

Institution: London Metropolitan University		
Unit of Assessment: UoA3 Allied Health Professions, Dentistry, Nursing and Pharmacy		
Title of case study: Fish consumption and fish oil supplementation rectified vitamin D and omega 3 fatty acid deficiency in Omani school children.		
Period when the underpinning research was undertaken: 2012 - 2016		
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:
Kebreab Ghebremeskel	Professor	1996 – Present
Yoeju Min	Senior Research Fellow	2006 – Present
Izzeldin Hussein	Research Fellow	2013 - 2015
Period when the claimed impact occurred: 2013 - 2020		
Is this case study continued from a case study submitted in 2014? NO		

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

The findings of this open-label randomised study, which investigated nutritional status and physical fitness of Omani school children, have:

- (1) Improved school nutrition information and advice for parents, school principals and teachers, and health professionals;
- (2) Changed nutrition, and physical activity practices of schools;
- (3) Led to the Oman national nutrition survey; and
- (4) Informed the recommendations of the fortification consultant commissioned by UNICEF Oman to assess food enrichment programmes in the country.

2. Underpinning research (indicative maximum 500 words)

Background - Non-communicable diseases (NCDs) - cardiovascular diseases, diabetes, cancer and respiratory diseases - account for more than 60% of the global disease burden and mortality. Over 50% of annual deaths in the Arabian countries, including Oman, are due to NCDs. Obesity, which is an antecedent of NCDs, has reached epidemic proportions in the region primarily due to the adoption of Western dietary habits and lifestyle. These diseases do not occur suddenly but develop gradually over time. Epidemiological and post-mortem studies demonstrate that atherosclerosis begins in early life and is manifested clinically in adulthood. Consequently, various national and international committees on NCDs have recommended that children and young adults have to be an integral part of action plans for prevention and control of the diseases.

We investigated the beneficial effects of intervention with fish oil or oily fish on micronutrient status, cognitive abilities and physical fitness of Omani school children.

Study protocol – Three schools which jointly accommodate 2700 pupils, aged 6 to 12, were selected randomly from Muscat Governorate, Sultanate of Oman. They were randomised into intervention (“oily fish”, “fish oil”) or control arm of the study. Three hundred twenty-eight (151 boys & 177 girls) children, 10% of the 9 & 10-year-old pupils in Muscat, were recruited from the schools with parental consent. The children from the intervention schools were given oily fish or fish oil capsules during lunch-time five days a week for three months under the supervision of their

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teachers to ensure full compliance. The control school children did not receive anything. Body composition, nutritional intake, blood biochemistry, cognitive function and physical fitness were assessed at baseline and the end of the intervention period.

Findings that led to the Impact

- A significant number of the children had low levels of vitamin D (n=225, 68.6%; R1 & R6) and omega-3 fatty acids (n=177, 54.0%; R2 & R6) and they were physically inactive (n=274, 83.5%; R3 & R6). 29 (8.8%, R4) of the children had attention deficit hyperactivity disorder (ADHD). These findings were disconcerting because: (1) Physical inactivity is positively associated with obesity risk. (2) Vitamin D and omega 3 fatty acids play a vital role in cognitive and immune system function and prevention of non-communicable chronic diseases.
- Oily fish consumption or fish oil supplementation rectified vitamin D and omega-3 fatty acid deficiencies (R1 & R6)
- Both oily fish and fish oil enhanced the cognitive abilities of the children (R5).
- The supervised exercise programme was effective in improving physical fitness (R6).

Investigators – Professor K Ghebremeskel (*Principal Investigator and Grant Holder*), Dr Yoeju Min (*co-investigator*), Ministry of Agriculture and Fisheries, Ministry of Education and Ministry of Health, Sultanate of Oman, and The Iodine Global Network (Formerly ICCIDD), Middle East (*Collaborators*). The research proposal was conceived, written and implemented by K Ghebremeskel, Y Min, IS Hussein and S Al Ghannami (Ministry of Health, Muscat, Sultanate of Oman).

Funding Body - Ministry of Agriculture and Fisheries Wealth, Sultanate of Oman (The 8th Five Year Development Plan), The Iodine Global Network (Formerly ICCIDD) and Efamol Ltd., UK.

Study design and registration - Open-label randomised study, registration number ISRCTN93233285.

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

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- R1. Al-Ghannami S, Sedlak E, Hussein IS, Min Y, Al-Shammkhi SM, Al-Oufi HS, Al-Mazroui A and Ghebremeskel K (2016) Vitamin D deficiency is prevalent in healthy Omani school children: Omega-3 fatty acids have a mitigating effect. *Nutrition – International Journal of Applied and Basic Nutrition* 32:73-78 (IF 3.42). doi: 10.1016/j.nut.2015.07.014
- R2. Al-Ghannami SS, Min Y, Sedlak E, Hussein IS, Al-Shammkhi SM, Al-Oufi HS, Al-Mazroui A and Ghebremeskel K (2018) Red Blood Cell Fatty Acid Profile of Oman Preadolescent School Children Before and After Intervention with Docosahexaenoic Acid Enriched Omega 3 Capsules or Oily Fish. *Prostaglandins, Leukotrienes and Essential Fatty Acids* 135:74-82. (IF 2.86). doi: 10.1016/j.plefa.2018.07.005.
- R3. Delextrat A, Hayes L, Al Ghannami SS, Min Y, Hussein I, Al Oufi H, Cohen DD and Ghebremeskel K (2018) Physical fitness characteristics of Omani primary school children according to body mass index. *J Sports Med Phys Fitness* 59(3):440-448. doi: 10.23736/S0022-4707.18.08136-7.
- R4. Al-Ghannami SS, Al-Adawi S, Ghebremeskel K, Cramer NT, Hussein IS, Min Y, Jeyaseelan L, Al-Sibani N, Al-Shammakhi SM, Al-Mamary F (2018) Attention Deficit Hyperactivity Disorder and Parental Factors in School Children Aged Nine to Ten Years in Urban Regions of Oman. *Oman Medical Journal* 33(3):193-199. doi: 10.5001/omj.2018.37.

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R5. Al-Ghannami SS, Al-Adawi S, Ghebremeskel K, Hussein S, Min Y, Jeyaseelan L, Saleh M. Al-Shammakhi S, Mabry RM and Al Oufi HS (2019) Randomised open-label trial of docosahexaenoic acid-enriched fish oil and fish meal on cognitive and behavioural functioning in Omani children. *Nutrition – International Journal of Basic and Applied Nutrition* 57:167-172 (IF 3.42). doi: 10.1016/j.nut.2018.04.008.

R6. Ghebremeskel K, et al (2014) The effect of fish consumption, fish oil supplementation and physical exercise on body composition, blood biochemistry, cognitive function and fitness of Omani school children (*Invited Opening Lecture*), *International Conference on Seafood Safety, Quality and Traceability Systems, Muscat, Oman, (March 5, 2014)*.

Research grants and amounts

- Ministry of Agriculture and Fisheries Wealth, Sultanate of Oman (The 8th Five Year Development Plan) - GBP192,830 (*Grant Holder, K Ghebremeskel*)
- International Council for Control of Iodine Deficiency Disorder – Gulf Regional Office - GBP30,000 (*Grant Holder, K Ghebremeskel*)
- Efamol UK (100,000 High DHA Fish Oil Domino capsules) – Retail price GBP10,620 (*Grant Holder, K Ghebremeskel*)

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

Prof Ghebremeskel and Dr Min's rigorously conducted study for the first time demonstrated a high prevalence of vitamin D and omega-3 fatty acid deficiency and physical inactivity in Omani school children aged 9 and 10 years. Their findings led directly to

- (1) improvements in school nutrition information and advice for parents, school principals and administrators and health professionals;
- (2) changed nutrition and physical activity practices of schools;
- (3) the implementation of the Oman national nutrition survey; and
- (4) informed the recommendations of the fortification consultant commissioned by UNICEF Oman to assess food enrichment programme, [S3].

School nutrition information and advice – As a result of the research conducted by Ghebremeskel et al, Dr Samia Al Ghannami, Director of Nutrition in the Ministry of Health of Oman, and her team introduced and are continuing to deliver nutrition education and advice to schools, parents and school food suppliers through multiple platforms - face-to-face meetings, newspapers and radio, [S2]. The purpose of the nutrition education programme is to:

- (1) Provide comprehensive information on the prevalence of vitamin D, omega 3 fatty acids, iron and other micro-nutrient deficiency in Omani school children and its adverse health consequences,
- (2) Educate parents and other stakeholders about the dietary sources of the aforementioned nutrients,
- (3) Influence positively parental attitude on nutritional and food selection behaviour of their children.

The newspaper and radio nutrition programmes introduced in 2018 have nationwide (Oman-wide)

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reach and impact. Since 2018, Dr Al Ghannami and her colleagues have delivered monthly face-to-face nutrition and health education sessions. Each session is aimed at children and parents of a class with an average size of 30 children. Over the three years to June 2020, 1440 children and their parents have been educated on a healthy and balanced diet and the adverse effects of nutrient deficiency on growth and development, and behaviour and cognitive ability. [S3]

Nutrition and physical activity practices of schools – In 2018, the three schools which participated in the study, after receiving feedback, advice and guidance based on the research findings from Dr Al Ghannami and her team, started to provide a fresh, healthy and nutrient-rich meals, which include fish, vegetables and fruits, during the mid-morning break five days a week for children aged 6 to 10 years (n=950). They have also instituted a regular supervised physical activity programme during school days for children aged 9 and 10 (n=400). [S2]

Oman national nutrition survey (2017) – Ghebremeskel and Min's research findings revealing vitamin D, omega-3 fatty acid and iron deficiency in school children in Muscat informed the Ministry of Health of Oman's decision to conduct further studies and evaluations of nutritional deficiencies amongst its population. Their findings, as Dr Salima Al Mamary, Director of Nutrition Department, noted, specifically provided a piece of strong evidence for the Ministry to conduct a national survey on the micronutrient status of children and women of childbearing age to find out if the deficiency is apparent in different age population groups. Subsequently, the Nutrition Department, Ministry of Health Sultanate of Oman, surveyed 1677 babies and infants 6 to 59 months of age and 1749 women of childbearing age. The sample sizes constitute about 15% of their respective population groups. The findings of the Ministry's survey, which was led by Dr Samia Al Ghannami and her team in collaboration with Professor K Ghebremeskel were "consistent with the findings of the study by Ghebremeskel and Min, revealing" a vitamin D deficiency in 10% of the children and insufficiency in 54%, [S3]. As a result of the survey and Ghebremeskel and Min's findings, the Ministry of Health in conjunction with UNICEF Oman "commissioned the fortification Consultant to evaluate [both] the findings of [Ghebremeskel and Min's research] and the Omani Nutrition Survey and to provide recommendations on the feasibility of [a] fortification programme" [S3].

Recommendations of the UNICEF commissioned fortification consultant (2018): After evaluating the findings of Ghebremeskel and Min's research, which identified deficiencies in vitamin D omega 3 fatty acids in school children, and the subsequent Oman National Nutrition Survey, the UNICEF consultant concurred with Ghebremeskel and Min's recommendations [S1] that vitamin D should be included in the fortification programme for staple foods including milk and cooking oils consumed by adults and children in the country to help alleviate the deficiency of the nutrient. In 2019, the World Bank estimated Oman's population to be 4.9 million people. Dr Mamary of the Ministry of Health's Nutrition Department confirmed that in 2020 Ghebremeskel and Min's recommendation is being implemented across Oman [S3].

Oman's economic development and self-sufficiency were explicitly linked to the health of its population at *The International Conference on Seafood Safety, Quality and Traceability Systems* in Muscat in March 2014. At the conference, co-sponsored by the regional office of the UN's Food and Agriculture Organization (FAO), the government's investment in the fishing sector and the importance of safe and healthy products for domestic markets were highlighted by Dr Hamed bin Said al Oufi, Under-Secretary, Ministry of Agriculture and Fisheries.[S4] He pledged to increase the number of fishing ports in the country by 10 by 2020 and "ensure the provision of safe and healthy products for human consumption in domestic markets". The need for accessible supply of fish to support the health of the population was affirmed by the inclusion at the conference of Prof

Ghebremeskel's keynote presentation of the research findings.[S5]

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

- S1. London Metropolitan University Research Report to Ministry of Agriculture and Fisheries of Oman
- S2. Testimonial letter Dr Halima Al Ghannami, Acting Director, School Health Department, Ministry of Health, Sultanate of Oman
- S3. Testimonial letter Dr Salima Al Mamary, Director, Nutrition Department, Ministry of Health, Sultanate of Oman
- S4. 'Oman – International Conference on Seafood Safety and Quality and Tracking Systems Commences' neareast.fao.org 3 March 2014
- S5. 'Country to have 21 fishing ports and harbours by 2020' Hasan Kamoopuri, Oman Daily Observer 3 March 2014