PHYSICIAN EVALUATION AMONG DENTAL PATIENTS WHO SCREEN HIGH-RISK FOR SLEEP APNEA

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ABSTRACT

Kristin D. Dillow: Physician evaluation among dental patients who screen high-risk for sleep apnea.
(Under the direction of Gregory K. Essick)

This study sought to investigate the feasibility of screening for obstructive sleep apnea (OSA) risk in a dental practice and to examine patient response to a recommendation for physician evaluation. OSA risk was assessed for 119 adults using the validated STOP screening questionnaire and overnight pulse oximetry. Patients classified as high-risk on one or both instruments were advised to seek physician evaluation. Fifty percent (50.4%) of patients screened high-risk on STOP questions, 58% on pulse oximetry, and 31.9% on both instruments. Follow-up information obtained from 111 patients (93.3%) revealed that 42 patients (35.3%) sought physician evaluation within three months of OSA screening. Probability of care seeking was similar for patients at high-risk by simple questions or pulse oximetry when instruments were jointly administered. Findings have implications for the establishment of recommendations for clinically based OSA screening.
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<table>
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<th>Description</th>
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<tr>
<td>AHI</td>
<td>Apnea-hypopnea index</td>
</tr>
<tr>
<td>BMI</td>
<td>Body mass index</td>
</tr>
<tr>
<td>CT(_{90})</td>
<td>Cumulative time spent below 90% saturation</td>
</tr>
<tr>
<td>ESS</td>
<td>Epworth Sleepiness Scale</td>
</tr>
<tr>
<td>ODI</td>
<td>Oxygen desaturation index</td>
</tr>
<tr>
<td>OHS</td>
<td>Obesity hypoventilation syndrome</td>
</tr>
<tr>
<td>OSA</td>
<td>Obstructive sleep apnea</td>
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<tr>
<td>PSG</td>
<td>Polysomnography</td>
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<tr>
<td>SpO(_2)</td>
<td>Oxygen saturation of peripheral artery</td>
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1. INTRODUCTION

Obstructive sleep apnea (OSA) is increasing in prevalence, widely undiagnosed, and a precursor of significant pathology. Marked by a lapse in breathing or a significant reduction of airflow during sleep, moderate OSA is estimated to affect 10% of men and 3% of women aged 30-49 years and 17% and 9% of men and women, respectively, aged 50-70 years. Additionally, more than 80% of moderate to severe OSA cases remain undiagnosed. The percentage of OSA among American adults is steadily increasing with the rising rate of obesity. Young et al. found that obesity is the strongest contributing factor to OSA, which strengthens the assumption that the increasing prevalence of OSA parallels that of obesity. OSA is the leading cause of excessive daytime sleepiness and is associated with the development of hypertension, cardiovascular disease, metabolic syndrome, stroke, and depression. When left untreated, OSA is a significant medical condition that can impair quality of life.

At present, polysomnography (PSG) provides formal diagnosis of sleep apnea; however, insufficient numbers of sleep laboratories and the prohibitive cost of their services may discourage this type of evaluation. As disease awareness increases, so does the demand for convenient and economical methods of diagnosing patients with OSA and of screening individuals to identify those at risk for OSA.

To assess a possible need for PSG, questionnaires such as the STOP, STOP-Bang, and Epworth Sleepiness Scale (ESS) are becoming widely accepted for their use in screening for OSA risk in clinical settings. Specifically, the STOP and STOP-Bang
questionnaires have been shown to have the highest methodological validity, reasonable accuracy, and simplicity.\textsuperscript{10} Likewise, home sleep testing devices measuring pulse oximetry provide objective data and often comparable diagnostic outcomes as those yielded with conventional PSG, particularly for patients with more severe disease.\textsuperscript{11-13}

As with many systemic diseases, OSA may have an association with periodontitis. Ahmad \textit{et al.} found that dental patients who screened high-risk for OSA were four times more likely to have moderate or severe periodontitis than those who screened low-risk (95\% CI: 1.5, 11.4).\textsuperscript{14} Similarly, a study conducted by Gunaratnam \textit{et al.} suggests that the prevalence of periodontitis is greater in patients with OSA.\textsuperscript{15} The high prevalence of undiagnosed sleep apnea and its potential relationship with chronic periodontitis suggest that dentists and dental hygienists could provide a valuable service to patients by incorporating sleep apnea screening into their practice.\textsuperscript{16} This is especially important for dental patients who do not regularly access general health care. An estimated 23\% of adults who visit their dentist regularly do not have contact with a physician.\textsuperscript{17} By incorporating OSA screening into clinical practice, dentists and dental hygienists can alert patients about the need for follow-up with a physician, when warranted. Therefore, the aim of this study was to investigate the feasibility of screening for OSA risk in a dental practice and to examine the response of patients to a recommendation for physician evaluation.
2. REVIEW OF THE LITERATURE

2.1 Classifications of Sleep Apnea

Sleep apnea is defined by events of complete cessation of breathing (apnea) or a marked reduction in airflow (hypopnea) during sleep. Hypopneas result from a decrease of $\geq 30\%$ in respiratory effort accompanied by $\geq 4\%$ oxygen desaturation, although alternative definitions are often reported in the literature. Apneas and hypopneas that last at least 10 seconds are considered clinically significant. In some individuals, these reductions in airflow may persist for 30-60 seconds. Sleep apnea is further classified as central, obstructive, or mixed. Central apneas result from a lack of neural output from the brainstem respiratory centers, which leads to a lack of inspiratory effort. In short, the brain temporarily stops sending signals to the muscles that control breathing. Obstructive apneas result from a closure or collapse of the upper airway during sleep, preventing airflow into the lungs. Mixed apneas are a combination of central and obstructive apneas. Mixed apneas typically start out as central; however, the apnea persists after respiratory effort commences due to collapse of the upper airway, resulting in obstruction to airflow.

2.2 Obstructive Sleep Apnea

Among the classifications of sleep apnea, obstructive sleep apnea (OSA) is the most common. Studies report 1 in 5 Americans have at least mild OSA while 1 in 15 have moderate to severe forms of the disease. Of these, more than 80% are unaware of their condition. OSA is a significant medical condition that can drastically decrease quality of life in severe cases when left untreated. OSA is also the leading cause of excessive
daytime sleepiness and is associated with the development of hypertension, cardiovascular disease, metabolic syndrome, stroke, and death. In addition, OSA is reported to increase depression by at least twofold in patients who suffer from the disease.

2.3 Polysomnography

In order to determine if a person has sleep apnea, a diagnostic test must be performed. Polysomnography (PSG) is considered the “gold standard” for diagnosing sleep apnea. During the overnight stay in a sleep laboratory, respiratory parameters are measured to determine a person’s apnea-hypopnea index (AHI). The AHI, or number of obstructive events per hour of sleep, is the key measure for OSA severity: AHI >5 is interpreted as mild OSA; AHI >15 as moderate OSA; AHI >30 as severe OSA. Although PSG is the formal method of clinically diagnosing sleep apnea, the number of sleep laboratories in the country is insufficient for the increasing population prevalence of the disease. Furthermore, the high cost and inconvenience of PSG sleep studies often discourage individuals from seeking this type of evaluation. Recent clinical guidelines suggest unattended home testing, in conjunction with a comprehensive sleep evaluation, is an option for patients with a high pretest probability of moderate to severe apnea when initiation of treatment is urgent and PSG is not readily available. The National Institute for Health and Clinical Excellence (NICE) also states moderate to severe OSA can be diagnosed from patient history and a sleep study using oximetry or other monitoring devices unattended in the patient’s home. However, patients suspected of having OSA who receive a negative home test result should follow-up with PSG.
2.4 STOP: A Screening Questionnaire

Reliable screening tools, such as the 4-item STOP questionnaire, are useful in identifying a patient’s probability of having sleep apnea. The STOP questionnaire was originally developed as a pre-surgical screening tool for OSA and represents a simple and efficient method of identifying patients at risk for the disorder.\textsuperscript{24} The questionnaire, using the acronym STOP, has patients report loud snoring, tiredness during the daytime, observed gaps in breathing, and a history of high blood pressure. Patients with two or more affirmative responses are classified as high-risk for OSA, while patients with scores of <2 are classified as low-risk. Sensitivity and specificity values for the STOP questionnaire are summarized in Supplementary Table 1. The study by Chung et al. found sensitivity and specificity of the STOP questionnaire to be 66\% and 60\%, respectively, for detecting patients with mild OSA.\textsuperscript{24} The same study also suggests the STOP questionnaire may have a greater sensitivity for detecting patients with moderate and severe forms of OSA, with values of 74\% and 80\%, respectively.\textsuperscript{24} Specificity for detecting patients with moderate and severe forms of OSA was estimated to be 53\% and 49\%, respectively. In comparison with other screening tools, the STOP questionnaire has been shown to have the highest methodological validity and reasonable accuracy when identifying patients at risk for OSA.\textsuperscript{10}

2.5 STOP-Bang

As a continuation of the STOP questionnaire, the STOP-Bang screening method includes additional measures of body mass index (BMI), age, neck circumference, and gender. Clinical characteristics of BMI $>35$ kg/$m^2$, over 50 years of age, neck circumference $>40$ cm, and male gender appear to increase the risk for OSA. A STOP-
Bang score of $\geq 3$ is classified high-risk for OSA, while scores of $<3$ are classified low-risk. Chung et al. estimate that the STOP-Bang has a higher sensitivity than the STOP for detecting moderate and severe cases of OSA: 93% and 100%, respectively.\textsuperscript{24} However, the specificity is lower: 43% and 37% for moderate and severe OSA, respectively, resulting in high false negative rate. Therefore, in this research study, we considered an individual at high-risk for OSA if STOP $\geq 2$ in order to achieve a reasonably high level of sensitivity and acceptable level of specificity in detecting moderate or severe cases of OSA.

2.6 Epworth Sleepiness Scale

Excessive daytime sleepiness is a cardinal feature of OSA. The Epworth Sleepiness Scale (ESS) is a screening tool used to measure an individual’s daytime sleepiness. This 8-item questionnaire asks subjects to rate how likely they are to doze in a variety of daytime situations using the following criteria: 0=would never doze; 1=slight chance of dozing; 2=moderate chance of dozing; 3=high chance of dozing. A score of $\geq 11$ indicates a high risk of excessive daytime sleepiness and a score of $<11$ is considered low risk. However, Gottlieb et al. found that a score $>11$ is present in only 35% of patients with severe OSA based on AHI.\textsuperscript{25} Although ESS is not a strong indicator of OSA on its own, it can be helpful in identifying persons at risk when used in conjunction with other methods. In this study, ESS was used to assess the relationship between OSA risk status and self-reported degree of daytime sleepiness.

2.7 Pulse Oximetry

In addition to screening questionnaires, overnight pulse oximetry provides a non-invasive, economical method of determining risk for OSA. The portable pulse oximeter continually monitors and records oxygen saturation (SpO$_2$) of a peripheral artery during
sleep and can detect a fall in SpO₂ caused by respiratory events. Oxygen saturation levels and heart rate are recorded simultaneously and the pulse oximetry device can provide the following information: oxygen desaturation index of 2% (ODI2), 3% (ODI3), or 4% (ODI4) and cumulative time spent below 90% oxygen saturation (CT90). ODI refers to the number of events per hour of 2%, 3%, or 4% or greater decrease in oxygen saturation from the baseline level, typically determined during the first few minutes of recording while the patient is awake. Cooper et al. determined that the sensitivity and specificity of pulse oximetry as a single predictor for identifying OSA was dependent on the AHI, concluding that pulse oximetry is more effective for screening patients with moderate to severe sleep apnea than for milder severity. The study found sensitivity was 100% and specificity 95% for patients with an AHI of ≥25 events per hour, but both sensitivity and specificity decreased as AHI decreased. Other studies reveal a broad range of sensitivity and specificity values. Overall, the body of evidence concludes that the combination of a screening questionnaire with pulse oximetry improves the specificity of oximetry as a screening tool for sleep apnea. Oeverland et al. found ODI3 to be the optimal measurement for determining OSA risk, which resulted in 91% sensitivity and 67% specificity in individuals with at least mild OSA, and 86% and 88% in moderate to severe cases (Supplementary Table 2). Furthermore, Niijima et al. concluded that a threshold of ODI3 ≥10 reduced the number of undetected OSA due to false negatives. Similarly, Nigro et al. noted sensitivity and specificity to be 88% and 94%, respectively, in moderate OSA cases at a threshold of ODI3 >10.5. The diagnostic usefulness of CT90≥1% has also been evaluated. Gyulay et al. found that CT90≥1% identified patients with at least moderate OSA with sensitivity of 93% and specificity 51%. Furthermore, Gyulay et al.
suggest that oximetry data should be analyzed by calculating both CT$_{90}$ and ODI in order to obtain the highest sensitivity and specificity for detecting OSA.\textsuperscript{32} Therefore, in this research study an individual was considered high-risk for OSA if ODI $\geq 10$ events per hour or CT$_{90} \geq 1\%$ of the recording period.

2.8 Significance to Dental Professionals

OSA is one of the most common undiagnosed chronic diseases. Dental professionals represent an important resource for identifying individuals at risk for OSA due to the frequency of examinations. Furthermore, many adults do not visit their primary care physician on a frequent basis. Recent research suggests approximately 23\% of the adult population who did not have contact with a physician did see their dentist on a regular basis.\textsuperscript{17} This relationship gives the dental practitioner the opportunity to closely monitor the patient’s medical health.\textsuperscript{2} For example, dental professionals play an important role in detecting undiagnosed and uncontrolled hypertension among patients by monitoring blood pressure at dental appointments. However, research shows that less than 50\% of dentists are familiar with the common signs and symptoms of sleep apnea.\textsuperscript{16} For this reason, it is important to educate dentists and dental hygienists in the recognition and screening of sleep apnea. Accepting dentistry’s position as a part of a team dedicated to the study of sleep related disorders is useful to proper and ethical participation in the screening and treatment of sleep apnea.\textsuperscript{33} At present, there are no accepted guidelines for screening patients in the dental office. Neither is it known whether patients who screen high-risk for OSA subsequently seek consultation with their physicians regarding the results of the screening tests.
2.9 Study Purpose

OSA is increasing in prevalence, widely undiagnosed, and a precursor of significant pathology.\textsuperscript{1-9} Collectively, these features point to the salience of OSA screening. Therefore, the purpose of this study was to investigate the feasibility of screening for OSA risk in a dental practice setting and to examine the response of patients to a recommendation for physician evaluation.
3. INTRODUCTION AND REVIEW OF THE LITERATURE

Obstructive sleep apnea (OSA) is increasing in prevalence, widely undiagnosed, and a precursor of significant pathology. Marked by a lapse in breathing or a significant reduction of airflow during sleep, moderate OSA is estimated to affect 10% of men and 3% of women aged 30-49 years and 17% and 9% of men and women, respectively, aged 50-70 years.\(^1\) Additionally, more than 80% of moderate to severe OSA cases remain undiagnosed.\(^2,3\) The percentage of OSA among American adults is steadily increasing with the rising rate of obesity. Young et al. found that obesity is the strongest contributing factor to OSA, which strengthens the assumption that the increasing prevalence of OSA parallels that of obesity.\(^4\) OSA is the leading cause of excessive daytime sleepiness and is associated with the development of hypertension,\(^5\) cardiovascular disease,\(^6\) metabolic syndrome,\(^7\) stroke,\(^8\) and depression.\(^9\) When left untreated, OSA is a significant medical condition that can impair quality of life.

At present, polysomnography (PSG) provides formal diagnosis of sleep apnea; however, insufficient numbers of sleep laboratories and the prohibitive cost of their services may discourage this type of evaluation.\(^10\) As disease awareness increases, so does the demand for convenient and economical methods of diagnosing patients with OSA and of screening individuals to identify those at risk for OSA.

To assess a possible need for PSG, questionnaires such as the STOP, STOP-Bang, and Epworth Sleepiness Scale (ESS) are becoming widely accepted for their use in screening for OSA risk in clinical settings. Specifically, the STOP and STOP-Bang
questionnaires have been shown to have the highest methodological validity, reasonable accuracy, and simplicity. Likewise, home sleep testing devices measuring pulse oximetry provide objective data and often comparable diagnostic outcomes as those yielded with conventional PSG particularly for patients with more severe disease.11-13

As with many systemic diseases, OSA may have an association with periodontitis. Ahmad et al. found that dental patients who screened high-risk for OSA were four times more likely to have moderate or severe periodontitis than those who screened low-risk (95% CI: 1.5, 11.4). Similarly, a study conducted by Gunaratnam et al. suggests that the prevalence of periodontitis is greater in patients with OSA.15 The high prevalence of undiagnosed sleep apnea and its potential relationship with chronic periodontitis suggest that dentists and dental hygienists could provide a valuable service to patients by incorporating sleep apnea screening into their practice.16 This is especially important for dental patients who do not regularly access general health care. An estimated 23% of adults who visit their dentist regularly do not have contact with a physician. By incorporating OSA screening into clinical practice, dentists and dental hygienists can alert patients about the need for follow-up with a physician, when warranted. Therefore, the aim of this study was to investigate the feasibility of screening for OSA risk in a dental practice and to examine the response of patients to a recommendation for physician evaluation.
4. MATERIALS AND METHODS

4.1 Study Population

The setting for this cross-sectional study was a community-based dental practice located in Raleigh, NC, USA. The study population was sampled using a non-probability convenience sampling method where subjects were selected on the basis of their accessibility and proximity to the investigator.

All patients scheduled for preventive dental care from April through September 2013 received an informational email prior to their scheduled visit that described the study. Upon presenting for their visit, potential subjects were presented with written details of the study and description of the incentive for participation. Participation incentive was a $10 gift card. Interested volunteers aged 18 years or older who were not pregnant and had not previously been diagnosed with OSA were eligible for enrollment. The study was approved by the Institutional Review Board at the University of North Carolina at Chapel Hill and all subjects gave written informed consent.

4.2 Data Collection

Enrolled subjects were issued a self-administered pencil and paper screening questionnaire to complete at home (Appendix A) that collected information about age, gender, weight, height, daytime sleepiness (Epworth Sleepiness Scale), and the STOP questions (snoring, tiredness during the day, observed apnea, and self-reported presence of high blood pressure). The investigator or research assistant measured each subject’s neck
circumference with a tape measure at the location just below the laryngeal prominence and recorded this measurement on the screening questionnaire.

In addition, a portable pulse oximetry device (VirtuOx VPOD-Ultra) for overnight monitoring of SpO2 was issued to each subject. This was accompanied by detailed written recommendations (Appendix B) and verbal instructions to wear the device overnight on a single night while asleep for a minimum of four hours. Subjects were asked to return the completed questionnaire and device to the dental practice in a sealed envelope. A numerical reference number recorded at the top of the screening questionnaire identified subjects. No personal identifying data were included on the study materials. Questionnaire data were transcribed by hand to a Microsoft Excel spreadsheet, and stored data from the pulse oximeter were uploaded into the device’s web-based computer program by the investigator.

4.3 Risk Assessment

(1) The validated 4-item STOP screening questions classified subjects high-risk for OSA in the presence of ≥2 of: loud snoring; daytime tiredness; witnessed apnea; hypertension.24

(2) Consistent with guidelines in the literature, overnight pulse oximetry classified high-risk for OSA as the presence of either: oxyhemoglobin saturation below 90% (CT_{90}) for ≥1% cumulative recording time; or oxygen desaturation index (ODI3) ≥10 events/hour in which oxyhemoglobin saturation decreased ≥3% from baseline.26,30,32

4.4 Follow-up Procedures

Subjects were notified by mailed letter (Appendix C) of their OSA risk status according to each screening instrument. Those classified as high-risk on one or both
instruments were advised to seek physician evaluation within three months. All subjects were contacted via telephone two weeks after mailing the letter to discuss screening results and inquire about the likelihood of physician consultation. Subjects were phoned again three months later to determine whether or not they had sought evaluation.

4.5 Statistical Analysis

Data from the spreadsheet were imported into Stata 13.1 (StataCorp. 2013. Stata Statistical Software: Release 13. College Station, TX: StataCorp LP) for statistical analysis. To address the study aim, analysis compared the physician-consulting behavior of subjects according to OSA risk status. The binary dependent variable classified these subjects as either having had a physician consultation about the OSA screening results within three months, or not having had a consultation. In univariate analysis examining the relationship of subjects’ characteristics and OSA risk status, Pearson’s chi-square test was used for categorical variables. The two-sample Wilcoxon rank-sum (Mann-Whitney) test for non-parametric continuous variables was used to compare components of the STOP questionnaire with the components of pulse oximetry: CT90 and ODI3. In multivariate analyses, prevalence ratios (PR) with 95% confidence limits (95% CL) were estimated using a log-binomial regression model in which the independent variable was OSA risk classified as high-risk on: neither instrument; STOP only; pulse oximetry only; or both instruments. Computationally, the prevalence ratio is the ratio of prevalence among the exposed to the prevalence among the unexposed. In the context of this study, prevalence refers to the percentage of subjects who sought physician evaluation, while exposure refers to their OSA risk status. Prevalence ratios were computed instead of the more commonly used odds ratios because when prevalence is not a rare event (<10%), the
odds ratio overestimates the strength of association. To adjust for potential confounding of the relationship between OSA risk status and physician evaluation, multivariable models included covariates of age, sex, body mass index, and daytime sleepiness.
5. RESULTS

5.1. Feasibility of Screening

A total of 124 subjects enrolled in the study. All subjects responded to all four STOP questions. A pulse oximetry recording of four or more hours was obtained from 119 (96%) of the subjects. No recording was obtained from one subject and for four subjects, a recording was obtained but it was less than four hours. Because these five subjects did not comply with the instructions for the screening protocol, their data were omitted from analysis. The mean duration of the recordings from the 119 subjects who completed the screening protocol as instructed was 7.0 hours (sd: 1.5 hours).

5.2 Demographics of Subjects who Screened High-Risk

Of the 119 subjects, the mean age was 51 years, 47.9% was male, and 24.4% was obese. Fifty percent (50.4%) screened high-risk based on the STOP questionnaire, 58% screened high-risk based on pulse oximetry, and 31.9% screened high-risk on both instruments. Seventy-seven percent (76.5%) of subjects screened high-risk on at least one instrument.

Men were significantly more likely than women to screen high-risk on the STOP questions (Table 1). An inverted U-shaped relationship observed between age and OSA risk using the STOP questions differed notably from the monotonic increase in OSA risk across age groups observed for pulse oximetry (Table 1, Figure 1A). However, the instruments were more concordant in the positive and generally linear relationship between BMI and OSA risk (Table 1, Figure 1B). When the two sleep parameters assessed by
pulse oximetry (CT\textsubscript{90} and ODI3) were assessed individually across BMI categories, both parameters were closely aligned (± 0.2) with probabilities determined by the STOP (Figure 1C).

Subjects whose neck circumference exceeded established thresholds for risk of OSA were significantly more likely to screen high-risk based on the STOP questions but not based on pulse oximetry (Table 1). Overall, 17.7% of adults reported excessive daytime sleepiness, a cardinal symptom of OSA. Yet no significant relationship was observed between daytime sleepiness and risk for OSA on either instrument (Table 1).

5.3 Concordance Among Screening Measures

The STOP questionnaire identified the highest percentage of patients at high-risk (50%) followed by the CT\textsubscript{90} parameter (47%) and then the ODI3 parameter (43%; Figure 2). There was greater dissimilarity than similarity in the screening results from the instruments. Specifically, of those subjects who screened high-risk on at least one instrument (n=91; 76.5% of total), only 42% screened high-risk on both the STOP and pulse oximetry; whereas, 24% screened high-risk on the STOP alone and 34% on oximetry alone. Of subjects who screened high-risk on pulse oximetry (n= 69), there was dissimilarity in the results from the two oximetry parameters. Only 55% screened high-risk on both CT\textsubscript{90} and ODI3; whereas, 26% screened high-risk on the CT\textsubscript{90} parameter alone, and 19% of subjects screened high-risk on the ODI3 parameter alone. Of the total number of subjects (n=119), only 21% (n=25) screened high-risk on the STOP questionnaire and both sleep parameters assessed by pulse oximetry.

Thirty-seven percent (n=22) of subjects who screened low-risk on the STOP questionnaire screened high-risk on the CT\textsubscript{90} parameter of pulse oximetry (Figure 2).
Likewise, 37% (n=22) of subjects who were low-risk on the STOP were high-risk on the ODI3 measure. Being overweight or obese increased the likelihood of screening high-risk on the oximetry parameters for subjects who screened low-risk on the STOP (Figure 1D). To illustrate, for normal weight adults who screened low-risk based on the STOP questionnaire, the probability of screening high-risk based on CT₉₀ and ODI3 approximated 0.30. The probabilities were higher and similar for obese I adults, approximating 0.8. That is, an obese adult who screened low-risk on the STOP questionnaire still had an 80% chance of screening high-risk on either pulse oximetry parameter. Subjects in the obese II/III category (n=8) had a 50% chance of screening high-risk on the CT₉₀ given low-risk based on STOP questions; however, no subjects in this category were identified at risk based on the ODI3 parameter alone.

Whether subjects who screened high-risk on the CT₉₀ also screened high-risk on the ODI3 sleep parameter was also determined, in part, by BMI. For obese adults who screened high-risk based on the CT₉₀ parameter, the probability of also screening high-risk based on ODI3 approximated 0.8 (Figure 1D). However, the probability was lower for normal weight adults, approximating 0.4. That is, normal weight adults who screened high-risk on the CT₉₀ parameter had only half the likelihood of also screening high-risk on the ODI3 parameter compared to subjects who were obese.

5.4 Pulse Oximetry Results

Consistent with the high percentage of subjects who screened high-risk on pulse oximetry (58%), the mean values of CT₉₀ and ODI3 were substantially above zero and the standard deviations were high: 5.9% (sd: 12.8%) and 11.3 events/hour (sd: 10.5), respectively (Table 2). The corresponding median values were 1% and 8 events/hour,
respectively. A greater cumulative time with oxyhemoglobin saturation below 90% (CT$_{90}$) tended to be associated with high-risk for OSA based on the STOP questionnaire (P=0.022, Table 2).

5.5 Calculation of Risk Status Based on the STOP-Bang

Although the STOP-Bang questionnaire was not used to advise subjects on their risk for OSA, it was determined that 80 subjects (67%) were at high-risk based on this instrument. As such, the STOP-Bang identified 17% of the subjects at high-risk who were not identified by the STOP alone.

5.6 Physician-Consulting Behavior

Physician consultation information was obtained from 111 of the 119 subjects (93.3%). Of those who screened high-risk for OSA by any instrument and were advised to consult with their physician about their risk of sleep apnea, 47.1% (n=40) sought physician evaluation within three months of screening. Of the 20 subjects at risk based on STOP questions alone, seven (35.0%) sought physician consultation. On the other hand, of the 30 subjects screening at risk based on pulse oximetry alone, 43.3% (n=13) consulted their physician.

A more valid comparison is that of subjects classified high-risk on the STOP questions alone compared to subjects who were classified high-risk on pulse oximetry alone. In this comparison there was no difference in consultation behavior (PR=1.42, 95% CI: 0.51, 3.94). Likewise subjects classified high-risk based on both instruments were not significantly more likely to consult a physician than those at risk on the STOP questions alone (PR=1.91, 95% CI: 0.73, 4.99).
6. DISCUSSION

This study sought to investigate the feasibility of OSA screening in a dental practice setting, and to examine patient response to a recommendation for physician evaluation. Overall, 47.1% (n=40) of individuals who screened high-risk for OSA on either instrument sought physician evaluation. Hence, screening motivated almost half of those at elevated risk for OSA to consult a physician. Although it was expected that subjects who screened high-risk on both questionnaire and pulse oximetry would be more likely to seek evaluation than those who screened high-risk on one measure alone, this finding was not supported by the current study. Rather, subjects were just as likely to seek evaluation when screened high-risk on one instrument versus both. However, it remains unknown if similar results would have been obtained if only one instrument had been used with separate groups of subjects.

6.1 Physician Follow-Up in Other Studies

Creanor et al. report that over 87% of individuals recognize the importance of screening for medical conditions among dental practitioners, supporting the proposed concept of a high acceptance of OSA screening among dental patients. However, support, in principle, does not necessarily mean that patients will take the next step in consulting with their physicians. Hypertension is perhaps the most common medical condition screened in the dental office that patients recognize as important. A previous study of the efficacy of hypertension screening in the dental office reported 97.1% physician follow-up by patients within a 3-year period. Unlike this previous study, the current study did not
account for those patients who followed-up after the 3-month period, which may result in a response rate comparable to hypertension screening over a 3-year period.

An objective of Healthy People 2020 is to “increase the proportion of persons with symptoms of obstructive sleep apnea who seek medical evaluation” to 28%. Based on the 2005-2006 and 2007-2008 National Health and Nutrition Examination Survey cycles, 25.5% of patients with symptoms seek medical evaluation. Thus, it is encouraging that a substantially higher percentage of individuals, about 35%, sought medical evaluation when made aware of symptoms of OSA through screening administered by the dental office.

6.2 Factors Associated with High-Risk

The current study found that men were significantly more likely to screen high-risk on the STOP questionnaire than women (61% compared to 40). Similarly, a gender difference was suggested by the oximetry screening results, although it did not attain statistical significance. These findings are consistent with community-based studies that report a 2-3:1 ratio in the prevalence of OSA for men compared to women. A number of factors might explain, at least in part, the gender difference. For example, men have a greater tendency for android fat distribution, resulting in a larger neck circumference. Neck circumference >40 cm appears to increase an individual’s risk for OSA. However, increased neck circumference only partially accounts for the high prevalence of OSA in men compared to women. It has also been suggested that functional differences in the upper airway may contribute to a higher prevalence of OSA in males. Similarly, another study suggests that women may have a protective advantage over men that prevents airway collapse in some stages of sleep. Although more research is necessary to determine the
reasons for the gender difference, men tend to have higher prevalence of OSA than women.

The relationship of OSA risk and age differed between the STOP questionnaire and pulse oximetry. The probability of screening high-risk based on STOP questions alone increased with age until approximately 55 years of age and then decreased. Individuals aged 45-54 had approximately 65% chance of screening high-risk for OSA compared to 50% in subjects 55-64 years old and 45% of subjects 65 and older (Fig. 1A). This result follows a similar trend reported by Young et al. which suggests prevalence of OSA may not continually increase with age.\(^{37}\) The finding suggests that age may not be a strong risk factor for OSA after the middle age or that the survival of individuals is poorer in older individuals who are not treated. While probability of risk based on STOP questions did not consistently increase with age, OSA risk based on pulse oximetry followed a monotonic increase across all age groups, suggesting that factors other than the presence of OSA may have contributed to these positive screening results in the oldest individuals studied.

Oeverland et al. report optimal agreement between PSG and pulse oximetry based on the ODI\(3\) in identifying individuals with OSA.\(^{30}\) Although both sleep parameters from the oximetry in the present study identified subjects at risk who were not identified by the STOP questionnaire, positive results on CT\(90\) and ODI\(3\) were not in strong concordance: Only about half of the patients who screened high-risk on one measure also screened high-risk on the other. In addition, CT\(90\) identified a greater percentage (7% more) of the individuals at risk than ODI\(3\). The probability that the ODI\(3\) parameter would indicate high-risk in subjects who were identified high-risk based on CT\(90\) increased with BMI.
The dependency of high-risk status based on the oximetry parameters on BMI suggests their potential relationship with obesity hypoventilation syndrome (OHS). OHS, a form of sleep disordered breathing, is defined by excessively slow or shallow breathing resulting from nighttime hypoxia. Therefore, high-risk status based on CT${}_{90}$ could reflect OHS in overweight subjects. This could also account for the high percentage of subjects (58%) that screened high-risk on one or both pulse oximetry parameters in the present study.

6.3 Implication to Screening Recommendations

The concurrent administration of two screening instruments yielded a large pool of subjects at risk for OSA. Specifically, 77% screened high-risk for OSA on at least one instrument. This percentage exceeds national prevalence estimates almost fourfold for mild or more severe OSA in the adult population. Clearly this protocol is unsuitable for screening in a dental practice as its limited capacity to identify those without disease places additional burden on the healthcare system, while misdirecting scarce healthcare resources away from people with genuine medical need. Concurrent administration of three screening measures increases sensitivity at the expense of specificity. These values can be predicted from the sensitivities and specificities of the individual measures and approximate 0.10 and 0.33, respectively, for detecting moderate to severe OSA using the protocol of this study.

Based on findings of this study, a protocol is recommended that would screen subjects using the STOP questionnaire and limit administration of pulse oximetry only to those who screen positive. The use of a sequential protocol has the benefit of a higher specificity at the expense of a lower sensitivity. In the present study, only 32% of the subjects met criteria for high-risk based on this sequential protocol in contrast to the 77%
found at high-risk using dual administration (Figure 2). This percentage is notably lower than that from use of any of the three screening measures individually. The predicted sensitivity and specificity of the sequential protocol both approximate 0.74 for detecting moderate to severe OSA.

An alternative sequential protocol is to screen subjects first with the STOP-Bang questionnaire, then administer pulse oximetry to only those individuals who screened positive. Based on the available estimates published in the literature, the predicted sensitivity is 0.92 and specificity is 0.69 for detecting moderate to severe OSA using this protocol. Although the STOP-Bang identifies a high proportion of false high-risk cases, the subsequent administration of pulse oximetry to those who screen high-risk would eliminate many of these from unnecessary physician referral.

6.4 Representativeness of the Study Sample

The study population was comprised of 124 dental patients selected by non-probability sampling from a community-based dental practice. Of these, 119 provided adequate data for analysis. Self-selection bias is highly likely. For example, only subjects who perceived themselves at risk were motivated to participate in the study. Alternatively, only those patients who had received care from the investigator dental hygienist were prompted to volunteer for screening. However, such bias is not unique to this study.

6.5 OSA Screening in the Dental Practice

The simplicity of the screening instruments described in this study makes it feasible for dental practitioners to incorporate a protocol into clinical practice. Research shows that patient response rate decreases as the length of the questionnaire increases.\textsuperscript{43} The STOP and STOP-Bang questionnaires can be answered in less than one minute, making them a
valuable screening tool in busy clinical settings. Further, the mnemonics STOP and STOP-Bang may serve as a useful reminder to clinicians when utilizing the questionnaires. The pulse oximetry device used in the current study was also well accepted among patients for its ease of use. Simple written instructions guided patients on the correct placement of the finger probe and powering the device on and off. Moreover, patients reported the device was comfortable to wear, and 96% (n=119) were able to wear the oximeter for the recommended minimum of four hours during sleep. Portable pulse oximetry devices offer some advantage to more elaborate home sleep testing devices when determining individuals at risk for OSA. For instance, portable pulse oximeters typically require fewer electrode or signal leads and are less costly than traditional type III home sleep testing devices.

The potential value of OSA screening in dental practices has been noted in only a few studies. In Levendowski et al., 67% of men and 28% of women were predicted to be at risk for at least mild OSA by the Apnea Risk Evaluation System (ARES™). The results were similar to the current study, which predicted 61% and 40% of men and women, respectively, to be at high risk for OSA by the STOP questionnaire. Moreover, the previous study found a high concordance between predicted risk of OSA by questionnaire and the degree of OSA determined by overnight sleep study. This finding suggests that dental practitioners can provide a valuable service to patients by incorporating OSA screening into practice.

Screening for undiagnosed medical conditions in the dental office has been proposed as a potentially valuable public health service. A recent study found that medical screenings in the dental office can save the health care system between $42.4 and $102.6
million over a one-year period. The same study suggests that oral health professionals can play a role in detecting chronic disease such as diabetes and hypertension, which have also been linked to OSA. For this reason, OSA screening in the dental office can not only lead to early detection of the disease, but may also result in substantial health care savings.
7. Conclusion

The findings of this study have implications for the establishment of a protocol for OSA screening in the dental office. The simplicity of the screening instruments makes it feasible for dental practitioners to incorporate into clinical practice. Although the screening measures used in this study identified an unreasonably high proportion of patients at risk for OSA based on current epidemiological studies, nearly half of high-risk subjects did follow a recommendation to seek physician consultation based on the outcome of their screening. Future studies should include sequential testing in order to eliminate unnecessary physician referral. While dental practitioners can help identify patients with risk factors, OSA is a potentially life-threatening disease; therefore, dentists and physicians must work as a team in the identification and referral of individuals at risk for OSA and the subsequent diagnosis and treatment of clinically significant disease.
Figures 1A to 1D depict predicted probabilities of screening high risk for OSA. Probabilities are from a logistic regression model that adjusts for sex and BMI (1A) or sex and age (1B, 1C, 1D). 1A plots probability based on STOP questions and pulse oximeter across age groups. 1B plots probability based on the STOP and pulse oximeter across BMI categories. 1C plots probability based on STOP and the two parameters of pulse oximetry (ODI, CT<90). 1D plots conditional probability of CT<90 given low risk on STOP, ODI given low risk on STOP, and ODI given high risk on CT<90.
Figure 2: Venn diagram of numbers of subjects who responded at high risk on none or each of the three screening measures, alone or in combination.
Table 1: Percentage of study subjects (a) who screened high-risk for OSA based on the STOP questionnaire (b), pulse oximetry (b), both instruments and neither instrument.

<table>
<thead>
<tr>
<th></th>
<th>N (%)</th>
<th>STOP questionnaire (c)</th>
<th>P-value</th>
<th>Pulse oximetry (d)</th>
<th>P-value</th>
<th>Both instruments</th>
<th>P-value</th>
<th>Neither instrument</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Total</strong></td>
<td>119 (100.0)</td>
<td>50.4</td>
<td>58.0</td>
<td>31.9</td>
<td>23.5</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Sex</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>62 (52.1)</td>
<td>40.3</td>
<td>0.022</td>
<td>53.2</td>
<td>0.273</td>
<td>25.8</td>
<td>0.135</td>
<td>32.3</td>
<td>0.019</td>
</tr>
<tr>
<td>Male</td>
<td>57 (47.9)</td>
<td>61.4</td>
<td></td>
<td>63.2</td>
<td></td>
<td>38.6</td>
<td></td>
<td>14.0</td>
<td></td>
</tr>
<tr>
<td><strong>Age (years)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;35</td>
<td>20 (16.8)</td>
<td>25.0</td>
<td>0.041</td>
<td>10.0</td>
<td>&lt;0.001</td>
<td>5.0</td>
<td>0.005</td>
<td>70.0</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>35–44</td>
<td>23 (19.3)</td>
<td>56.5</td>
<td></td>
<td>34.8</td>
<td></td>
<td>17.4</td>
<td></td>
<td>26.1</td>
<td></td>
</tr>
<tr>
<td>45–54</td>
<td>24 (20.2)</td>
<td>66.7</td>
<td></td>
<td>50.0</td>
<td></td>
<td>37.5</td>
<td></td>
<td>20.8</td>
<td></td>
</tr>
<tr>
<td>55–64</td>
<td>27 (22.7)</td>
<td>59.3</td>
<td></td>
<td>85.2</td>
<td></td>
<td>51.9</td>
<td></td>
<td>7.4</td>
<td></td>
</tr>
<tr>
<td>≥65</td>
<td>25 (21.0)</td>
<td>40.0</td>
<td></td>
<td>96.0</td>
<td></td>
<td>40.0</td>
<td></td>
<td>4.0</td>
<td></td>
</tr>
<tr>
<td><strong>Body mass index (kg/m^2) (e)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Normal (18.5-24.9)</td>
<td>47 (39.5)</td>
<td>34.0</td>
<td>0.010</td>
<td>51.1</td>
<td>0.059</td>
<td>19.2</td>
<td>0.012</td>
<td>34.0</td>
<td>0.023</td>
</tr>
<tr>
<td>Overweight (25.0-29.9)</td>
<td>43 (36.1)</td>
<td>53.5</td>
<td></td>
<td>51.2</td>
<td></td>
<td>30.2</td>
<td></td>
<td>25.6</td>
<td></td>
</tr>
<tr>
<td>Obese Class I (30.0-34.9)</td>
<td>21 (17.7)</td>
<td>76.2</td>
<td></td>
<td>76.2</td>
<td></td>
<td>57.1</td>
<td></td>
<td>4.8</td>
<td></td>
</tr>
<tr>
<td>Obese Class II/III (≥35.0)</td>
<td>8 (6.7)</td>
<td>62.5</td>
<td></td>
<td>87.5</td>
<td></td>
<td>50.0</td>
<td></td>
<td>0.0</td>
<td></td>
</tr>
<tr>
<td><strong>Neck circumference (cm) (f)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low risk (&lt;40)</td>
<td>60 (50.4)</td>
<td>33.3</td>
<td>&lt;0.001</td>
<td>50.0</td>
<td>0.075</td>
<td>18.3</td>
<td>0.001</td>
<td>35.0</td>
<td>0.003</td>
</tr>
<tr>
<td>High risk (≥40)</td>
<td>59 (49.6)</td>
<td>67.8</td>
<td></td>
<td>66.1</td>
<td></td>
<td>45.8</td>
<td></td>
<td>11.9</td>
<td></td>
</tr>
<tr>
<td><strong>Excessive daytime sleepiness (g)</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No excess sleepiness (≤10)</td>
<td>98 (82.4)</td>
<td>49.0</td>
<td>0.497</td>
<td>60.2</td>
<td>0.289</td>
<td>31.6</td>
<td>0.879</td>
<td>22.5</td>
<td>0.548</td>
</tr>
<tr>
<td>Excessive sleepiness (&gt;10)</td>
<td>21 (17.7)</td>
<td>57.1</td>
<td></td>
<td>47.6</td>
<td></td>
<td>33.3</td>
<td></td>
<td>28.6</td>
<td></td>
</tr>
</tbody>
</table>

(a) Values are row percentages. The percentage of subjects who screened at low risk for OSA according to each screening device is not reported.
(b) These are not mutually exclusive categories
(c) Classifies high risk for obstructive sleep apnea (OSA) as the presence of ≥2 of: loud snoring; daytime tiredness; witnessed apnea; hypertension
(d) Classifies high risk for OSA as cumulative percentage of recording time with oxyhemoglobin saturation below 90% (CT90) and/or the oxygen desaturation index (ODI) defined as ≥10 events per hour in which the oxyhemoglobin saturation is decreased by ≥3% from baseline
(e) World Health Organization categories
(g) Epworth Sleepiness Scale
Table 2: Summary statistics for the relationship of CT\textsubscript{90}\(^{(a)}\) and ODI\textsubscript{3}\(^{(b)}\) with STOP questionnaire risk categories

<table>
<thead>
<tr>
<th></th>
<th>Cumulative time with oxyhemoglobin saturation below 90% (CT\textsubscript{90})</th>
<th>Oxygen desaturation index of 3% (ODI\textsubscript{3})</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean (sd)</td>
<td>Median (IQR)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5.9 (12.8)</td>
<td>1 (0, 5)</td>
</tr>
<tr>
<td><strong>STOP questionnaire</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low risk for OSA</td>
<td>4.8 (11.7)</td>
<td>1 (0, 3)</td>
</tr>
<tr>
<td>High risk for OSA</td>
<td>6.9 (13.8)</td>
<td>2 (0, 7)</td>
</tr>
</tbody>
</table>

(a) Cumulative percentage of recording time with oxyhemoglobin saturation below 90%
(b) Number of events per hour in which the oxyhemoglobin saturation is decreased by $\geq$3% from baseline
(c) Two-sample Wilcoxon rank-sum (Mann-Whitney) test, nonparametric
Table 3: Prevalence ratios (PR) and 95% confidence limits (CL) for consulting a physician about obstructive sleep apnea following OSA risk screening initiated in a dental clinic (n=111)

<table>
<thead>
<tr>
<th></th>
<th>PR</th>
<th>95% CL for PR</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low risk for OSA on both instruments</td>
<td>0.19</td>
<td>0.04, 0.95</td>
<td>0.043</td>
</tr>
<tr>
<td>High risk on STOP, low risk on pulse oximetry [referent]</td>
<td>1.42</td>
<td>0.51, 3.94</td>
<td>0.502</td>
</tr>
<tr>
<td>High risk on pulse oximetry, low risk on STOP</td>
<td>1.91</td>
<td>0.73, 4.99</td>
<td>0.188</td>
</tr>
<tr>
<td>High risk for OSA on both screening instruments</td>
<td>0.91</td>
<td>0.70, 1.19</td>
<td>0.487</td>
</tr>
<tr>
<td>Age per decade</td>
<td>0.91</td>
<td>0.70, 1.19</td>
<td>0.487</td>
</tr>
<tr>
<td>Female sex [referent]</td>
<td>0.72</td>
<td>0.39, 1.33</td>
<td>0.287</td>
</tr>
<tr>
<td>Male sex</td>
<td>0.99</td>
<td>0.94, 1.05</td>
<td>0.856</td>
</tr>
<tr>
<td>Body mass index</td>
<td>0.71</td>
<td>0.09, 5.42</td>
<td>0.744</td>
</tr>
<tr>
<td>Intercept</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Supplementary Table 1: Sensitivity and specificity of STOP and STOP-Bang\textsuperscript{22}

<table>
<thead>
<tr>
<th>AHI &gt;5</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STOP</td>
<td>65.6</td>
<td>60.0</td>
</tr>
<tr>
<td>STOP-Bang</td>
<td>83.6</td>
<td>56.4</td>
</tr>
<tr>
<td>AHI &gt;15</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>74.3</td>
<td>53.3</td>
</tr>
<tr>
<td>STOP-Bang</td>
<td>92.9</td>
<td>43.0</td>
</tr>
<tr>
<td>AHI &gt;30</td>
<td></td>
<td></td>
</tr>
<tr>
<td>STOP</td>
<td>79.5</td>
<td>48.6</td>
</tr>
<tr>
<td>STOP-Bang</td>
<td>100.0</td>
<td>37.0</td>
</tr>
</tbody>
</table>

AHI= apnea-hypopnea index  
STOP= snoring, tiredness, observed apnea, and high blood pressure  
STOP-Bang= STOP questionnaire including BMI, age, neck circumference, and gender
Supplementary Table 2: Sensitivity and specificity of the Oxygen Desaturation Index (ODI)\textsuperscript{28}

<table>
<thead>
<tr>
<th>AHI &gt;5</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODI3</td>
<td>0.91</td>
<td>0.67</td>
</tr>
<tr>
<td>ODI4</td>
<td>0.73</td>
<td>1.00</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>AHI &gt;15</th>
<th>Sensitivity (%)</th>
<th>Specificity (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ODI3</td>
<td>0.86</td>
<td>0.88</td>
</tr>
<tr>
<td>ODI4</td>
<td>0.64</td>
<td>1.00</td>
</tr>
</tbody>
</table>

AHI= apnea-hypopnea index  
ODI3= oxygen desaturation index of 3%  
ODI4= oxygen desaturation index of 4%
APPENDIX A - SCREENING QUESTIONNAIRE

SLEEP APNEA SCREENING QUESTIONNAIRE

<table>
<thead>
<tr>
<th>DATE: ________</th>
<th>GENDER (M/F): ________</th>
<th>AGE: ________</th>
<th>WEIGHT: ________ lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HEIGHT: _____ feet _____ inches</td>
<td>NECK CIRCUMFERENCE: _____ inches</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Answer No or Yes to the following four questions by checking the box that applies.

<table>
<thead>
<tr>
<th>Question</th>
<th>No</th>
<th>Yes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Do you snore loudly (louder than talking or loud enough to be heard through closed doors)?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you often feel tired, fatigued, or sleepy during the daytime?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Has anyone observed you stop breathing during your sleep?</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do you have, or are you being treated for, high blood pressure?</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Check the box that describes how likely are you to doze off or fall asleep in the following situations, in contrast to feeling just tired. This refers to your usual way of life in recent times. Even if you have not done some of these things recently, try to work out how they would have affected you.

<table>
<thead>
<tr>
<th>Situation</th>
<th>Never doze</th>
<th>Slight chance of dozing</th>
<th>Moderate chance of dozing</th>
<th>High chance of dozing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting and reading</td>
<td></td>
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<tr>
<td>Watching television</td>
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<tr>
<td>Sitting inactive in a public place (e.g. a theater or a meeting)</td>
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<tr>
<td>As a passenger in a car for an hour without a break</td>
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<tr>
<td>Lying down to rest in the afternoon</td>
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<tr>
<td>Sitting and talking to someone</td>
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<tr>
<td>Sitting quietly after lunch when you’ve had no alcohol</td>
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<tr>
<td>In a car, while stopped for a few minutes in traffic</td>
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</tbody>
</table>
APPENDIX B- INSTRUCTIONS FOR OVERNIGHT PULSE OXIMETRY

Please read the following instructions prior to using the pulse oximeter. In order to obtain a quality test, it is essential that you closely follow these instructions. If you have any questions, you can contact Kristin Dillow at 919-720-6594 for further assistance.

You must stay awake for the first 10 minutes of the test!

<table>
<thead>
<tr>
<th>Step 1</th>
<th>Step 2</th>
<th>Step 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>It is suggested that you remove fingernail polish and coverings from the finger you will be using.</td>
<td>Sensor should be attached as shown below to device.</td>
<td>Attach sensor to index finger, apply tape or Band-Aid to secure sensor to finger.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Step 4</th>
<th>Step 5</th>
<th>Step 6</th>
</tr>
</thead>
<tbody>
<tr>
<td>Place device on wrist, hold top button until powered on.</td>
<td>Go to sleep, wear device throughout the night.</td>
<td>In the morning take device off, hold down power button then place device and probe back in original box and return per directions.</td>
</tr>
</tbody>
</table>

If Sensor falls off during the night:
1. Replace sensor on finger
2. Check to ensure device is on and displaying numbers
3. If device is off, press power button to turn on.

If you awake during the night and need to get out of bed, please only remove the probe in case of hygienic necessity.

The probe may be used on any finger, although it is recommended to use either the index or middle finger for best results.
APPENDIX C- FOLLOW-UP LETTER TO PARTICIPANTS

(Date)

Dear (participant),

This letter is to inform you of the results from your recent sleep apnea screening. Our screening methods are not meant to diagnose, but rather to inform you of your risk for having sleep apnea. Your results indicated the following:

**(High or Low) risk** based on the validated screening questionnaire
**(High or Low) risk** based on overnight pulse oximetry

The only way to clinically diagnose and treat sleep apnea is through a laboratory sleep study; therefore, we suggest you discuss these results with your primary physician for further evaluation. You should expect a phone call from us within the next two weeks to answer any questions you may have.

Thank you for your participation in this study.

Sincerely,

Kristin Dillow, RDH
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University of North Carolina at Chapel Hill
School of Dentistry
kdillow@dentistry.unc.edu
919-720-6594
REFERENCES


