

Spring 5-1-2020

Predicting the Unexpected: Applying Advanced Underwriting to Accurately Predict Early Duration Claims in Life Insurance

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Howe, Jessica, "Predicting the Unexpected: Applying Advanced Underwriting to Accurately Predict Early Duration Claims in Life Insurance" (2020). *Honors Scholar Theses*. 674.
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**Predicting the Unexpected: Applying Advanced Underwriting to
Accurately Predict Early Duration Claims in Life Insurance**

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University of Connecticut, 2020

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An Undergraduate Honors Thesis Submitted in Partial Fulfillment of the
Requirements for the Degree of Bachelor of Arts at the University of Connecticut

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1. Introduction

Life insurers sell promises to provide certain income in the event of an unpredictable event—the death of a policyholder. This promise creates a lot of risk for the insurer because the insurer cannot pinpoint the exact time of the payment. However, there are ways that insurers can mitigate this risk and prevent losses from life insurance benefit payments. One of the ways that insurers can detect risky policyholders is through prospective policyholder screening known as underwriting. Underwriting is used to determine if an applicant is likely to live a long life and subsequently generate profit for the insurer or if he/she is a bad risk and should not be issued a policy. In theory, these underwriting results should correlate with issuing to good risks on the average.

However, there is always a chance that a policyholder who met underwriting standards dies soon after their policy goes into effect. These claims are very costly for insurers, as insurers would not have collected sufficient premiums to cover the claim and recoup acquisition costs. Moreover, there is no way for the insurer to cover the loss in the future because there is no more incoming premium from the policy. These claims are known as early duration claims, and, for the purposes of this paper, will be defined as life insurance claims that are filed within the first five years of the policy's effective date. Due to the nature of early duration claims, there is no current technology that is used to predict the likelihood of early duration claims for a single policyholder or for policies in aggregate, so life insurers must stomach the losses associated with early duration claims as they occur.

Although the nature of these losses may make it seem as though they do not happen often, they are in fact quite costly. For example, five of the eleven insurance companies surveyed by the Society of Actuaries reported that they had greater than 250 million dollars of uncontestable

claims and between 1 and 10 million dollars of contestable claims, meaning that the claim occurred within the first two years of the policy's effective date, in 2015 alone (Early Duration Claims 2017...8). Early duration claims are a large part of company's losses and cannot be predicted by current underwriting procedures.

This thesis will discuss the creation of a model that can better predict the likelihood of early duration claims by creating a more comprehensive risk assessment related to early duration claims and detail the model's application to accelerated underwriting to help prevent losses associated with early duration claims.

2. Preliminary Research

2.1. Causes of Early Duration Claims

According to an Individual Life Cause of Death Impact study conducted by MunichRe, the three leading causes of death for both males and females are heart disease, cancer, and other miscellaneous causes of death. Interestingly, accidents, including both motor vehicle accidents and accidental deaths, only accounted for about 5-10% of all causes of death (Serykh). Upon reviewing the Early Duration Claims Survey Report conducted by the Society of Actuaries in 2009, it was clear that early duration claims originated from three main causes across all age groups: motor vehicle accidents, cardiovascular disease, and cancer. Although current underwriting does assess for cardiovascular and cancer illnesses, there are no underwriting questions that assess risky driving behavior for life insurance.

Figure 1: Cause of Death by Issue Age Group (Early Duration Claims 2009...44-45)

Cause	Issue Ages 20-34	Issue Ages 35-49	Issue Ages 50-69	Issue Ages 70+	Overall
Cancer	16%	34%	48%	39%	37%
Cardiovascular	12%	22%	27%	31%	23%
Motor Vehicle Accidents	29%	14%	5%	2%	11%
Other Accidents	11%	7%	3%	2%	6%
Suicide	10%	8%	3%	1%	5%
Respiratory	3%	4%	5%	11%	5%
Infectious Disease	3%	4%	4%	5%	4%
Homicide	13%	3%	1%	0%	3%
Stroke	1%	2%	3%	5%	3%
Mental/Nervous	2%	2%	2%	5%	2%
Total Claims	7,795	16,136	20,914	4,404	50,091

With this observation, it was determined that the model will assess the likelihood of filing an early duration claim on two levels: with respect to driving behavior, and by extension risky

behavior in general, and with respect to medical risk, which encompasses risky lifestyle habits. By incorporating information from automobile insurance underwriting, the early duration claims model will create a more comprehensive risk assessment of a life insurance applicant in order to accurately predict the likelihood of an early duration claim from that policyholder. To incorporate this information, the model will be assessing a variety of traits that are believed to be correlated with early duration claims, which will be referred to as risk factors, based off the applicant's responses to the early duration claims underwriting questionnaire.

2.2. Risk Factor Brainstorming

In order to create an accurate risk profile for predicting the likelihood of an early duration claim, it is necessary to develop a comprehensive list of risk factors that encompasses all risky behaviors related to early duration claims. These risky behaviors will be shown primarily through habits or lifestyle choices of the applicant. When developing an initial list of risk factors, risk factors were divided into two categories: risk factors related to automobile accidents and risk factors related to early death, excluding automobile accidents. The risk factors related to automobile accidents were then further divided into two subcategories: risk factors related to an applicant's lifestyle outside of driving that have a proven correlation to an increased risk of a fatal automobile accident, and risk factors related to risky driving behavior.

Once the risk factor categories were created, brainstorming of potential risk factors could begin. The central focus of the model is to capture risky behaviors that are related to early death and that are not normally assessed as an early duration claim risk in traditional life insurance underwriting. Therefore, it was vital that traditional life insurance underwriting information was reviewed to evaluate its connection to early duration claims and additional creative risk factors

were considered, with risk factors ranging from education level and car type to stress level while at work and texting while driving.

After the initial list of risk factors was developed, each of the risk factors was researched and a literature review was conducted to verify that there is a proven correlation between the risk factor and the associated cause of early death, whether it be a fatal automobile accident or an early death due to medical reasons. In order for a potential risk factor to be considered, there needed to be evidence of a correlation between the risk factor and an increased risk of an early duration claim found in multiple reputable sources. After researching each brainstormed risk factor, a list of 32 potential risk factors was created.

2.3. Risk Factor Selection

Once the list of potential risk factors was developed, criteria for selecting final risk factors was devised. The creation of risk factor criteria helped to ensure that risk factors were being selected to help accomplish the overall goal of designing a risk assessment tool to measure the likelihood of an early duration claim. Furthermore, the criteria would allow for the risk factor selection process to be objective and prevent subjective preferences from masking a potentially strong risk factor. The criteria used to select the final risk factors for the early duration claims model are listed below:

- **Clear Relationship to a Cause of Early Death:** A risk factor must have a clear and logical connection to a cause of early death or be connected to a risky lifestyle choice that could result in an early death.
- **Readily Available:** A risk factor must be easy to attain, measurable, and practical.

- **Not Included in Regular Underwriting with Respect to Early Duration**

Claims: A risk factor must not already be used to assess the likelihood of an early duration claim in traditional life insurance underwriting.

*Note: Risk factors used in traditional life insurance underwriting can be used in the early duration claims model as long as it is being used to evaluate another type of risk in traditional underwriting.

- **Encompasses Modern Technologies and Lifestyles:** A risk factor should reflect how people live in modern society and reflect new risks presented by modern technologies.

The risks factors were evaluated against the above criteria and were selected based on how many criterions the risk factor met. If a risk factor met all of the selection criteria, it was automatically added to the list of final risk factors. Risk factors that met two or three of the above criteria were discussed and researched further to increase confidence in the risk factor before being added to the list of final risk factors. Any risk factor that met only one criterion was not discussed and was not added to the list of final risk factors.

Once the risk factor selection process was complete, 24 risk factors were added to the model as final risk factors and are listed in the table below:

Figure 2: List of Final Risk Factors Used in Early Duration Claims Model

Age	Residency Area	Marital Status	Education Level	Speeding Tickets	Car Model	Car Model Year	Streaming Music While Driving
Night Shift	Number of Hours Worked	Sleep	Exercise Level	Frequency of Eating Out	Stress Level at Work	Depression History	Addiction History
Credit Score	Risky Recreational Hobbies	BMI	Texting While Driving	Debt	Length of Commute	Alcohol Consumption	Pre-Existing Illness

An early duration claims underwriting questionnaire was then created based off the list of final risk factors. The underwriting questions were designed to sort applicants into Low Risk, Medium Risk, and High Risk levels for each respective risk factor based on their answers. The risk factors that could be manipulated by the applicant had answers in the form of ranges to decrease the likelihood of applicants providing the wrong answer to receive a better rate. The final version of the early duration claims underwriting questionnaire can be found in Appendix A.

2.4. Risk Factor Evaluation

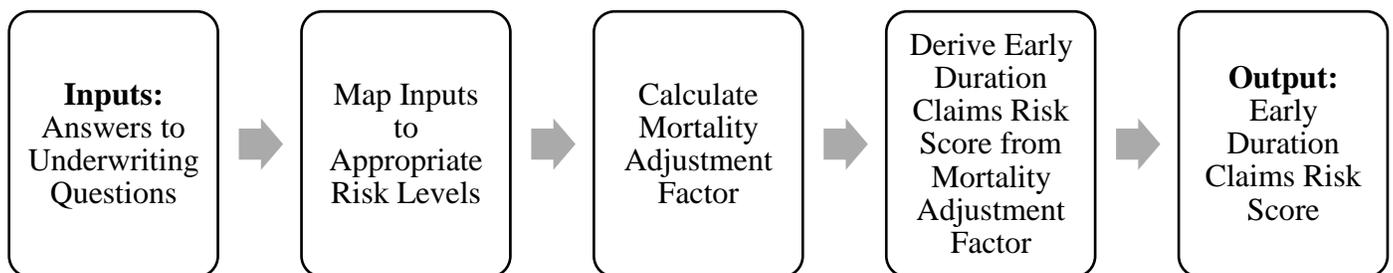
In order to assess the reasonableness of the selected risk factors, it was necessary to consult members of the insurance industry for feedback. An iteration of the Delphi method was used to gain insight on opinions that the insurance industry would have on the final list of risk factors. A Delphi questionnaire was created to allow industry leaders to give their feedback about the logic of the final list of risk factors and to provide information about what they have witnessed in their experience with respect to causes of early duration claims. The questionnaire was intended to be given to an underwriter as well as an actuary to obtain feedback from multiple perspectives. Underwriters have more experience with current underwriting models being used across the industry, and actuaries can share their experiences related to early duration claims.

Due to the sudden change in the spring semester schedule from the COVID-19 pandemic, the Delphi questionnaire was unable to be distributed to an underwriter and an actuary, thus no feedback from the industry was received at this time. However, the distribution and discussion of the Delphi questionnaire results will be one of the next steps for this project, as the feedback can help to increase the legitimacy of the model and help strengthen its marketability to potential clients.

3. Model Construction

With all of the necessary risk factor research and risk factor selection complete, the model construction phase of the project could begin. The model's functions are illustrated at a high level in the chart below.

Figure 3: Model Functionality Flow Chart



The overarching purpose of the early duration claims model is for it to be used as an applicant risk assessment tool, wherein the answers from the early duration claims underwriting questionnaire would be used to calculate a mortality adjustment factor to be applied to the probability of the applicant dying within the next five years, or ${}_5q_x$. The adjusted mortality rate, which will be referred to as ${}_5q_x^*$, would then be transformed into an early duration claims risk score on a scale between 0-100, with 50 being the early duration claims risk score of an average policyholder. The risk score allows a potential client to easily interpret how risky an applicant is, and, by extension, how likely he/she would file an early duration claim. In addition, the risk score may be readily used in a variety of different applications, from premium adjustments to an accelerated underwriting criterion. The multitude of applications for the risk score increases the marketability of this model to potential clients by allowing them to decide how this information should be used in their business practices.

3.1. Risk Factor Mapping

The majority of the questions on the early duration claims underwriting questionnaire have pre-defined answers with three or four options for the applicant to choose from. The pre-defined answers are especially important for risk factors that have a greater likelihood of applicants providing misinformation, such as texting while driving and hours of exercise per week. For this type of question, each possible answer was sorted into three risk levels: Low Risk, Medium Risk, or High Risk.

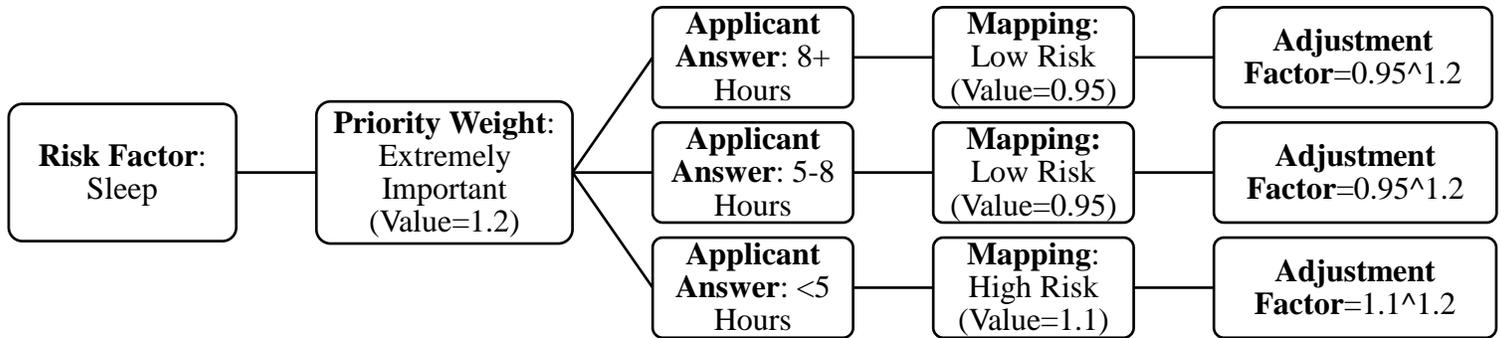
In order to prevent arbitrary selection of an initial adjustment factor for each possible answer to every underwriting question, directional analysis was utilized to assign one initial adjustment factor to each of the three risk levels. Directional analysis involves sorting answers with similar levels of risky behavior into groups and assigning each of those groups a number that is correlated with the likelihood of filing an early duration claim based off that answer. Directional analysis was ultimately chosen as the method for determining adjustment factors for each risk factor due to the nature of the sources of information used. Deriving quantitative information from qualitative research sources would cause the adjustment factors to become subjective, thereby decreasing the marketability of the model to potential clients.

In order to make the adjustment factors more tailored to each individual risk factor, priority weights were introduced. A risk factor's priority weight was an additional adjustment to the current adjustment factor (ranging from 0.9 to 1.2) that was determined based off the strength of the correlation between the risk factor and early death. To decrease the subjectivity of these weights, all risk factors were sorted into three priority weight categories: extremely important, equally important, less important. The priority weights were intended to make each adjustment

factor more individualized to each risk factor while simultaneously avoiding subjectivity through an additional application of directional analysis.

For example, the risk factor sleep is categorized as an extremely important risk factor, so it receives a priority weight of 1.2. If an applicant answered that he/she gets less than 5 hours of sleep on average, that is considered a High Risk answer, making the initial adjustment factor 1.2. The adjustment factor for sleep is then calculated by raising the initial adjustment factor to the power of the priority weight, which makes the adjustment factor in this example $1.2^{1.2}$, which equals approximately 1.245. All possible adjustment factors for sleep are illustrated in the figure below:

Figure 4: Risk Factor Calculation Example



3.2. Mortality Adjustment Factor Calculation

In order to calculate the final mortality adjustment factor, risk factors were first sorted into two categories based on which cause of early death with which they were correlated. Thus, the two categories were automobile accident risk factors and medically related risk factors. It is

important to note that some of the risk factors were included in both groups because they were proven to have a correlation with increased risk of a fatal automobile accident and with increased risk of an early death due to medical reasons. Some risk factors that were included in both categories include education, marital status, credit score, and sleep. Once the priority weight was applied to each risk factor’s initial adjustment factor, all adjustment factors in each group were multiplied together to produce an automobile accident adjustment factor and a medically related adjustment factor.

It is apparent from Figure 1 that the leading causes of early death can change depending on the age of the applicant. Therefore, the final mortality adjustment factor is calculated with a weighted average of the two mortality adjustment sub-factors to incorporate this trend into the model, with the weights defined as the likelihood of each cause of early death (i.e., automobile accidents and cardiovascular-related death) relative to the age of the applicant. Using the data from Figure 1, the following weights were calculated to be used in the final mortality adjustment factor calculation.

Figure 5: Final Mortality Adjustment Factor Age Weights

Age Range	Medically Related Age Weight	Automobile Accident Age Weight
20-34	0.30	0.70
35-49	0.60	0.40
50-69	0.85	0.15
70+	0.95	0.05

3.3. Risk Score Calculation

The final mortality adjustment factor is used in the derivation of the early duration claims risk score, and the early duration claims risk score is calculated such that it has a one-to-one

relationship with the final mortality adjustment factor. It is imperative to maintain this relationship so that the same information regarding the applicant's propensity to an early duration claim can be derived from both the final mortality adjustment factor and the early duration claims risk score.

The final mortality adjustment factor is used to calculate ${}_5q_x^*$ using the constant force of mortality assumption. The calculation of ${}_5q_x^*$ is derived below:

$${}_5q_x^* = 1 - {}_5p_x^* = 1 - (p_x^* p_{x+1}^* p_{x+2}^* \dots p_{x+4}^*)$$

$$\text{and } p_x^* = p_x^{(1+c_1)(1+c_2)\dots(1+c_n)} \text{ under constant force of mortality}$$

where $\{c_i\}$ =Risk Factors

$$\text{and } q_x^* = 1 - p_x^*$$

Once ${}_5q_x^*$ is calculated, the probability of dying in the first five years for an average policyholder, which will be denoted as ${}_5q_x$, must be calculated using the early duration claims model and under the same principles as illustrated above. It is important to note that proper risk levels for each risk factor were selected to properly adjust the unadjusted mortality rate to account for the risks associated with early duration claims for an average policyholder.

The two probabilities, ${}_5q_x^*$ and ${}_5q_x$, are then used to calculate the early duration claims ratio, denoted R^* , and is defined as:

$$R^* = {}_5q_x^* / {}_5q_x$$

where ${}_5q_x^* = \text{Prob}(\text{dying in the first 5 years for a new issue based on various characteristics}),$

and ${}_5q_x = \text{Prob}(\text{dying in the first 5 years for a "normal" new issue}).$

R^* is the measure that is used to translate the final mortality adjustment factor to the early duration claims risk score. The early duration claims risk score is derived from R^* by setting the maximum value of R^* equal to 100, setting the minimum value of $R^*=0$, and setting the average value of R^* (i.e., $R^*=1$) equal to 50. Under these conditions, every R^* value can then be normalized to have an early duration claims risk score between 0 and 100. Subsequently, an early duration claims risk score that is over 50 implies that the applicant has a greater risk for an early duration claim compared to a “normal” new issue. Furthermore, it can be deduced that an early duration claims risk score that is less than 50 implies that the applicant is a good risk and is less likely to file an early duration claim than the average policyholder.

4. Application to Accelerated Underwriting

One way that a company could utilize the early duration claims model is by using it to screen applicants to determine if they qualify for accelerated underwriting. This decision would be reached through the creation of a confidence interval with a confidence level equal to $(1 - \alpha)$ for n newly issued policies, with both parameters α and n set by the company.

In order to calculate a confidence interval for a single applicant, the confidence interval is calculated using the random variable Y , which is defined as $Y = \frac{X}{n}$, where X is equal to the number of deaths in the first five years for n newly issued policies. X is a random variable that follows a binomial distribution because it is the sum of n Bernoulli random variables (Chevallier 1). Each Bernoulli random variable has only two outcomes: a policyholder either dies within the first five years of the policy, with an associated probability of $5qx$, or survives for all five years. Since Y is equal to the random variable X divided by a constant, it also follows a Binomial distribution. The expected value and variance of Y are shown in the derivations below:

$$E(Y) = \frac{1}{n}E(X) = \frac{n * 5qx}{n} = 5qx$$

where $5qx$ is the adjusted mortality for a “normal” new issue

$$Var(Y) = \frac{1}{n^2}Var(X) = \frac{1}{n^2}(n)(5qx)(1 - 5qx) = \frac{5qx(1 - 5qx)}{n}$$

The $(1 - \alpha)$ confidence interval can then be calculated using the following formula:

$$(1 - \alpha)C.I. = 5qx \pm Z_{1-\frac{\alpha}{2}}\sqrt{\frac{5qx(1 - 5qx)}{n}}$$

To translate this confidence interval into early duration risk scores, set the upper bound of the confidence interval as the upper bound of R^* and calculate the upper bound of the early duration claims risk score using the R^* value. Similarly, to find the lower bound of the early duration

claims risk score, set the lower bound of the confidence interval as the lower bound of R^* and derive the lower bound of the early duration claims risk score using the R^* value (Vadiveloo 2). After translating the confidence interval values into a risk score interval, the company can use this interval to evaluate an applicant's early duration claims risk score and make decisions regarding accelerated underwriting. An example of how the company could use this risk score interval to make a decision regarding accelerated underwriting is described below:

For a new issue, if R^* and the corresponding early duration claims risk score:

- a. Is within the $(1 - \alpha)C.I.$ for a "normal" new issue, issue the policy with accelerated underwriting.
- b. Exceeds the upper bound of R^* for a "normal" new issue, require full underwriting.
- c. Is below the lower bound of R^* for a "normal" new issue, issue the policy with preferred rates.

The company being able to set values for n and α allows for more flexibility and increases the marketability of the early duration claims model. However, it is imperative that potential clients understand how the values of these parameters impact the confidence interval and subsequent decision making. The larger n is made, the smaller the confidence interval width becomes, thereby increasing the likelihood that full underwriting will be required. Additionally, the smaller α is made, the wider the confidence interval width becomes, which increases the likelihood that accelerated underwriting will be permitted. With these impacts in mind, companies can use this function of the early duration claims model to help accurately assess early duration claim risk and use the risk assessment as an accelerated underwriting criterion.

5. Conclusion

The early duration claims model fills a void in the current traditional life insurance underwriting by predicting the likelihood of an applicant filing an early duration claim. After preliminary research, it was determined that automobile accidents are a leading cause of early death, thus automobile insurance underwriting contains information that is useful for predicting early duration claims. Additional literature review helped to create a final list of risk factors that examine all potential behaviors that are correlated with early duration claims. In the future, the Delphi questionnaire regarding the legitimacy of the selected risk factors will be sent to an underwriter and an actuary in the life insurance industry to further improve the risk factors. To calculate the final mortality adjustment factor, directional analysis and other fine-tuning was used to make adjustment factors individualized to each risk factor while also preventing arbitrary selection of numbers. Finally, the confidence interval mechanism with the early duration claims risk score was created to be used as a criterion for an applicant to qualify for accelerated underwriting.

Overall, the early duration claims model is a tool that can be used to create a more robust risk assessment of a life insurance applicant relative to the likelihood of filing an early duration claim by incorporating information not currently utilized in traditional underwriting. Furthermore, the model can be used by companies to decrease the likelihood of issuing to an applicant with a high risk of an early duration claim and could potentially decrease the immense losses related to early duration claims.

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Appendix A: Early Duration Claims Underwriting Questionnaire

Early Duration Claims Advanced Underwriting

General Information:

Age: _____

Address: _____

Do you live in a rural area, a suburban area, or an urban area?

Rural Suburban Urban

Marital Status:

Single Married Divorced Widowed

What is the highest level of education you have completed?

Less than High School High School College Graduate

Credit Score: _____

Current Outstanding Debt Owed: _____

Do you regularly participate in any risky recreational activities, including skydiving, base jumping, racecar driving, etc.?

Yes No

Automobile Information:

License Plate: _____

What type of vehicle do you drive?

Sedan SUV Truck Sportscar

Vehicle Model Year: _____

How often do you stream music via Spotify, Apple Music, etc. while driving?

Never Sometimes Often Always

How often do you text while driving?

Never Sometimes Often Always

Work Environment Information:

Occupation: _____

How long is your commute to work, on average?

0-30 minutes 30-45 minutes 45+ minutes

How often do you work the night shift at your job per week, on average?

Never 1-3 times/week 4-6 times/week Always

How many hours do you work at your job per week, on average?

20 hrs/week 40 hrs/week 60 hrs/week 60+ hrs/week

Health Information:

Height: _____

Weight: _____

Have you been diagnosed with any of the following illnesses: Diabetes, Heart Disease, High Blood Pressure, Cancer?

Yes No

How many hours do you sleep per night, on average?

0-5 hours 5-8 hours 8+ hours

How often do you exercise per week, on average?

Never 1-3 times/week 4-6 times/week Everyday

How often do you dine out and/or order food from a restaurant per week, on average?

Never 1-3 times/week 4-6 times/week Everyday

How often do you consume alcohol, on average?

Never 1-2 times/month 1-2 times/week 3+ times/week

How often do you feel stressed per week, on average?

Never A few times Often Always

Have you ever been diagnosed with depression?

Yes No

Do you have a history of opioid addiction?

Yes No