Author’s response to reviews

Title: Evidence on the magnitude of the economic, health and population effects of palm cooking oil consumption: An integrated modelling approach with Thailand as a case study

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We thank the reviewers for their helpful comments and suggestions. We have endeavoured to implement all suggestions and to answer all questions and agree that the revisions suggested have made improvements to the paper. We hope that these changes will prove acceptable. We have also included a supplementary file with this submission which shows tracked changes of all edits to the paper since the original submission. Our responses to reviewer comments follow.
[Reviewer #1: Please clarify the following]

1. The changes in the ratios of fatty acids consumed are translated to changes in total-to-HDL cholesterol ratio using parameters from the literature —In the reference used here, there were no significant changes in the Total C/HDL ratio when palmitic acid was replaced. Since the biggest culprit in atherogenicity of palm oil is palmitic acid, were these the right parameters to input into the model?

   **The paper highlights longitudinal evidence which shows particular benefits from replacement of palmitic acid (Zong et al, BMJ 2016) but Mensink is the basis for our health calculations in part because we felt it was more conservative and robust to proceed through the total-to-HDL cholesterol ratio given that the more experimental evidence as opposed to long-term observational evidence favours the total/HDL cholesterol-affecting pathway as more mechanistic whereas the palmitic acid aspects may be more from observational selection bias.**

2. What is the percentage of contribution of vegetable oils as SFA in the daily energy intake? Does this also have a geographical variation in Thailand that may affect the disease burden?

   **The data used in our model, taken from the TNSO household survey indicate that, on average, vegetable oils contribute approximately 14% of the SFA in daily energy intake and this does vary (from 11% to 19%) by region and urban/rural area. However, the strongest evidence relating to health effects from consumption of fatty acids, upon which our health model is based, concentrates on the consumption ratio of SFA to PUFA and MUFA rather than the overall SFA consumption and this ratio also varies by region. We have added a line to the results section of the paper which states the SFA contribution of vegetable oils before our explanation of the importance of the ratio of fatty acids as follows (line 340):

   “Vegetable oils contribute, on average, approximately 14% of Thai daily SFA energy intake, with variation (from 11% to 19%) by region and urban/rural area (not shown). The changes in disease burdens are driven by the increased consumption share of PUFA….**

3. Why is the consumption of palm oil for cooking favoured in the regions that produces it? I believe that commercialisation of the food industry is able to reach the entire Thailand. Differences in consumption across the regions could also be due to the different dietary patterns across the different regions?]
This is an interesting question. Our consumption data do show that palm oil consumption is highest in the areas which produce it. One explanation for this is that, whilst palm oil is readily available throughout Thailand, alternative oils are less competitive and less available in areas where there is an abundance of directly supplied locally produced palm oil. However, there is a more general theory that a combination of habit persistence and initial comparative advantage granted by agro-climatic endowments helps explain why consumption is often seen to mirror production, despite the expansion of trade. This general theory is described in David Atkin’s paper in the American Economic Review on trade and nutrition: https://www.aeaweb.org/articles?id=10.1257/aer.103.5.1629

[Reviewer #2:

Keogh-Brown et al report an integrated complex modelling exercise in Thailand to determine the health and economic impact of substituting palm oil using demographic, nutrition, and health surveys. The approach is interesting as it aims to combine macroeconomic model of change in nutrition to change in lipids to individuals within the household levels, and effect on adverse clinical outcomes (MI, stroke, and related deaths) over 20 years. Direct costs of hospitalizations, patients' time out of work and caregiver time are projected.

Overall, the approach is interesting. The authors acknowledge the limitation that it lacks practical application as no "method" and related costs for the substitution of palm oil were accounted for. Thus, how much of their results can actually be translated remains unknown, and the work is a purely academic exercise, which is OK. It may stimulate a discussion on controlling palm oil production which continues to increase in many Southeast Asian LMICs.

We thank the reviewer for their helpful summary and observations. We would suggest that our macroeconomic disease burden calculations are useful as a macroeconomic measure of the disease burden attributable to palm oil. Very often, estimates of the economic cost of disease burdens take a societal perspective allocating unit costs to individuals who suffer from a particular illness and scaling up by the population who are affected. This does not provide a true macroeconomic valuation of the economic cost and spillover effects in the way which our Computable General Equilibrium model does. In the case of palm oil, neither societal or macroeconomic disease burden estimates are available. Substitution has been excluded in order to isolate the disease burden attributable to palm oil from the (unspecified) method to achieve it, but the general equilibrium effects of the palm cooking oil burden are captured for the “pure health” rather than “policy” impact.**
[However, I have the following concerns:

1. First, in terms of a comprehensive model accounting for the macroeconomic effects of labor, one would assume that the full market effect of palm oil on national economy (GDP) of Thailand would be accounted for. Clearly this is not the case in the study as it does not account for reduced production (and thus any potential effect on export/trade deficits). This needs to be discussed under limitations of a "comprehensive model".

**We thank the reviewer for this comment. In our submitted manuscript we alluded to the absence of broader economic impacts from our disease burden focus “One further limitation of the results presented is that the disease burden focus in this application omits the broader economic and environmental impacts which could be produced with the simulation framework”.

In addition to this, we have now drawn out this distinction more explicitly at the end of the results section by stating (line 440) ………

One further limitation of the results, presented, is that the ‘total disease burden’ scenario specification, in this application, does not produce the broader economic and environmental impacts, which are likely to result from changes in oil palm production patterns. These impacts could be captured if a policy instrument was employed in the simulation. Policy analysis is a strength of the CGE framework, and an example of reducing palm oil consumption using a sales tax has been published elsewhere [48]. However, whilst the substitution effects within an equilibrium model ensure realistic policy simulations, they contaminate estimation of the pure disease burden effect, which is the focus of this study.**

[2. Please provide details of the simulations done for each of the sub- models. How many times were the data replicated?]  

**The health-sub model in our integrated framework, from which the lookup tables were produced, created 10,000 simulated individuals by sampling from normal distributions based on the mean and standard deviation of total/HDL cholesterol ratio from the cohort in the Thai-HES survey. This has been added to the paper in the “model integration” sub-section as follows (line 253):

“The clinical health lookup tables were derived from a simulated cohort of 10,000 individuals for whom the mean and standard deviation of total/HDL cholesterol ratio were taken from the Thai National Health Examination Survey. The health model, adapted for this purpose, has been previously published [6] and is used to translate changes in total-to-HDL cholesterol ratios into incidence and mortality rates for MI and stroke.”

The Demographic and economic models are not stochastic but are calibrated based on real data. The demographic module utilises a set of 2010-35 Thai regional population projections from the
National Economic and Social Development Board together with the 2015 revision of UN population projections (UN 2015). The economic model is parameterised based on a palm-oil focussed Social Accounting Matrix obtained from the NESDB and this is outlined in the paper (line 221 and appendix page A2 “Demographics” sub-section).

In view of the additional comments below we feel that it might be helpful to explain here the deterministic nature of the CGE model since some of the reviewer’s comments relate to including uncertainty in the estimates. Our fully integrated framework consists of more than 50,000 equations and more than 50,000 variables. The model is initially calibrated with real data and, then the model is shocked to reflect the nutrient matching simulation and a new equilibrium solution is found. Whilst it is possible to vary parameters, assumptions and shocks, our parameters are not statistically estimated and therefore formal confidence intervals for most parameters are not readily available. However, in response to the reviewer’s request we have implemented a Monte Carlo simulation of the key health model (Mensink et. al) parameters in order to estimate upper and lower bounds. This methodology has been briefly explained in the paper in the final paragraph of the methods section (line 305). **

[3. Please label the units table 1. Please report 95% CI for the estimates from the simulation results. What is meant by "cooking oil burden" in table 1? What do the numbers in column 2 reflect? Please clarify.]

**Thank you for this helpful suggestion. The units (mn USD) or (1000s) for clinical incidence, deaths and life years are given in column 1 of table 1. The column title mentioned has been re-labelled “MI/Stroke burdens from palm cooking oil”. The numbers in this table are elucidated in the paragraphs following the table. First the total burden results (line 323) and then, under the “Nutrient Matching Results” header, we explain (line 337) that “incidence of MI and stroke would be expected to decline by 8,280 and 2,639 cases, respectively, and cumulative MI and stroke deaths by 4,683 and 894, respectively, if an aggregate of other oils could be introduced, in a costless way, to replace household consumption of palm cooking oil over our 20 year time horizon....”

We hope that this answers the reviewer’s question, if further clarification is required or more detailed explanation of these results, we would be happy to provide it.

In addition, we have added upper and lower bound confidence intervals for the “MI/Stroke burdens from palm cooking oil” and percentage of total columns of the table 1 results. These are also commented on in the text (line 380). **
[4. For Fig B1 (dynamic trajectory total disease burden) in appendix- provide 95% CI, and include in the main paper. Clarify "Change in real consumption (of what?)" Label the y-axis, provide units.]

**We thank the reviewer for this suggestion. The dynamic plots for health and economic disease burdens have been brought into the main paper, 95% confidence intervals have also been introduced and both the central values (line 367) and sensitivity results (line 381) have been commented on in the results section. The units have also been provided in the vertical axis titles of the plots. Our model includes fully specified private demand systems for nine representative households, and our measure of real (private) consumption therefore encompasses all Thai consumption items, including agricultural and processed foods, manufactures, and all types of services including medical services. The change in real consumption is measured relative to our counterfactual growth path over our 2016-2035 simulation horizon. A brief explanation of this has been added in the paper towards the end of the results section (line 371).**

[5. How were economic effects of MI/stroke computed? How is the figure US 70billion (line 367) arrived at? Was 308m potential saving over 20 years from palm oil substitution for other oils based on direct cost of hospitalization? Include detailed description of the economic modelling (assumptions) in the appendix.]

**The clinical health lookup tables in our integrated model framework translate changes in total-to-HDL cholesterol ratio into changes in incidence and excess (rather than total) mortality rates for MI and stroke. By this means, it was possible to estimate the total excess health burdens from MI/stroke as well as those that correspond to our nutrient matching scenario, this has been further clarified at the end of the methods section (line 298).

The economic impacts corresponding to the MI/stroke are attributable to both healthcare unit cost and labour market feedback effects. We have made an additional mention of this at the end of the methods section (line 300) and referred the reader to an additional explanation on the modelling of healthcare unit costs, which has been added to appendix A. Mention is also made of how the health related economic impacts are estimated via productive labour supply and healthcare costs in various sections including the “modelling health related disease burden”, “macroeconomic modelling component”, “model integration” and “model scenario” sections.

Extensive (79 page) documentation of the IFPRI standard economic model, its assumptions, equations and variables is published elsewhere but was not referenced in the original submission, this reference has now been included in the “Macroeconomic Modelling Component” subsection of the paper (line 205) and documentation of the health and nutritional model integration was also referenced in that sub-section (line 229).**
We thank the reviewer for this suggestion. The introduction section has been reduced by almost 1000 words. It remains slightly more than 50% of the original size but we felt that the information currently contained in the introduction was necessary to highlight the various different perspectives which feed into this holistic modelling and to establish the value of the approach and to provide a sufficiently strong justification of the health evidence which has been the subject of some controversy.**