

Institution: Ulster University		
Unit of Assessment: Allied Health Professions, Dentistry, Nursing and Pharmacy (3)		
Title of case study: ICS-2 Improving vitamin D intake and status in populations worldwide		
Period when the underpinning research was undertaken: 2000 - 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 JJ Strain	Professor of Human Nutrition	1981-present
Dr Emeir McSorley (née Duffy)	Senior Lecturer in Human Nutrition	2002-present
Professor Helene McNulty	Professor of Nutritional Science	1992-present
Professor Mary Ward	Professor of Nutrition and Dietetics	1998-present
Dr Maria Mulhern (née Barnes)	Lecturer in Food Science	2006-present
Dr Kirsty Pourshahidi (née Forsythe)	Teaching Fellow in Food Science and Technology	2011-present
Dr Pamela Magee	Senior Lecturer in Human Nutrition	2001-present
Professor Sumantra Ray	Professor of Global Nutrition, Health and Disease	2019-present
Period when the claimed impact occurred: 2014 – 2020		
Is this case study continued from a case study submitted in 2014? N		
1. Summary of the impact Vitamin D is essential for health. Setting dietary recommendations enables intake and status to be monitored and improved in populations. Impact 1: Our research is used by policymakers and risk managers in setting current dietary vitamin D requirements in the USA, Canada, UK, and the EU member states. Impact 2: These guidelines are used globally by health professionals and food manufacturers to improve vitamin D status. The significance of the impact can be appreciated in that optimising vitamin D status is crucial for preventing vitamin D deficiency and associated chronic diseases and health conditions, with resultant health and economic benefits worldwide.		
2. Underpinning research Low vitamin D status Low vitamin D status is linked to osteoporosis and chronic diseases throughout the world, and optimising vitamin D intake can therefore have important consequences in reducing the risk of such conditions. Nutrition and health professionals (e.g. medical doctors, dietitians, sport		

nutritionists) as well as food manufacturers rely on evidence-based dietary vitamin D requirements, not only to prevent vitamin D deficiency diseases (e.g. rickets and osteomalacia), but also to improve the overall health of populations worldwide.

Optimising vitamin D dietary intake to improve status

In 2006, Professors Wallace (deceased) and Strain at Ulster secured funding from the UK Food Standards Agency (FSA), in collaboration with University College Cork, to investigate the relative contribution of dietary intake and sunlight to vitamin D status in young adults and older individuals. This collaboration produced several high impact papers (e.g. **R1**, **R2**). The randomised controlled trial outputs from this research (**R1**, **R2**) have had considerable impact during this current REF timeframe in informing policymakers when they were devising dietary guidelines for vitamin D. In 2008, additional funding from the UK FSA, also in collaboration with University College Cork, enabled the Ulster team to assess potential benefits of vitamin D supplementation on bone health, immune function and cardiovascular risk markers.

This research built upon a previous collaborative project with University College Cork, also led by Professors Wallace and Strain and which identified the prevalence of vitamin D deficiency in the Northern Ireland Young Hearts Project. This investigation was the first to highlight low vitamin D status among 12- and 15-year olds, particularly in girls, in a representative sample of adolescents in Northern Ireland (**R3**). This finding was of concern, as low vitamin D status was also associated with low bone mineral density in these adolescents. Our prior research in this age group showed low vitamin D status among young adults in wintertime but established that 8 weeks' supplementation in our randomised controlled trial was effective at improving status (**R4**).

Vitamin D status in elite sports

Research led by Dr Magee and funded by the Irish Rugby Football Union, Cricket Ireland, and the Irish Amateur Boxing Association demonstrated deficiency of vitamin D in elite athletes and Paralympians in Ireland (not cited here). As a result, Sport Ireland has revised its vitamin D supplementation policy and research at Ulster has subsequently demonstrated improved status in athletes some 4-5 years after the revision of Sport Ireland's vitamin D supplementation policy (**R5**).

Vitamin D status in the COVID-19 pandemic

Significant research funding was awarded in 2009 by the Department for Employment and Learning for a cross-border Irish Universities Nutrition Alliance collaboration, led by Professors McNulty and Strain, to set up a 'Centre of Excellence in Nutrition and Ageing' (CENA). Research emanating from CENA (not cited here) supports a role for adequate vitamin D status for optimal immune function, particularly within the older adult population (≥ 60 yrs). The importance of optimal vitamin D status for immune function during the COVID-19 pandemic is highlighted in a recent (2020) review (**R6**) with invited co-authors from Ulster. The review highlights the importance of vitamin D for immune health and recommends vitamin D supplementation according to country-specific government guidelines (which in turn utilised data from **R1**, **R2**) with emphasis on those self-isolating with limited access to sun exposure.

3. References to the research

The following outputs are published in leading peer-reviewed journals and are reviewed by internationally based editorial boards.

R1: Cashman KD, Hill TR, Lucey AJ, Taylor N, Seamans KM, Muldowney S, FitzGerald AP, Flynn A, **Barnes MS**, Horigan G, Bonham MP, **Duffy EM**, **Strain JJ**, **Wallace JMW**, Kiely M (2008). Estimation of the dietary requirement for vitamin D in healthy adults. *American Journal of Clinical Nutrition*, 88(6):1535-42. DOI:10.3945/ajcn.2008.26594.

R2: Cashman KD, **Wallace JMW**, Horigan G, Hill TR, **Barnes MS**, Lucey AJ, Bonham MP, Taylor N, **Duffy EM**, Seamans K, Muldowney S, FitzGerald AP, Flynn A, **Strain JJ**, Kiely M (2008). Estimation of the dietary requirement for vitamin D in free-living adults ≥ 64 y of age. *American Journal of Clinical Nutrition*, 89(5):1366-74. DOI:10.3945/ajcn.2008.27334.

R3: Hill TR, Cotter AA, Mitchell S, Boreham CA, Dubitzky W, Murray L, **Strain JJ**, Flynn A, Robson PJ, Wallace JMW, Kiely M, Cashman KD. (2008) Vitamin D status and its determinants in adolescents from the Northern Ireland Young Heart's 2000 cohort. *Br J Nutr* 99, 1061-1067. DOI: 10.1017/S0007114507842826

R4: Barnes MS, Robson PJ, Bonham MP, **Strain JJ**, Wallace JMW (2006). Effect of vitamin D supplementation on vitamin D status and bone turnover markers in young adults. *European Journal of Clinical Nutrition*, 60(6):727-33. DOI:10.1038/sj.ejcn.1602374.

R5: Todd J, Madigan S, **Pourshahidi LK**, **McSorley EM**, Laird E, Healy M, **Magee P** (2016). Vitamin D Status and Supplementation Practices in Elite Irish Athletes: An Update from 2010/2011. *Nutrients*, 8(8). pii: E485. DOI:10.3390/nu8080485.

R6: Lanham-New SA, Webb AR, Cashman KD, Buttriss JL, Fallowfield JL, Masud T, Hewison M, Mathers JC, Kiely M, Welch AA, Ward KA, **Magee P**, Darling A L, Hill TR, Greig C, Smith C, Murphy R, Leyland S, Bouillon R, **Sumantra R**, Kohlmeier M (2020). Vitamin D and SARS-CoV-2 virus/COVID-19 disease. *British Medical Journal Nutrition, Prevention & Health*, [000089]. DOI: <https://doi.org/10.1136/bmjnp-2020-000089>.

Key research grants:

- Wallace JMW, Strain JJ, Robson PJ, Boreham C and Dubitsky W. Evaluation of the prevalence of vitamin D deficiency in a representative sample of adolescents from Northern Ireland and its implications for bone health (in collaboration with University College Cork). Funded by the Higher Education Authority of Ireland, 2003-2006; GBP72,816.
- Wallace JMW, Bonham MP, Duffy EM and Strain JJ. Dietary requirements for vitamin D: An investigation of the relative significance of dietary intake and sunlight on vitamin D status in adolescents and adults (in collaboration with University College Cork). Funded by the UK Food Standards Agency, 2006-2009; GBP321,119.
- Wallace JMW, Bonham MP, Duffy EM, Magee PJ, Campbell DJ and Strain JJ. Vitamin D status and associated health outcomes: Towards an evidence basis for defining vitamin D status sufficient to reduce risk of chronic disease (in collaboration with University College Cork). Funded by UK Food Standards Agency, 2008-2010; GBP161,958.
- McNulty H, Strain JJ, Ward M and Wallace JMW. Irish Universities Nutrition Alliance Project: Building additional and sustainable research capacity in nutrition and bone health at the University of Ulster. Funded by the Department for Employment and Learning, 2009-2011; GBP1,242,392.

4. Details of the impact

Impact 1: Setting current vitamin D requirements for populations by policymakers and risk managers

- *The EU:* In 2016, our studies (**R1**, **R2**, **R4**) were critical to the European Food Safety Authority's (EFSA) approach (meta-regression) to assess intake-status for deriving dietary reference values (DRVs) for vitamin D for adults under conditions of minimal vitamin D synthesis from sunlight [**C1**].
- *The UK:* The Scientific Advisory Committee on Nutrition (SACN, 2016) used our data (**R1-R3**) as underpinning evidence [**C2**] to revise the DRVs for vitamin D for the UK population aged 4 years and over. The UK government cascaded this information to all health professionals for dissemination to the public in the UK [**C2**].
- *The German-speaking countries:* The German-speaking countries (D-A-C-H, 2015) used our data to set a DRV for vitamin D in adults aged <60 years (**R1**) and for older adults aged >60 years (**R2**) [**C3**].
- *The Nordic countries:* The Nordic Council of Ministers (2014) considered a meta-regression analysis of supplementation studies (including **R1**, **R4**) in setting requirements for adults aged <60 years and supplementation studies (including **R2**) for adults aged >60 years [**C4**].

Impact 2: Use of dietary recommendations by health professionals and food manufacturers

- *Global reach*: The current global reach of the impact is clear in that end users (e.g. health professionals and food manufacturers) of the recommendations based on Ulster's underpinning research (**R1-R4**) reside in more than 35 territories, including the UK, the 27 EU countries, the USA, Canada, Norway and Switzerland [**C1-C4**]. This impact includes prevailing recommendations set by the The Institute of Medicine (for the USA and Canada) and The Health Council of the Netherlands using our research (**R1, R2**). The significance and reach of the impact relating to our research is that dietary recommendations are crucial from a public health perspective for the prevention of vitamin D deficiency and low status, with benefits to populations worldwide. The recommendations are essential public health policy instruments developed with the evidence base and data available at that time (including **R1-R4**).
- *COVID-19*: The current COVID-19 pandemic caused the National Institute for Health and Care Excellence (NICE) in June 2020 to produce a rapid evidence summary, informed by the recent review (**R6**), recommending all people to follow Government recommendations (based on data from **R1-R3**) on vitamin D [**C5**]. NICE also published a medicines evidence commentary on vitamin D supplementation for preventing intensive care admission in people with COVID-19 [**C5**]. The UK National Health Service (NHS), Public Health England (PHE), the British Dietetics Association (BDA) and the Need for Nutrition Education/Innovation Programme (NNEdPro) Global Taskforce for COVID-19 have recently (April-June 2020) emphasised the importance of vitamin D supplementation in advice for the general public [**C5**]. A particular emphasis is given to the importance of following vitamin D dietary recommendations (based on data from **R1-R3**) for those with increased time spent indoors during lockdown, shielding/cocooning and in self-isolation during the COVID-19 pandemic [**C5**].
- *Food fortification*: As a consequence of the revised dietary recommendations (**R1-R4**), nationally implemented voluntary food fortification programmes have demonstrated vitamin D status improvements in populations, e.g. the Finnish policy has doubled the vitamin D status of the general population with deficiency rates <1% [**C6**]. Similarly, in response to the revised dietary recommendations (based on data from **R1-R4**), vitamin D food fortification has been introduced or revised in countries such as India (vitamin D fortified milk and edible oils, 2014), the USA (doubling of vitamin D fortification in milk, 2016) and Sweden (dairy products and margarine spreads, 2018), [**C6**].
- *Food industry*: Industry now uses these dietary guidelines on packaging and in promotional literature [**C7**] in response to the revised recommendations as underpinned by Ulster's research (based on data from **R1-R4**). These industry initiatives have economic benefits in line with addressing global nutritional needs. Revisions to the vitamin D dietary recommendations automatically impact the entire food industry in that every product with a claim relating to vitamin D will always comply with the applicable dietary recommendations (based on data from **R1-R4**) [**C1-C4**] as set by the authorities in the relevant country or region.
- *Elite athletes*: Sport Ireland has revised its policy so that the vitamin D status of all athletes is now routinely monitored, with vitamin D supplementation implemented (if necessary) using protocols designed by Sport Ireland [**C8**]. The Sport Ireland Institute, using resources based on our research, now educates athletes on their vitamin D requirements which has improved their status (**R5**).

5. Sources to corroborate the impact

C1: European Food Safety Authority (EFSA) (2016). The EFSA Journal Dietary reference values for vitamin D. DOI: 10.2903/j.efsa.2016.4547.

C2: United Kingdom (UK) Scientific Advisory Committee on Nutrition (SACN) (2016). Vitamin D and Health report. 304pp. **DoH UK** (2017) **Northern Ireland**: New advice on vitamin D intake.

Wales: New advice on vitamin D intake. **Scotland**: New recommendations on vitamin D supplementation.

C3: The German Speaking Countries References for Nutrition: Germany (D), Austria (A), and Switzerland (CH) D-A-C-H (2015). Referenzwerte für die Nährstoffzufuhr. 2. Auflage/1. Ausgabe, DGE, Bonn, Germany.

C4: Nordic Council of Ministers (2014). Nordic Nutrition Recommendations 2012. Integrating nutrition and physical activity. Nordic Council of Ministers, Copenhagen, Denmark, 627pp.

C5: NICE: COVID-19 rapid evidence summary (ES28) (June 2020). **BDA:** Covid-19/Coronavirus – Advice for the General Public. **NNEdPro:** Covid-19: Nutrition Resources. **NHS:** Coronavirus (Covid-19): Vitamin D. **PHE:** Public Health England extends supplement advice during lockdown (Nutraingredients article). **HSC/PHA:** PHA recommends daily vitamin D supplement during lockdown.

C6: Finland: Finland the Vitamin D Pioneer (IADSA). **India (2014):** Milk (FFSAI). **USA (2016):** Food Additives Permitted for Direct Addition to Food for Human Consumption; Vitamin D2 and Vitamin D3 (FDA). **Sweden (2018):** (i) Livsmedelsverkets föreskrifter om berikning av vissa livsmedel; and, (ii) **(2015):** Sweden to expand mandatory vitamin D fortification.

C7: Examples: **Glanbia: (i)** Benefits of Vitamin D; and, (ii) Vitamin D and Immunity. **Kellogg:** Kellogg ramps up Vitamin D to Address Health Needs.

C8: Testimonial and information leaflet from Head of Performance Nutrition, Sports Ireland Institute.