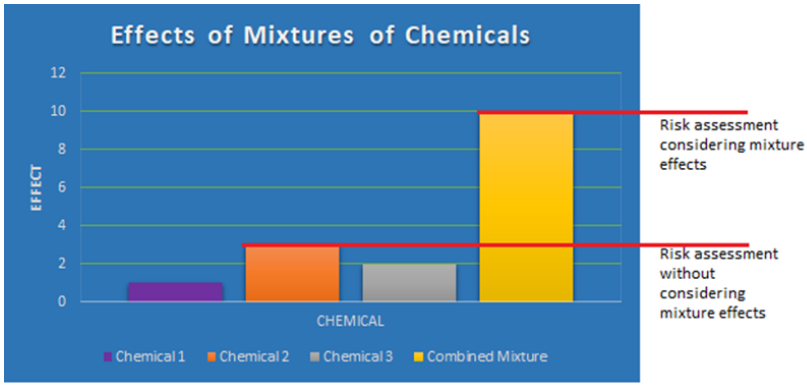


Figure 7: Representative illustration of mixture toxicology effects.

We are conducting proof of concept experiments with cultured cells to reveal whether combined genotoxic effects between radiation and chemical exposures can occur in principle. This approach will enable us to establish basic cell biological principles which will provide a solid foundation for examining whether combined risks exist under more realistic exposure scenarios.

This work is being carried out by Finlay Smith as part of his Doctoral studies, supervised by Prof Andreas Kortenkamp and Dr Rhona Anderson.

Radiation risk from high LET alpha-emitters using radium-223 as a model.

Prostate cancer is the most common cancer affecting men in the UK with over 400,000 new cases each year. Bone metastases are associated with stage IV prostate cancer, are linked with

poor prognosis and often result in spinal cord fractures and/or compression leading to nerve damage and paralysis. Radium-223 (^{223}Ra) is a radiopharmaceutical that delivers high-linear energy transfer α-particles to regions of bone metastatic disease. α-particles have a range of <100 µm and are effective in targeting bone metastases and delaying the onset of skeletal related events, however it remains unclear if this targeted radiotherapy may result in unwanted exposure of normal neighbouring bone marrow (BM) cells.

To assess potential BM toxicity, whole blood is being sampled from metastatic castration-resistant prostate cancer patients who are receiving ^{223}Ra as part of the ADRRAD clinical trial. Castration-resistant prostate cancer patients enrolled on the ADRRAD clinical trial are treated by intravenous administration of ^{223}Ra and acting as a calcium mimic it rapidly localises to areas of bone remodelling. The administration schedule follows 6 monthly injections of ^{223}Ra (55 kBq/kg) in conjunction to 6 weeks of 2Gy/fraction external beam radiotherapy (EBRT). PBL originate from haematopoietic stem cells (HSCs) of the BM and follow a hierarchical path of differentiation. Radiation-induced chromosome aberrations in surviving HSCs and PBL exposed in circulatory pool should be detectable in the resulting metaphase cell sampled. Multiplex-fluorescence in situ hybridization is being used to determine the type and frequency of chromosomal rearrangements in PBL whilst solid-stain analysis used to examine for the occurrence of any radiation-induced genomic instability.

Complex chromosomal aberrations characteristic of α-particle exposure have also been observed in PBL using M-FISH, this could indicate direct exposure of transit PBL. Preliminary data suggests an increase in frequency and complexity in aberrations coinciding with progression of treatment. We are also using the data collected to make estimates of PBL exposure in-transit and potentially BM toxicity dose. For this, we are employing biological dose assessment software "Dose estimate" to make an assessment of dose from the different radiation qualities during the treatment schedule. Outcomes from this work will contribute new understanding on the risks of internalised α-particle exposure.

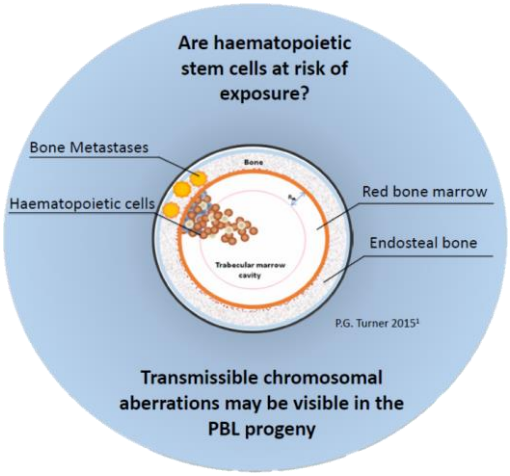


Figure 8: Image modified from Turner and O'Sullivan. British Institute of Radiology, vol. 88, no. 1050, 2015.

This work is being carried out by Isabella Bastiani as part of her Doctoral studies, supervised by Dr Rhona Anderson and Dr Liz Ainsbury. This is a collaborative project with PHE, Chilton and the Northern Ireland Cancer Centre, Belfast. Isabella Bastiani[1] , Dr Liz Ainsbury[2], Prof Joe O'Sullivan[3], Prof Kevin Prise[3], Dr Philip Turner[3], Dr Rhona Anderson[1].

[1] Centre for Health Effects of Radiological and Chemical Agents, College of Health and Life Science, Brunel University London, Kingston Lane, Uxbridge, London UB8 3PH

[2] Centre For Radiation, Chemical & Environmental Hazards, Public Health England, Didcot OX11 0RQ

[3] Centre for Cancer Research and Cell Biology, Queen's University Belfast, Belfast BT7 1NN

3. Health and Wellbeing

Exposure worry, ageing, and cognitive functioning: An in-depth study of British nuclear test veterans.

It could be argued that impaired cognitive functioning may result from possible ionising radiation exposure, but it is unclear whether or not the dosage received by the test-veteran would cause significant cognitive impairment. Apart from any possible impact from potential exposure, the persistent psychological stress of witnessing a nuclear event, and years of worry about the potential damage to oneself and potential genetic damage to descendants, may be associated with poorer cognitive functioning. Currently there is no such research on cognitive effects of witnessing nuclear tests among UK or other national groups of test veterans. However, this aspect is being explored with increasing priority in relation to populations affected by the Chernobyl and Fukushima accidents.

No measure for assessing exposure worry in nuclear test-veterans has been developed, and without such a measure we are unable to examine the relationship between exposure worry and cognitive functioning. Our current work is focussed on developing such an 'exposure worry scale', which will be used in the overall project. The stages for this are involving gaining information through focus groups, individual telephone interviews, and from quantitative analysis methods. Our scale is being tested for normality and skew. Once completed, it will be a useful tool to examine exposure worry in the nuclear community, and will also indicate the severity of this, perhaps indicating extra support to be implemented to help overcome this worry.

The aim of this study is to explore the nature of 'exposure worry' and the possible association with cognitive impairment in old age. Firstly, an exposure worry scale has been developed and is currently being used to examine the relationship between exposure worry and cognitive functioning in BNTVs. Secondly, in-depth interviews are being conducted to explore the nature of exposure worry throughout life. This project will extend our understanding of the psychological consequences of radiation exposure, and add to the growing body of research on the impact of life events on cognitive ageing.

Figure 9: Components of exposure worry

This work is being carried out by George Collett as part of his Doctoral studies, supervised by Dr Wendy Martin, Dr Rhona Anderson, Dr Will Young and Professor Mary Gilhooly.

Sport, culture & wellbeing: community approaches to promote wellbeing among British nuclear test veterans and their families.

This research project aims to understand how community sport and cultural activities may help contribute to improving the health and wellbeing of British nuclear test veterans and their families. The purpose of this work is to develop partnerships with members of the nuclear community to understand their health and wellbeing needs and to design and provide activities that can improve their daily lives.

This qualitative study utilises a Participatory Action Research approach. The methods employed are: self-reporting questionnaires, telephone and face-to-face interviews. The project is being conducted in 3 phases. Phase 1: advertising and recruitment; phase 2: data

collection with 25-30 BNTVs and phase 3: co-designing community projects relating to health and wellbeing issues. These phases will allow BNTVs to explore the impact that involvement in the nuclear tests has had on their health, wellbeing and on the community.

Phase 2 commenced in November 2018, therefore conclusive findings are currently unavailable. Preliminary thematic analysis has identified areas of interest including: ageing, military involvement, widowhood, loneliness, wellbeing and the impact of participation in physical activity, leisure and community activities. This study will make a unique contribution by understanding how sport, culture and leisure activities can potentially improve health and wellbeing issues experienced by the ageing BNTV community with future prospects of designing community approaches to allieviate these issues.

This work is being carried out by Amy Prescott as part of her Doctoral studies, supervised by Professor Louise Mansfield and Dr. Alistair John.

4. Education and Engagement

As part of our knowledge transfer CHRC has created an external website (www.chrc4veterans.uk) which continues to be a source of information for external visitors with ~1000 new visitors to the website in the last year. To date, all of this information has been limited to the one-way presentation of information on the function and scope of the Centre and its current projects however, over the past year, work has focussed on developing content to be accessed through the sites 'knowledge hub'. Studies have shown that a large section of the general public lack a basic understanding of radiation and genetics. Accordingly, in order to assist our stakeholders in their understanding of CHRCs scientific research we are creating an education pack series which give basic information / facts about the relevant science underway (Figure 9).

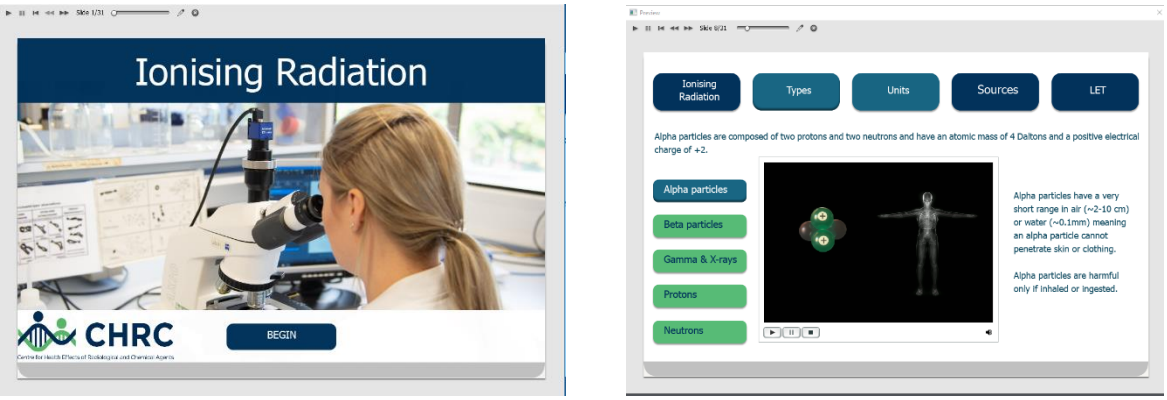


Figure 10: Example pages of 'Ionising radiation' basic facts.

Our intention is that this educational content will act as a foundation for achieving a deeper scientific understanding of the key methods and processes involved in CHRCs research.

Education through STEM

Brunel University's STEM (Science, Technology, Engineering and Maths) Centre aims to get children of all ages excited about science and technology. It features an array of exhibitions and work areas to help inspire young minds. Currently, the Centre does not have a biology offering in its core programme, with many of the activities being engineering-based. CHRC applied for and received a grant of £2,000 from the Brunel University London Public Engagement Fund to create an interactive, digital resource that aligned with CHRCs research and in doing so, will become the first, regular biological science workshop at this STEM Centre. Known as the *Radiation Biomarkers* Module, this audio-visual educational resource features animations showing interactions between radiation and DNA and, how this results in the formation of chromosome aberrations. It also takes users through the process of how to make estimations of radiation dose by counting the number and type of chromosome aberrations in

human cells, illustrating how chromosome aberrations are useful biomarkers of radiation exposure. To make it engaging for schoolchildren aged 14-16 it is stylised as a 'digital game' and contains quizzes to assess the children's learning.

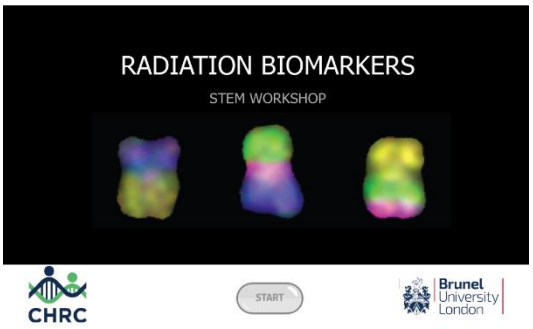


Figure 11: The *Radiation Biomarkers* module represents the first collaborative output between CHRC, STEM and our media colleagues.

For development, we worked in partnership with Digital Design students (Alireza Royaei and Marcelina Stempak) and staff (Alan Mannion) from Brunel's College of Engineering, Design and Physical Sciences and also, staff from the Brunel STEM Centre (Lesley Ann Warren) and Head of Digital Education (Alice La Rooy), building new working relationships for future projects. STEM Ambassadors are being trained to support their effective delivery of this module; involving thirty children in each STEM Wednesday Programme and sixty children at each STEM Saturday Masterclass Programme.

The first event is scheduled to take place early 2020. In a calendar year there are approximately thirty STEM programme events and so it is anticipated we shall reach over 1,000 children per year and in doing so, with this module, share CHRC's research looking for cytogenetic evidence of historical exposure in a group of British nuclear test veterans. The *Radiation Biomarkers* module will also be available beyond the STEM Centre by liaising directly with schools. An important benefit of developing this *Radiation Biomarkers* module is that it will be available through www.chrc4veteran.uk, increasing the visibility and the number of beneficiaries who engage with our research. The content will also be adapted to produce printed fact sheets, for audiences that lack access to the internet.

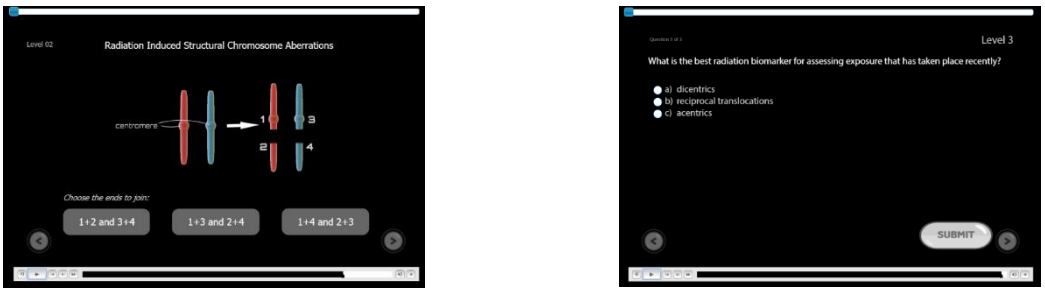


Figure 12: The *Radiation Biomarkers* module showing interactive structured chromosome aberrations and one of the level 3 quiz sections

Publications

Scientific

1) Cytogenetic biomarkers of radiation exposure. Clinical Oncology (2019) 31 (5) pp311-318. Anderson R.

Exposure Magazine

August 2019:

Article: Radiation Exposed Populations by Alex Perry.

April 2019:

Article: Assessment of Risks from Combined Exposures to Radiation and Chemicals by Finlay Smith.

December 2018:

Article: Investigating the DNA of British Nuclear Test Veterans and their Families by Alex Perry.

Article: Sport, Culture and Wellbeing by Amy Prescott.

August 2018:

Article: Exposure Worry, Ageing and Cognitive Functioning by George Collett.

Article for Genome Biology series: Techniques to study *de novo* mutations by Alex Moorhouse.

Scientific Conferences attended and invited seminars

1) British Sociological Association Sport Study Group Student Conference, Oxford Brookes University, 5 September 2019. *Sport, culture & wellbeing: community approaches to promote wellbeing among British nuclear test veterans and their families.* Oral presentation by Amy Prescott.
2) 16th International Congress for Radiation Research (ICRR), Manchester Central, 25-29 August 2019 http://icrr2019manchester.com/. CHRC was very well represented:

- *A genetic and cytogenetic study of British nuclear test veterans and their children.* Rhona Anderson oral presentation in 'non-targeted and transgenerational effects' session.
- *Exposure Worry, Ageing and Cognitive Functioning: An in-depth study of British Nuclear Test Veterans.* Poster presentation by George Collett. Co-chair of 'psycho-societal' session.
- *An M-FISH study to assess the presence of radiation-induced chromosomal damage in British nuclear test veterans.* Poster presentation by Kai Craenen. Co-chair of 'non-targeted and transgenerational effects' session.
- *A Radiation Biomarkers Module: A Digital Resource for Education and Public Engagement.* Poster presentation by Alex Perry.

- *A solid stain approach to assess genomic stability in British nuclear test veterans and their children.* Poster presentation by Jose Seixo.
- *Assessment of Risk from Combined Exposures to Radiation and Chemicals.* Poster presentation by Finlay Smith.
- *A Systematic Review of Evidence for the Transgenerational Effects of Parental Pre-conceptual Exposure to Ionising Radiation*. Poster presentation by Jade Stephens.
- *Radiation risks from high-LET α-particle emitters using Radium-223 as a model*. Poster presentation by Isabella Bastiani.

3) 12th International Symposium for Chromosome Aberrations, Manchester, 27th August 2019. Presentations included:

- *Complex chromosome aberrations as biomarkers of internal exposures*. Oral presentation by Rhona Anderson.
- *Dose estimation of radium-223 treated patients*. Oral presentation by Isabella Bastiani.

4) 3rd European Radiological Protection Research Week 1 – 5th October 2018, Rovini - Rovigno, Croatia https://erpw2018.com/. *A genetic and cytogenetic study of British nuclear test veterans and their children*. Oral presentation by Alex Moorhouse.

5) US Annual Meeting for Radiation Research and the 24th Meeting of the Conference on Radiation & Health. Chicago, Illinois,23 – 25th September, 2018. *A genetic and cytogenetic study of British nuclear test veterans and their children.* Poster presentation by Rhona Anderson.

6) Global Co-ordination of Low-Dose Research: Scoping Meeting, Milan 17 – 18th September, 2018, Milan University, Milano Italy https://www.oecd-nea.org/rp/workshops/science-values2018/. Attended by Paul Leonard (on behalf of Rhona Anderson).

7) Association for Radiation Research 2018: Health and Environmental Implications of Multidisciplinary Radiation Research. - Riddel Hall, Queen's University Belfast, 25 - 27th June, 2018. https://www.le.ac.uk/cm/arr/home.html.

- *A genetic and cytogenetic study of British nuclear test veterans and their children.* Oral presentation by Rhona Anderson.
- *Radiation risk from High LET a-emitters using Radium-223 as a model.* Oral presentation by Isabella Bastiani.

Funds sought and received.

We continue to be active in submitting applications for external research funding. Small awards include:

- UK Association for Radiation Research young investigator travel award for Jade Stephens to attend ICRR 2019, Manchester, 25-29th August, 2019 (£500).
- UK Association for Radiation Research young investigator travel award for George Collett to attend ICRR 2019, Manchester, 25-29th August, 2019 (£500).
- Brunel University London Public Engagement fund. *Develop a Radiation Biomarkers STEM Module*. February 2019 (£2,000).
- Biochemical Society general travel grant for Alex Moorhouse to present at the European Radiological Protection Research Week, Croatia, 1-5 October, 2018 (£350).
- College of Health and Life Sciences, Brunel University London. M-FISH analysis software upgrade and brightfield microscope. 2017. (£25,889.89).
- College of Health and Life Sciences, Brunel University London. Fluorescence microscope filters. 2017 (£4,582.11).

CHRC

Centre for Health Effects of Radiological and Chemical Agents

Contact Details

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Visit our website:
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