Institution: University of Manchester

Unit of Assessment: UoA5

Title of case study: Providing healthcare training and increasing public awareness of neglected tropical diseases via national and international engagement activities

1. Summary of the impact

WHO estimates that 600 million school-age children need deworming treatment and preventive intervention.

The University of Manchester (UoM) Immunology Group delivered an educational programme on the immune response and biology of parasitic worm infections in areas where worm infections are most prevalent, including Uganda and Pakistan, and with UK immigrant communities.

International benefits include health worker and educator training, which is critical for improving the understanding of worm infection and distribution of health education messages to endemic communities. Nationwide engagement activities provided immigrant communities and school pupils with improved awareness of global health issues and a greater understanding of immunology, and have inspired some participants to pursue careers in science.

2. Underpinning research

The impact is based on research conducted at UoM from 1993 to date. The key researchers were:

Dr Sheena Cruickshank (Lecturer, 2007 to date)
Dr Joanne Pennock (Lecturer, 2007 to date; Post-Doctoral Research Associate, 1998-2007)
Professor Richard Grencis (1998 to date; Reader, 1997; Senior Lecturer, 1993-1997)
Professor Kathryn Else (2009 to date; Senior Lecturer, 2007-09; Wellcome Trust Fellow, 1993-2007)
Professor Werner Muller (2006 to date)

The UoM Immunology Group focuses on understanding the biology of human parasites and the role of the immune system in infection. The key steps in the research are as follows:

(a) Defining the immune factors underlying susceptibility to parasitic worm infection. Research from 1993 to date aims to characterise how the specific immune response is switched on [1] and controlled [2, 3].

(b) Defining the function of parasite derived factors that dampen the immune response and the mechanisms by which the immune response is inhibited [4]. External clinical trials using parasites have had mixed results for treatment of conditions including allergy and autoimmunity. Therefore Cruickshank and colleagues are working to elucidate the function of the parasite derived secretions and immune response with a view to developing better therapies.

(c) Developing a greater understanding of the biology of whipworm infection. Cruickshank and colleagues have defined how parasite eggs hatch in the body [5]. They have also defined the intimate relationship with the host and specifically the role of the gut barrier and immune response in promoting worm expulsion by altering the rate of barrier renewal [6] and the nature of the epithelial barrier mucus secretions.

3. References to the research

The research was published in leading journals, including top journals in the field.

1. **Cruickshank, S.M.**, Deschoolmeester, M.L., Svensson, M., Howell, G., Bazakou, A., Logunova, L., Little, M.C., English, N., Mack, M., **Grencis, R.K., Else, K.J.**, Carding, S.R. (2009) Rapid dendritic cell mobilisation to the large intestinal epithelium is associated with resistance to *Trichuris muris* infection. *Journal of Immunology.* 182. p. 3055-3062. DOI: 10.4049/jimmunol.0802749

2. Fasnacht, N., Greweling, M.C., Bollati-Fogolín, M., Schippers, A., **Muller, W**. (2009) T-cell-specific deletion of gp130 renders the highly susceptible IL-10-deficient mouse resistant to intestinal nematode infection. *European Journal of Immunology.* 39. p. 2173–2183. DOI:

10.1002/eji.200838710

3. Levison, S.E., McLaughlin, J.T., Zeef, L.A., Fisher, P., **Grencis, R.K., Pennock, J.L.** (2010) Colonic transcriptional profiling in resistance and susceptibility to Trichuriasis: phenotyping a chronic colitis and lessons for iatrogenic helminthosis. *Inflammatory Bowel Diseases.* 16. p. 2065-2079. DOI: 10.1002/ibd.21326
4. d'Elia, R., Behnke, J.M., Bradley, J.E., **Else, K.J**. (2009) Regulatory T cells: a role in the control of helminth-driven intestinal pathology and worm survival. *Journal of Immunology.* 182. p. 2340-2348. DOI: 10.4049/jimmunol.0802767
5. Hayes, K.S., Bancroft, A.J., Goldrick, M., Portsmouth, C., Roberts, I.S., **Grencis, R.K.** (2010) Exploitation of the intestinal microflora by the parasitic nematode *Trichuris muris. Science*. 328. p.1391-1394. DOI: 10.1126/science.1187703
6. Hasnain, S.Z., Wang, H., Ghia, J.E., Haq, N., Deng, Y., Velcich, A., **Grencis, R.K.**, Thornton, D.J., Khan, W.I. (2010) Mucin gene deficiency in mice impairs host resistance to an enteric parasitic infection. *Gastroenterology.* 138. p.1763-1771. DOI:10.1053/j.gastro.2010.01.045

4. Details of the impact

Context

Globally, ~two billion people have gut worm infections, with pregnant women and children worst affected (WHO estimate). Worm infections have an enormous impact on the primary education of children who become too ill to go to school. Worm species also infect livestock, thus affecting the global economy. Although there are cheap, effective medicines for gut worms, their use encourages drug resistance and does not prevent re-infection. Therefore these medicines are not a sustainable solution. Education about worm transmission and appropriate treatment is critical to reduce the impact of worm infection worldwide.

Pathways to impact

The research focuses on tropical diseases that do not affect the western world, so Cruickshank and colleagues work with endemic communities to improve their understanding of worm infections and appropriate treatment. Grencis contributes to an internationally funded training/educational course based in Uganda.

Nationally, the research is presented via 'The Worm Wagon', which is a comprehensive suite of engagement activities. Activities are designed for groups of mixed age, ability and language. There is a direct link from research to engagement activities, as shown in the table below:

Research Topic	Public Resource
Immune factors underlying susceptibility to parasitic worm infection	Interactive computer simulation of the immune response and card based games
Immune response to parasite infection	Displays of parasites and "parasite uses"
Biology of whipworm infection	Games, pamphlets, YouTube video

Events are assessed via resource uptake (e.g., number of video views), participant feedback and engagement in activities, questionnaires and participant drawings to demonstrate learning. Additionally, the UoM Immunology Group trains researchers and museum educators in public engagement practice.

The success of these engagement activities has been recognised: Cruickshank, Pennock and Else were awarded the Manchester International Women's Day 2013 Award for Women in Science, Technology, Engineering and Mathematics for their work with the Worm Wagon. Cruickshank was also awarded the 2013 Society of Biology Science Communication Award for Established Researchers.

Reach and significance of the impact

The impact has three components:

i. International impact: through the 'Immunology in the Tropics' course in Africa
ii. Working with immigrant communities in the UK: via engagement with the 'Inspired Sisters'

iii. National impact: through public events such as the 'Big Bang' science fair, and engagement with primary and secondary schools across the UK, including a majority of students (>60%) from disadvantaged backgrounds

Cruickshank and colleagues have hosted/been involved in over 40 events from 2009 to date, with over 68,000 participants.

i. Training African healthcare workers

Trained health workers and educators in endemic countries are critical in improving the understanding of worm infection and distributing health education messages.

Grencis contributes to the 'Immunology in the Tropics' course in Uganda (2009-2012). Attendees from across Africa are primarily from educational and research establishments. This includes people from Uganda, Kenya, Tanzania, Nigeria, Malawi, Cameroon, Ghana, Gabon, Rwanda and Burkina Faso. Attendees highly rated the course with feedback including: "*Gained good experience in research involving worms and how they cause infections in humans*" [A].

A Ugandan doctor studying an MSc in Immunology at UoM, provided the following feedback: "*You gave wonderful presentations about helminths infections. It was very interesting and I wanted to do some work in your field… The course* [Immunology in the Tropics] *was very helpful to me in* making my decision to enroll for this course [MSc in Immunology]" [B].

ii. Educating immigrant communities from Asia, Africa and the Middle East

In collaboration with the Development Education Project (DEP), the UoM Immunology Group worked with the "Inspired Sisters" to raise their awareness of the causes and impact of worm infection [D]. Inspired Sisters are a female community group who are recent immigrants from Asia, Africa or the Middle East, based in Manchester. It is important to educate this community so that they can feed back information to relatives in affected countries.

Cruickshank and colleagues correct misunderstandings about parasitic worm infections, dispel mistrust and encourage uptake of anti-worm therapies. A key message is the importance of worm treatments in preventing children losing education and improving immunity to co-infections such as malaria. Sample feedback: "*this is really important thank you*" (Inspired Sister community group participant) and "*You are breaking barriers*" (Student/ex refugee from Sierra Leone) [A].

iii. Increased student engagement with science and uptake of science subjects

Feedback from teachers states that events like the Worm Wagon enrich the science curriculum and influence student career choices. For example: *"It's actually events like this that can determine what they* [school pupils] *study and where they study at University*" (Year 8 teacher, Calday Grange Grammar School) [E].

Student questions indicate understanding/interest of fundamental immunological processes, for example, "*What happens to the debris once the T cells have killed the bugs?"* (Year 6 pupil, St Mary's Primary School, Horwich) [A]. Students who had not been taught immunology were able to answer questions and complete scientific drawings, such as parasite life cycles [A].

5. Sources to corroborate the impact

A. Participant questionnaires and drawings from public engagement activities, 2009 to date.
B. Email from a Ugandan doctor and participant of 'Immunology in the Tropics' course in March 2012. *Describes how the course inspired her to do an MSc.*
C. Letter from Director of 'Immunology in the Tropics' and Senior Immunologist, MRC/UVRI Uganda Research Unit on AIDS. *Corroborates Grencis' contribution to the course.*
D. Letter from Development Education Project (DEP) Director. *Corroborates the work of the UoM Immunology Group activities with the Inspired Sisters.*
E. Email from teacher at Calday Grange Grammar School. *Corroborates that the Worm Wagon influences student career choices.*