On Optimization of Personalized Fish Intake Recommendations

Dietary recommendations are more effective on behavioral change than population-based advice. Personalized advice can account for an individual’s preferences, needs, beliefs, behaviors, and objectives, whereby they may be perceived as more relevant, motivational, and achievable by the individual. The aim of this thesis was to develop methods for generating foodbased personalized dietary advice. We applied mathematical optimization techniques to account for individual food consumption preferences and beneficial and adverse effects of specific food intakes, using fish in Denmark as a case study. Mathematical optimization involves finding the minimum of an objective function subject to a set of constraints. In this thesis, we developed a Quadratic Programming (QP) model that accounts for personal preference by minimizing the deviation from observed individual intake. To account for potential beneficial and adverse effects of fish consumption, we defined constraints in terms of minimal nutrient requirements and maximum contaminant levels. The model constraints ensure that the generated fish intake advice meets recommendations for Eicosapentaenoic Acid (EPA), Docosahexaenoic Acid (DHA), and vitamin D without violating tolerable intake recommendations for methyl mercury, dioxins, and dioxin-like Polychlorinated Biphenyls (dl-PCBs). Since other sources than fish may provide these nutrients and contaminants, the model constraints were adjusted according to such background exposure. We also expanded the model to account for cost of fish by minimizing deviation from personal preference and cost simultaneously, with different relative importance of the cost and the preference. This approach enables the generation of individual optimal trade-off curves between deviation from personal fish preference and cost of fish.

The QP model was applied to generate personalized fish intake recommendations for 3016 Danish adults, whose current fish intakes and body weights were recorded in a national dietary survey. About half of the individuals in the study population had an observed intake lower than the nutrient constraints allowed. These individuals should be recommended to increase their fish intake. Few individuals, just 2%, had an observed fish intake that exceeded the contaminant constraints and should be recommended to decrease fish intake. The remaining individuals had an observed fish intake that fulfilled the recommendations for the nutrients and contaminants, and should therefore be suggested to maintain their current fish consumption. The personalized fish intake recommendations were sensitive to the variation in background exposure to the nutrients and contaminants. Hence, including individual intake data for background exposure is important for generating the best recommendations. On the basis of nutrients and contaminants included in the model, the Danish official recommendation for fish is expected to be healthy and not harmful. However, our results also suggest that this recommendation for fish requires larger behavior changes than necessary, in order for the individuals to meet the recommendations for EPA+DHA and vitamin D. Personal optimal trade-off curves between preference and cost of fish intake were generated for the individuals in the study population. These show trade-off curves how much the individuals have to deviate from fish intake preference in order to reduce the cost. When only minimizing the cost, the vast majority of the study population should be recommended to only consume herring. This is an unrealistic recommendation for several reasons, and this result indicates how the model may generate unrealistic results when current dietary patterns are not considered. Thanks to the multidimensional property of optimization techniques, the models developed in this thesis can integrate information on health related limit values to generate personalized dietary fish intake recommendations that deviate as little as possible from individual observed fish intake. Such recommendations may be perceived as more acceptable by individuals as compared to advice that deviates more from personal preferences, which may increase the compliance to the recommendations. Furthermore, it may be appropriate to expand the model to minimize the deviation from preference and cost simultaneously, since both factors may affect consumer’s choice. However, further investigation on the relative importance of the cost is needed, as this is a subjective consumer choice. The models can be applied for other or additional foods than fish, or whole diets if desired. The models can be expanded to include constraints based on evidence on health effects associated with the whole foods, in addition to constraints on nutrients and contaminant recommendations. In the future, the methods of this thesis can be applied in the personal communication of healthy and safe food recommendations that fit the preferences of individual consumers. Applications in real-life settings require further research, in terms of implementation of the models, communication of the advice, and follow-up. The models may also be useful for providing evidence for the development of population-based FBDGs, especially regarding consumer acceptability. A future challenge is to extend the models to include additional dimensions of diet sustainability, such as environmental impact.

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