

## PEER REVIEW HISTORY

BMJ Open publishes all reviews undertaken for accepted manuscripts. Reviewers are asked to complete a checklist review form (<http://bmjopen.bmj.com/site/about/resources/checklist.pdf>) and are provided with free text boxes to elaborate on their assessment. These free text comments are reproduced below.

This paper was submitted to a another journal from BMJ but declined for publication following peer review. The authors addressed the reviewers' comments and submitted the revised paper to BMJ Open. The paper was subsequently accepted for publication at BMJ Open.

(This paper received three reviews from its previous journal but only two reviewers agreed to published their review.)

### ARTICLE DETAILS

<b>TITLE (PROVISIONAL)</b>	Global sustainability (health, environment, and monetary costs) of three dietary patterns: results from a Spanish cohort (the SUN project).
<b>AUTHORS</b>	Fresán, Ujué; Martínez-González, Miguel; Sabate, J.; BesRastrollo, Maira

### VERSION 1 – REVIEW

<b>REVIEWER</b>	LAIRON Denis past: NORT Joint Research Laboratory, Inserm,Inra, Aix-marseille University, Marseille, France present : C2VN Joint Research Laboratory, Inserm,Inra, Aix-marseille University, Marseille, France
<b>REVIEW RETURNED</b>	12-Mar-2018

<b>GENERAL COMMENTS</b>	<p>General comment</p> <p>The manuscript reports a really interesting and original study based on a large prospective cohort of young adults/university graduates in Spain. The aim was to evaluate the sustainability potential of three discriminated dietary patterns ie the Western pattern, the Mediterranean diet pattern and the pro-vegetarian pattern. A composite sustainability index was constructed based on 10y NCDisease rates, some environment impacts and the retailed cost of consumed foods in the diet. Overall, the methods used seem appropriate, the results are well presented while the discussion can be somewhat extended. Detailed comments are found below to stress more specific points.</p> <p>Detailed comments</p> <p>Introduction.</p> <p>P4 L12 among other should rather be among others; “price” has not been used in the 2010 FAO definition, but in fact rather affordability (and accessibility): this definition should be cited (FAO 2012, Sustainable diets and biodiversity against hunger, conference proceedings) instead the paper referenced 5 as present.</p> <p>The present introduction is very concise : for non experts in this field, it should be important to better summarize in the introduction the key aspects of the three patterns and they already known key impacts on various aspects.</p> <p>Methods.</p> <p>I did not found the Trial registration references</p>
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P5 L35 : “pVD” should be developed for this first citation in the full text ?

P7 L25 : 10y follow up seems really relevant but can RAP relevance for the health outcomes selected in a young people cohort be questioned ? Possible imitations due to such criterion should be discussed.

P8 L13 : ref 23 by the authors refers to an “in press” paper: this does not allow the reader to evaluate in details the modes of calculation used that are presented “in brief” only: needs some extension, including sources of estimated food impacts used. L14 : the unit used for impact assessment is “serving” : because daily quantities are mostly used in Europe and publications, it would be worthwhile for the reader that the quantities (g) of main foods/food groups of related servings are given too.

P8 L37 : “price” or “Food cost”: given this work aims at fortunately embracing various aspects of diet patterns, wording about “price” should be more carefully used. Indeed, the cost of purchase of a food item is only a part of the actual cost of a food that includes all externalized expenses linked to life cycle and side effects of production until home consumption, plus health and environment impacts. I suggest to rather use the more precise term “purchase cost” or similar (retail price, monetary cost, ...) to clearly state that the “price” or “cost” referred in this work is the amount payed during purchase only. This should be expressed/discussed too in the discussion section, because consideration of the actual full cost of diets is a clear challenge of sustainability evaluation (a recent paper (Schepers and Annemans, Nutrition, 2018) has provided calculations of the potential health and economic costs of some dietary habits)

P9 L2-24 : in the composite sustainability index, health and environment items seem considered appropriately but only qualitatively ie the amplitude of the various effects do not seem to be taken into account., this could limit the interpretability of the impacts reported. Regarding the daily “purchase” cost of food, the relevance of this item as part of the sustainability index can be discussed : at first look a lower purchase price could be viewed as better for people with limited income but it is not obviously the life-style choice of all people (more and more people are focusing on food quality). Considering that the “cheapest one” is the best in term of sustainability really needs question and raises controversial debates: searching for reducing the purchase cost of food for decades resulted in a food system with many very severe adverse effects on farmers number and conditions, soil erosion, water use, water and air pollutions, loss of biodiversity, eco-toxicity, ultra-processing and fast/junk foods, low nutrition quality and health status (NCDs), etc. Unfortunately, the actual overall cost of a food/diet is not yet available. The purchase cost of food thus seems to be a criterion to be used very carefully and one would appreciate having also a sustainability index without the cost item for purpose of comparison and discussion, given the true actual cost of a food is not yet available..

#### Results

P13 L5 : while RAP can be seen as a very interesting indicator the reader would greatly appreciate having the detailed data of the 10y impacts of the 3 patterns on the rates (cases/n ; %) of the specific health items making the overall health score : could be added in the Supplemental file.

	<p>Discussion</p> <p>The two first sentences of the discussion clearly highlight the point raised above regarding the true significance of “price”: the observed reduction in the 10y disease outcomes and thus associated economic costs can be considered as a sustainable benefit too, not only considering the retail price paid by the consumer which is also a citizen! But the discussion only focuses on the extra purchase cost of the healthiest diets (about 1.4 €/d). I guess that some costs of main diseases in Spain are available as in some other countries that could reinforce discussion on health/economic aspects.</p> <p>P15 L 37 : last sentence needs some editing.</p> <p>One observes a low amplitude of Q4s vs Q1s (Sup table 2) on overall sustainable diet index (maximum around 1 point /9 max) and max scores around 6-7 / 9 max: could the authors comment ? (effect of low mean age, low rate of adherence to MeD or pVD ?, etc ? . There should be potential much greater differences with integration of the true global cost of food patterns, and with inclusion of numerous other social or environmental impacts, can deserve more emphasis.</p> <p>Some few specific references about compared environment impacts of dietary patterns could be added. The differences or similarities between the MeD and the pVD food patterns as well as their various impacts could deserve some more emphasis (even if their overall sustainability indexes are comparable).</p> <p>Limitations ? : overall young age of cohort; cohort specific cut-offs for adherence to Med diet or Western diet; no calculations of cost impacts of NC disease appearances after 10y.; possible impact/confounding by ultra-processed foods present in the dietary patterns.</p> <p>Conclusion, last sentence: “highly recognized health benefits” ...and eco-friendliness ...</p>
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<b>REVIEWER</b>	Kristina Petersen Penn State University, USA
<b>REVIEW RETURNED</b>	07-May-2018

<b>GENERAL COMMENTS</b>	<p>This paper presents novel analyses examining the sustainability, in terms of health outcomes, cost and environment footprint, of three dietary patterns in a Spanish cohort of university graduates. Overall the research question is interesting and the analyses conducted are appropriate. The manuscript would benefit from editing for English language. Specific comments are as follows:</p> <p>Abstract Design: you need to describe the study as a prospective cohort study of university graduates.</p> <p>Introduction Line 6, Sentence 1: this sentence needs to be revised. See the following paper for reasons why the field of nutrition is moving towards evaluating diet patterns: Adv Nutr. 2016 May 16;7(3):445-54. doi: 10.3945/an.115.011718 Line 15: revise to state that an environment footprint is defined as...</p>
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## VERSION 1 – AUTHOR RESPONSE

### Reviewer: 1

Reviewer Name: LAIRON Denis

#### General comment

The manuscript reports a really interesting and original study based on a large prospective cohort of young adults/university graduates in Spain. The aim was to evaluate the sustainability potential of three discriminated dietary patterns ie the Western pattern, the Mediterranean diet pattern and the pro-vegetarian pattern. A composite sustainability index was constructed based on 10y NCDisease rates, some environment impacts and the retailed cost of consumed foods in the diet. Overall, the methods used seem appropriate, the results are well presented while the discussion can be somewhat extended. Detailed comments are found below to stress more specific points.

#### Detailed comments

##### Introduction.

P4 L12 among other should rather be among others; “price” has not been used in the 2010 FAO definition, but in fact rather affordability (and accessibility): this definition should be cited (FAO 2012, Sustainable diets and biodiversity against hunger, conference proceedings) instead the paper referenced 5 as present.

Thank you for these suggestions. We have changed the term other by others, price by affordability and have added the proceedings paper as the reference.

The present introduction is very concise : for non experts in this field, it should be important to better summarize in the introduction the key aspects of the three patterns and they already known key impacts on various aspects.

We have add some brief information about the three dietary patterns in the introduction section. We have reported that MeD and pVD are plant-based diets (no giving details about the differences among them as we paid more attention to the differences later on, in the discussion section according to one of your suggestions) and that the WDP is characterized by being rich in highly-processed and animal-based foods. According to this, we have commented on previous publications assessing these 3 dietary patterns, or their main food components (plant- or animal- derived products) according to health, environment and retail price.

##### Methods.

I did not found the Trial registration references

We have included the SUN cohort registration at clinicaltrials.gov in the new version of the manuscript.

P5 L35 : “pVD” should be developed for this first citation in the full text ?

Done.

P7 L25 : 10y follow up seems really relevant but can RAP relevance for the heath outcomes selected in a young people cohort be questioned ? Possible imitations due to such criterion should be discussed.

We have added this issue as a limitation, as you can see now in the new version of the manuscript. Nevertheless, although the mean age of the SUN cohort is relatively low and they are on average

young participants, we have a very high variability in terms of age. Our participants are between 18 and 91 years.

P8 L13 : ref 23 by the authors refers to an “in press” paper: this does not allow the reader to evaluate in details the modes of calculation used that are presented “in brief” only: needs some extension, including sources of estimated food impacts used.

Currently, the ref of Fresan et al. is available in Pubmed: PMID: 29380717. We have added the full information in the reference section. In addition, according to this and your following suggestions, we have rewritten this paragraph in order to clarify it.

L14 : the unit used for impact assessment is “serving” : because daily quantities are mostly used in Europe and publications, it would be worthwhile for the reader that the quantities (g) of main foods/food groups of related servings are given too.

We have rewritten this paragraph avoiding using the term “serving” because, as you mentioned, it is not clear. In fact, the original data were recorded according to 1kg of each food product, and then we estimated the value per serving of that commodity. Thus, the final version is

*In brief, the impact of the production of 1kg of each food product reported in the FFQ on resource use (land, water and energy) and GHG emission was assessed using secondary data. The impact on the environment of each participant was estimated considering the amount of every item consumed per day, and the specific value of each of them. Total use of land, water and energy, and GHG emission were calculated as the sum of all items values, obtaining the impact on these 4 footprints according to the daily food consumption of each participant.*

P8 L37 : “price” or “Food cost”: given this work aims at fortunately embracing various aspects of diet patterns, wording about “price” should be more carefully used. Indeed, the cost of purchase of a food item is only a part of the actual cost of a food that includes all externalized expenses linked to life cycle and side effects of production until home consumption, plus health and environment impacts. I suggest to rather use the more precise term “purchase cost” or similar (retail price, monetary cost, ...) to clearly state that the “price” or “cost” referred in this work is the amount payed during purchase only.

You are completely right and we agree with you. We have replaced the term “price” by “monetary cost” all along the manuscript, and also tables and figures.

This should be expressed/discussed too in the discussion section, because consideration of the actual full cost of diets is a clear challenge of sustainability evaluation (a recent paper (Schepers and Annemans, Nutrition, 2018) has provided calculations of the potential health and economic costs of some dietary habits)

We have mentioned this issue in the introduction and added a paragraph discussing about it.

P9 L2-24 : in the composite sustainability index, health and environment items seem considered appropriately but only qualitatively ie the amplitude of the various effects do not seem to be taken into account., this could limit the interpretability of the impacts reported.

We have reported it at the same time that commenting about the low amplitude between Q1 and Q4 according the overall sustainability index (in one of the following comments of the reviewer)

Regarding the daily “purchase” cost of food, the relevance of this item as part of the sustainability index can be discussed : at first look a lower purchase price could be viewed as better for people with limited income but it is not obviously the life-style choice of all people (more and more people are focusing on food quality). Considering that the “cheapest one” is the best in term of sustainability really needs question and raises controversial debates: searching for reducing the purchase cost of food for decades resulted in a food system with many very severe adverse effects on farmers number and conditions, soil erosion, water use, water and air pollutions, loss of biodiversity, eco-toxicity, ultra-processing and fast/junk foods, low nutrition quality and health status (NCDs), etc. Unfortunately, the actual overall cost of a food/diet is not yet available. The purchase cost of food thus seems to be a criterion to be used very carefully and one would appreciate having also a sustainability index without the cost item for purpose of comparison and discussion, given the true actual cost of a food is not yet available..

We have mentioned in the paragraph related to price in the introduction and discussion sections the potential lack of relevance of the monetary cost when assessing an overall sustainability of a diet, and highlighted the importance of take the full cost into account.

We rerun the analysis assessing the overall sustainability of the three dietary patterns without the cost item, and the main results even reinforce the benefits of following plant-based diets, in particular the MeD, as you could see in the following table.

<b>Western dietary pattern</b>				
	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>
Overall sustainable diet index (0-6 points)	3.88 (3.87, 3.90)	3.65 (3.64, 3.67)	3.40 (3.38, 3.42)	3.10 (3.08, 3.12)
<b>Mediterranean dietary pattern</b>				
	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>
Overall sustainable diet index (0-6 points)	3.04 (3.03, 3.06)	3.45 (3.43, 3.47)	3.70 (3.69, 3.72)	4.13 (4.11, 4.14)
<b>Provegetarian dietary pattern</b>				
	<b>Q1</b>	<b>Q2</b>	<b>Q3</b>	<b>Q4</b>
Overall sustainable diet index (0-6 points)	3.07 (3.06, 3.09)	3.41 (3.40, 3.43)	3.65 (3.64, 3.67)	3.96 (3.95, 3.98)

Adjusted for age, sex and total energy intake

## Results

P13 L5 : while RAP can be seen as a very interesting indicator the reader would greatly appreciate having the detailed data of the 10y impacts of the 3 patterns on the rates (cases/n ; %) of the specific health items making the overall health score : could be added in the Supplemental file.

We have added a sentence according to this suggested analysis in the method section, and reported the results in the supplemental table 2.

## Discussion

The two first sentences of the discussion clearly highlight the point raised above regarding the true significance of “price”: the observed reduction in the 10y disease outcomes and thus associated economic costs can be considered as a sustainable benefit too, not only considering the retail price paid by the consumer which is also a citizen! But the discussion only focuses on the extra purchase cost of the healthiest diets (about 1.4 €/d). I guess that some costs of main diseases in Spain are available as in some other countries that could reinforce discussion on health/economic aspects.

As previously mentioned, we have added a paragraph in the discussion section in order to reinforce the importance of taking into account a full perspective of the cost, and not just the retail price.

One observes a low amplitude of Q4s vs Q1s (Sup table 2) on overall sustainable diet index (maximum around 1 point /9 max) and max scores around 6-7 / 9 max: could the authors comment ? (effect of low mean age, low rate of adherence to MeD or pVD ?, etc ? . There should be potential much greater differences with integration of the true global cost of food patterns, and with inclusion of numerous other social or environmental impacts, can deserve more emphasis.

Thank you for your appreciation. We have added this information in the discussion section.

Some few specific references about compared environment impacts of dietary patterns could be added.

As you can appreciate in the new version of the manuscript, more references according to environmental sustainability of different dietary patterns have been added in the introduction and discussion sections.

The differences or similarities between the MeD and the pVD food patterns as well as their various impacts could deserve some more emphasis (even if their overall sustainability indexes are comparable).

We have mentioned it in the new version of the manuscript in the paragraph that reported that the MeD is a special type of pVD.

Limitations ? : overall young age of cohort; cohort specific cut-offs for adherence to Med diet or Western diet; no calculations of cost impacts of NC disease appearances after 10y.; possible impact/confounding by ultra-processed foods present in the dietary patterns.

We have reported all these limitations all along the discussion, and especially in the limitation section.

We have not added in the multivariable model the consumption of ultra-processed foods as a confounder because it is embodied in the fact of following a healthy or unhealthy diet.

Conclusion, last sentence: “highly recognized health benefits” ...and eco-friendliness ...

We have removed the term highly, and substituted eco-friendly by environmentally sustainable.

**Reviewer: 2**

Reviewer Name: Kristina Petersen

This paper presents novel analyses examining the sustainability, in terms of health outcomes, cost and environment footprint, of three dietary patterns in a Spanish cohort of university graduates. Overall the research question is interesting and the analyses conducted are appropriate. The manuscript would benefit from editing for English language. Specific comments are as follows:

**Abstract**

Design: you need to describe the study as a prospective cohort study of university graduates. We have added this information, according to your suggestion.

**Introduction**

Line 6, Sentence 1: this sentence needs to be revised. See the following paper for reasons why the field of nutrition is moving towards evaluating diet patterns: Adv Nutr. 2016 May 16;7(3):445-54. doi: 10.3945/an.115.011718

Thank you for your suggestion. We have added this information in the introduction.

Line 15: revise to state that an environment footprint is defined as...

We have added the definition of environmental footprint in the introduction, according to your suggestion.

**VERSION 2 – REVIEW**

<b>REVIEWER</b>	LAIRON Denis UMR INRA/1263 INSERM/Université d'Aix-Marseille "C2VN : Centre Cardio-Vasculaire et Nutrition de Marseille" France
<b>REVIEW RETURNED</b>	10-Jul-2018

<b>GENERAL COMMENTS</b>	<p>General comment</p> <p>I really appreciated the careful attention payed by the authors to my review of their manuscript and suggestions raised. Overall, they well addressed all the points I raised on their first manuscript with very limited exceptions. Thus, the revised R1 version fits almost all points raised before, as clearly highlighted in the marked version.</p> <p>I just have few detailed comments to raise :</p> <ul style="list-style-type: none"><li>- the authors did not really substantiated in details the content of the limitation due to the use of a young-age cohort, but fortunately they clearly stated this as a limitation for the interpretation and the generalization of the present data.</li><li>- On new P9, Line 3: in line with my question about servings, they have mentioned "secondary data"; me and the readers would have difficulties to understand the meaning of "secondary", please try to be more explicit here. Because it is very important to know for this study and also for purpose of comparisons, in addition to the useful new reference 33, it is necessary that the authors provide some minimal informations and references about the exact sources of data/calculations for environmental items (it is a new domain and with several sources</li></ul>
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	<p>and calculation options, that need to be clearly stated for sounded understanding).</p> <ul style="list-style-type: none"> <li>- The author's response regarding use of servings is fine (data obtained in kg of foods) but in Table 1, the data given are still only in servings, which does not allow the reader to get the true quantitative amounts of food consumed and will unfortunately make comparisons with other studies much limited. I thus suggest that either food data in Table 1 are presented in kg or g per day (the data are available) or in the case the authors would really like to keep servings data, to show both in table 1 if possible, or make a Supplementary Table to provide these food data in the unit not presented in Table 1.</li> <li>- I am co-author of a new publication in 2018 on a very close topic and approach (Climatic Change <a href="https://doi.org/10.1007/s10584-018-2195-1">https://doi.org/10.1007/s10584-018-2195-1</a>). The authors could like to look at them and evenly use for citation if/when suitable.</li> </ul>
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## VERSION 2 – AUTHOR RESPONSE

**Reviewer: 1**

**Reviewer Name: LAIRON Denis**

**Institution and Country: UMR INRA/1263 INSERM/Université d'Aix-Marseille, C2VN: Centre Cardio-Vasculaire et Nutrition de Marseille, France**

**Please state any competing interests or state 'None declared': None declared**

**Please leave your comments for the authors below**

**Review of R1 revised Manuscript bmjopen-2018-021541**

### **General comment**

**I really appreciated the careful attention payed by the authors to my review of their manuscript and suggestions raised. Overall, they well addressed all the points I raised on their first manuscript with very limited exceptions. Thus, the revised R1 version fits almost all points raised before, as clearly highlighted in the marked version.**

Thank you so much. The authors hope that this new version of the manuscript completely address your queries and nice suggestions, that we appreciate.

**I just have few detailed comments to raise :**

- **the authors did not really substantiated in details the content of the limitation due to the use of a young-age cohort, but fortunately they clearly stated this as a limitation for the interpretation and the generalization of the present data.**

We have further substantiated this fact with additional details, as a potential limitation of our cohort in the new version of the discussion to comply with your suggestion.

“Another potential limitation for the external validity of our results is the relatively young age of our cohort, that we acknowledge. The interquartile range for age was 27 to 45. Only 1.53 percent of participants in the cohort were older than 65 years at baseline. The percentage of women older than 65 years at baseline was especially low (0.5 percent). These limitations highlight the need for replication of our findings in other independent cohort with older age at baseline.”

- **On new P9, Line 3: in line with my question about servings, they have mentioned “secondary data”; me and the readers would have difficulties to understand the meaning of “secondary”, please try to be more explicit here. Because it is very important to know for this**

**study and also for purpose of comparisons, in addition to the useful new reference 33, it is necessary that the authors provide some minimal information and references about the exact sources of data/calculations for environmental items (it is a new domain and with several sources and calculation options, that need to be clearly stated for sounded understanding).**

We have reworded “secondary data” as “data previously reported by several institutions and/or research groups”. Furthermore, we have added a supplemental table where the main sources of data are shown. Finally, to provide further details about the calculations used for the environmental impact assessment, we have followed the same methods reported in the paper that you suggested *Seconda L, Baudry J, Allès B, et al. Comparing nutritional, economic, and environmental performances of diets according to their levels of greenhouse gas emissions. Climatic Change. 2018;148(1):155-172.*

The final version of the paragraph is as follows:

“Environmental footprints index was assessed as previously described by Fresan et al. [34] In brief, the impact of the production of 1 kg of each food product reported in the FFQ on resource use (land, water and energy) and GHG emission was assessed using data previously reported by several institutions and/or research groups. The main data sources of each environmental domain were collected in Supplemental table 3. Those foods that are composed by more than one ingredient were broken down into their main ingredients. The environmental impact of these composed foods were assessed as the sum of the footprints of their individual ingredients, taking into account the proportion of each of them, and the food losses. For example, we took in consideration that 600 g of wheat flour, 180 g of butter, 180 g of sugar and 70 g of eggs were assumed to be necessary to produce 1 kg of cookies. Finally, the environmental impacts embodied in the processing of the ingredients into the final food product were added to the ingredients’ production figures”.

**- The author’s response regarding use of servings is fine (data obtained in kg of foods) but in Table 1, the data given are still only in servings, which does not allow the reader to get the true quantitative amounts of food consumed and will unfortunately make comparisons with other studies much limited. I thus suggest that either food data in Table 1 are presented in kg or g per day (the data are available) or in the case the authors would really like to keep servings data, to show both in table 1 if possible, or make a Supplementary Table to provide these food data in the unit not presented in Table 1.**

According to the reviewer suggestion, the new version of the manuscript shows the food data in Table 1 in grams per day.

**- I am co-author of a new publication in 2018 on a very close topic and approach (Climatic Change <https://doi.org/10.1007/s10584-018-2195-1>). The authors could like to look at them and evenly use for citation if/when suitable.**

Thanks for this suggestion. This interesting and recent publication is perfectly suited to the aim of our manuscript. We added it as a new reference in the manuscript (reference number 20 in the new version of the manuscript). Additionally, it was useful for us to improve the reporting of the calculations we performed for the assessment of the environmental impact of the food products (see answer to your second comment).