SLEEP APNEA SCREENING AND SURVEILLANCE

Low Cost Monitoring Device

Sammy Homsi and Mustafa Muhyi
Team Number: 42
Teacher: Rebecca Galves
Mentor: Noor Muhyi

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Sammy Homsi and Mustafa Muhyi

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Abstract

Sleep Apnea is a very important under diagnosed disease. 1 in 5 Americans have from mild to severe sleep apnea. When people hear about heart diseases, diabetes, and strokes; they seek immediate help. But when they hear about Sleep Apnea; they have no idea what damages it can do to a person's health. It is not about getting no sleep or bad sleeping habits, it's about the brain being awake the whole night for many nights. But most importantly it is not getting the rest it should to function well. People should know that Sleep Apnea is linked to an increase risk of Heart disease, diabetes, stroke, obesity, high blood pressure and kidney disease.

With all that being said, doctors and patients should address Sleep Apnea if the patient is not getting the sleep he/she needs to function well. Our Hypothesis was that the questionnaire and device developed in this project could accurately detect Sleep Apnea. Our experimental results supported our hypothesis because the questionnaire showed accurate results and the device proved to detect sleep apnea. The experiment also showed that sleep apnea causes the entire body to react in a negative way causing major risk factor.

Introduction

The purpose of this experiment is to shine the light on sleep apnea and the danger behind it not being discovered. There are sleep apnea clinics but they could be expensive for people therefore, we are going to try and come up with a low cost device to monitor the first sign of sleep apnea. The goal for this project is to create a comprehensive program that consists of a questionnaire and a low cost device that would detect the oxygen level. Together we will have the first step to detecting Sleep Apnea with high accuracy.

Question

Can we make a low cost device that would detect Sleep Apnea? Can we make a questionnaire that would accurately detect the first symptoms of Sleep Apnea?

Hypothesis

The questionnaire and device developed in this project can accurately detect Sleep Apnea.

Variables

Independent Variable: the low cost device and questionnaire.

Dependent Variable: Oxygen Level

Constants

We kept the testing time the same. All tests were done at night for all patients while they were sleeping.

Background Research

Sleep Apnea is a major sleep disorder. It deals with the number of breathing interruptions that occur during sleep. There are 2 types of Sleep Apnea:

1. Obstructive, which is more common
2. Central, which is when the brain fails to give a signal for the lungs to breathe.

Obstructive sleep apnea is caused by a partial or complete collapse of the upper airway. This is caused when the muscles that control the soft palate and tongue relaxes.

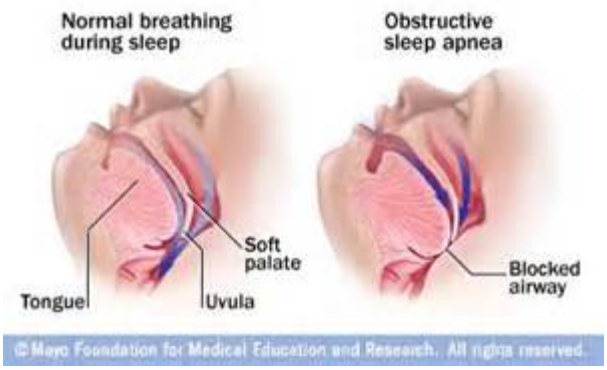


Figure 1: OSA versus Normal breathing

There are many signs of sleep apnea:

- Overweight
- Large neck size
- Lack of energy
- Morning headaches
- Depression
- Sleeping during the day
- Snoring
- Gasping for air during sleep

Grading the severity of sleep apnea

Grade	Oxygen Saturation (%)
• **Mild Sleep Apnea**	**>85%**
• **Moderate Sleep Apnea**	**75%-85%**
• **Severe Sleep Apnea**	**<75%**

Figure 2: Grading the severity of sleep apnea

The importance of sleep apnea:

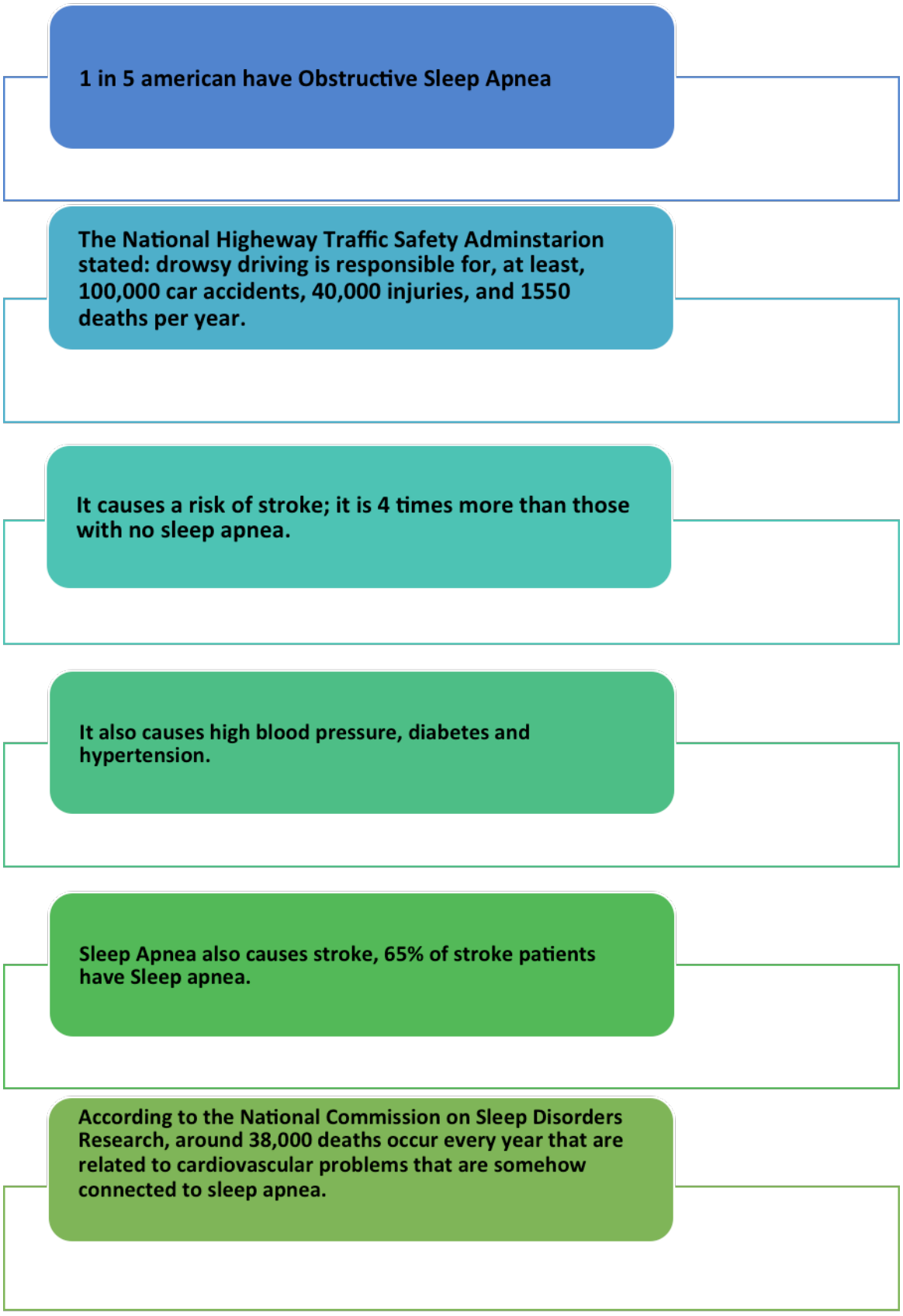


Figure 3: Prevalence of OSA in patients

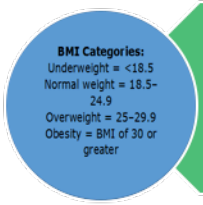
Treatment of Sleep Apnea

Mandibular repositioning device. It can be custom made by the dentist. It keeps the lower jaws in a forward position while sleeping.

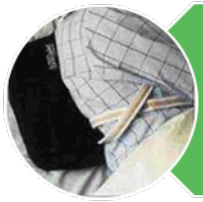
Positive Airway pressure device. It is a mask worn over the nose. It is used for the moderate and severe sleep apnea patients.

Upper airway stimulation device.

Nasal decongestant for mild Sleep Apnea



Weight loss only if the BMI is over 30.



Positional therapy. You drop a tennis ball in a sock and then pin the sock to the back of the pajama top.

In severe cases, surgery is recommended.

Figure 4: Treatment of sleep apnea

Materials List

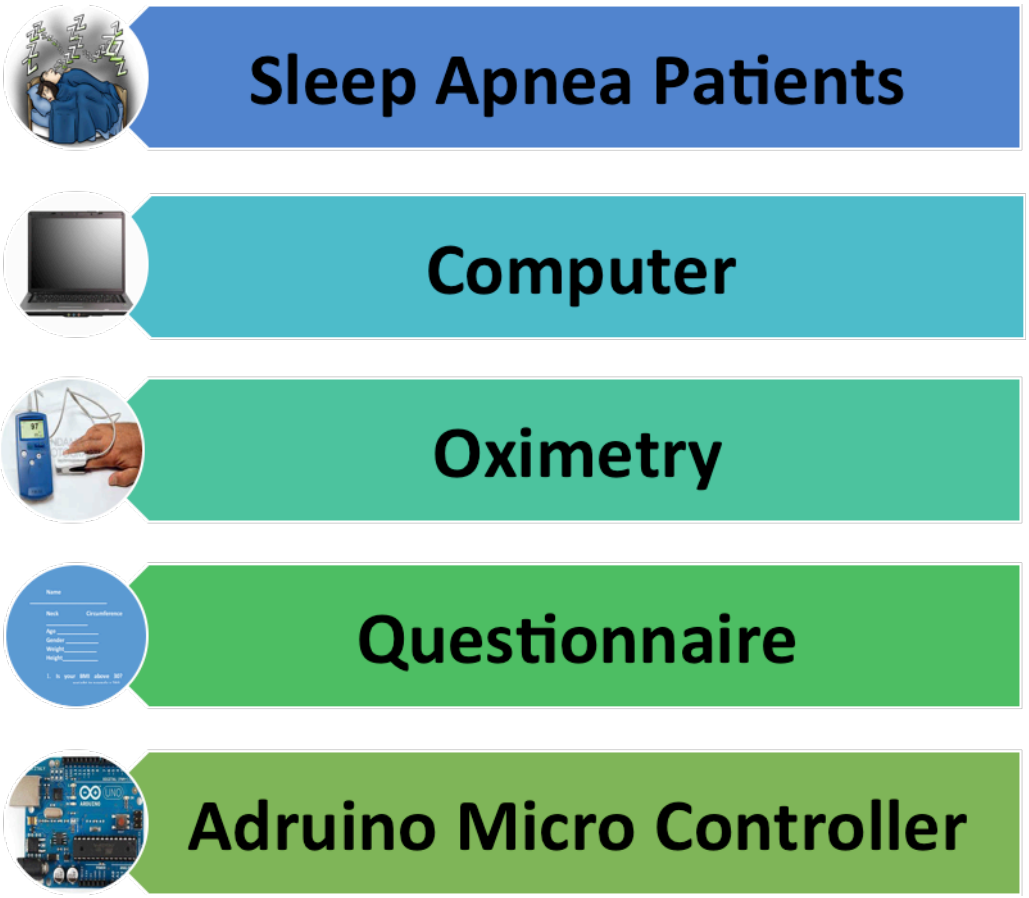


Figure 5: Materials used

Experimental Procedures

1. We researched existing Sleep Apnea questionnaire.
2. We looked at the most important factors of sleep apnea and eliminated the least important in order to design our questionnaire.
3. We consulted with a doctor and 2 sleep apnea clinics.
4. We Had a number of patients fill in a questionnaire
5. If they answered yes to 8 questions and above, they are at high risk for Sleep Apnea.
6. We requested them to ask their doctor to be referred to a sleep apnea clinic.
7. We also tested a few with our low cost device to test their oxygen level at night.
8. We followed with them after they did the sleep apnea test in the sleep clinic.
9. We compared our questionnaire with the results done by the clinic to determine the presence and severity

The Computational Thinking and Modeling

- **Part I**

  In this project we are developing an APP using App Inventor. App Inventor for Android is a new visual programming platform for creating mobile applications (apps) for Android-Based smart phones. It was developed at Google Labs by a team led by MIT's Hal Abelson. To develop apps in App Inventor you do not write code. Instead you visually design the way the app looks and use blocks of interlocking components to control the app's behavior. Computational thinking refers to solving an abstract idea or problem, by first developing an algorithmic thinking (Process of stems to solve a problem). In this project we will demonstrate the computational thinking using App Android.

  In this project we used APP Inventor for android as a new visual programming platform to develop the questioner. App inventor [7] is a visual programming platform for creating mobile applications for Android-based mobile devices. To develop an App in APP inventor you visually design the app layout and add events to each components. It is open source and many examples are available for new learners.

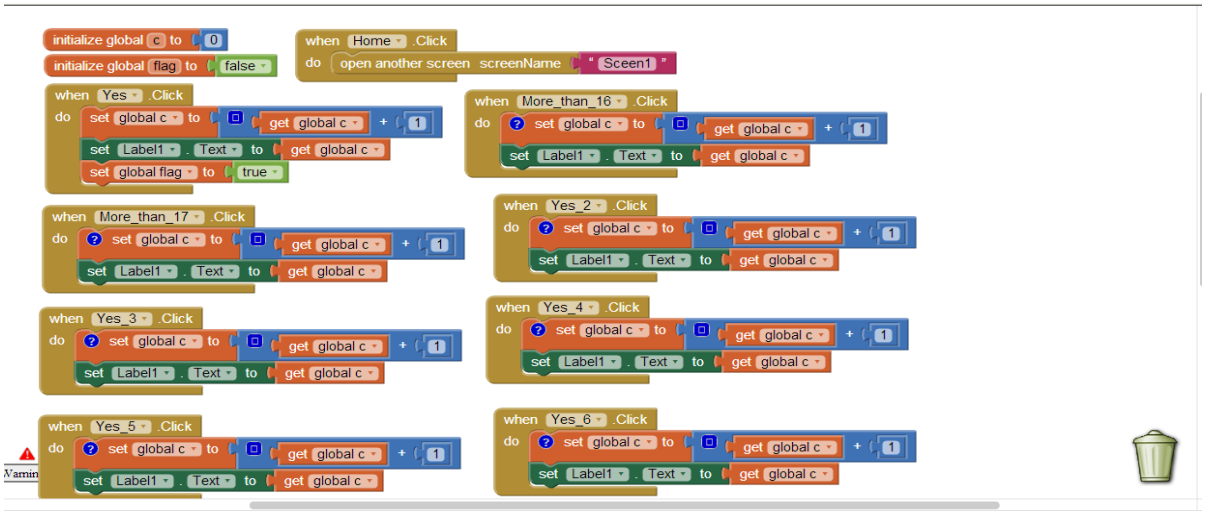


Figure 6: App Inventor Design Block

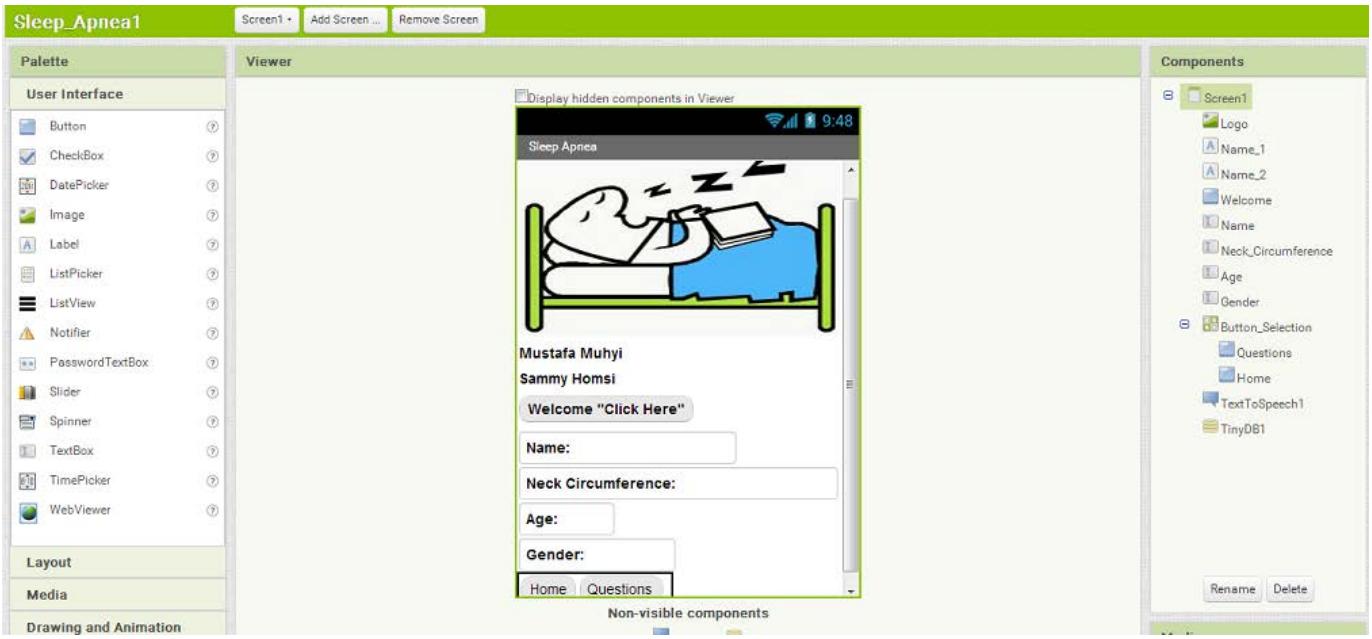
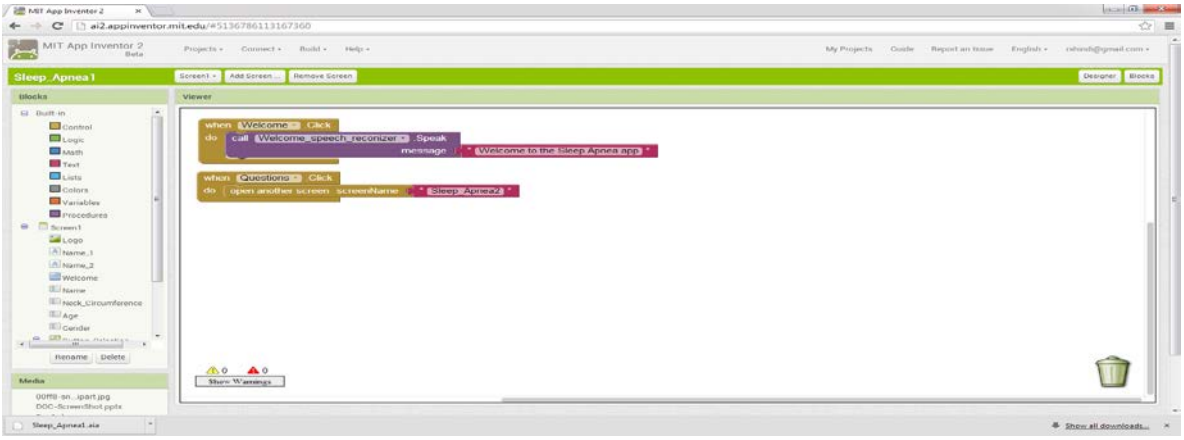


Figure 7: App Inventor Design

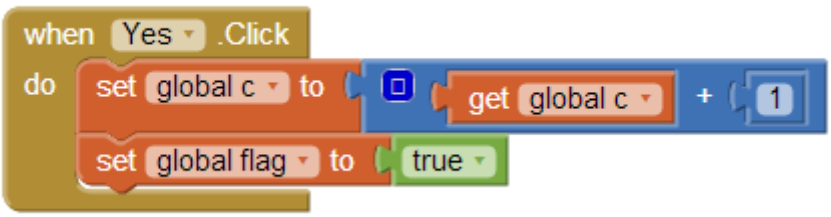
App Inventor programs are just a collection of event handlers.

Event-Based Programming in App Inventor 2

Simple Events: welcome



Callback Events:



- **Part 2**

  The prototype SYSTEM ARCHITECTURE

  The main architecture of the system is generic and can be implemented to target various applications. Our prototype is implemented as shown in Figure 8 which shows the high level system architecture with the main interfaces. The following Subsections provide more details of the components used in our prototype

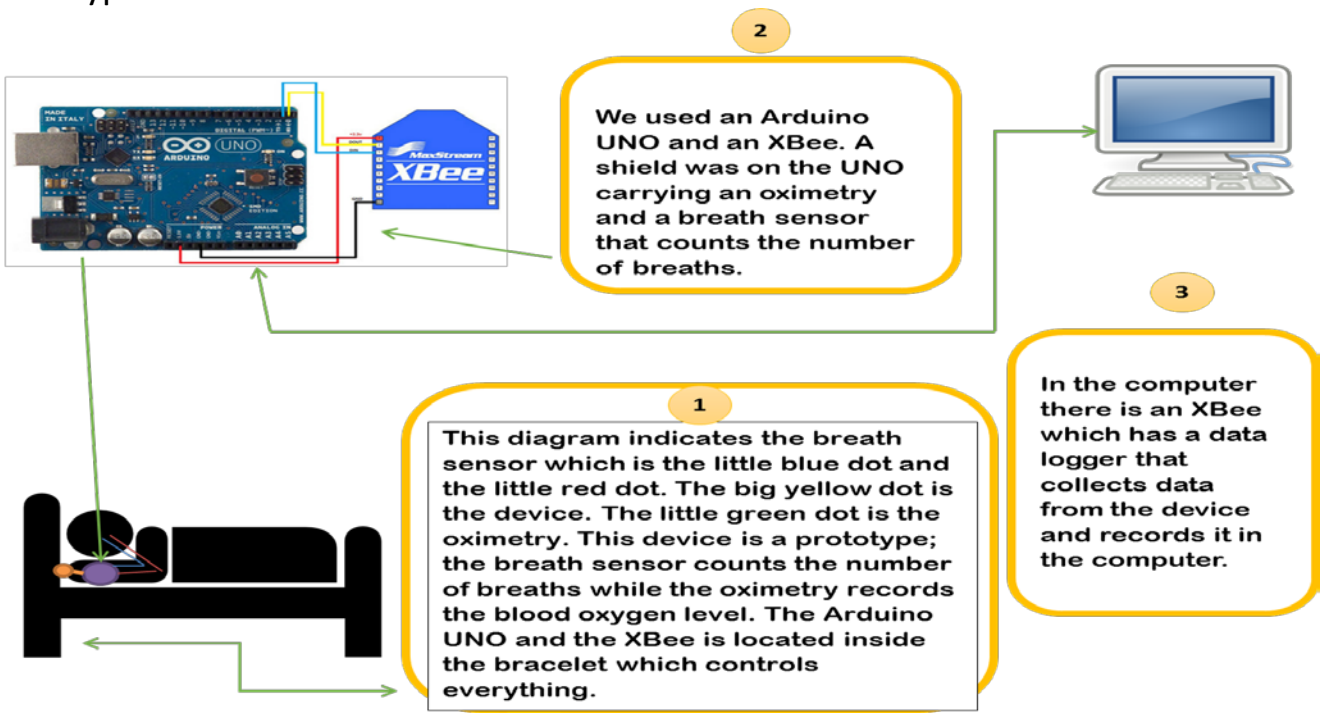


Figure 8: Device Connection

A. Arduino Microcontroller:

Figure 9: Micro Controller

Arduino is an open-source platform used for building electronics projects. Arduino consists of both a physical programmable circuit board (often referred to as a microcontroller) and a piece of software, or IDE (Integrated Development Environment) that runs on your computer, used to write and upload computer code to the physical board. The Uno is one of the more popular boards in the Arduino family and a great choice for beginners. We'll talk about what's on it and what it can do later in the tutorial.

B. Pulse and Oxygen in Blood (SPO2)

Pulse oximetry a noninvasive method of indicating the arterial oxygen saturation of functional hemoglobin. Oxygen Saturation is defined as the measurement of the amount of oxygen dissolved in blood, based on the detection of Hemoglobin and Deoxyhemoglobin. Two different light wavelengths are used to measure the actual difference in the absorption spectra of HbO2 and Hb. The bloodstream is affected by the concentration of HbO2 and Hb, and their absorption coefficients are measured using two wavelengths 660 nm (red light spectra) and 940 nm (infrared light spectra). Deoxygenated and oxygenated hemoglobin absorb different wavelengths

Figure 10: Pulse and Oxygen Measurement sensor to Arduino board

C. Wireless Communication between Arduino and PC using XBee

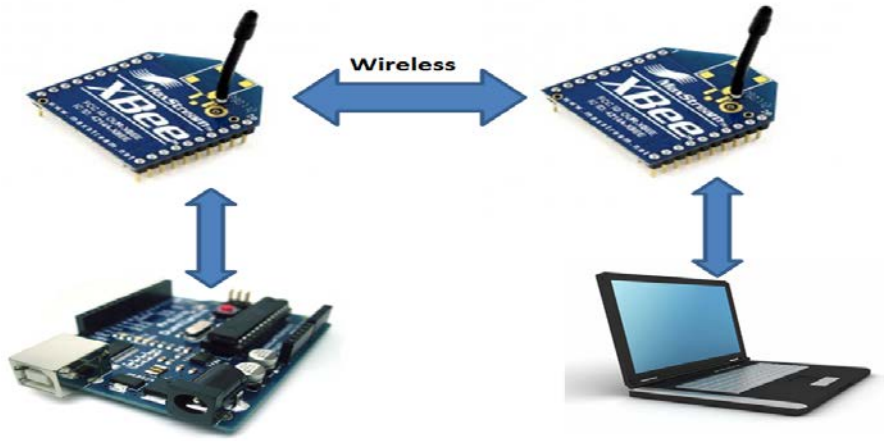


Figure 11: Wireless Communicatio

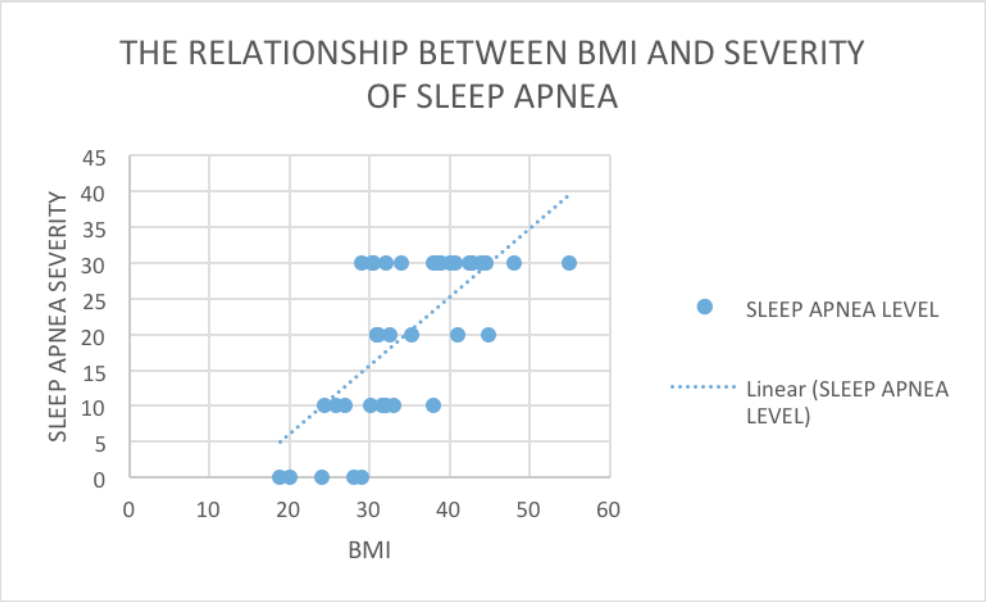
Data Analysis

GENDER	AGE	NECK SIZE	WEIGHT	HEIGHT	BMI	HIGH BLOOD PRESSURE	CAFFEINE	OXYGEN LEVEL	QUESTIONNAIRE
MALE	49	17.5	224	66	38	+	+	83	9
FEMALE	45	13	156	60	30.49	-	+	93	8
FEMALE	68	18	243	66	39	+	-	59	9
MALE	46	17.5	220	69	32.5	+	-	83	8
MALE	56	18.5	345	71	48	+	+	64	9
MALE	64	17.5	230	74	30.3	+	+	81	9
MALE	41	18	333	73	43.9	+	-	63	8
FEMALE	61	15	200	66	33	+	+	77	8
MALE	41	22	245	72	40	+	+	54	10
FEMALE	61	16.5	240	60	35.2	+	+	80	10
MALE	48	16	195	66	31.5	+	+	81	10
MALE	51	19	220	64	38.45	+	+	82	11
MALE	67	19.5	274	72	42.7	+	-	78	7

MALE	69	17	200	70	29	+	+	79	8
FEMALE	49	16.25	269	65	44.8	+	-	75	5
MALE	58	18.5	219	72	30.41	+	+	80	10
MALE	37	16.5	174	69	25.8	-	+	85	7
MALE	88	18.5	212	67	34	+	+	80	10
FEMALE	62	16	238	61	42.5	+	+	67	8
MALE	75	18	239	72	32	+	+	58	10
FEMALE	67	16.25	200	68	30.4	+	-	68	8
MALE	40	17.5	261	75	32	+	+	86	8
FEMALE	59	16.5	243	62	44.5	+	+	55	9
FEMALE	67	14	13.8	63	24.4	+	-	79	7
MALE	34	20	420	73	55	+	+	57	9
FEMALE	67	15.5	199	67	31.1	+	-	84	8
FEMALE	49	17	171	53	42.7	+	-	73	8
MALE	68	19	284	70	40.75	+	+	64	11
MALE	76		216	71	30.1	+	+	75	8
FEMALE	61	18	206	62	38	+	+	88	9
MALE	37	17	177	68	27	-	+	85	6
FEMALE	70	16	168	61.5	31.2	+	-	73	8
MALE	69	18	237	64	41	+	-	57	9
MALE	45	15.5	190	65	31	+	+	75	7
MALE	35	15.5	200	69	29	-	+	96	4
MALE	61	15.5	150	66	24	-	-	95	4
FEMALE	43	12.5	124	68	18.85	-	-	98	2
FEMALE	45	11.5	130	66	20	-	+	97	2
MALE	47	16	197	70	28	-	-	95	5

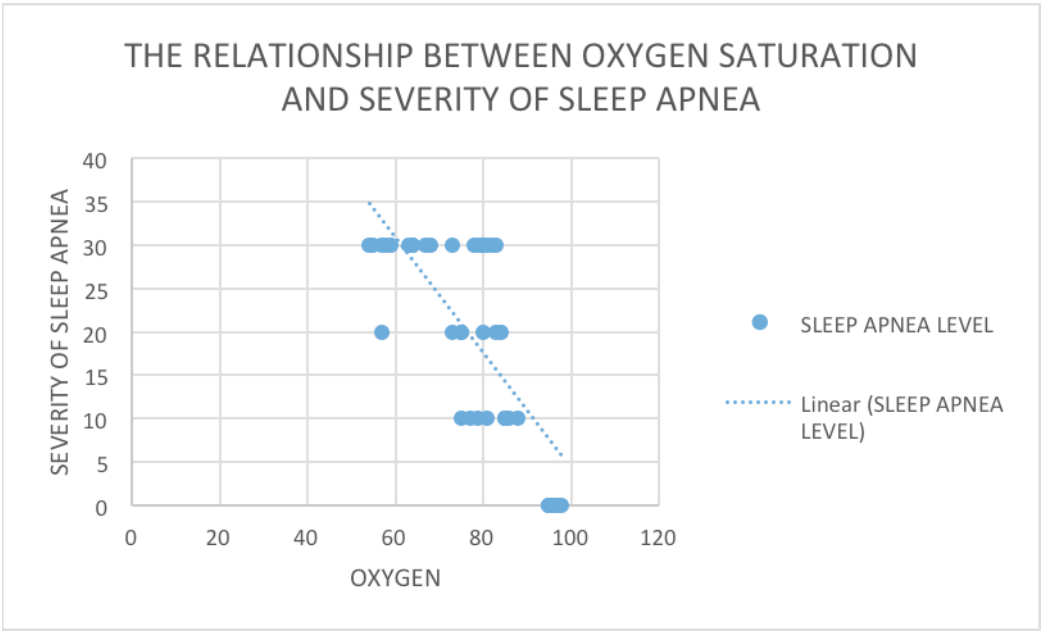
Table 1: Data Analysis

Data Graphs



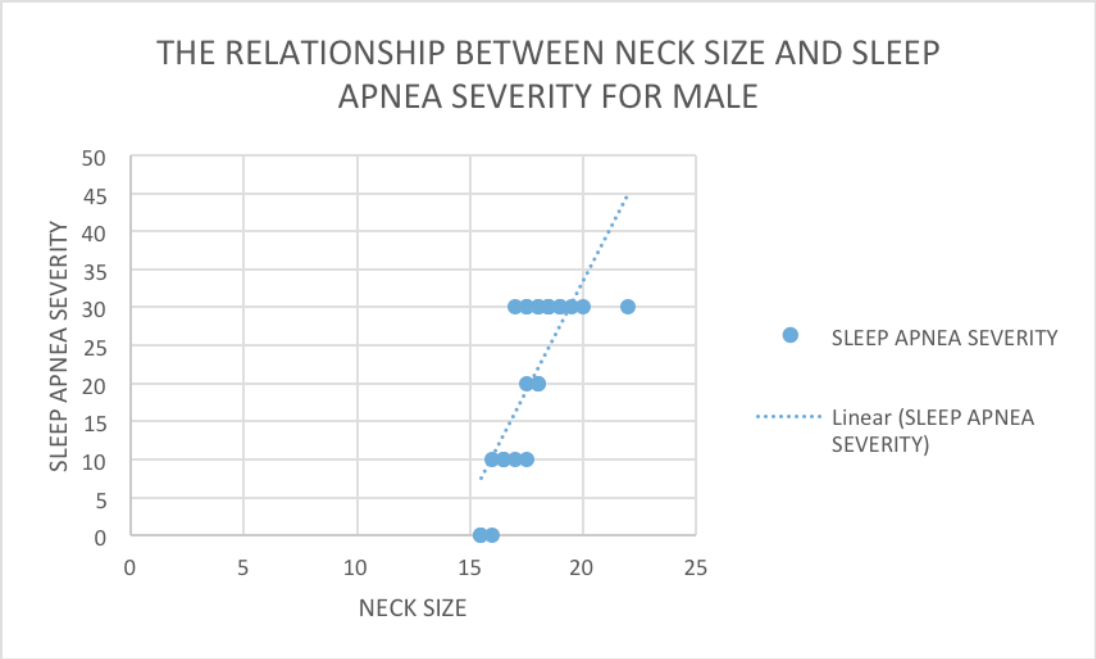
0 = No sleep apnea 10 = Mild 20 = Modertae 30 = Severe

Figure 12: The Relationship between BMI and severity of sleep apnea



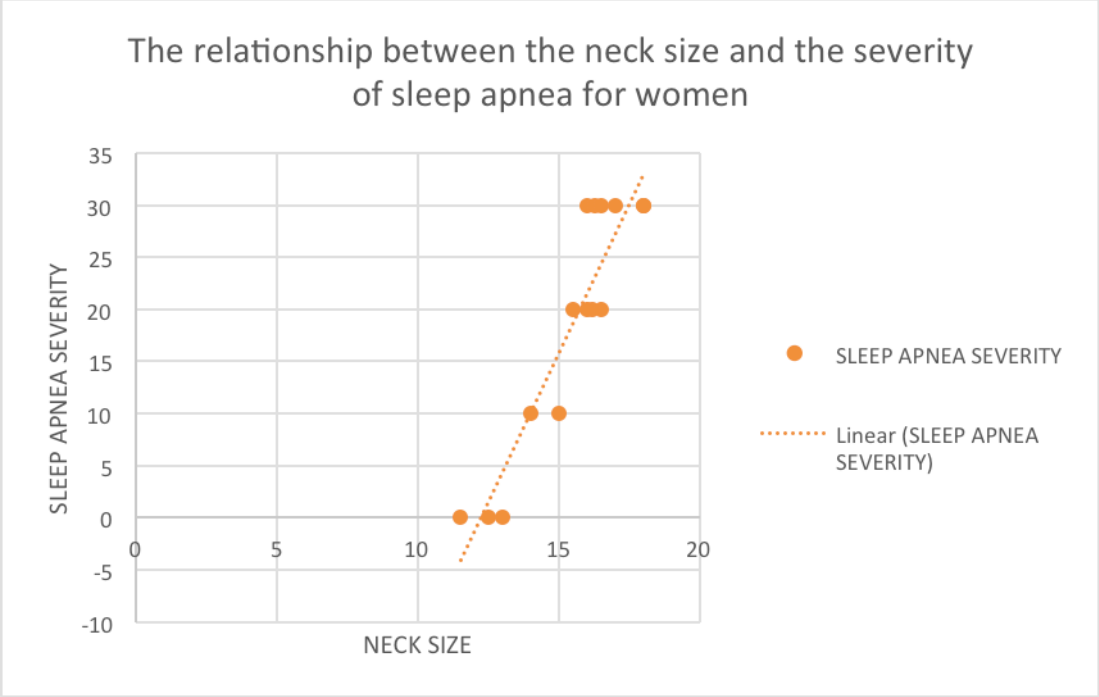
0 = No sleep apnea 10 = Mild 20 = Modertae 30 = Severe

Figure 13: The relationship between oxygen saturation % and severity of sleep apnea



0 = No sleep apnea 10 = Mild 20 = Modertae 30 = Severe

Figure 14: The relationship between neck size and the severity of sleep apnea for male



0 = No sleep apnea 10 = Mild 20 = Modertae 30 = Severe

Figure 15: The relationship between neck size and the severity of sleep apnea for female

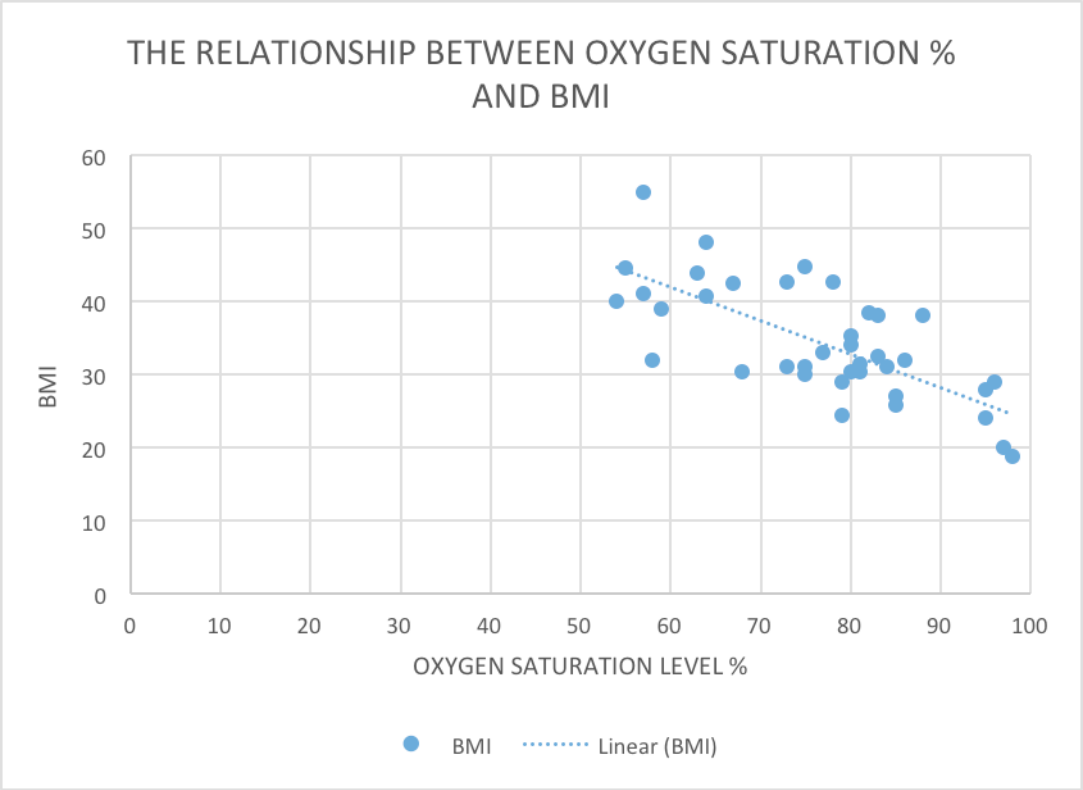


Figure 16: The relationship between oxygen saturation % and BMI

Figure 17: A snapshot of the oxygen level over time for a female patients using the low cost device that we developed.

Results

According to our experiment, we found massive numbers of people with the under-diagnosed Sleep Apnea disorder. We also found a link between low oxygen level, Sleep Apnea and major health problems. People with untreated sleep apnea stop breathing repeatedly during their sleep. Sometimes, it can be as much as hundreds of times. We found that a lot of people are not aware of this important under-diagnosed disease. The smart devices we used helped not only spread the word but also indicate signs of sleep apnea. Due to the lack of urgency when it comes to sleep apnea, people did not realize that most of their health problems could actually be related to Sleep Apnea. The solution could be surgery or simple night gadget that would help people sleep better to resolve this great issue.

- 100% of Sleep Apnea patients have low oxygen level at night.
- Patients who scored 8 and above for our questionnaire had Sleep Apnea.
- 94% of Sleep Apnea patients with high blood pressure tested positive.
- 67.6% of Sleep Apnea patients with daily caffeinated soda consumption tested positive.
- Male patients were at higher risk
- 88% of Sleep Apnea patients are over-weight.
- 90% of Sleep Apnea patients have a neck size above 17" for male and 16" for female.

Analysis

The first part of this project is to try and find whether a person has sleep apnea. Signs that one should look for are: fatigue, weakness, snoring, depression, obesity, dry mouth, drooling, choking, restlessness, smoking, insomnia, etc. Then we should look for the oxygen level while a person is asleep. From there, they should go to a sleep clinic to determine the severity and the steps that should be considered such as surgery or a simple night device. The 2nd part of this project is to make a low cost device that would read data, such as, heart rate and oxygen level to determine if the person has Sleep Apnea. This device will be connected to a computer program in order to analyze and read the given data. The available devices for Sleep Apnea can cost $50,000- $100 depending on the accuracy and complexity of the device. The 3rd part of this project is to create a questionnaire App that would detect sleep apnea in general. The App consists of Quiz type questions, such as; "do you snore"? "How often do you wake up at night? Etc…" By doing this App, we will be able to raise awareness and introduce this important untreated illness to people from different ages.

Figure 18: Sleep Apnea Cycle

Low cost device Cost Analysis

Commercial wrist pulse oximeter	Our Device
$ 150	$ 75
Monitor and record blood oxygen saturation (SpO2) Record over time.	Monitor and record blood oxygen saturation (SpO2) Record over time.
Not Expandable	Expandable Add other sensors such as breathing sensor, positioning sensor, etc.
Not Open Source Software	Open Source Software (Free Development).

Figure 19: Low cost device Cost Analysis

Conclusion

Our hypothesis was that if we make a reliable questionnaire and monitoring device, then we will be able to detect sleep apnea. Our results do support our hypothesis. We think that the tests that we did on the patients proved to be 97% accurate and the device worked as we expected. We were able to collect enough data to make our experiment work. We will do further studies and we will collect more data by engaging more people to take the sleep apnea test.

We concluded that 100% of the Sleep Apnea patients have low oxygen level while sleeping. Our questionnaire indicated that people who scored 8 and above had Sleep Apnea. Sleep Apnea patients also had high blood pressure, caffeinated soda drinkers, over-weight, and a big neck size. Therefore, we have to continue this program to collect more data. This project ended up being more intense and more crucial to peoples' health than we expected. The results and the research we did proved that Sleep Apnea should not be taken lightly.

Possible Experimental Errors

We did not concentrate on the patients with average weight and normal blood pressure. Our main concentration was on the people who fit the characteristics of Sleep Apnea, such as, *high* blood pressure, Obese and large neck sizes.

Recommendations for further experimentation

We would like to do more research on people who drink coffee and alcohol to see if it is linked to Sleep Apnea. We would also like to come up with an easy to use and low cost solution to help people with sleep apnea breath better while sleeping. We will also add the breathing sensor to our device to make it read the breathing pauses as well as the oxygen level.

Acknowledgements

We would like to thank the staff of Mimbres Internal Medicine for giving us their input and our parents and grandparents for being our first test subjects

Name _____

Neck Circumference _____
Age _____
Gender _____
Weight_____
Height_____

1. **Is your BMI above 30?** **BMI =** $\frac{weight\ in\ pounds \times 703}{height\ in\ inches^2}$

   Yes **No**

2. **Neck Size**
   Male: Yes (More than 17”) No (Less than 17”)
   Female: Yes (More than 16”) No (Less than 16”)

3. **Do you have high Blood Pressure?**
   Yes **No**

4. **Do you snore on most nights (more than 3 nights a week)?**
   Yes **No**

5. **Have you been told that you snore loudly (can be heard from another room)?**
   Yes **No**

6. **Have you been told that you stop breathing while sleeping?**
   Yes **No**

7. **Do you feel tired and sleepy during the day?**
   Yes **No**

8. **Do you drink caffeinated soda (12 oz. or more per day)?**
   Yes **No**

9. **Do you drink Alcohol (3 or more times a week)?**
   Yes **No**

10. **Do you wake up a lot at night?**
    Yes **No**

11. **Do you doze off when you are inactive or watching T.V.?**
    Yes **No**

Works Cited

- Internal Medicine News. 2008. Severe sleep apnea may raise all-cause mortality. www.penton.com
- WNDU. 2014. Sleep apnea isn't just a male thing, it effects women as well. www.wndu.com
- About Obstructive Sleep Apnea. 2014. Obstructive Sleep Apnea.

  www.muvigil.com
- Sleep Apnea articles. 2014. Sleep Apnea. www.helpguide.org
- Brenda Neugent. 2014. Raising Apnea Awaremness through Sleep Apnea Prevention Project. Diabetes Health Magazine.
- Duc A. Tien, MD, Alan Kominsky, MD. October 2014. Managing snoring: When to consider surgery. CLEVELAND CLINIC JOURNAL OF MEDICINE
- Ohio sleep medicine institute. 2014. Sleep Questionnaire. http://sleepmedicine.com
- Wisconsin sleep. 2014. Sleep Apnea screening. http://wisconsinsleep.org
- Mayo Clinic. 2014. Diseases and Conditions. Sleep Apnea. www.mayoclinic.org
- Pharmacy. 2012. Obstructive Sleep Apnea: an important Wake-Up Call. www.pharmacytimes.com
- Sleep Studies. 2015. Sleep Disorders Health Center. Sleep Studies. www.webmd.com
- Dr. Homsi. 2014-2015. Mimbres Internal Medicine. Deming, NM. Personal Communication.