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Research Article

Assessing STOP-Bang Questionnaire Sensitivity and Specificity for Sleep Apnea Detection in Iraqi Adults

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Abstract: **Introduction:** Obstructive sleep apnea (OSA) is a common sleep-related breathing disorder that can lead to severe health complications if left untreated. The STOP-Bang questionnaire, developed in Canada, is a widely used screening tool for OSA. However, the applicability of this tool in different populations, including the Iraqi population, requires further examination due to ethnic and physiological variations, particularly regarding body mass index (BMI). **Aim:** This study aimed to evaluate the effectiveness of the STOP-Bang questionnaire in detecting OSA among the Iraqi population and to determine whether adjusting the BMI cut-off value could improve its accuracy. **Methods:** A prospective cross-sectional study was conducted at Khanzad Teaching Hospital in Erbil, Iraq, between January 2022 and December 2023. A total of 500 adult patients (aged 18-60 years) who reported sleep-related breathing issues were included. Patients completed the STOP-Bang questionnaire, and those categorized as moderate-risk underwent further evaluation using the Medi Byte home sleep apnea testing device. The original BMI cut-off of 35 kg/m^2 was tested and adjusted using the ROC curve to improve the questionnaire's sensitivity and specificity. **Results:** With the original BMI cut-off of 35 kg/m^2, the risk distribution was: 18.5% low-risk, 48.2% moderate-risk, and 33.4% high-risk. Adjusting the BMI cut-off to 31.65 kg/m^2 led to a revised distribution of 18.5% low-risk, 34.4% moderate-risk, and 47.2% high-risk, indicating improved sensitivity in detecting severe cases. The adjusted BMI value aligned more closely with the average BMI of the Iraqi population, leading to a more accurate classification of OSA risk levels. **Conclusion:** The study suggests that a BMI cut-off of 31.65 kg/m^2 in the STOP-Bang questionnaire is more suitable for the Iraqi population, improving its accuracy in detecting OSA. This adjustment emphasizes the need to adapt screening tools to account for ethnic variations, enhancing early diagnosis and appropriate patient management.

Keywords: Obstructive Sleep Apnea (OSA), STOP-Bang Questionnaire, BMI Adjustment, Iraqi Population, Sleep Apnea Screening, Sleep Disorders, Diagnostic Sensitivity.

INTRODUCTION

Sleep problems associated with breathing is a name used Amberle under which many conditions lie like simple snoring, upper airway resistance syndrome and obstructive sleep apnea [1]. Obstructive sleep apnea is one of the most widespread breathing problems during sleep, affecting about 2–26% of the from different sex, age, and the definition of criteria [2]. Medical research can utilize many types of questioners including multi-item ones to evaluate transient changes in the health of members of groups or they may target the entire population, or a subset of the population based on exposure characteristics. Health professionals may use these questionnaires as an objective instrument to assist in the enhancement of patients' live quality level and the referral of individuals to the most appropriate health care. Moreover, their efficiency in research and clinical settings is enhanced by the fact that they are adaptable and translatable to diverse population groups [3,4].

The questioner should collect accurate and meaningful data through the development of efficient questions for further research and gain a deeper understanding of clinical conditions [1]. Ensuring unity in observations across various groups is critical in establishing the questionnaire's validity. Validity pertains to the extent to which a given questionnaire assesses the construct that it is designed to evaluate. Acquiring consistency in observations enables researchers to evaluate the questionnaire's validity with respect to the groups under investigation. This procedure facilitates the

assessment of whether the questionnaire adequately elicits the desired data from various demographic groups, thereby augmenting the overall rigor and precision of the research outcomes. [3,5].
In 2008 The questionnaire (STOP-Bang) was developed by Chung F. et al in Canada and introduced as a sensitive, simple, and easy to be used for screening obstructive sleep apnea [4].
It was considered that this questionnaire bears sufficient sensitivity so that effectively detects obstructive sleep apnea. Several studies have documented high sensitivity values for OSA, particularly in the detection of severe and moderate-to-severe cases. It has been reported that the STOP-Bang score measures moderate OSA with a sensitivity of 93% and great sensitivity of 100% for sever cases. Furthermore, the questionnaire has undergone approval as a highly effective screening instrument, specifically for obstructive type of sleep apnea, in sleep study clinics and /or suspected surgical populations. Additionally, its sensitivity for OSA in patients referred to sleep medicine clinics has been documented to range between 75.3% and 93.4%. Furthermore, it has been determined that the questionnaire detects both types of patients, those considered moderate-to-severe and those with severe situation more effectively than other screening instruments. In brief, the STOP-Bang questionnaire has exhibited a notable degree of sensitivity in accurately diagnosing severe and moderate-to-severe instances of obstructive apnea [6,7].

Patients' sensibility to sleep apnea were evaluated by using this special questioner. To identify patients with high potential to be at risk of obstructive type apnea, this method evaluates many measures like the index of body mass, patient age and circumference of neck, sex, snoring, fatiguability, and blood pressure. The utilization of the questionnaire obviates the necessity for dependable polysomnography diagnosis after overnight test, the gold standard for diagnosing OSA (although its implementation may not always be feasible). healthcare personnel can identify patients who may necessitate additional assessment and treatment for obstructive sleep apnea by employing the questionnaire.[7]

STOP-Bang questionnaire.

The STOP-bang questioner consists of two parts the first one STOP part which include: Snoring, tiredness, observed apnea, and high blood pressure and second part which include four demographics items which are BANG: BMI, Age, Neck circumference, Gender.[8]

The STOP-Bang questionnaire is composed of eight dichotomous key like items (yes/no) including most of the clinical characters of sleep apnea [9].
The answers score in the range between 0 to 8. Patients are categorized according to their susceptibility for developing OSA. There probability increases with the elevation of score from 0 and 1 up to 7 or 8. Those who score between 0 to 2 can be subcategorized as the lowest risk probability, whereas those with highest possible a score 5-8 are grouped as high risk. and those who record in the range between (3 or 4) are the moderate ones [10].

The questions composed of the following parts:

1. Do you snore loudly?
2. any mention of daytime tired, fatigue?
3. anyone confirm you stop breathing at sleep time?
4. Do you use anti-hypertensive drugs?
5. Is your body mass index over run 35 kg/m^2?
6. Are you in Fifth decade?
7. Neck circumference exceeds 40 cm?
8. Are you male? [10]

BMI

Body Mass Index (BMI)is the measurement of body fat by evaluating the values of weight and height, it might vary significantly across different ethnic groups. While BMI is commonly used to assess health risks related to weight, it's essential to recognize that these risks are not uniform across all populations. Let's delve into the fascinating world of BMI variations:

1- Risk factors for some diseases associated with different Ethnic groups also Differences in BMI averages.

a- Asians show more susceptibility to develop type 2 diabetes in range of about the double compared to white peoples with same BMI.
b- weight rise with time looks more harmful for Asians, leading to an 84 % increase in their risk for type 2 diabetes with each one of 11 pounds increases during maturity.

2-Genetics and Environment:

a- While genetic differences play a role in body fat patterns among ethnic groups, environmental factors exert a more significant influence.
b- low level nutrition in early life, such what happen during the famous Chinese famine at (1954 -1964), associated with raises the risk of diabetes in later adulthood, particularly with those persons who their later live show satisfaction in nutrition field, these findings emphasize the need to consider ethnicity-specific factors [3,11].

The nationally representative cross-sectional survey conducted in Iraq in 2015 included a total of 3916 participants. The finding average BMI in Iraq is as follows:

- 3.6 percentage from the participants show underweight as their BMI was less than18.5 kg/m^2.
- 30.8percent recorded with normal weight level BMI with 18.5 kg/m^2.
- 31.8 percent were categorized as overweight as they were over 25 kg/m^2.
- The remining 33.9 percent labeled as obese with BMI level exceed 30kg/m^2

The range of prevalence of obesity around Middle East was ranging between 40.62% for Syrian and 8.80% in Yemenis, and the mean weight for the Iraqi population was recorded is female around 25.7kg/$m^2$and male average was 19.9 kg/m^2[12].

Home Sleep Apnea Testing Device

Portable monitors can be used for sleep monitoring as they show the ability to be used at home, they cost less, are faster to deploy, more accessible, and show great accuracy as laboratory polysomnography. There are four types of portable monitors based on the number and type of recording channels, The American Academy of Sleep Medicine recommends that lowest level of portable monitors should be able to record airflow, respiratory effort, and blood oxygenation; this level of monitoring is found among type 3 portable monitors [13]. This device is used to assess sleep-disordered respiration, a 12-channel Type 3 home sleep apnea and snoring recorder, Medi Byte®, was utilized. The subsequent variables were monitored for a specified number of minutes: Snoring (airflow vibrations at high frequencies), oronasal pressure the airflow, user events, SpO2, RIP Chest/Abdominal/Sum Effort, thermal airflow, pulse rate, and the body position. The scoring of respiratory events was conducted in accordance with the subsequent guidelines: Apneic events necessitated an airflow reduction of 90% or greater, whereas hypopnea events demanded a 30% airflow reduction in addition to a 3% oxygen desaturation [14]

MATERIALS AND METHODS

Study design and population.

In our study we take samples from Erbil city in Iraq as paradigm of Iraq population, 700 persons who visited diagnosis department in khanzad teaching hospital for dental care in period between January 2022 till December 2023 and who describe some breathing problems during sleep times they were invited in this prospective cross-sectional study and asked to answer stop bang questioner According to inclusion and exclusion criteria only five hundred were included. (a) age between 18-60 years, (b) willingness to answer the questionnaire (c) obese patients (d) patient who suffering from snoring problems.

The following criteria used to exclude patients:(a) patients with nasal obstruction problems (b) patient with known neurological problems(c) who use medications to treat insomnia e.g. Belsomra, Ambien (d)patients with chronic respiratory failure. Looking for the most appropriate BMI cutoff value for Iraqi patients which is a part of questioner used to detecting obstructive sleep apnea (OSA) is tried to be done by using a prospective cross-sectional study type. A total of 500 qualified consecutive patients at Khanzad teaching hospital, from April to December 2022 were included in the study. The patients were asked to complete the STOP-Bang questionnaire (Table 1). The ability of the STOP-Bang questionnaire to detect moderate to severe OSA (AHI 15 events/h) was then assessed. Resulted in highest sensitivity with only a small decrease in specificity.

The part of the questioners that need assistance to be completed like BMI, neck circumference was done by supervising dentist. neck perimeter was recorded with aid of special tape for measuring the neck circumference, for other measurements like those of height and weight, if patients know his measurements it was written by him/herself and if not, it has been measured too. The original stop Bang questionnaire was composed of 8 different questions. All precipitants were asked to complete the part of questions which is related to the symptoms, whilst the researchers or supervisor taking the responsibility of completing the remaining part of the questions with the patient. The results were calculated as follows; For each yesanswerprecipitant will get+1 while 0 for each No answer. After answering all questions and collecting the final score for each participant results sub groped to those with high level risk to obstructive apnea with score equal or exceed 5 and those records between 3-4considered as Intermediate risk and finally low risk group with record equal and bellow 2, In the original STOP-Bang screening tool, the break point level was sited at BMI > 35 kg/m^2.cases which categorized under moderate group according to the questioner in general were first asked to answer the STOP questionnaire twice for reliability checking. then those with border line BMI difference subjected to overnight sleep study using the at home polysomnography (Medi Byte) to confirm the finding of the questioner which was suspicious for some patient especially those who indicated as moderate cases and more 30 BMI although they give history of sever cases (Fig1,). the result of polysomnography study (Fig.2)

support the idea that show many of moderately indicated in the questioner have Haigh risk records and the point where the questioner didn't catch them as sever cases as a result off BMI level at 35 , there miss +1 from the questioner because the high sited level of BMI so they fall under the moderate group whereas the polysomnography study show them as sever category questioner show greater sensitivity and accuracy (Table 2). In summary, BMI is a valuable tool, but its interpretation should be nuanced, accounting for ethnic diversity and other individual factors. interventions, The ROC curve was used to adjust the limit of BMI which is to be considered as a limit for obesity. This resulted in adjusting it to Iraqi 31.65 kg/m^2 rather than 35 kg/m^2 which is more precisely evaluate the risk level of OSA.

RESULTS

After obtaining the result from all patients, the frequency of patient in each risk group (low , moderate, high) were like that (34% = 167) high risk, (48.2%= 241) moderate risk, (18.5% =92) were low risk group , this result obtained by using original STOP-bang criteria including original BMI cutoff which is 35 kg/m^2(Table.1)

Table 1: risk factor level and group according to original STOP-Bang questioner:

Frequency	Risk	Percentage	Gender	BMI
167	High	33.4%	68.2% Male	97.4%< 35
241	Moderate	48.2%	31.8 % Female	2.6% >35
92	Low	18.5%		
500		100%	100%	100%
478 precipitants have BMI <35 = 97.4% When official cut off at 35 for BMI has been used				

After reviewing the original results and trying different cutoffs (table.3) and manipulate the or genial questioner and adjusting original BMI =35 kg/m^2 to another value BMI = 31.65 kg/m^2, the result differ as follow (47.2% = 236) high risk, (18.5%= 92) moderate risk, (34.4% =172) were low risk group, this result obtained (Table.2)

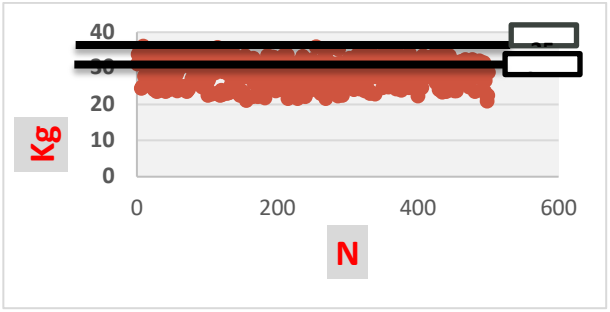
patient this again show the necessity of adjusting BMI level after testing different cut offs (table 3) and with the aid of ROC curve, it was decided that the original value of BMI is very high for Iraqi population and difficult to be reached and after adjusting it to 31.65 the

Table 2: risk factor level and group after adjusting the STOP-Bang questioner:

Frequency	Risk	Percentage	Gender	BMI
236	High	47.2%	68.2% Male	83.6% < 31.65
172	Moderate	34.4%	31.8 % Female	22.4% > 31.65
92	Low	18.5%		
500		100%	100%	100%
388precipitants have BMI <31.65 = 83.6% When adjusting the cut off for BMI to 31.65				

Table 3: different levels BMI cut off and patient observed to exceed highest limit.

BMI > 30	BMI > 31	BMI > 32	BMI > 33	BMI > 34	BMI > 35
214	160	100	64	29	12
42 %	32 %	20 %	13 %	5.8 %	2.4 %



(Figure 1) Adjusting the BMI level from 35 Kg to 31.65 Kg.

DISCUSION

After reviewing the patient records from original STOP-bang, and considering some patient complains especially those who are grouped as media risk but they seem to sever more seriously, and to assure those findings by using portable polysomnography and notice that there is some miss catching of high risk patient by the questioner it was thought that there is problem in the question regarding BMI as its sited at vale of 35 which seems to be high value to reached by our patients, there for and after trying different levels of cutoff and with the help of ROC

test, the Value of BMI were changed to (31.65).
The new approach for determining the best cut-point value in ROC curve differs from existing methods in many ways:

1. Justification of Calculation: The novel methodology is founded upon the assessment of the area under the ROC curve (AUC), whereas previous approaches relied on distinct criteria like the Youden index, concordance probability, point nearest to (0, 1) on the ROC curve, maximum attainable value of the chi-square statistic, and the product of sensitivity and specificity.
2. Determination of the Optimal Cut-Point: The new methodology delineates the cut-off value as the point at which the absolute value of the discrepancy between the sensitivity and specificity values is least significant, and where sensitivity and specificity values approach the value of the AUC. This method derived from current available methodologies that anticipate criteria like Youden function magnification, Euclidean range decrease between the ROC curve and the (0, 1) point, or sensitivity and specificity product maximization.
3. Practicality: this new method is very practical, identifying cut-point value that depends on a straightforward standard related to the AUC. This differs from other available methods which may involve complex calculations.
4. Performance: comparing this the new methodology exhibits superior performance to certain established approaches, specifically with consideration to enhancing interpretability and improve the cut-point. In summary, the new approach for determining the optimal cut-point value in ROC curve analysis differs from existing methods in its basis of calculation, criteria for optimal cut-point, practicality, and performance.[15]

The ROC (Receiver Operating Characteristic) test does not directly adjust the cut-off point. But instead, it provides a graphical representation of the trade-off between the true positive rate (sensitivity) and the false positive rate (1 - specificity) for all possible cut-off points. The ROC curve helps in evaluating the diagnostic accuracy of a biomarker and identifying the optimal cut-off point, which is the threshold value that best discriminates between the two groups being studied (e.g., diseased, and healthy individuals).[16][17].

Various techniques used, including the Youden index, the point closest to the (0, 1) corner in the ROC plane, and the IU method proposed in the study, can be utilized to determine the optimal cut-off point. These methodologies consider a multitude of variables, such as sensitivity, specificity, and the area under the ROC curve, to determine the optimal cut-off value that optimizes diagnostic precision. In summary, the ROC test itself does not adjust the cut-off point, but it provides the information needed to estimate the optimal cut-off point through various analytical methods.[18]

In the original STOP-Bang questionnaire, the following cut point are used usually: BMI > 35 kg/m^2, which might be more suitable for the Canadian or north American or western population according to the following findings:
The mean BMI in Canadian population has been on the rise over the past few decades. The prevalence of obesity is considered when body mass index of 30 or higher shows noticeable increase in a constant manner. According to survey done in 1985 by Canadian Health Promotion, the results show 6.1% of Canadian adults can be considered as obese, and if these results compared with 18.1% reported from the findings of the 2010 Canadian Community Health Survey. The prevalence of obesity has increased in great manner, with a disproportionate growth in excessive weight categories (BMI 35.0–39.9 and BMI ≥ 40.0).[19][20]

Another finding was that the prevalence of obesity in Canada for individuals with a BMI over 35 has increased significantly over the past few decades. According to the data, the prevalence of obesity in class II (BMI 35.0–39.9) increased from 0.8% to 3.6% between 1985 and 2011. The trend analysis predicts that by 2019, the prevalence of obesity in class II and class III will increase to 4.4% and 2.0%, respectively.[19][21][22].

A BMI of 30kg/m2 is considered obese because it falls within the obesity range according to the (WHO) classification. The WHO defines obesity as a BMI equal to or greater than 30kg/m2. This classification is based on extensive research and epidemiological evidence linking BMI to health outcomes. A BMI of 30kg/m2 or higher seems to increase the risk for hypertension, diabetes, cardiovascular diseases, and certain types of cancer. Therefore, it serves as a widely recognized indicator of obesity and its associated health risks.

The average BMI of adults in Middle Eastern countries from 2000 to 2020, according to the study's findings, is 33.14 kg/$m^2$for obesity and21.17 kg/m^2.for overweight. Which still look far from 35 kg/m^2.

The study found that the obesity cut-off for adults in Middle Eastern countries from 2000 to 2020 was defined as a BMI of 30 kg/m^2.
(Fig.2) STOP-Bang questionnaire answered by same patient X [22]

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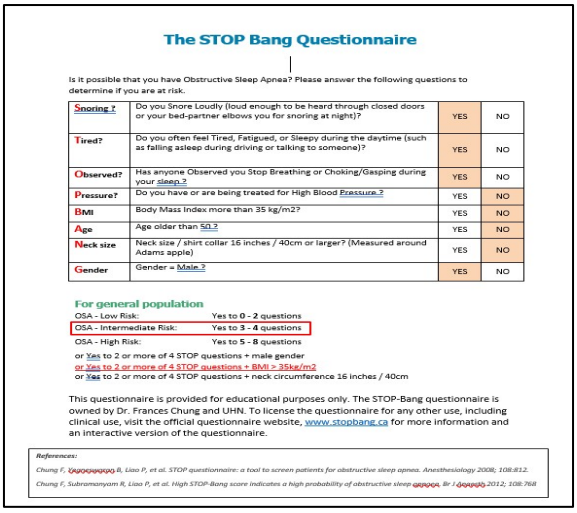

The STOP Bang Questionnaire

Is it possible that you have Obstructive Sleep Apnea? Please answer the following questions to determine if you are at risk.

Snoring ?	Do you Snore Loudly (loud enough to be heard through closed doors or your bed-partner elbows you for snoring at night)?	YES	NO
Tired?	Do you often feel Tired, Fatigued, or Sleepy during the daytime (such as falling asleep during driving or talking to someone)?	YES	NO
Observed?	Has anyone Observed you Stop Breathing or Choking/Gasping during your sleep.?	YES	NO
Pressure?	Do you have or are being treated for High Blood Pressure.?	YES	NO
BMI	Body Mass Index more than 35 kg/m2?	YES	NO
Age	Age older than 50.?	YES	NO
Neck size	Neck size / shirt collar 16 inches / 40cm or larger? (Measured around Adams apple)	YES	NO
Gender	Gender = Male.?	YES	NO

For general population

OSA - Low Risk:	Yes to 0 - 2 questions
OSA - Intermediate Risk:	Yes to 3 - 4 questions
OSA - High Risk:	Yes to 5 - 8 questions

or Yes to 2 or more of 4 STOP questions + male gender
or Yes to 2 or more of 4 STOP questions + BMI > 35kg/m2
or Yes to 2 or more of 4 STOP questions + neck circumference 16 inches / 40cm

This questionnaire is provided for educational purposes only. The STOP-Bang questionnaire is owned by Dr. Frances Chung and UHN. To license the questionnaire for any other use, including clinical use, visit the official questionnaire website, www.stopbang.ca for more information and an interactive version of the questionnaire.

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Chung F, Subramanyam R, Liao P, et al. High STOP-Bang score indicates a high probability of obstructive sleep [illegible]. Br J [illegible] 2012; 108:768

The average BMI for the Iraqi population according to the study's findings is 29.1 kg/m^2.

According to finding of a study the prevalence of obesity in the Iraqi population ranges from 14.3% to 40.9%. The prevalence of overweight and obesity among adults in Iraq was reported to 33.4% for obesity in some studies, while other studies reported lower rates of 14.3% for overweight and 33% for obesity.

Those above-mentioned observations show grate variation in BMI values between Canadian population where the original stop bang questioner were sited and middle eastern population generally and Iraqi population specifically, which might miss lead the questioner for differentiating between sever and moderate cases as the BMI value makes a score difference equal to 1.

The purpose of the research was to determine a BMI threshold value for the STOP-Bang questionnaire that would be more suitable for Iraqi patients. When the BMI threshold was established at 31.65 kg/m^2, the results indicated that the questionnaire was more effective at identifying moderate to severe OSA. The implementation of this threshold value led to increased sensitivity while marginally diminishing specificity. This research indicated that a BMI criterion value of 31.65 kg/m^2 for the STOP-Bang questionnaire would be more appropriate when assessing Iraqi patients.

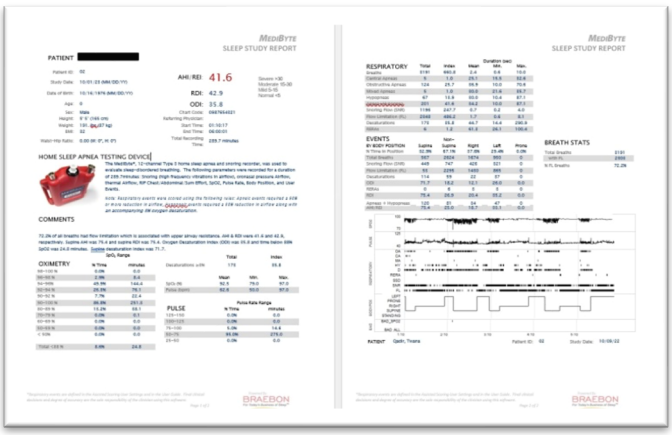
LIMITATION

The primary limitation of this study is the relatively small sample size, which was confined to a single teaching hospital in Erbil, potentially limiting the generalizability of the findings to the broader Iraqi population. Additionally, the study's cross-sectional design restricts the ability to assess long-term outcomes of using the adjusted STOP-Bang questionnaire. The absence of a control group and reliance on self-reported data for certain measures, such as BMI and neck circumference, may have introduced measurement biases. Furthermore, due to limited prior research on OSA screening within the Iraqi population, comparisons with other studies were constrained, emphasizing the need for larger, multi-center studies to validate these findings across different regions of Iraq.

CONCLUSION

As the STOP-bang questioner is considered as the first line diagnostic tool for sleep apnea, it's precisely ability is a matter of concern as many judgements will depend on its results, such as the referral of the patient for different treatments and more simply the condition of the patient which he/she should be worried about or not, the results of this study show that adjusted questioner will be more accurate if it take in consideration the differences between ethnic groups and adapting it to these groups or populations, this will show better performance of the questioner as many of later decisions will depend on that, those adjustments seen in these study representing itself by BMI, in which change in its value make the questioner more able to precisely detecting sleep apnea level for Iraqi population. The study suggested that using a BMI separative value of 31.65 kg/$m^2$of the STOP-Bang questionnaire would be more suitable for Iraqi patients and more accurately refer patients to orthodontic or surgical treatment.

(Fig.1) SLEEP STUDY REPORT by Medi Byte®, of patient X. [10]



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Consent for publications: The author read and approved the final manuscript for publication.

Ethics approval and consent to participate: The

study was approved by the Hawler Medical University's College of Dentistry's Ethics and Scientific Committee.

Informed Consent: All patients are informed that they are participating in medical research and their answer can be used in the research.

Availability of data and material: Data are available from the corresponding author upon request.

Authors' contributions
Haval J. Rasheed and Zana Q. Omer have made substantial contributions to the conception or the design of the manuscript, Haval Jalal Rasheed to acquisition, analysis and interpretation of the data. All authors have participated in drafting the manuscript, Haval J. Rasheed and Zana Q. Omer revised it critically. All authors read and approved the final version of the manuscript. All authors contributed equally to the manuscript and read and approved the final version of the manuscript.

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Ethical approval: The research was approved by the Hawler Medical University's College of Dentistry's Ethics and Scientific Committee. Ethical Code No.= D-2022-114.

Data Availability Statement: Data are available from the corresponding author upon request.

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