Institution: Oxford Brookes University

Unit of Assessment: 3 - Allied Health Professions, Dentistry, Nursing and Pharmacy

Title of case study: New equations to estimate basal metabolic rate (BMR) - Its Nutritional application and worldwide use

1. Summary of the impact (indicative maximum 100 words)

Jeya Henry's research into Basal Metabolic Rate (BMR) and applied equations for predicting BMR led to the development of new equations. The 'Henry' equations have recently been adopted and recommended for clinical use by UK and EU bodies, and are now used in daily dietetic practice throughout the European region, influencing the way in which patients and clients' treatments and therapies are designed in a variety of complex clinical settings. They also form the basis on which the food industry can make recommendations on their products based around recommended daily allowances (RDA) of energy intake, improving the power of the consumer to make informed choices about the food they eat.

2. Underpinning research (indicative maximum 500 words)

Basal Metabolic rate (BMR) may be defined as the minimal rate of energy expenditure compatible with life and is measured when a subject is at rest. BMR represents up to 70% of total energy expenditure (TEE) of any individual.

Prof. Jeya Henry has been researching BMR since 1984 at Oxford Brookes University. At the time of the publication of a Food and Agriculture organization of the United Nations/World Health Organization/United Nations University (FAO/WHO/UNU) report in 1985, it was acknowledged that there were shortcomings in the Schofield equations that were used to estimate BMR in the report, which related to their not accounting for ethnic variations. The chair of the FAO committee which produced the report, John Waterlow, encouraged Henry to begin investigations into identifying what the variation in BMR produced by ethnic factors might be. This included some preliminary work on the development of new predictive equations (Henry & Rees 1991), undertaken in collaboration with the late David Rees, a statistician also at Brookes.

In 1993, Professor Jeya Henry was awarded funding from Fondation Nestlé (Switzerland) to investigate human energy expenditure, focussing particularly on BMR in UK and Malaysian children. This was a unique study comparing growth, development and BMR in children living in two contrasting environments. The funding was initially for three years, and was extended for a further 4 years. The study found that UN/FAO/UNU recommended Schofield equations, and Henry's own earlier equations (Henry & Rees 1991) overestimated BMR of Malaysian children [1].

In 1994, Henry, with his PhD student Hayter, identified the European bias that the subject selection had in the development of the Schofield equations [2], which contributed to the overestimation identified in the earlier study. While conventionally it had been usual to collate information from European subjects who were the major source of nutritional research investigation, it was understandable that this bias was present. However, given that a greater proportion of the global population are not from European and north American backgrounds, there was clear need to take account of differences that ethnic origins may have on BMR. One of the key findings was determining that there was a circa 10% reduction in Asian BMR values compared to European and North American equivalents [2].

Between 1995 and 2005, Henry worked with collaborators internationally to continue to investigate BMR in different demographic groups and gather together a much wider-ranging dataset of BMR measurements [3-5]. As the dataset grew and was integrated with earlier datasets, the process of mathematical analysis using regression, eventually culminated in the creation of the 'Henry' equations and the 'Oxford' database [6]. These equations for the first time assembled data generated from Brookes' laboratories and collated from the world literature to generate predictive equations of greater accuracy and universal application.

3. References to the research (indicative maximum of six references)

1 Henry, CJK (1993) *Relationship between basal metabolic rate (BMR) and fasting metabolic*

rate (FMR) – some theoretical and practical implications, International Journal of Obesity, Volume: 17 Supplement: 1, Pages: S79-S79
This paper can be made available on request.

2 Hayter, JE & Henry, CJK (1994) *A re-examination of Basal Metabolic Rate predictive equations – the importance of geographic origin of subjects in sample selection*, European Journal of Clinical Nutrition, Volume 48, Issue 10, Pages 702-707
Hayter was a PhD student in Henry's research group at Brookes at the time.
This paper can be made available on request.

3 Shetty, PS; Henry, CJK; Black, AE; et al. (1996) *Energy requirements of adults: An update on basal metabolic rates (BMRs) and physical activity levels (PALs)*, European Journal of Clinical Nutrition, Volume 50, Supplement 1, Pages S11-S23
Shetty was collaborator at the London School of Hygiene & Tropical Medicine.
Black was collaborator at University of Cambridge.

4 Henry, CJK; Dyer, S; Ghusain-Choueiri, A (1999) *New equations to estimate basal metabolic rate in children aged 10-15 years*, European Journal of Clinical Nutrition, Volume 53, Issue 2, Pages 134-142, http://www.nature.com/ejcn/journal/v53/n2/pdf/1600690a.pdf
Ghusain-Choueiri and Dyer both Post-doctoral researchers in Henry's research group at Brookes.
Submitted to RAE2001, Oxford Brookes University, UoA14-Biological Sciences, RA2, CJK Henry, Output 3.

5 Poh BK, Ismail M, Zawiah H, Henry C. (1999) *Predictive equations for the estimation of basal metabolic rate in Malaysia adolescents*, Malaysian Journal of Nutrition, Volume 5, Issue 1, Pages 1-14.
Poh, Ismail and Zawiah all collaborators at Universiti Kebangsaan in Malaysia, who provided data from the Malaysian end of the study, and assisted with analysis.

6 Henry, CJK (2005) *Basal metabolic rate studies in humans: measurement and development of new equations*, Public Health Nutrition, Volume 8, Issue 7A, Special Issue: SI, Pages 1133-1152, DOI: 10.1079/PHN2005801
Submitted to RAE2008, Oxford Brookes University, UoA12-Allied Health Professions and Studies, RA2, CJK Henry, Output 1.

4. Details of the impact (indicative maximum 750 words)

Due to his significant contribution to the understanding of BMR across populations, as shown above, Henry was invited to be a special scientific advisor to the FAO/WHO/UNU Expert Consultation on Energy in Human Nutrition, for which he produced a background document. This development formed the foundation on which later impacts were achieved in the period of assessment:

In 2011 the Scientific Advisory Committee on Nutrition (SACN) reviewed Dietary Reference Values (DRVs) for energy requirements in the UK, which required a review of the means of calculating BMR. Their report [a] was one of the most comprehensive reviews of energy requirements. It found that the Henry equations showed a greater degree of accuracy in predicted BMR compared with measured BMR than any other equation tested. As a result, the SACN recommended that the Henry equations should be adopted by the UK and Europe for the estimation of energy requirements and the associated food production requirements at the population level (see paragraphs 192-3, [a]). Until the publication of the Henry equations every dietitian was using the Schofield equations. Following the recommendations by SACN the Henry equations have now replaced these equations and are the ones recommended for use by dietitians in most clinical conditions.

Also in 2011, the British Dietetic Association's Parenteral and Enteral Nutrition Group (PENG) produced the 4th edition of their *A Pocket Guide To Clinical Nutrition*, in which the authors

recommend the use of the Oxford equations to estimate BMR rather than the Schofield equations [b]. In September 2012, the Nutrition Support Interest Group of Ireland (NSIG) advised the Irish and Nutrition Dietetic Institute (INDI) to recommend the use of the Henry/Oxford equations rather than the Schofield equations (or COMA update of these), to estimate BMR. Most dietitians have already changed over to using these equations [c]. Similarly, the 2013 updated print-run of the *Oxford Handbook of Nutrition and Dietetics* [d] , which is a key resource for dietetics practitioners and students, was updated to use the Henry equations for estimated BMR, relating to issues of general nutritional Energy Balance, nutrition for people with Cardiovascular disease, other illnesses and burn injuries.

In January 2013, the European Food Safety Authority (EFSA) published their report [e] defining DRVs for energy, which relies heavily on the use of the Henry predictive equations for BMR (referred to as Resting Energy Expenditure (REE) in this document). The report notes that, in common with the SACN findings, the Henry equations provide the best predictive values for estimating energy requirements, giving a greater accuracy. It was recommended that the Henry equations be utilised to develop guideline DRVs for energy in all demographic groups. Moreover, the EFSA document will now serve as a basis to estimate the energy requirements in the 27 countries within the EU.

Dietetic and Nutritional consultants make daily use of predicted BMR in their practice, and the widespread recommendation of the new Henry equations for estimation in the above resources has therefore had an impact on both them and their patients and clients. The Henry equations are,

> *"used to calculate an individual's basal metabolic rate, which forms the basis of the calculation of energy requirements in individuals, groups and populations. This calculation is used to prescribe diets in the treatment of many conditions including obesity, malnutrition, gastroenterology and spinal cord injuries. It is also used when prescribing nutritional supplements, enteral and parenteral nutrition for patients with a wide variety of conditions e.g. burns, stroke, cancer. Therefore the Henry equations are an essential element of everyday dietetic practice. Dietitians working in other settings such as schools and public health use them to form the basis of a lot of their work e.g. menu planning, interventions aimed at reducing the prevalence of obesity*." - excerpt from statement from consultant dietitian and nutritionist [f].

The chief editor of the *Manual of Dietetic Practice (5th Ed)* has also ensured that this publication also makes use of the Henry equations as opposed to the Schofield equations [g].

By association, as the food and nutrition industry relies on scientific evidence to support any claims on food items being 'healthy' they are required to test their products against recommended standards. This includes being able to show what proportion of the Recommended Daily Allowance (RDA) of energy is contained within any product. This means that as the Henry equations are becoming integrated into national guidance via the EFSA recommendations, they also underpin the claims against RDA of food products produced and sold in those countries.

National and international bodies require a sound scientific basis in planning for procuring food supplies, stockpile of food for emergencies and as a tool for monitoring national food requirements. It is essential that there is a defined methodology that may be used for assessing the above needs and that an accurate predictive equation is available to estimate energy needs. The recent uptake of the Henry equations by the EFSA and SACN will have an effect on the on-going policy revisions concerning issues such as these, as this one of the inherent purposes of developing them.

5. Sources to corroborate the impact (indicative maximum of 10 references)

a) Scientific Advisory Committee on Nutrition (2011) *Dietary Reference Values for Energy,* http://www.sacn.gov.uk/pdfs/sacn_dietary_reference_values_for_energy.pdf
b) *A Pocket Guide To Clinical Nutrition, 4th Edition* (2011), The Parenteral and Enteral Nutrition Group of the British Dietetics Association, http://www.peng.org.uk/publications/publications.html

c) Corroborative statement author 1. Email to Prof. Henry from chair of The Nutrition Support Interest Group of Ireland, dated 23/11/2012 - can be made available on request from Oxford Brookes University Research and Business Development Office
d) Gandy, Madden & Holdsworth, *Oxford Handbook of Nutrition and Dietetics, 2nd Edition*, (2011), Oxford Medical Publications. 2013 Print run which has updated from the Schofield to the Henry equations – proofs supplied by the author available on request.
e) *Scientific opinion on Dietary Reference Values for Energy*, EFSA Panel on Dietetic Products, Nutrition and Allergies (NDA)2 EFSA Journal 2013;11(1):3005, DOI: 10.2903/j.efsa.2013.3005
f) Corroborative statement author 2. Statement from consultant dietitian and nutritionist, and Visiting Researcher at Brookes, co-author and editor of the Manual of Dietetic Practice (5th Edition), co-author and editor of the Oxford Handbook of Nutrition and Dietetics, Fellow of the British Dietetic Association (BDA) and former editor in chief of the Journal of Nutrition and Dietetics (The official journal of the BDA).
g) *Manual of Dietetic Practice*, 5th Edition, Wiley-Blackwell (in press)