

PEER REVIEW HISTORY

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ARTICLE DETAILS

TITLE (PROVISIONAL)	Projecting the prevalence of obesity in South Korea through 2040: a microsimulation modeling approach
AUTHORS	Jung, Yoon-Sun; Kim, Young-Eun; Go, Dun-Sol; Yoon, Seok-Jun

VERSION 1 – REVIEW

REVIEWER	Jin-Won Kwon KyungPook National University, South Korea
REVIEW RETURNED	24-Feb-2020

GENERAL COMMENTS	<p>Review Comments</p> <p>This study is meaningful to project the prevalence of obesity in order to set up the public health policy in the future. However, the results of this study show the different trends when considering the recent prevalence of obesity in South Korea. I strongly recommended the check the reason of the inconsistency, and I think that it is necessary to modify the model. There are specific comments as below.</p> <ul style="list-style-type: none">- This study mentioned that Population Health Model (POHEM)-BMI was developed by Canada. I am wondering whether this model can be used for South Korea. The generalizability of this model should be addressed in the method section.- This study used Korea Health Panel Data. As far as I know, self-reported BMI was collected in this data. As indicated in this study, the BMI was calculated by the measurement of weight and height in Korea National Health and Nutrition Examination Survey (KNHNES). I don't understand why the author used the Korea Health Data instead of KNHNES. The reason should be mentioned in this study.- The main drawback of the study is the inaccuracy of the predictions. According to the data from KNHNES, the prevalence of obesity was reported by 2017 as below. The prevalence of obesity (>25 of BMI) was increasing. As far as I know, the prevalence of obesity class II/III was also increasing even though the absolute percent was much lower than western society. However, this study predicted the prevalence of obesity was decreasing, and there were very few populations with obesity class II/III. This is not consistent with the recent trend of obesity in Korea. There is a strong doubt as to whether these predictions are adequately calculated. The adequacy of the parameters used in the model should be reconfirmed and adjusted.- The prevalence of obesity(> 25 of BMI) from 1998-2017 as per KNHANES
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연령(%)		1998	2001	2005	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
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전체		26.0	29.2	31.3	31.7	30.7	31.1	30.9	31.4	32.4	31.8	30.9	33.2	34.8	34.1
남자		25.1	31.8	34.7	35.2	35.3	35.8	36.4	35.3	36.3	37.7	37.8	39.7	42.3	41.5
여자		26.2	27.4	27.3	28.3	25.2	26.0	24.8	27.1	28.0	25.1	23.3	25.9	26.4	25.6

REVIEWER	Alisha Wade University of the Witwatersrand, South Africa
REVIEW RETURNED	09-Mar-2020

GENERAL COMMENTS	<p>This work utilises a novel method to project the prevalence of obesity in South Korea in 2040. It would benefit from revision prior to being suitable for publication.</p> <ol style="list-style-type: none"> 1. Abstract- I would suggest reworking the conclusion of the abstract. At present, it refers solely to current interventions, but does not link to the objective of the paper i.e. the obesity prevalence in 2040. Recommendations on interventions should relate to how the authors expect these to impact the future obesity prevalence. 2. Methods- I would suggest inclusion of a sentence on ethics. Presumably no additional ethical approval was required as this was a secondary data analysis, but I would recommend stating this explicitly as well as noting the procedure for informed consent for the primary data collection. 3. Results. Table 2 quite difficult to read. Consideration should be given to redesigning the table so immediate comparison can be made between 2012 and 2040 estimates. Indication of the uncertainty of the estimates given should be included. The median may be a better indicator of central tendency, particularly as the mean does not change between time points, but obesity classification does. The authors should also indicate what the numbers in the tables mean-in Table 2, for example, are the numbers in brackets percentages? The authors should standardize the age groups which they compare. In the text on Table 2, there is comparison of those 19-54 in 2012 with those less than 65 in 2040. Consideration should also be given to separating underweight from normal weight. 4. Discussion- I would recommend restructuring of the discussion. The first paragraph largely repeats information provided in the background. I would also suggest moving the Korean-specific definition of obesity and its justification to the background. As noted above, separation of underweight from normal weight would be helpful-underweight is not necessarily desirable, despite the implication by the authors. Additionally, the implications of using a definition of obesity that is different from much of the world should be discussed more fully. 5. Study limitations. I would suggest far more in-depth discussion of the study limitations, including the limitations of using a model developed in another setting with a different definition of obesity and those limitations associated with their primary assumptions.
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VERSION 1 – AUTHOR RESPONSE

Reviewer 1:

1. This study mentioned that Population Health Model (POHEM)-BMI was developed by Canada. I am wondering whether this model can be used for South Korea. The generalizability of this model should be addressed in the method section.

► Author's response:

Thank you for bringing this to our attention. As you suggested, we have further commented on the applicability in other countries, with an overview of the POHEM in the methods section.

► Revised manuscript (page 7, lines 177-179):

POHEM is accessible because it wants the general process to be constant across the country's population, with the exception of variables unique to each country, such as marriage and mortality.

2. This study used Korea Health Panel Data. As far as I know, self-reported BMI was collected in this data. As indicated in this study, the BMI was calculated by the measurement of weight and height in Korea National Health and Nutrition Examination Survey (KNHNES). I don't understand why the author used the Korea Health Data instead of KNHNES. The reason should be mentioned in this study.

► Author's response:

Thank you for highlighting this. We have fully understood what you are concerned about and have considered it. Unfortunately, the main explanatory variable in this model itself is the previous year's BMI value, and we also consider this as important. However, to establish a behavioral equation for predicting the BMI of the year through the individual's previous year' BMI, the only solution was to use panel data. Therefore, leaving behind the merits of the KNHNES, we used the Korea Health Panel data as the main source. Eventually, the limitations in interpreting the results of using data sources are described in the final part of the conclusion as follows:

► Revised manuscript (page 17, lines 389-400):

Second, it is a limitation of data sources. There is a difference between the current prevalence of obesity calculated from the Korea Health Panel data used in this study and the Korea Health Statistics using the KNHANES. As of 2011, the prevalence of adult obesity in Korea Health Statistics was 31.9%, and the prevalence of adult obesity calculated by the Korea Health Panel data was 23.7%, a difference of 8.2%.[39] Unlike the Korea Health Statistics, which contains body-measured height and weight information, the Korea Health Panel (although this is a representative data source) generates data based on self-reported by respondents, which may underestimate obesity. However, in the POHEM-BMI model used in this study, the BMI of the previous year was regarded as the main explanatory variable, and therefore, the Korea Health panel data that followed the same subject once a year was inevitably used. In addition, the original POHEM-BMI model includes the process of converting self-reported BMI into a measured BMI, but we omitted this due to limitations of the data source.

3. The main drawback of the study is the inaccuracy of the predictions. According to the data from KNHNES, the prevalence of obesity was reported by 2017 as below. The prevalence of obesity (>25 of BMI) was increasing. As far as I know, the prevalence of obesity class II/III was also increasing even though the absolute percent was much lower than western society. However, this study predicted the prevalence of obesity was decreasing, and there were very few populations with obesity class II/III. This is not consistent with the recent trend of obesity in Korea. There is a strong doubt as to whether these predictions are adequately calculated. The adequacy of the parameters used in the model should be reconfirmed and adjusted.

► Author's response:

Thank you for your comments. As mentioned in the answers above, panel data was inevitably used because we first faithfully followed the existing prediction model. However, unlike KNHNES, which

includes BMI calculated by measuring height and weight directly, the Korea Health Panel survey implies the possibility of underestimating BMI because it collects height and weight information through self-reports of respondents. The limitations of the predicted value are considered to arise from the underestimation of the BMI estimate and the consideration of variables included in the existing POHEM-BMI predictive equations (sex, age, smoking, physical activity, BMI of the previous year) as predictive factors. In this study, as we progressed with the greatest purpose in exploring the possibility of microsimulation models being applied and expanded in Korea in the field of healthcare, many limitations were discovered in the process of borrowing model developed in foreign countries. Eventually, the limitations found in the methodological dimension were considered in the discussion.

► Revised manuscript (page 16-17, lines 381-400):

Findings from this study should be interpreted with consideration of several limitations. First, since a microsimulation model for predicting obesity prevalence has not been developed in this country, we borrowed the model developed by the Statistics Canada, and accordingly it is not built to fit the domestic situation. Therefore, not only is the definition of obesity different, but the predictors of BMI include only sex, age, smoking, physical activity, and preceding year's BMI values. In the future, research to develop a new model of microsimulation in the field of healthcare for domestic conditions will be very valuable. In this process, it is necessary to consider practical suitability and efficiency in selecting basic data, module-specific behavioral equations, and variables for use in the model. Second, it's a limitation of data sources. There is a difference between the current prevalence of obesity calculated from the Korea Health Panel data used in this study and the Korea Health Statistics using the KNHANES. As of 2011, the prevalence of adult obesity in Korea Health Statistics was 31.9%, and the prevalence of adult obesity calculated by the Korea Health Panel data was 23.7%, a difference of 8.2%.[39] Unlike the Korea Health Statistics, which contains body-measured height and weight information, the Korea Health Panel (although this is a representative data source) generates data based on self-reported by respondents, which may underestimate obesity. However, in the POHEM-BMI model used in this study, the BMI of the previous year was regarded as the main explanatory variable, and therefore, the Korea Health panel data that followed the same subject once a year was inevitably used. In addition, the original POHEM-BMI model includes the process of converting self-reported BMI into a measured BMI, but we omitted this due to limitations of the data source.

Reviewer 2:

1. Abstract- I would suggest reworking the conclusion of the abstract. At present, it refers solely to current interventions, but does not link to the objective of the paper i.e. the obesity prevalence in 2040. Recommendations on interventions should relate to how the authors expect these to impact the future obesity prevalence.

► Author's response:

Thank you for highlighting this. We fully agree with what you have advised. We were concerned about the predicted outcomes of maintaining a health behavior level in 2012, and we came to a quick conclusion from the abstract, recognizing the necessity of developing a microsimulation model and applying policy scenarios (health interventions) suitable for Korea. In response to your advice, we have deleted the existing sentence from the manuscript and corrected it as follows:

► Revised manuscript (page 2, lines 44-48):

We explored the possibility of applying and expanding on the concept of microsimulation in the field of healthcare by combining data sources available in Korea using the POHEM model. In future studies, it is necessary to develop a microsimulation model suitable for Korea's domestic situation, and it is necessary to evaluate the effectiveness of special health policies by applying various prediction scenarios to the basic model.

2. I would suggest inclusion of a sentence on ethics. Presumably no additional ethical approval was required as this was a secondary data analysis, but I would recommend stating this explicitly as well

as noting the procedure for informed consent for the primary data collection.

► Author's response:

Thank you for your insightful comments. In this study, considering the entire process that occurs over an individual's life cycle, the sources used are diverse, so we think that the sentence of ethical approval should be mentioned in the methods. We have inserted the sentences related to ethical approval into the method where all the subject descriptions have been completed in the methods as follows:

► Revised manuscript (page 9, lines 223-227):

In this study, all necessary data for model building and projection were obtained from publicly available data and does not include any identifiable personal information, so no additional ethical approval was required. In addition, ethical and governance approvals were granted by the Korea Institute for Health and Social Affairs which conducts Korea Health Panel Survey. All participants gave written informed consent to take part before they were allowed to complete the survey.

3. Results. Table 2 quite difficult to read. Consideration should be given to redesigning the table so immediate comparison can be made between 2012 and 2040 estimates. Indication of the uncertainty of the estimates given should be included. The median may be a better indicator of central tendency, particularly as the mean does not change between time points, but obesity classification does. The authors should also indicate what the numbers in the tables mean-in Table 2, for example, are the numbers in brackets percentages?

► Author's response:

Thank you for your valuable suggestion. The table was not clear because we tried to compare the demographic and obesity population rates at the same time between 2012, the initial population year, and 2040, the predicted year. We apologize for any inconvenience this might have caused you. For clearer expression, the existing table 2 was redesigned by separating it into table 2 and table 3. First, table 2 compares the demographic structure according to sex in 2012 and 2040, and includes individual health behaviors of the initial population. To indicate the uncertainty of age estimates, standard deviations were presented together, and each value presented in the table 2 was labeled so as not to confuse whether it was a number or a percentage. Values meaning percentages are in brackets.

In table 3, we compared the distribution of the population according to the BMI classification of the initial year and the predicted year and the median value of BMI according to sex. As the central tendency was changed from the mean to the median, it became possible to grasp the change relatively better than before, and the median value was described in all parts of the manuscript (results, discussion, abstract, and figure2) as well as the table 3.

► Revised manuscript:

[Page 11] Table 2: Comparison of number of people, South Korea, 2012 and 2040

[Page 12] Table 3: Comparison of number of people, by BMI classification, South Korea, 2012 and 2040

[Page 13] Figure 2: Population Health Model(POHEM) projections of median BMI in South Korea, 2012-2040

[Page 2, lines 40-41] Abstract: Results-The median BMI for Korean adults in 2040 was forecast to be 23.55 kg/m² (23.97 and 23.17 kg/m² for men and women, respectively).

[Page 11, line 264] Results: There was no significant difference between the median BMIs in 2012 and 2040;

[Page 13, lines 275-282] Results: Figure 2 shows the median predicted BMIs between 2017 and 2040. Each median BMI value from 2013 to 2016 was estimated from the Korea Health Panel survey. The median BMI for the entire adult population is predicted to increase very slightly from 23.23 kg/m² in 2018 to 23.53 kg/m² in 2036 and is expected to remain steady thereafter. The predicted median BMI trends are similar for men; the median BMI in adult men was projected to increase only slightly, from 23.74 kg/m² in 2018 to 23.95 kg/m² in 2036 and then almost plateau thereafter. On the other hand, women were expected to experience a relatively steep rise compared to men; the median BMI

in adult women was projected to increase from 22.66 kg/m² in 2018 to 23.17 kg/m² in 2040.
[Page 14, lines 306-308] Discussion: Summarizing the predicted results, the median BMI of South Korea's adult population aged 19 years and older was expected to be 23.55 in 2040,
[Page 17, lines 401-404.] Discussion: Nevertheless, our study's importance is that it is the first to examine the possibility of using microsimulation to predict future BMI medians in South Korea

4. Results. The authors should standardize the age groups which they compare. In the text on Table 2, there is comparison of those 19-54 in 2012 with those less than 65 in 2040. Consideration should also be given to separating underweight from normal weight.

► Author's response:

Thank you for bringing this to our attention. As you suggested, we have standardized the age range to be compared and corrected by reflecting it in the table, figure3, results, and discussion. Additionally, for the sake of simplicity, the age group of the existing 10-year-old section was changed to three sections such as '19-39', '40-64', '65-'. In addition, underweight and normal were classified throughout the manuscript, and were reflected in both the results and the content description.

► Revised manuscript :

[Page 11] Table 2: Comparison of number of people, South Korea, 2012 and 2040

[Page 22, lines 555-556] Figure 3A: Projection of distribution of BMI, Men aged 19 years and older, South Korea, 2012-2040

[Page 22-23, lines 557-558] Figure 3B: Projection of distribution of BMI, Women aged 19 years and older, South Korea, 2012-2040

[Page 2, lines 41-43] Abstract: Results-According to the Korean BMI classification, 70.05% of all adults were forecast to be 'pre-obese' (i.e., have BMIs 23 to 24.9) by 2040 (81.23% of men and 59.07% of women), followed by 24.88% who would be 'normal'.

[Page 10, lines 255-261] Results: In 2012, the proportion of young people (those in the 19–39 and 40–64 year age groups combined) accounted for approximately 85.54% of the adult population, while the proportion of individuals aged 65 years and older was relatively low at approximately 14%. However, the age group structure in South Korea 28 years later (2040) is predicted to be quite different, as the proportion of individuals 19–64 years (i.e., the working age population) was only 60.95% of the adult population, while the proportion of the elderly population (≥65 years) was estimated to be almost 40% of the total adult population.

[Page 11, lines 264-265] Results: however, according to the BMI classification in South Korea, approximately 41.48% of the adult population was 'normal' in 2012, whereas only 24.88% of the population was predicted to be the same in 2040. (see Table 3)

[Page 13, lines 286] Results: while the proportions of individuals who are classified as 'normal' and 'obese' will gradually decrease.

[Page 14, 308-311] Discussion: While it is encouraging that the proportion of 'obese' people (i.e., those with BMIs ≥25 kg/m²) in 2040 is predicted to be much lower than that in 2012, it is discouraging that the proportion of 'normal' individuals is also markedly lower.

5. I would recommend restructuring of the discussion. The first paragraph largely repeats information provided in the background. I would also suggest moving the Korean-specific definition of obesity and its justification to the background. As noted above, separation of underweight from normal weight would be helpful-underweight is not necessarily desirable, despite the implication by the authors. Additionally, the implications of using a definition of obesity that is different from much of the world should be discussed more fully.

► Author's response:

Thank you for your comments and valuable suggestion. We fully agree with what you suggested, and several paragraphs from the discussion have been moved to the background. In addition, the BMI classification system and obesity definition differentiated from other countries to be mentioned in this study were moved to the Background to strengthen the justification of background explanation and definition in the flow of logic. In addition, regarding the application of the definition of obesity

differently from other countries, it was supplemented and described in the discussion that it is necessary for the selection of high-risk groups for obesity management at the national level and the setting of goals by gender and age.

► Revised manuscript):

[Page 13-14, line 294-300] Discussion: In the field of healthcare, microsimulation can predict the burden of disease by modeling various health risk factors that occur during an individual's lifetime. Given macro-effects such as changes in population structures in the forecasting model, microsimulation is very useful in that it can estimate both disease burdens and medical needs across the country.[24] While microsimulation models have been steadily evolving across health- and economy-related fields in many European countries,[32] they have yet to be actively utilized in South Korea (especially for healthcare).

↓

[Page 6, lines 143-146] Background: In other words, microsimulation can predict the burden of disease by modeling various health risk factors that occur during an individual's lifetime. Given macro-effects such as changes in population structures in the forecasting model, microsimulation is very useful in that it can estimate both disease burdens and medical needs across the country.[28]

[Page 6, lines 153-156] Background: However, while microsimulation models have been steadily evolving across health- and economy-related fields in many European countries,[31] they have yet to be actively utilized in South Korea (especially for healthcare).

[Page 14, lines 301-306] Discussion: POHEM is one of several population-based health dynamic microsimulation models used worldwide. Dynamic microsimulation, in the context of social science and population health, is a simulation of individuals (i.e., micro-level) and their behaviors, statuses, and actions (dynamics) over time.[33] These are modeled as desired using multiple sources of empirical data, including cross-sectional surveys, administrative databases, vital statistics, and census data.[31]

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[Page 7, lines 171-174.] Methods: Dynamic microsimulation, in the context of social science and population health, is a simulation of individuals (i.e., micro-level) and their behaviors, statuses, and actions (dynamics) over time.[35] These are modeled as desired using multiple sources of empirical data, including cross-sectional surveys, administrative databases, vital statistics, and census data.[36]

[Page 15, lines 332-336] Discussion: With respect to worldwide comparisons, whether cutoff points for overweight and obesity should be lower for Asians than for another ethnic group remains debated.[35] Because of racial differences, the World Health Organization has proposed regarding BMIs of 18.5–22.9 kg/m² as optimal, 23–24.9 kg/m² as overweight, 25–29.9 kg/m² as moderate obesity, and ≥30 kg/m² as severe obesity for Asians.[36]

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[Page 4, lines 97-101] Background: Meanwhile, with respect to worldwide comparisons, whether cutoff points for overweight and obesity should be lower for Asians than for another ethnic group remains debated.[20] Because of racial differences, the World Health Organization has proposed regarding BMIs of 18.5–22.9 kg/m² as optimal, 23–24.9 kg/m² as overweight, 25–29.9 kg/m² as moderate obesity, and ≥30 kg/m² as severe obesity for Asians.[21]

[Page 15-16, lines 342-361] Discussion: However, more research is needed to determine particular BMI values that increase the likelihood of developing particular chronic disease, depending on the sex and age of the individual. The Korean Society of Obesity, which was established to improve obesity management through research and education, revised its clinical practical guidelines for the prevention and treatment of obesity in 2018. The new guidelines renamed the "overweight" category to "pre-obese", and divided obesity into 3 categories, thereby aiming to highlight the risk of obesity instead of promoting the term "overweight." The most recent guidance is based in part on data from 84,690,131 Korean adults extracted from the Korean National Health Insurance Service Health

Checkup Database between 2006 and 2015. By including the entire population registered in the National Health Insurance Services Database, they calculated the first and second cutoff points corresponding to the increased risk of any of 3 accompanying diseases (type 2 diabetes, hypertension, and dyslipidemia). The first and second BMI cutoff levels were 23 kg/m² and 25 kg/m², respectively.[37,38] Rather than emphasizing the BMI classification criteria, however, future studies ought to analyze the BMI reference points that can significantly predict the occurrence of chronic diseases by sex and age group. Based on such evidence, the developing governmental 'National Health Promotion Comprehensive Plan' needs to incorporate additional, wider-ranging goals that take into account the characteristics of each sex and age group, rather than presenting goals for obesity prevalence among adult men and women. Moreover, systematic public health interventions that are tailored to individual characteristics need to be established.

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[Page 4-5, lines 101-114] Background: However, it is more important to determine particular BMI values that increase the likelihood of developing particular chronic disease, depending on the sex and age of the individual. The Korean Society of Obesity, which was established to improve obesity management through research and education, revised its clinical practical guidelines for the prevention and treatment of obesity in 2018. The new guidelines renamed the "overweight" category to "pre-obese", and divided obesity into 3 categories, thereby aiming to highlight the risk of obesity instead of promoting the term "overweight." The most recent guidance is based in part on data from 84,690,131 Korean adults extracted from the Korean National Health Insurance Service Health Checkup Database between 2006 and 2015. By including the entire population registered in the National Health Insurance Services Database, they calculated the first and second cutoff points corresponding to the increased risk of any of 3 accompanying diseases (type 2 diabetes, hypertension, and dyslipidemia). The first and second BMI cutoff levels were reported to be 23 kg/m² and 25 kg/m², respectively, [22,23] suggesting that obesity criteria reflecting the actual risk of chronic disease in Koreans is necessary.

[Page 14, lines 308-311] Discussion: While it is encouraging that the proportion of 'obese' people (i.e., those with BMIs ≥ 25 kg/m²) in 2040 is predicted to be much lower than that in 2012, it is discouraging that the proportion of 'normal' individuals is also markedly lower.

[Page 15-16, 340-380] Discussion: Of course, it would be appropriate to use international standards in international comparison, but it is necessary to reflect the situation of individual countries in the management of obesity for the purpose of preventing and managing chronic diseases. Therefore, rather than emphasizing the BMI classification criteria, more research is needed to analyze the BMI values that can significantly predict the occurrence of chronic diseases. In other words, it is necessary to continuously accumulate sufficient epidemiologic evidence for the relationship between the BMI and the actual risk of disease and death for Koreans, and based on such evidence, efforts to establish appropriate diagnostic and medical standards for Korea are needed. In particular, the relationship is likely to vary by age as well as sex, so it should be considered as well. In the meantime, the obesity standard has been applied collectively regardless of sex and age. However, in order to deviate from a uniform approach to obesity, gender- and age-based approaches are needed, considering the changes in hormones and body composition.

Because health management policies including obesity management requires a large budget, it is most important to establish cost-effective policies, and this requires selecting targets for policy intervention. The results from this study made it possible to grasp the obese high-risk group by sex and age group, and furthermore, it is expected to enable estimation of medical needs. As it is necessary to apply obesity standards differently according to sex and age group, it is a similar problem in setting goals of the 'National Health Promotion Comprehensive Plan'. The developing governmental 'National Health Promotion Comprehensive Plan' needs to suggest additional, wider-ranging goals considering the characteristics of each sex and age group, rather than presenting goals for obesity prevalence among adult men and women. In this case, the goal should be presented at an

achievable level in consideration of future prediction patterns. Finally, systematic public health interventions that are tailored to individual characteristics need to be established.

6. Study limitations. I would suggest far more in-depth discussion of the study limitations, including the limitations of using a model developed in another setting with a different definition of obesity and those limitations associated with their primary assumptions.

► Author’s response:

Thank you for bringing this to our attention. This study has significance in the application of new prediction techniques that have never been tried in Korea, so it has many limitations in terms of methodology. The contents related to this were prepared in detail as follows.

► Revised manuscript (page 16-17, lines 381-400):

Findings from this study should be interpreted with consideration of several limitations. First, since a microsimulation model for predicting obesity prevalence has not been developed in this country, we borrowed the model developed by the Statistics Canada, and accordingly it is not built to fit the domestic situation. Therefore, not only is the definition of obesity different, but the predictors of BMI include only sex, age, smoking, physical activity, and preceding year’s BMI values. In the future, research to develop a new model of microsimulation in the field of healthcare for domestic conditions will be very valuable. In this process, it is necessary to consider practical suitability and efficiency in selecting basic data, module-specific behavioral equations, and variables for use in the model. Second, it’s a limitation of data sources. There is a difference between the current prevalence of obesity calculated from the Korea Health Panel data used in this study and the Korea Health Statistics using the KNHANES. As of 2011, the prevalence of adult obesity in Korea Health Statistics was 31.9%, and the prevalence of adult obesity calculated by the Korea Health Panel data was 23.7%, a difference of 8.2%.[39] Unlike the Korea Health Statistics, which contains body-measured height and weight information, the Korea Health Panel (although this is a representative data source) generates data based on self-reported by respondents, which may underestimate obesity. However, in the POHEM-BMI model used in this study, the BMI of the previous year was regarded as the main explanatory variable, and therefore, the Korea Health panel data that followed the same subject once a year was inevitably used. In addition, the original POHEM-BMI model includes the process of converting self-reported BMI into a measured BMI, but we omitted this due to limitations of the data source.

VERSION 2 – REVIEW

REVIEWER	Alisha Wade University of the Witwatersrand, South Africa
REVIEW RETURNED	05-Jul-2020

GENERAL COMMENTS	<p>This manuscript uses microsimulation to predict the prevalence of obesity in South Korea in 2040. The manuscript has been significantly improved since the previous version, but there are still some outstanding issues.</p> <p>Major comments:</p> <ol style="list-style-type: none"> 1. Abstract-The conclusion should link to the study objective in addition to reflecting on the appropriateness of the methodology. 2. Study strengths and limitations-the argument being made in the second bullet point is unclear. The limitation in the fourth bullet point isn't necessarily a limitation of this study per se, and I would suggest it be limited to the Discussion section. The authors should also elaborate or reword the fifth bullet point so the argument is clearer.
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	<p>3. Background-this section is somewhat long and repetitive. I would recommend the authors focus on a few key points that justify why their study is being conducted.</p> <p>4. Results-the readability of Table 2 could be improved by reformatting how the percentages are presented. It is also somewhat redundant to present both options in a binary variable e.g. both smoker and non-smoker as the one implies the other. I would suggest omitting Table 3 as the same data are presented in Figures 2 and 3. Figures 2 and 3 should be modified to clarify that only data from 2017 has been produced by microsimulation.</p> <p>5. Discussion-The discussion would benefit from further revision. The authors should further elaborate on the contrasts between their study and Baik's and provide more details on the differences in sources, variables and prediction models. The points made later in the discussion about the differences between KNHANES and the panel study should appear here. The authors should note in the methods section that BMI is self-reported. There is a brief mention of projections in Canada-while comparisons of the South Korean projections with other countries may be valuable, i would suggest that this is given a dedicated paragraph and other countries are included with a focus on other East Asian countries. Given the limitations of differing BMI cutoffs noted by the authors, consideration could be given to comparing BMI as a continuous variable in cross-country comparisons. The discussion of the policy implications needs to re-framed; of note the authors argue for recommendations based on age and sex, but provide no age-specific projections. The authors note that their model differs from the Canadian model from which it is adapted, but provide no detail as to these differences. The utility of the assumption that attributes remained the same from 19 years onward is a limitation that should be discussed.</p> <p>Minor comments</p> <ol style="list-style-type: none"> 1. There are grammatical errors and errors in the use of English that need to be corrected. These include, but are not limited to: line 94 (authors' numbering)-"commensurate" is an adjective and not an adverb; line 94 "are" should be "is"; the first and second sentences of the paragraph beginning with line 97 should be reworded for clarity; line 102 "diseases" rather than "disease"; formatting of number in line 116 should be reviewed; line 199 "practicing" should be "practising"; sentence beginning with line 226 should be reworded for clarity; the word "Korean" in line 236 appears to be a misspelling; the sentence beginning with line 363 should be reworded for clarity 2. In line 110-it is unclear to what first and second cutoffs refer 3. Lines 245 and 246 are unclear; i would suggest removal 4. References-these should be reviewed to ensure standardisation in formatting including, but not limited to, reference 2, 3 and 31. the appropriateness of reference 38 is unclear.
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VERSION 2 – AUTHOR RESPONSE

Reviewer 2:

Major comments

1. Abstract-The conclusion should link to the study objective in addition to reflecting on the appropriateness of the methodology.

▶ Author's response:

Thank you for highlighting this. We forgot to describe the purpose of our research, biased towards the importance of the methodology. We modified the sentence in the revised manuscript as follows by including the result that is linked to the goal of this study:

▶ Revised manuscript (p. 2):

In future studies, it is necessary to develop a microsimulation model suitable for Korea's domestic situation, and it is necessary to evaluate the effectiveness of special health policies by applying various prediction scenarios to the basic model.

and found that more than half of the adults in this study population will be pre-obese, and the proportions of "obesity" and "normal" will decrease compared with those in 2012. The results of our study will aid in devising healthy strategies and spreading public awareness for preventing this condition.

2. Study strengths and limitations-the argument being made in the second bullet point is unclear.

▶ Author's response:

Thank you for bringing this to our attention. We deleted the sentence written in the second bullet point, and re-described as follows with a focus on the usefulness of the research results:

▶ Revised manuscript (p. 3):

This study has the greatest significance in exploring the possibility of applying and expanding the concept of microsimulation in the field of healthcare by combining data sources available in Korea. The results of our study aid in suggesting additional and wider-ranging strategies for obesity prevention by considering sex and age group in the formulation of the 'National Health Promotion Comprehensive Plan'.

3. Study strengths and limitations-The limitation in the fourth bullet point isn't necessarily a limitation of this study per se, and I would suggest it be limited to the Discussion section.

▶ Author's response:

Thank you for your valuable suggestion. It was difficult to carefully select the strengths and limitations of the study. However, according to your suggestion we have deleted this point from the article summary section of the manuscript.

▶ Revised manuscript (p. 3):

The estimated BMI value differs from the Korea Health Statistics, which is based on the data measured by actual measurement.

4. Study strengths and limitations-The authors should also elaborate or reword the fifth bullet point so the argument is clearer.

▶ Author's response:

Thank you for highlighting this. We have revised this point as follows:

▶ Revised manuscript (p. 3):

There is a limitation that it does not accurately reflect the domestic situation because it borrows a micro-simulation model developed abroad.

This study uses a micro-simulation model developed abroad, and hence, may not reflect the domestic scenario accurately.

5. Background-this section is somewhat long and repetitive. I would recommend the authors focus on a few key points that justify why their study is being conducted.

► Author's response:

Thank you for your valuable suggestion. We have revised it.

We organized the Background section into the following 7 paragraphs; (1) The problem of increasing obesity, (2) The severity of the obesity problem (increases chronic diseases, causing socioeconomic burden), (3) Cutoff points for BMI Classification and BMI Classification Criteria in Korea, (4) The necessity of a study to predict the prevalence of obesity in Korea (not enough previous studies), (5) Limitations of the macroscopic approach in predictive research in the healthcare sector, (6) Usefulness of microsimulation methodology in health care field, (7) The necessity of research to predict the prevalence of obesity in establishing health policy.

While revising the manuscript as follows, some sentences were deleted, and some were moved to other sections.

► Revised manuscript (p. 4-7):

In the Global Burden of Disease Study,[4] globally in 2017, a high body mass index (BMI) accounted for 4.72 million deaths and 148.0 million disability-adjusted life-years.

☞ deleted

However, it is more important to determine particular BMI values that increase the likelihood of developing particular chronic disease, depending on the sex and age of the individual.

☞ deleted as mentioned in Discussion section

A study of data from the National Health Insurance Service in Korea found that the socioeconomic cost of obesity in 2016 was approximately 9,665.32 million US dollars; medical expenses accounted for 51.3% of this amount, followed by decreasing productivity (20.5%), productivity loss (13.1%), early mortality (10.0%), care costs (4.3%), and transportation costs (0.8%).[24] Several studies on the long-term trends of obesity prevalence in South Korea found that obesity is increasing in men but not in women.[25-27]

☞ moved to paragraph(2)

In other words, microsimulation can predict the burden of disease by modeling various health risk factors that occur during an individual's lifetime.

☞ deleted because it is a repetitive description

Collecting individual events from within a population that has varying attributes can be used to predict and plan outcomes (such as incidence, prevalence, and cost), and can also be used to assess the clinical and cost effectiveness of alternative health interventions.[29]

☞ deleted as mentioned in Discussion section description

As mentioned above, it is necessary to estimate the magnitude of obesity because it has been identified as a risk factor for various chronic diseases.

☞ deleted because it is a repetitive description

6. Results-the readability of Table 2 could be improved by reformatting how the percentages are presented. It is also somewhat redundant to present both options in a binary variable e.g. both smoker and non-smoker as the one implies the other.

► Author's response:

Thank you for your comments. We reformatted Table 2 reflecting your valuable opinion.

► Revised manuscript (p. 13-14)

7. Results-I would suggest omitting Table 3 as the same data are presented in Figures 2 and 3. Figures 2 and 3 should be modified to clarify that only data from 2017 has been produced by microsimulation.

► Author's response:

Thank you for your valuable suggestion. We agree with your advice, and have deleted table 3. Since only data for men and women can be confirmed from Figure 3-a and Figure 3-b, data regarding all

men and women are depicted in Figure 3-c.

Figures 2 and 3 have been modified to represent only data produced by microsimulation from 2017.

► Revised manuscript (p. 15):

There was no significant difference between the median BMIs in 2012 and 2040; however, according to the BMI classification in South Korea, approximately 41.48% of the adult population was 'normal' in 2012, whereas only 24.88% of the population was predicted to be the same in 2040. (see Table 3) On the other hand, the 'pre-obese' group was expected to account for approximately 70% of the total adult population.

8. Discussion-The discussion would benefit from further revision. The authors should further elaborate on the contrasts between their study and Baik's and provide more details on the differences in sources, variables and prediction models. The points made later in the discussion about the differences between KNHANES and the panel study should appear here.

► Author's response:

Thank you for highlighting this. Above all, we realized that it is important as a national-level research to deal in detail with the differences between Baik's research results and the research design. To this, the following sentences were added as further explanation.

► Revised manuscript (p. 19-22):

(p.20) The differences appeared to be caused by the different secondary sources used in the 2 studies, as well as the different independent variables and prediction methodologies.

☞ Since the sentence is insufficiently explained, it was deleted and replaced with the paragraph below.

(p.19-20) The differences in prediction results appeared to be caused by the different secondary sources and prediction model in the 2 studies. First, in Baik's study, a prediction model was constructed by applying a linear regression model and an autoregressive integrated moving average model using the KNHANES data. The dependent variable in the prediction model was BMI, and the independent variables included the survey year, age, marital status, job status, income status, smoking, alcohol consumption, sleep duration, psychological factors, dietary intake, and fertility rate. In contrast, in this study, the Korea Health Panel data was used as the data source, and BMI was predicted by performing microsimulation with sex, age, smoking, physical activity, and previous year's BMI as independent variables. Above all, the dependent variable, BMI, differs in the method of measurement between the two sources; unlike the KNHANES, which contains body-measured height and weight information, the Korea Health Panel (although this is a representative data source) generates data based on self-reported by respondents, which may underestimate obesity.

(p.20) Most importantly, Baik's study did not consider the preceding year's BMI, which was a major independent variable in our study; this may be a major explanation for the differences in findings between the 2 studies.

☞ Deleted as it was judged to be insufficiently persuasive

(p.22) Unlike the Korea Health Statistics, which contains body-measured height and weight information, the Korea Health Panel (although this is a representative data source) generates data based on self-reported by respondents, which may underestimate obesity.

☞ Moved to page 19 and deleted from where it was.

9. Discussion-The authors should note in the methods section that BMI is self-reported.

► Author's response:

Thank you for pointing out an important point. It has been revised.

► Revised manuscript (p. 9):

Height and weight, which are components of BMI, were based on self-reported data.

10. Discussion-There is a brief mention of projections in Canada-while comparisons of the South Korean projections with other countries may be valuable, i would suggest that this is given a dedicated paragraph and other countries are included with a focus on other East Asian countries.

Given the limitations of differing BMI cutoffs noted by the authors, consideration could be given to comparing BMI as a continuous variable in cross-country comparisons.

► Author's response:

Thank you for your valuable suggestion. We fully agree with your opinion, and to do this, we diligently searched for studies that predicted the future prevalence of obesity among countries such as Japan, China and Taiwan. However, we did not find any, and hence, we expanded the scope of the literature search to the world for review. Nevertheless, few studies have predicted BMI itself. The results in India, the United States, and Australia were similar to our study design, so we added a paragraph on the results of the international comparison as follows:

► Revised manuscript (p. 20-21):

We also tried to compare the results from this study with the predicted estimate by country, but few studies have empirically predicted the prevalence of obesity in the future using simulation models. A study that compiled nationally-representative data from various sources and predicted the future prevalence of overweight and obesity in Indian adults aged 20-69, predicted that the prevalence of overweight and obesity will reach 30.5% and 9.5% among men, 27.4% and 13.9% among women, respectively, by 2040.[35]. According to a study that estimated the prevalence of obesity in the future through regression modeling, 42% of Americans are expected to be obese by 2030.[36] Similarly, a study that predicted the prevalence of obesity in Australian adults by 2025 using a multiple linear regression model predicted that 83% of male adults over the age of 20 and 75% of female adults would be overweight or obese.[37] In all three countries, India, the United States, and Australia, overweight and obesity were defined according to the classifications defined by the WHO, and had values much higher than those in Korea.

11. Discussion-The discussion of the policy implications needs to be re-framed; of note the authors argue for recommendations based on age and sex, but provide no age-specific projections.

► Author's response:

Thank you for your highlighting this. Since we were able to obtain BMI predictions for each age group in addition to sex, we added table 3 and the analysis results to provide a broader perspective.

► Revised manuscript (p. 17-18):

According to the BMI classification in South Korea by age group, in 2012, about 20.36% of the population aged 19-39 were 'pre-obese', but in 2040, it increased to 39.59%, almost double. The proportion of the 'normal' population was almost the same in 2012 and 2040, and the 'obese class I' decreased by nearly half. However, in the population aged 40 to 64 and over 65, the proportion of 'pre-obese' increased almost three times in 2040 compared to that in 2012, and the proportion of 'normal' decreased to less than 20%. (Table 3)

12. Discussion-The authors note that their model differs from the Canadian model from which it is adapted, but provide no detail as to these differences.

► Author's response:

Thank you for highlighting this. We apologize for any confusion caused by this.

We wanted to mention as a limitation that we were not able to construct a predictive equation suitable for the domestic situation in the process of borrowing the research model. This is because the predictors of BMI of the Canadian population and those of Koreans will differ for a number of reasons. However, even if the research model was adapted, the operational definition of each predictor was consistent with the definition used in health statistics in Korea, and the procedure for correcting self-reported BMI was inevitably omitted due to limitations in the data source. These two are the differences confirmed in the Canadian study.

► Revised manuscript (p. 22):

nonetheless, we defined each variable in the predictive equation according to the operational definition in Korea Health Statistics. However, if the model is more suited to the domestic situation, besides sex, age, smoking, physical activity, and previous year's BMI value, various factors related to BMI may be added to the predictors of BMI. However, in this study, as we faithfully followed the

existing model and explored the possibility of domestic application, the process of constructing a prediction equation was omitted.

(p. 23) In addition, the original POHEM-BMI model includes the process of converting self-reported BMI into a measured BMI, but we omitted this due to limitations of the data source.

13. Discussion-The utility of the assumption that attributes remained the same from 19 years onward is a limitation that should be discussed.

► Author's response:

Thank you for pointing this out. We realized that we missed this important point as a limitation of our study, and we added the following as a third limitation. We also added this as the last bullet in Strengths and limitations.

► Revised manuscript:

(p. 23) Third, we assumed that the attributes of 19-year-old individuals entered each year remain at a similar level each year. This means that the individual attributes of 19-year-old adults are the same for 29 years from 2012 to 2040; thus, it can be considered somewhat less realistic. In future studies, it is expected that more meaningful and realistic results will be derived if the model is constructed by reflecting the trend of changes in the attributes of the 19-year-old population and updating it according to the year.

(p.3) Another limitation is that we assumed the attributes of 19-year-old individuals to remain similar each year.

Minor comments

1. There are grammatical errors and errors in the use of English that need to be corrected. These include, but are not limited to: line 94 (authors' numbering)-"commensurate" is an adjective and not an adverb; line 94 "are" should be "is"; the first and second sentences of the paragraph beginning with line 97 should be reworded for clarity; line 102 "diseases" rather than "disease"; formatting of number in line 116 should be reviewed; line 199 "practicing" should be "practising"; sentence beginning with line 226 should be reworded for clarity; the word "Korean" in line 236 appears to be a misspelling; the sentence beginning with line 363 should be reworded for clarity

► Author's response:

Thank you very much for your meticulous review. We have corrected all the points you pointed out, found and corrected the problem with English grammar and expression as a whole.

2. In line 110-it is unclear to what first and second cutoffs refer

► Author's response:

Thank you for your comment. We clarified this by modifying it to read as follows:

► Revised manuscript (p. 5):

The first cutoff BMI level was 23 kg/m², and the second cutoff BMI level was 25 kg/m².

3. Lines 245 and 246 are unclear; i would suggest removal

► Author's response:

Thank you for your comment. Unfortunately, however, we did not remove the phrase in accordance with the BMJ open guidelines.

4. References-these should be reviewed to ensure standardisation in formatting including, but not limited to, reference 2, 3 and 31. the appropriateness of reference 38 is unclear.

► Author's response:

Thank you for pointing this out. We checked the writing guidelines and reviewed and revised all expressions of references.

VERSION 3 – REVIEW

REVIEWER	Dr Alisha Wade University of the Witwatersrand
REVIEW RETURNED	16-Nov-2020

GENERAL COMMENTS	<p>The revisions undertaken by the authors have considerably improved this manuscript. My remaining suggestions are as follows:</p> <ol style="list-style-type: none"> 1. Strengths and limitations-the second bullet point needs slight rewording 2. Background-this remains quite long; the paragraph beginning with line 127, for example, could be largely omitted 3. Methods- I would suggest the first mention of POHEM as well as the Korea Panel Health Survey and population-based statistics be referenced 4. Methods-the authors refer to BMI values throughout the methods, but it is not clear to which year's values they are referring. it would be helpful if these were specified 5. Methods-line 199:the authors should clarify which variable definitions were different 6. Methods-line 221: the authors should clarify the year of the estimates to which they are referring 7. Methods-clarify which BMI values are projected and which are estimated 8. Results-line 225: the authors should avoid the use of the word "average" and specify whether the estimate is a mean or median 9. Results-no uncertainty parameters were provided for estimates; if the model does not provide these, that should be stated. Otherwise, these should be given 10. Results-Table 2 needs to be reformatted and should include the measurement units 11. Results-Figure 2 (no new figures were uploaded, so comments are based on figures in previous revision)-line 280: this figure in fact shows data between 2012 and 2040. The authors should rephrase this sentence if they wish to highlight the data between 2017 and 2040 12. Results-Table 3-this should be reformatted and the title changed to reflect that the reflected comparison is by age 13. Discussion-line 319: the presented data do not support this conclusion 14. Discussion-line 379-National Health Promotion Comprehensive Plan should be referenced 15. Discussion-the point in lines 389-392 is unclear 16. Discussion-lines 399 to 411 are redundant
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VERSION 3 – AUTHOR RESPONSE

Reviewer 2:

1. Strengths and limitations-the second bullet point needs slight rewording

► Author's response:

Thank you for highlighting this. We reflected the meaning described in the Discussion section and revised the awkward words as follows:

► Revised manuscript (p. 3, lines 56-61):

The results of our study aid in suggesting additional and wider-ranging strategies for obesity

prevention by considering sex and age group in the formulation of the 'National Health Promotion Comprehensive Plan'.

"The results of our study will be beneficial in suggesting additional and wider ranging goals for obesity prevention, by taking into consideration the influence of sex and age in the formulation of the 'National Health Plan'."

2. Background-this remains quite long; the paragraph beginning with line 127, for example, could be largely omitted

► Author's response:

Thank you for your valuable suggestion. We deleted the duplicated or unnecessary sentences, and the confusing sentences were condensed and modified so that the key messages could be reflected clearly.

► Revised manuscript:

However, when establishing a healthcare policy, it is necessary to estimate the future disease burden and medical needs of the entire population based on future projections that reflect individual characteristics because a real-world understanding of factors that are influenced by policies or institutions is required. (page 5, lines 112-115)

"However, when establishing a healthcare policy, it is necessary to predict the future burden of disease and medical needs of the entire population based on a real-world understanding of individual-level factors that are influenced by policies or institutions". (page 5, lines 115-118)

Individuals are independent entities with different characteristics and needs that govern their future decisions and behaviors. By applying these needs, health-related projections can be modeled to reflect health risk factors such as sex, age, life cycle activities, smoking, etc., and the effects of policy interventions can be quantified. (page 5-6, lines 118-121)

"Individuals are independent entities with different characteristics and needs, and health-related projections can be modeled to reflect these individual characteristics, including health risk factors." (page 6, lines 121-123)

Additionally, the longitudinal framework of these models allows for interpreting a person's change in BMI as it is affected by factors such as a person's physical activity and behavior, and thus, acts as a contributing factor for other diseases. (page 6, lines 135-138)

3. Methods- I would suggest the first mention of POHEM as well as the Korea Panel Health Survey and population-based statistics be referenced

► Author's response:

Thank you for your comments. We almost missed this important point. We added the references in the sentences in which the source is mentioned as follows:

► Revised manuscript:

"We used the Population Health Model (POHEM)-BMI[26]" (page 7, line 152)

"To create the base population for the POHEM-BMI model, we used the 2011–2012 Korea Health Panel survey[34] and the resident registration-based population statistics.[35]" (page 7-8, lines 169-170)

"The definitions of the variables in this study are consistent with the definitions of the indicators in the Korea Health Statistics.[36]" (page 8, lines 186-188)

4. Methods-the authors refer to BMI values throughout the methods, but it is not clear to which year's values they are referring. it would be helpful if these were specified

► Author's response:

Thank you for pointing this out. It seems that we had not included a detailed explanation on the model validation and calibration. We apologize for any confusion in this regard.

As of now, the most recent data available on BMI are those of the 2016 Korea Health Panel Survey. Therefore, we tried to predict BMI from 2013 to 2016 through the constructed model and verified the validity by comparing the results with the BMI results estimated by the Korea Health Panel Survey.

We modified the relevant part in the Methods section to convey these details clearly, and we mentioned the calibration results in the Results section.

► Revised manuscript:

Methods section: We established the model's validity by comparing the projected BMI median obtained from the prediction model to estimates obtained from the Korea Health Panel survey. We set the calibration cutoff point to 5% and adjusted the model by comparing the difference between the median BMI estimates observed from the Korea Health Panel survey and the values derived from the prediction model categorized by sex and age. We analyzed the BMIs of each group by comparing the 2016 data available from the Korea Health Panel with the most recent data. We accepted a difference of less than 5% overall in the sex- and age-categorized groups. Finally, we adjusted the demographics of the 2040 population so that the predictions were within a 5% margin of error. (page 9, lines 209-217)

"In order to establish the validity of the prediction model, we adjusted the model by comparing the 2013 to 2016 median BMIs projected from the model with the 2013 to 2016 Korea Health Panel Survey median BMI estimates. We compared the median BMI values for each sex and age group from 2013 to 2016, and accepted a difference between the median BMI values in the prediction model and in the Korea Health Panel Survey to less than 5% by setting the calibration cutoff point to 5%. Finally, we adjusted the demographics of the 2040 population so that the predictions were within the 5% margin of error." (page 9-10, lines 217-224)

Results section: "The model was well calibrated in both the initial population and from 2017 to 2040. to establish the validity. Differences in each of the variables estimated between 2013 and 2016, which were derived from the Korea Health Panel data, were within the 5% range only when using the predictive model. The difference in median BMI between that estimated from the 2013 and 2016 Korea Health Panel survey and that predicted by the 2013 and 2016 model was within the 5% range." (page 14, lines 270-275)

5. Methods-line 199:the authors should clarify which variable definitions were different

► Author's response:

Thank you for your pointing this out. Since the Korea Health Panel Survey, which is a domestic data source for investigating the health status of Koreans, was applied to the model, of course, it cannot be consistent with the operational definitions of all the variables such as the smoking status and physical activity in the original Canadian data source.

It seems that the sentence expression was not clear. This part has been modified as follows:

► Revised manuscript (p. 8, lines 180-188):

For comparison with other international studies using this model, the variable composition was the same, but the variable definition was not. The definition of variables was consistent with the definition of indicators in the Korea Health Statistics.

"We matched the composition of the variables considered as covariates in the POHEM-BMI model. We did not match the operational definition of the variables because we applied the Korea Health Panel Survey data (not the survey data obtained in Canada where the POHEM model was developed). The definitions of the variables in this study are consistent with the definitions of the indicators in the Korea Health Statistics.[36]."

6. Methods-line 221: the authors should clarify the year of the estimates to which they are referring

► Author's response:

Thank you for highlighting this. In line with comment no.6, we have revised our texts; the answer is the same as shown in the response for comment no.4 above.

7. Methods-clarify which BMI values are projected and which are estimated

► Author's response:

Thank you for highlighting this. In line with comment no.7, we have revised our texts; the answer is the same as shown in the response for comment no.4 above.

8. Results-line 225: the authors should avoid the use of the word "average" and specify whether the estimate is a mean or median

► Author's response:

Thank you for your comments. We looked up the word 'average' throughout the manuscript, and confirm that 'average' was used while referring to the age of the population at the beginning of the Results.

The central tendency of BMI to be predicted was determined as the median in line with your valuable suggestion, we also changed average age to "mean age" in the results section, to show the characteristics of the population group. (page 11, line 252)

9. Results-no uncertainty parameters were provided for estimates; if the model does not provide these, that should be stated. Otherwise, these should be given

► Author's response:

Thank you for pointing this out. In this study, each time the analysis for one year was updated, only the changed state of each individual was derived, and no information on uncertainty parameters was provided. We added this information in addition to the explanation on Figure 2, which is the main analysis result.

► Revised manuscript (p. 14, lines 290-291):

"The model in this study, used to predict the BMI of the population, did not include any uncertainty parameters for the estimates."

10. Results-Table 2 needs to be reformatted and should include the measurement units

► Author's response (p. 13):

Thank you for highlighting this. We reformatted Table 2 and added the measurement units according to your valuable suggestion.

11. Results-Figure 2 (no new figures were uploaded, so comments are based on figures in previous revision)-line 280: this figure in fact shows data between 2012 and 2040. The authors should rephrase this sentence if they wish to highlight the data between 2017 and 2040

► Author's response:

Thank you for your valuable suggestion. We did not add Figure 2 in the second revision, we only reformatted it, such as the changing of the color. The explanation of Figure 2, which shows the main result, is very important, thanks to you we were able to figure out our error. To help readers to understand the figure, we have revised the sentences as follows.

► Revised manuscript (p. 14, lines 278-283):

Figure 2 shows the median predicted BMIs between 2017 and 2040. Each median BMI value from 2013 to 2016 was estimated from the Korea Health Panel survey.

"Figure 2 shows the median BMI of the adult population from 2012 when the initial population was generated to 2040, the final projected year. Each median BMI value from 2013 to 2016 was estimated from the Korea Health Panel survey, and the median BMI from 2017 to 2040 is the predicted value determined by the model."

12. Results-Table 3-this should be reformatted and the title changed to reflect that the reflected comparison is by age

► Author's response (p. 15):

Thank you for highlighting this. We reformatted the table in consideration of enhanced readability and modified the title to 'Comparison of the number of people according to the BMI classification by age group, South Korea, 2012 and 2040', which is a more appropriate title for the content of the table.

13. Discussion-line 319: the presented data do not support this conclusion

► Author's response:

Thank you for pointing this out. We have carefully read and reviewed what you pointed out. Depending on the process of constructing and analyzing the predictive model, the sentence was not wrong and is supported by our analysis results. However, prior to this expression, related explanations should have been mentioned in the Methods and Results sections, which we overlooked. Therefore, we supplemented the Methods, Results, and Discussion sections as follows:

► Revised manuscript:

Discussion section: "The distributions of these factors were assumed to remain equal across the years. It was assumed that the status of these health risk factors remain consistent from the initial population period to the final projected year of 2040; hence, our results showed that maintaining smoking and physical activity rates in 2012 among adults will lead to a sharp increase in the 'pre-obese' population by 2040." (page 17, lines 323-327)

Methods section: "Therefore, in this model, since each individual's smoking status and physical activity in the initial population remained the same until 2040, the model predicted the BMI when the adult smoking and physical activity rates in the initial year (2012) persisted until 2040." (page 9, lines 205-207)

Results section: "As of 2012, men and women smoking rates were 45.05% and 2.24%, respectively, and physical activity rates were 15.41% and 20.84%, respectively. In this study, only the BMI was updated annually by the predictive equation, so the adult smoking rate and physical activity rate in 2040 are the same as in the initial 2012 population." (page 12, lines 261-265)

14. Discussion-line 379-National Health Promotion Comprehensive Plan should be referenced

► Author's response:

Thank you for pointing this out. We almost missed this important point. We added a reference to the 'National Health Plan' (reference 41, page 19, line 382).

15. Discussion-the point in lines 389-392 is unclear

► Author's response:

Thank you for pointing this out. We have carefully reviewed the points you pointed out, and revised the texts as follows to clarify their meaning:

► Revised manuscript: (p. 20, lines 391-401):

nonetheless, we defined each variable in the predictive equation according to the operational definition in Korea Health Statistics. However, if the model is more suited to the domestic situation, besides sex, age, smoking, physical activity, and previous year's BMI value, various factors related to BMI may be added to the predictors of BMI.

"If the BMI predictors are suitable for our domestic situation, that is, if variables that are important for predicting BMI of Koreans are constructed through empirical analysis or literature review, the composition of the covariates may be different from that of the existing POHEM-BMI model. However, in this study, since we faithfully followed the existing model and explored the possibility of domestic application, explored the possibility of a domestic application of the model and carefully adapted the existing model, the process of constructing a prediction equation was omitted."

16. Discussion-lines 399 to 411 are redundant

► Author's response:

Thank you for pointing this out. We overlooked the fact that we had mentioned the same point earlier, and the second limitation was described at length. We took care to avoid making the sentences appear cluttered; we modified the texts as follows in order to convey only the key points in a compressed manner.

► Revised manuscript: (p. 20-21, lines 405-420):

There is a difference between the current prevalence of obesity calculated from the Korea Health Panel data used in this study and the Korea Health Statistics using the KNHANES. As of 2011, the prevalence of adult obesity in Korea Health Statistics was 31.9%, and the prevalence of adult obesity calculated by the Korea Health Panel data was 23.7%, a difference of 8.2%.[38] As mentioned earlier

in the difference between the results of Baik's study, this difference originated from the method of measuring BMI in the two data sources. However, in the POHEM-BMI model used in this study, the BMI of the previous year was regarded as the main explanatory variable, and therefore, the Korea Health panel data that followed the same participants once a year was inevitably used.

“The prevalence of obesity calculated in this study is different from that of the Korea Health Statistics using the KNHANES, and as of 2011, the prevalence of adult obesity in the Korea Health Statistics was 8.2% higher than that of the Korea Health Panel Survey.[42] Although the method of measuring BMI in KNHANES is more accurate, in the POHEM-BMI model used in this study, the BMI of the previous year was regarded as the main explanatory variable, and therefore, the Korea Health panel data that followed-up the same participants once a year was inevitably used.”

VERSION 4 – REVIEW

REVIEWER	Dr. Alisha Wade MRC/Wits Rural Public Health and Health Transitions Research Unit, School of Public Health, University of the Witwatersrand, South Africa
REVIEW RETURNED	09-Dec-2020
GENERAL COMMENTS	The unit for BMI in table 3 is incorrect There are a few grammatical errors that should be corrected