

Institution: Aberystwyth University		
Unit of Assessment: 6: Agriculture, Veterinary and Food Science		
Title of case study: A platform for improving the assessment of eating behaviour in populations: Urine biomarkers of dietary exposure to improve health and well-being		
Period when the underpinning research was undertaken: 2011- 2020		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	Role(s) (e.g. job title):	Period(s) employed by submitting HEI:
Professor John Draper	Chair (Research Lead: Diet & Health Research Group)	1 December 1997 – present
Dr Manfred Beckmann	Lecturer	1 November 2001 – present
Dr Amanda Lloyd	Research Assistant; PDRA Clinical Trials & Scientific Co-ordinator- Future Foods	1 January 2009 – present
Dr Tom Wilson	Research Assistant – Data pre-processing and Chemical Identification; PDRA: Metabolomics Data Analyst	1 August 2015 – present
Period when the claimed impact occurred: 2016- 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact (indicative maximum 100 words) <p>Investigating the relationship between diet and health is complicated as self-reported dietary intake data often contain inaccurate information as a result of misreporting or bias. Our research has led to impact on professional practice and policy, health and well-being, commercial benefits and public understanding. A technology platform centred on the analysis of urine chemistry which objectively reports dietary exposure is based on our research, providing accurate tools, e.g. to show that public health initiatives can positively impact eating behaviour, to provide protocols for nutritional assessment in clinical trials, to support health claims associated with foods, and to provide an infrastructure for detecting malnutrition in vulnerable members of society.</p>		
2. Underpinning research (indicative maximum 500 words) <p>Our understanding of causal relations between diet and health is hindered by the lack of robust biological markers of food exposure. Evidence suggests, people inaccurately record their own diets; under-reporting unhealthy food whilst over-reporting fruit and vegetable intake. Inaccurate food intake data impacts negatively on the conclusions of many clinical trials and national surveys in which dietary intake and nutritional status are important. Measurement of food-derived metabolites in biofluids provides an alternative approach.</p> <p>Draper and Beckmann in 2011 were the first to describe an experimental protocol for the discovery of putative intake biomarkers for several foods of high public health significance, including citrus fruits, red berries, oily fish, poultry and brassicas [3.1]. In 2012, Draper and Beckmann led a successful bid for a collaborative Programme Grant (MAIN) to develop urine biomarker technology to investigate dietary intake in free-living populations [3.7]. With advice</p>		

from the Public Health England National Diet and Nutrition Survey (NDNS) team, this programme produced a study protocol based on complex food interventions that mimics exposure to the whole of a typical UK diet, allowing for the first time the validation of food intake biomarker specificity in free-living populations [3.2]. Led by Lloyd and Wilson, the team gradually discovered and/or validated biomarker leads for a wide range of foods/food groups, including chocolate, coffee, grapes, legumes, strawberry, red meat, white fish, strongly heated foods, fizzy drinks, onion, potato, apple, banana, soy and wine (publications summarised in a 2020 'perspective') [3.3]. The dietary intake biomarker technology was validated in a range of clinical trials between 2016 and 2019 [3.8, 3.9]; a major output of this effort was the first report internationally of a comprehensive biomarker panel to measure habitual diet [3.3, 3.4]. In 2018, Draper and Beckmann were invited to standardise the biomarker analysis protocols for the UK research community as part of the MRC MAP-UK Partnership [3.10].

Urine chemistry varies throughout the day, dominated by food intake and urination patterns. Thus, the majority of nutrition studies collected 24hr urine samples, which is both expensive and of significant burden to participants. Of great importance for the universal deployment of food intake biomarker technology was the need to define appropriate and affordable methods to obtain urine samples. The Draper team were able to demonstrate that small spot urine samples collected at specific times were suitable replacements for 24hr urine [3.5] and highly acceptable to study participants [3.6]. These observations enabled the possibility of obtaining urine samples on multiple days and, for the first time, to monitor habitual diet in individuals using biomarkers. Initiating in 2016, Wilson and Lloyd developed new approaches for the collection, storage and preservation of spot urine samples using vacuum tubes [3.3]. With core support from EIT-health [3.8], a bespoke commercial urine collection kit was developed with Shuttlepac in 2018, and is now manufactured by Co-Vertec [3.3]. This urine collection technology is undergoing market testing in eight clinical trials, focusing on nutrition research [e.g. 3.8, 3.9] within collaborations operating in the UK, France, Spain, Canada and Malawi.

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

- 3.1 Lloyd, A.J., Favé, G., Beckmann, M., Lin, W., Taillart, K., Xie, L., Mathers, J.C and Draper, J.** *Use of mass spectrometry fingerprinting to identify urinary metabolites following consumption of specific foods*, 2011, American Journal of Clinical Nutrition. 94, 981-991. [10.3945/ajcn.111.017921](https://doi.org/10.3945/ajcn.111.017921)
- 3.2 Lloyd, A., Willis, N. D., Wilson, T., Zubair, H., Xie, L., Chambers, E. S., Garcia-Perez, I., Taillart, K., Beckmann, M., Mathers, J. C. & Draper, J.** [*Developing a food exposure and urine sampling strategy for dietary exposure biomarker validation in free-living individuals*](#), 03 Jun 2019, Molecular Nutrition and Food Research. 63. 1900062. DOI: [10.1002/mnfr.201900062](https://doi.org/10.1002/mnfr.201900062)
- 3.3 Beckmann, M., Wilson, T., Lloyd, A.J., Torres, D., Goios, A, Willis, N.D., Lyons, L., Phillips, H., Mathers, J.C., Draper, J.** *Challenges associated with the design and deployment of food intake urine biomarker technology for assessment of habitual diet in free-living individuals and populations – a perspective*, 25 Nov 2020, Frontiers in Nutrition, DOI: [10.3389/fnut.2020.602515](https://doi.org/10.3389/fnut.2020.602515)
- 3.4 Beckmann, M., Wilson, T., Zubair, H., Lloyd, A. J., Lyons, L., Phillips, H., Taillart, K., Gregory, N., Thatcher, R., Garcia-Perez, I., Frost, G., Mathers, J. C., Draper, J.** *A standardized strategy for simultaneous quantification of urine metabolites to validate development of a biomarker panel allowing comprehensive assessment of dietary exposure*, 14 Sept 2020, Molecular Nutrition & Food Research, 64, 2000517. DOI: [10.1002/mnfr.202000517](https://doi.org/10.1002/mnfr.202000517)
- 3.5 Wilson, T., Garcia-Perez, I., Posma, J. M., Lloyd, A., Chambers, E. S., Taillart, K., Zubair, H., Beckmann, M., Mathers, J. C., Holmes, E., Frost, G. & Draper, J.** [*Spot and cumulative urine samples are suitable replacements for 24-hour urine collections for objective measure*](#)

[of dietary exposure in adults using metabolite biomarkers](#), 26 Jun 2019, Journal of Nutrition. 149, 1692-1700, DOI: [10.1093/jn/nxz138](#)

3.6 Lloyd, A. J., Wilson, T., Willis, N. D., Lyons, L., Phillips, H., Janssen, H. G., Stiegler, M., Xie, L., Taillart, K., Beckmann, M., Stevenson, L., Mathers, J. C., Draper, J. *Developing community-based urine sampling methods to deploy biomarker technology for assessment of dietary exposure*, 11 Jun 2020, Public Health Nutrition, 23, 3081-3092. DOI: [10.1017/S136898002000097X](#)

Research Grants

3.7 Draper (PI) and Beckmann (Co-PI); Metabolomics for monitoring dietary exposure (MAIN); MRC Programme Grant MR/J010308/1; 2013-2016; GBP1,225,708

3.8 Draper (PI) and Beckmann (Co-PI); Cook to Health; EIT-Health Consortium Project; 2016-2019; EUR125,000 (max per year to Aberystwyth) (EU consortium led by Groupe SEB)

3.9 Draper (PI) and Beckmann (Co-PI); FACET – Frailty assessment technology; EIT-Health Consortium Project; 2016-2018; EUR125,000 (max per year to Aberystwyth) (EU consortium led by Abbott PLC and including ATOS, GMV, SERMAS)

3.10 Draper (Co-PI) and Beckmann (Co-PI); MAP-UK; MRC Partnership Grant; 2019-2023; GBP163,000

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

Based on the expertise and procedures developed by the Draper team, accurate tools and protocols have been developed for dietary exposure assessment in clinical trials and population surveys. These have been taken up and have had direct impact in the following sectors.

Public health policy and underpinning strategic research – nationally and internationally

In 2016, the dietary exposure biomarker technology was integrated into the National Food, Nutrition and Physical Activity Survey of the Portuguese general population:

“Based on the technical approaches published by Prof. Draper we were able to redesign our survey protocol ” and also “..it is expected that many national dietary surveys and clinical trials will adopt the use of dietary exposure biomarker technology alongside traditional tools used to assess diet which will boost the quality of research aiming to link health outcomes to food intake”.

[5.1]

Further, in 2016, Draper was invited to contribute to a major strategic review of nutrition research in the UK under the auspices of the Office for Strategic Coordination of Health Research (OSCHR), which resulted in the development of the MRC Nutrition Research Partnership in 2018, of which Draper is a founding member [5.2]. In 2017, Draper joined a similar expert advisory group funded by Wellcome, with input from the World Health Organisation (WHO). As a result, the MRC and Wellcome decided to specifically highlight dietary intake assessment research: “... there is a need to find more accurate and objective ways to measure dietary intake” [5.3].

The NDNS team established the NIHR BRC Nutritional Biomarker Laboratory to incorporate biomarker technology developed by Draper in future UK population surveys:

“..the use of biomarker technology in conjunction with on-line diet recording tools such as Intake24 will not only improve the quality of the dietary intake data collected by the NDNS but would also allow an increase in the scale of sampling activity. Both of these developments would result in the acquisition of enhanced data for use by PHE to develop UK Government policy and to

assess the effectiveness of public health campaigns to improve the diet of the UK population.” [5.4]

In 2018, Draper was invited to help design and participate in a workshop on Biomarkers of Dietary Intake and Exposure for the US National Institute of Health (NIH) (an agency of the US Department of Health) and has been influential in the acceleration of nutrition research in the USA:

“His earlier seminal work... guided the start of our research approaches in the area of dietary biomarker development ... and has influenced the field more broadly in the US”. “Professor Draper played a key role in a NIH workshop on the topic of dietary biomarkers”. “In the planning phases of the program, the organizing committee and co-chairs (Drs. Maruvada, Lampe and Wishart) recognized that several aspects of Professor Draper’s research were exceptional examples of the kinds of approaches the field needs to move forward.” As a result, an “..improved understanding of the potential offered by dietary intake biomarker technology has now become part of a NIH strategic plan to accelerate nutrition research over the next 10 years.” [5.5]

Commerce and Economy

With support from the European Institute of Technology (EIT) Health the Draper team, jointly with Shuttlepac Ltd., developed a new methodology for biological sampling in community settings. A commercial kit for collecting urine samples is now being manufactured by Co-Vertec Ltd. The first sales to a major clinical trial (STREAM) [5.6] were achieved in 2018:

“This collaborationled to more than £77,616 of additional R&D investment for the company...A success on many levels, with the main result being a new and unique product for the company to bring to market.” “The ongoing COVID19 pandemic has highlighted the further importance of sampling for clinical diagnostic purposes and Co-Vertec believes there is a significant market for home sampling and transporting from the community to analytical facilities.” [5.7]

Previously in 2016, the urine collection kit in combination with biomarker technology had been integrated into two major industry-led projects with Abbott and Groupe SEB in Spain, France and the UK, to validate eating behaviour changes correlated with the use of novel digital ‘health coaching’ tools.

“Prof Draper joined the FACET project consortium, as his research on nutritional metabolomics and particularly urinary biomarkers of dietary intake could have value for the metabolic phenotyping of potentially frail individuals.” “His...community-based frailty assessment and biofluid collection in the home allowed for the rapid execution of an affordable pilot study”. [5.8]

“I realised that Prof Draper’s research on urinary biomarkers of dietary intake could have great value for validating objectively any changes in eating behaviour associated with the use of dietary coaching Apps.” “..urine sampling in the home allowed for the rapid execution of affordable clinical trials in Grenoble and Aberystwyth to test the impact of the Cook2Health coaching tool on eating behaviour”. [5.9]

Impact on clinical trial design

With the successful development of both a biomarker panel and urine sampling methodology appropriate for community settings, the Draper team provided input into the design of a range of clinical trials (from 2017– present) aimed at improving the way that the NHS and NGOs support vulnerable members of society, for example:

“The comprehensive biomarker panel technologyoffered an opportunity to monitor dietary intake without total reliance on self-reporting, a method suitable for the homeless population”

“Particularly important from a practical and logistical perspective was his finding that first morning void spot urine samples could be used for food intake assessment but, importantly, were much less burden on survey participants than 24hr urine collection and could be used in any community setting.” [5.10]

“The STREAM study is a major NIHR biomedical research project involving 110 GP surgeries in 6 different CRNs with the aim of recruiting, assessing and treating more than 1500 study participants.” “The input from the Aberystwyth group has led to the revision of our study protocols to include assessment of urine and blood sampling technology in community settings.”

“Furthermore, we believe that the biomarkers will also prove to be of great value in wider, important research on the detection of protein undernutrition in the elderly and its effect on the development of sarcopenia.” [5.6]

Understanding, learning and participation

Draper was approached by Firecracker Films to help develop a 90-minute documentary “The Great British Urine Test” for Channel 5 which was shown in March 2020 with almost one million viewers:

“Commissioners at the channel were delighted with the viewing figures and the finished product.” “It is always difficult to put over complicated scientific concepts to the viewing public. By virtue of working with Prof. Draper and his team Firecracker benefited from exposure to the rigors of designing and undertaking a demanding research study in a very short time using cutting edge medical technology.” “As a producer experiences of this sort certainly helps to provide confidence within the industry to embark on similar ventures in the future which are both good television but also informative at the same time.” [5.11].

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

- 5.1** Testimonial (Uni. of Porto) – integration of food intake biomarker technology in National Food, Nutrition and Physical Activity Survey of the Portuguese general population (04/12/2020)
- 5.2** MRC/NHIR Review of Nutrition and Human Health Research for OSCHR (July 2017)
- 5.3** Report on Wellcome/WHO consultation - “Transforming Nutrition Science for Better Health” (01/10/2019)
- 5.4** Testimonial (Cambridge Uni.) – integration of food intake biomarker technology in Public Health England National Diet and Nutrition Survey (NDNS)(16/12/2020)
- 5.5** Testimonial (Fred Hutchinson Cancer Research Centre) – impact on development of the field of dietary assessment biomarkers in the USA (04/12/2020)
- 5.6** Testimonial (Uni. of Southampton) – integration of dietary exposure biomarker technology in NHIR Screen and TREAT for Malnutrition (STREAM) study (04/12/2020)
- 5.7** Testimonial (Co-Vertec & Shuttlepac Ltd.) – commercialisation of a urine sampling kit (04/12/2020)
- 5.8** Testimonial (Abbott Nutrition, Granada) – biomarkers to validate a frailty management App. (02/12/2020)
- 5.9** Testimonial (Groupe SEB, Lyon) - biomarker technology to validate a healthy eating coaching App. (02/12/2020)
- 5.10** Testimonial (Uni. of Reading) – biomarkers in Reading Homeless study (10/12/2020)
- 5.11** Testimonial (Firecracker Films) – Channel 5 documentary “The Great British Urine Test” (24/11/2020)