Institution: University of Ulster

Unit of Assessment: 3B Allied Health Professions, Dentistry, Nursing and Pharmacy – Biomedical Sciences

Title of case study: Dietary Mis-reporting

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

Changing global patterns of agricultural production, food availability and processing are having profound impacts on individual food consumption and population health. Thus accurate data on individual food consumption are fundamental for effective planning of agricultural investments and for the implementation of sound public health nutrition policy. Research undertaken at the University of Ulster has demonstrated that mis-reporting in dietary surveys is pervasive and consequently is obscuring diet-health associations. This research has prompted a major paradigm shift in the way public health policy makers interpret dietary intake data.

2. Underpinning research (indicative maximum 500 words)

The ability to accurately measure food, and thus, nutrient intake, is of fundamental importance. For example, food regulatory authorities and agencies require valid intake data for a variety of policy making and research purposes in the areas of nutrition monitoring and surveillance, dietary guidance, food fortification, environmental exposure assessment, and nutrition assistance and education program planning and evaluation.

However, until relatively recently, no biomarkers were available for independently evaluating the validity of dietary assessments. Consequently, up until 1990 there existed a large body of literature spanning five decades which, in drawing conclusions about the relationships between diet and health made the tacit assumption that the usual methods of dietary assessment provided valid measures of habitual dietary intake. The possibility that human subjects may, consciously or sub-consciously, mis-report their food intakes was not widely contemplated. The advent of the doubly labelled water (DLW) method for providing robust and accurate measurements of energy expenditure offered the first opportunity to objectively assess the validity of reported energy intakes in free-living, weight-stable human subjects.

In collaboration with the MRC Dunn Nutrition Laboratory, Cambridge, two validation studies were carried outat the University of Ulster.. In the first study of a randomly selected sample of free-living men and women, mean energy intake by weighed dietary records was 82% and 81% of energy expenditure respectively, indicating substantial bias to the under-estimation of habitual food intake (Livingstone *et al*, 1990). If these results were assumed to be representative of all randomly selected population samples, then the implications for all dietary surveys, and particularly large epidemiological surveys, were enormous. In the second validation study in 78 young people mis-reporting was shown to increase with increasing age and, moreover, was not specific to any one dietary intake methodology (Livingstone *et al*, 1992).

Initially there was enormous reluctance by the nutrition community to accept the possibility of such bias in dietary surveys. The results of the DLW studies were viewed as based on a new and untried technique in a small and highly selected sample of subjects. This led Black *et al* (1991) to review published national dietary surveys in the UK, elsewhere in Europe and the US and to demonstrate conclusively that under-reporting of energy intake was both serious and widespread.

Subsequently in 2001, Barbara Livingstone was invited by the International Life Sciences Institute (North America) to write a systematic review of the current status of knowledge with regard to markers of the validity of reported energy intake (one of a series of reviews evaluating the science of biomarkers of exposure in nutritional epidemiology) (Livingstone & Black, 2003). This paper provided the first comprehensive review of 43 DLW validation studies and confirmed the serious under-estimation of energy intakes (-20% on average). This seminal review, published in the Journal of Nutrition has since been highly cited by researchers worldwide.

Key Researchers at Ulster:

Current key staff: Dr MBE Livingstone (Lecturer/Senior Lecturer in Nutrition)

External academic collaborators (1987 – 2003):
Dr AM Prentice (Senior Scientist)
Dr WA Coward (Senior Scientist)
Dr AE Black, (Chief Research Officer)
MRC Dunn Nutrition Unit, Cambridge, CB4 1XJ

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

The work has been published in top nutrition and medical journals and was undertaken in collaboration with researchers at MRC Dunn Nutrition Laboratory:

Livingstone, M. B. E., Robson, P. J., Wallace, J. M. W. (2004). Issues in dietary intake assessment of children and adolescents. *British Journal of Nutrition*, 92: Suppl.2: S213-S222.
DOI: 10.1079/BJN20041169
Times Cited: 181 SJR: 1.052 SNIP: 1.176 Impact Factor: 3.013

Livingstone, M. B. E., Black, A. E. (2003). Markers of the validity of reported energy intake. *Journal of Nutrition*, 133: Suppl 3: 895S-920S.
Times Cited: 348 SJR: 1.505 SNIP: 1.551 Impact Factor: 3.916

Black, A. E., Prentice, A. M., Goldberg, G. R., Jebb, S. A., Bingham, S. A., Livingstone, M. B. E., Coward, W. A. (1993). Measurements of total energy expenditure provide insights into the validity of dietary measurements of energy intake. *Journal of the American Dietetic Association,* 93: 572-579.
DOI: 10.1016/0002-8223(93)91820-G
Times Cited: 248 SJR: 1.145 SNIP: 1.292 Impact Factor: 3.586

Livingstone, M. B. E., Prentice, A. M., Coward, W. A., Strain, J. J., Black, A. E., Davies, P. S. W., Stewart, C. M., McKenna, P. G., Whitehead, R. G. (1992). Validation of estimates of energy intake by weighed dietary record and diet history in children and adolescents. *American Journal of Clinical Nutrition,* 56: 29-35.
Times Cited: 235 SJR: 2.816 SNIP: 2.404 Impact Factor: 6.669

Black, A. E., Goldberg, G. R., Jebb, S. A., Livingstone, M. B. E., Cole, T. J., Prentice, A. M. (1991). Critical evaluation of energy intake data using fundamental principles of energy physiology: 2. Evaluating the results of published surveys. *European Journal of Clinical Nutrition*, 45: 583-599.
Times Cited: 373 SJR: 1.001 SNIP: 1.106 Impact Factor: 2.462

Livingstone, M. B. E., Prentice, A. M., Strain, J. J., Coward, W. A., Black, A. E., Barker, M. E., McKenna, P. G., Whitehead, R. G. (1990). Accuracy of weighed dietary records in studies of diet and health. *British Medical Journal*, 300: 708-712.
Times Cited: 213 SJR: 1.400 SNIP: 1.489 Impact Factor: 14.093

Grant income obtained to undertake the studies was from Department of Health and Social Services for Northern Ireland (DHSS NI) and Department of Health London (1987-1989):

Livingstone, M. B. E., Strain, J. J. Validation of diet histories. Funded by DHSS (Clinical Award); 1989-1990; £5,350.

Livingstone, M. B. E., Strain, J. J., McKenna, P. G. (in collaboration with the MRC Dunn Nutrition Unit, Cambridge). Validation of food intake and energy expenditure in free living subjects in Northern Ireland. Funded by DHSS; 1988-1989; £54,000.

Livingstone, M. B. E., Strain, J. J., Nathu, N., Nevin, G. B., Barker, M. E., Hickey, R., McKenna, P. G. Studies of food intake and energy expenditure in free living subjects in Northern Ireland. Funded by DHSS (Clinical Award); 1988-1989; £4,050.

Livingstone, M. B. E., Strain, J. J., Nathu, N., Nevin, G. B., Barker, M. E., Hickey, R., McKenna, P. G. Validation of food intake and energy expenditure in free living subjects in Northern Ireland. Funded by DHSS; 1987-1988; £10,000.

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

The categorical demonstration, for the first time, of substantial under-estimation of food intake in randomly selected individuals was revolutionary at the time. Not surprisingly, the nutrition community was not initially convinced that bias in self-reported food intakes was a major problem in dietary surveys and the paper by Livingstone *et al* (1990) provoked a critical letter to the British Medical Journal (1). However, as more validation studies were undertaken and published, the initial findings were substantiated and there is now universal recognition that mis-reporting in dietary surveys is pervasive. This issue, including citation of the underpinning research, has now been highlighted in a spectrum of reports and reviews published worldwide (2-5).

Now regarded as seminal work, the research has prompted a major paradigm shift in the way policy makers interpret dietary intake data to establish Dietary Reference Values for Food Energy and Nutrients and develop Food Based Dietary Guidelines for Healthy Eating. Firstly, the papers by Livingstone *et al* 1990; 1992*)* led to a radical shift in thinking about dietary assessment techniques and initiated a new era in research in the field. In continuing collaboration with the MRC Dunn Nutrition Laboratory, Cambridge, researchers in the Northern Ireland Centre for Food and Health went on to pioneer a cost effective way of enabling researchers to critically examine their own data through comparing energy intake data with estimated energy requirements based on Basal Metabolic Rate (Black *et al,* 1991) This concept has been hugely influential in spreading awareness about under-reporting and has allowed dietary data to be examined in a much more critical way than hitherto. The application of these principles has ensured a more critical and informed interpretation of national dietary data [e.g. the UK National Diet and Nutrition Survey (NDNS) (6); the US National Health and Nutrition Examination Survey (7) which are widely used to establish nutrition policy, to track progress toward achieving health and nutrition objectives, to provide reference information on nutrition intakes, to develop dietary guidance and to study diet-health relationships.

For example, average reported energy intakes in the UK are consistently below the estimated average requirement, while paradoxically, the prevalence of overweight and obesity has been increasing. However, this anomaly is likely to reflect under-reporting of food intake given that it has been estimated that under-reporting in the NDNS is approximately 25% of energy needs and is particularly pronounced in the overweight and obese (8). Consequently, in the face of compelling evidence about the extent and magnitude of under-reporting of national dietary data, both the US Institute of Medicine (2005) (9) and the UK Scientific Advisory Committee on Nutrition (2011), when revising their respective energy reference values for specific population groups, considered that it was no longer tenable to base these on self-reported food intake data (8).

Another major problem in examining food intake data to derive Food Based Dietary Guidelines for Healthy Eating is that of selective under-reporting (either frequency of intake or serving size) of foods which are generally perceived to be “bad for health”. This reporting bias could either attenuate or exaggerate associations between nutrient intake and health parameters. For example, systematic under-estimation of dietary fat may overestimate the positive association observed between percentage energy from fat and health outcomes such as cancer and heart disease (10). Thus differential biases in dietary reporting could have unpredictable consequences and emphasise that improved assessment of dietary intake in epidemiological studies is imperative for the future development of evidence-based recommendations for diet and health.

In summary, the research described in this case study has been pivotal in demonstrating that one

of the most fundamental and intractable problems we face in human nutrition research is our inability to measure what people actually eat. Poor validity of dietary assessments has fundamental implications for nutritional epidemiology and dietary surveillance. Biased under-reporting of food intakes will inflate estimates of nutrient inadequacies, attenuate risk estimates, obscure diet-disease associations and ultimately generate misleading evidence on which to base public health policy about healthy eating.

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

1) Jackson, A. A., Wootton, S. A. (1990). Accuracy of weighed dietary records. Comment. *British Medical Journal*, 300: 1138-1139.

2) University of Otago and Ministry of Health. (2011) A Focus on Nutrition: Key findings of the 2008/09 New Zealand Adult Nutrition Survey. Wellington: Ministry of Health.
Available at: http://www.health.govt.nz/publication/focus-nutrition-key-findings-2008-09-nz-adult-nutrition-survey [Accessed May 2013].

3) Roberts, K. (2010) Dietary Surveillance and Nutritional Assessment in England: what is measured and where are the gaps? Oxford: National Obesity Observatory.
Available at:
http://www.noo.org.uk/uploads/doc/vid_5191_Dietary_Surveillance_and_Nutritional_Assessment_in_England.pdf [Accessed August 2012].

4) The Institute of Medicine (2008) Nutrition Standards and Meal Requirements for National School Lunch and Breakfast Programs: Phase I. Proposed Approach for Recommending Revisions. Washington, DC: The National Academies Press.
Available at: http://www.fns.usda.gov/Ora/menu/Published/CNP/FILES/SchoolMealsIOMPhaseI.pdf [Accessed August 2012].

5) WSRO (2012) Position Statement Sugars and Micronutrient Dilution. Available at: http://www.wsro.org/Portals/12/Docs/position-statement-sugars-and-micronutrient-dilution-2012.pdf [Accessed May 2013]

6) Rennie, K., Coward, A., Jebb, S. Under-reporting of energy intake in the National Diet and Nutrition Survey: Adults aged 19-64. Report of a study commissioned by the Food Standards Agency and the Medical Research Council, 2004.

7) Briefel, R. R., Sempos, C. T., McDowell, M. A., Chien, S., Alaimo, K. Dietary methods research in the third National Health and Nutrition Examination Survey: underreporting of energy intake. *American Journal of Clinical Nutrition,* 1997;65 (suppl): 1203S-9S

8) Scientific Advisory Committee on Nutrition (SACN). (2011) Dietary Reference Values for Energy. London: TSO.
Available at: http://www.sacn.gov.uk/pdfs/sacn_dietary_reference_values_for_energy.pdf [Accessed May 2013].

9) The Institute of Medicine (2005) Dietary Reference Intakes for Energy, Carbohydrate, Fiber, Fat, Fatty Acids, Cholesterol, Protein and Amino Acids. Washington, DC: The National Academies Press.
Available at: http://www.nal.usda.gov/fnic/DRI/DRI_Energy/energy_full_report.pdf [Accessed July 2013]

10) Heitman, B. L., Lissner, L. (2005) Can adverse effects of dietary fat intake be overestimated as a consequence of dietary fat underreporting? *Public Health Nutrition*, 8: 1322-1327.