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# Prediction of Levels of Happiness Using Multinomial Logit as a Neural Network: Evidence in Kenyan Youths

**Martin Kinyua Ngari[1, *], Anthony Kibera Wanjoya[1], John Mwaniki Kihoro[2]**

[1]Department of Statistics and Actuarial Science, Jomo Kenyatta University of Agriculture and Technology, Nairobi, Kenya

[2]Department of Mathematical Sciences, Cooperative University of Kenya, Nairobi, Kenya

## Email address:

mqkinyuamartin@gmail.com (M. K. Ngari), awanjoya@gmail.com (A. K. Wanjoya), kihoro.jm@gmail.com (J. M. Kihoro)

[*]Corresponding author

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**Abstract:** Happiness has become a major concern across many disciplines starting form public policy, economics and psychology because of the effects that come with not being happy. Psychologist would want to know the effects of low levels of happiness, economist would want to know the effects of levels of happiness in to the market place, researchers from health would be concerned with effects of high and low levels of happiness to health status. While predominantly, people had just a philosophical notion about happiness, currently there are numerous scientific studies on happiness. Approaches like cluster analysis have been employed before. This research used neural networks to classify multinomial levels of happiness of Kenyan youths by considering life style aspects of current life such as Internet usage, Physical activeness, Health, Social life, Education, Income, Country's top leadership, Dining and Sleeping Habits. The research was able to fit a 14-1-4 neural network model to classify levels of happiness in Kenyan youths, an accuracy of 73% was achieved. The data was randomly split in to 70% training set and 30% test set. The training set was balanced using SMOTE approach. This research trained the model by applying gradient descent using error back propagation algorithm with initial weights drawn from uniform distribution and applied softmax activation function. Accuracy metrics were confusion matrix, precision and recall for each level of happiness, and F-Scores. The top leading factor related to happiness positively was physical activeness with youths who were more active being happier. The second factor was relationship type, the married youths were happier than the singles, separated or engaged. Youths who were more satisfied with their relationship, they were happier. Health was also positively related to happiness. On the other hand, the number of hours a youth spent on social media negatively affected their levels of happiness. The more the number of hours the low levels of happiness.

**Keywords:** Happiness, Neural Network, Multinomial, Training, Cross-Entropy, Confusion Matrix, F-Score, Variable Importance

## 1. Introduction

Recently, Happiness has become a major concern across many disciplines starting form public policy, economics and psychology because of the effects that come with not being happy. Happiness can be defined as the meaning and the purpose of life, whole aim and end of human existence as it was put by one great ancient Greek Philosopher Aristotle over 2,000 years ago, and it sound true to many till today. In another version happiness is defined as an emotional state of feeling good [9]. To be specific, Happiness describes the experience of positive emotions such as contentment, joy, and satisfactory. While initially many people had just a philosophical notion about impotence of happiness, currently there are numerous science studies and research to back it up and to show that being happy is not just a better feeling but it brings a package of several advantages in various ways.

Over the past ten years several studies have been done to link happiness with several advantages. A good example of a very fresh study by Steptoe who in sought of relationship between happiness and health demonstrated that the very

primary advantage of being happy is good health [16]. Again, the landmark Stiglitz-Sen-Fitousi commissioned measurement of Economic Performance and social progress by bringing awareness of happiness to public. And this inquiry on happiness issue led by economist exposed the limitations of conventional indicators of economic performance as measures of social progress and insisted that well-being should be considered too. In 2011, a United Nations (UN) General Assembly resolved to welcome all member countries to measure happiness and use it as a guide in public policy. The assembly initiated a World Happiness Report which provides league table of happiness across countries annually. Many scholars have helped in understanding the concept of happiness or well-being across the world. We have many journals written in United Kingdom talking about how to be happy and several causes of happiness. It is has been done in USA, Canada and Australia.

There are many aspects we would want to know about happiness, Psychologist want to understand the causes of happiness and psychological processes involved in it. Many factors would be mentioned here; factors like drugs, exercises, objective conditions such as marriage, employment, money, food, and work would be considered to be part of a study about causes of happiness. Economists would be concerned on influence of well-being in economy. For example, Sacks discussed how level of satisfactory is related to spending habits and reported that a happier person is likely to be an active worker and spend more, and as a result the economy would run faster in a situation where many people are happier [15]. The health sector is also not left behind; uncountable journals, studies have shown how well-being can lead to higher survival rate, lower risk of many chronic diseases especially the cardiovascular related illnesses. Furthermore, increased level of happiness leads to better and physical perception of self, better dietary habits and maintenance of normal body weight, and physically active lifestyles [5]. Work life and school life is also greatly attached to state of wellbeing of a worker of a students. This translate to production output, high level of happiness means a high level of output and unhappiness could make people perform poorly. Therefore it is very crucial for a country to be concerned with wellbeing of its youths and people in general.

This study was mainly concerned on how to identify a happier person based on several factors associated with human being life style. There were five levels of happiness and persons were asked to rate their general feeling happiness or contentment. Initially this has been achieved by just asking people how they felt and what other activities they did. These activities vary over time, for instance, there was no internet before 3 decades ago when the concept of happiness was very young in terms of research exploration. So this study was able to distinguish and predict a happier person by considering life style aspects of current life. They include Internet usage, Physical activeness, Social life, Education, Income, Country's top leadership, Dining and Sleeping Habits. On mobile phone usage, participants were asked to mention on average the time they spent on social per day. Dining question asked a person how many times or how many meals they took in a day. About physical activeness, they were asked to mention on average how many kilometers they covered by walking per day. Youths were asked how much they earned as income either by working or gifts per month. There was a question of number of sleeping hours per day. They were also asked to rate their satisfaction on their friends association and support on a scale rating, and give information on their relationships and interaction rate. Further, they were asked to rate their satisfaction on top leadership of the state and support from family members on a five point scale. Finally, Education level, Age, and Gender of a person was recorded.

All these factors have been linked to explain level of happiness before by employing cluster analysis and cross-section studies and in this case, they were used to classify and predict a happier person by employing neural networks (NN) to the multinomial levels of happiness. Neural Networks (NNs) are mathematical models that are motivated by the process of learning in biological animals' system. Happiness being a difficult aspect to measure and considering that Neural Network is best for linear and non-linear relationships, this study was motivated to employ hybrid of Neural Network with Multinomial Logit Model (MLM).

### *1.1. Statement of the Problem*

Happiness is intrinsically necessary for it help us achieve many of our goals and help us change the lives of others. Sometimes we tend to neglect cultivation of our happiness which can cause harm to our lives and to our friends, and sometimes lead to global harmfulness. Unhappiness is at the core of all breeding grounds of war and terrorist activities. Countries only attack other countries if they are feeling unhappy. Unhappiness has also been associated with depression so there is need to observe on our happiness individually and globally. The many tests available to test happiness are long and mainly subjective, and depend mostly on counting stories asked by researchers through a series of questions about their feelings. There are problems with these psychological measures as they can't be really quantified.

Recent studies have shown happiness is extremely dependent on social life, daily activities, exercises, and time management and there are conflicting results in some of the factors studied [2, 6, 7, 11, 13]. Current study relied and explored the same factors by examining how people can allocate time and attention to better their lives financially, physically, and socially by employing a neural network that involved a pool of fourteen variables to keenly follow up on factors affecting happiness and predict whether a person is happy or not happy. This means only few objective questions were asked to the person unlike other cases which asks very many subjective questions. Kenya having young adults as the biggest constitute of its population there must be a concern to monitor their happiness in order to form a strong country

which was also another motivator of this study.

### *1.2. Objectives of the Study*

#### *1.2.1. General Objective*

To classify the levels of happiness among Kenyan youths using the Multinomial Neural.

#### *1.2.2. Specifics Objectives*

i. To fit a model on levels of happiness in Kenyan youths using the Multinomial Neural Network;
ii. To assess to what extent a Neural Network can be used to model happiness using the fitted model in modelling of levels of happiness;
iii. To determine the most contributing factors in happiness among Kenyan youths.

### *1.3. Justification of the Study*

The research mainly shed insights on how people should spend time in their daily activities to maintain good life. It greatly address psychologist, health experts and economist who can use the results to advice and recommend better life habits.

### *1.4. Scope of the Study*

The study was carried in Kenya and targeted youths since they are the majority in Kenya and that is where the backbone of the country progress lie. Data was obtained through online surveys from individuals aged 18 to 36 years. A multinomial logit as an NN model was used to carry out prediction of happiness.

## 2. Literature Review

### *2.1. Acknowledged Work*

Happiness is a human process that has been studied in various dimensions and by different groups. Happiness seems to be a complex aspect to study, its literature dates back in ancient time [3]. Many studies in this area have been contradicting showing how researchers have struggles to explore happiness. Various factors have been linked to happiness and the key factors are Love, Exercising, Relaxing, Career, Friends, Family, Sleep, Traveling, Health, and income [1, 7, 11, 13]. Numerous studies found physical activeness as the main factor to determine happiness. A study on the keys to happiness found that social life was associated with greater chance of happiness while factors like money power and health were adversely associated with happiness [10]. In another study, happiness was correlated with age, income, violence, social support, and subjective health [7]. On the other hand, a research on factors affecting happiness index found that physical well-being was the most influential factor in determining happiness index [13]. It is clear there has been conflicting results and this study also reviewed the same factors to add on happiness literature.

One study that is closely related to this study applied artificial neural networks to assess student's happiness by considering ten factors that influence happiness in a learning institution [2]. These include education, institution facilities, career and financial aid services, campus dining and health care, social life and family relationship and support. In their research, they came up with sub categories of those factors to make a total of twenty five sub categories. Then run twenty eight multiple linear regression models as a base for ANN models. There were 32 input variables and the student happiness as the output used to build ANN model(s). 70% of their data was used for training and 15% was used for validation to cater for over-fitting, the remaining 15% was used for testing. They run an automated ANN training and came up six candidates ANN models to determine the happiness of a student. Finally, only five models were picked and out of the five the best ANN network consisted of eight hidden layers with exponential activation functions and logistic activation function with the output (due to being a categorical output). ANN outperformed MLR due to nonlinear characteristics. In their results they found that family support, family relationships, and critical demographics in addition to school or education related categories provided more insights about the happiness determinants.

Another related study modelled students' happiness by applying machine learning to physiology, phone, mobility and behavioral data. The followed up on student's physiological signals, location, and smartphone logs, and survey responses to behavioral questions for one month. Because of complexity of their data they applied variety of machine learning algorithms and feature selection techniques to find appropriate model for each type of data. These included Support Vector Machines (SVM), Random Forests (RF), Neural Networks (NN), Logistic Regression (LR), K-Nearest Neighbor (KNN), Native Bayes, and Adaboost. They were able to achieve 70% classification accuracy. In their finding, they found that mobility or physical activeness is the leading factor to detect if a person is happy or not. They also found physiology, which deals with behavior of a human body is another promising factor to detect changes of happiness of a person, especially [6].

### *2.2. Neural Networks (NN)*

A neural network is a parallel connection of massive nodes known as neurons to form models which functionality is motivated by process of learning biological animal networks (systems). Its application imitates animal neurons communicate but specifically the input and output relationships are modelled using linear and non-linear functions in a multi-layered network structure. A NN model basically consist of three elements namely; Architecture, Training or learning algorithm and Activation functions.

#### *2.2.1. Network Architecture*

NN contains computational neurons which are connected to each other through weights to form a network mentioned in definition above. These nodes are grouped into three layers; input, hidden, and output layers. The input is to receive data; output is meant to send results of overall computation while the hidden layer is between the input

and output and is for extra complex calculations so that more relationships between the input and output can be determined. The network architecture is shown in simple diagram below;

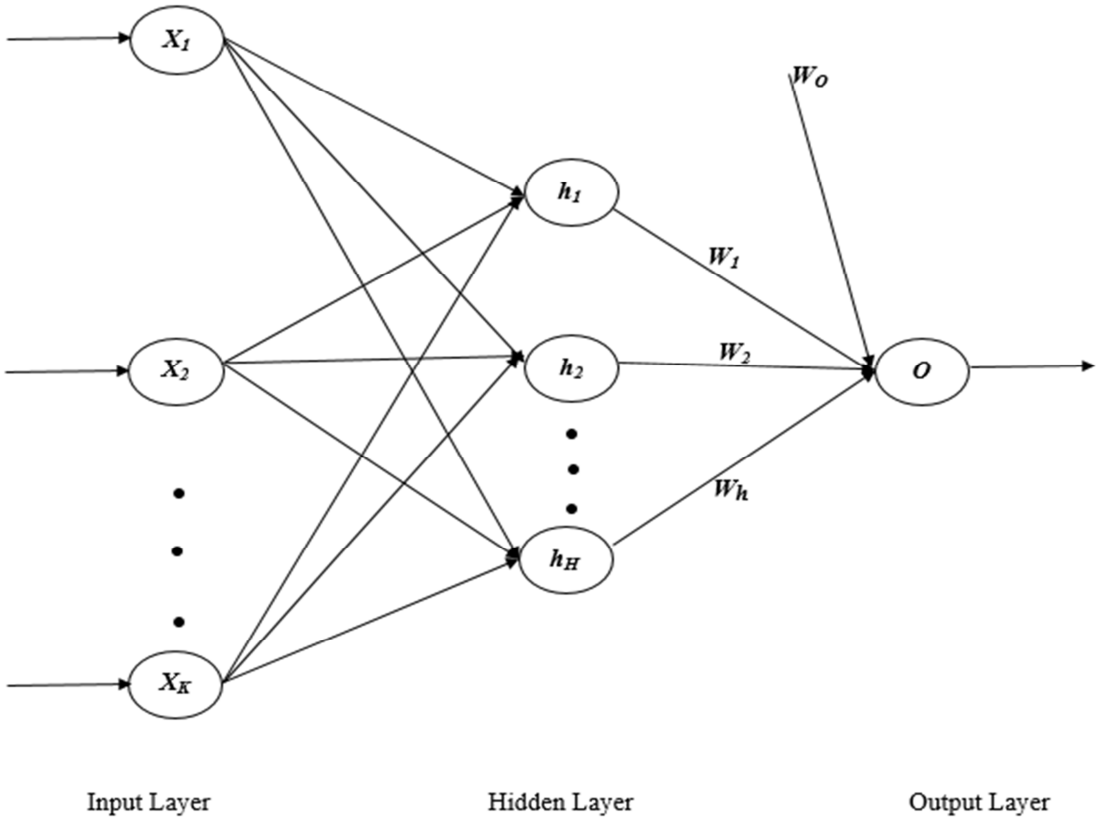



***Figure 1.*** *Neural Network Architecture.*

In architecture diagram shown in figure 1 above there are K inputs nodes, H hidden nodes and one output node O. The hidden layer and the output are connected by Weights $W_O$ to $W_h$.

#### *2.2.2. Training*

We initialize the weights to use in our modelling and adjust them through training. There are two training paradigms; supervised learning and unsupervised learning. This study employed supervised learning. Basically, it means that we defined input, output variables, and data was labelled. Neural network is a regression technique which is a technique of supervised training. Supervised learning is reliable, highly accurate, and simpler technique. For a successful supervised learning we required the following;

i. A sample (data) of K vectors $X=X_1, X_2,\ldots, X_K$ and associated output Y,
ii. Selection of an initial weight set,
iii. A repetitive method to adjust weights to obtain optimal results.

#### *2.2.3. Activation Functions*

Activation functions are any mathematical functions used to update weights and bias in neural network learning or training in order to obtain an optimal output from the inputs. There are many functions and the choice of an activation is a mandatory step in Neural Network training. The common functions include; ReLU, Sigmoid, Tanh and Linear function.

## 3. Methodology

### *3.1. Survey Design*

From a through literature review, the determinants of happiness are categorized in the following eleven main factors: Age, education level, Social life, Physical activeness, Financial Income, Country Leadership, Internet Usage, Dining habits, Sleeping habits, health, and Family support. They were extended to have some factors having sub-factors. The social life had six sub categories; satisfaction on and kind of relationship involved, how frequent they interact with new people, satisfaction on their friends support, family support, how active on social media platforms. The factor of Age was not considered as part of variables to include in this research since the study focuses on youth. However, question of age of the respondent was asked for validity purposes. This resulted in forming sixteen survey questions to capture all the sub-factors. A general rating of one's happiness on a five-point scale was also asked. These questions led to the fourteen following variables and the last question formed happiness as independent variable.

### *3.2. Variable Definition*

***Table 1.*** *Variable Labels.*

| Variable | Definition | Measure |
|---|---|---|
| 1. Gender | Gender of respondent | 1=male<br>2=female |
| 2. income | Level of income in (Ksh) | 1=Below 20K<br>2=From 20K to 30K<br>3=Above 30K to 40K<br>4=Above 40K to 50K<br>5=Above 50K to 60K<br>6=Above 60K |
| 3. education | Level of education | 1=Below High school<br>2=High School<br>3=College<br>4=Undergraduate<br>5=Post graduate |
| 4. online.hrs | Number of hours one spend on social media platforms | Scale of 0-24 |
| 5. family.members | Rate of satisfaction on support from family members | 1=Very poor<br>2=Poor<br>3=Acceptable<br>4=Good<br>5=Very good |
| 6. from.friends | Rate of satisfaction on support from friends | 1=Very poor<br>2=Poor<br>3=Acceptable<br>4=Good<br>5=Very good |
| 7. Interaction | Physical interaction with new people | 1=Never<br>2=Very rarely<br>3=Rarely<br>4=Occasionally<br>5=frequent<br>6=very frequent |
| 8. relationship.type | Type of relationship that one is involved in | 1=Single<br>2=Dating<br>3=Engaged<br>4-separated<br>5=Married |
| 9. rship.satisfaction | Satisfaction on the type of relationship | 1=Very Dissatisfied<br>2=Dissatisfied<br>3=Neutral<br>4=Satisfied<br>5=Very Satisfied |
| 10. movement.km | Physical movement, kilometres covered by walking in a day | Real number |
| 11. meals | Number of meals in a day | Meals in scale of 0-8 |
| 12. Sleeping.hrs | Number of sleeping hours in a day | Hours in sale of 0-24 |
| 13. government | Satisfaction on top government leadership | 1=Very Dissatisfied<br>2=Dissatisfied<br>3=Neutral<br>4=Satisfied<br>5=Very Satisfied |
| 14. health | Satisfaction on one's health | 1=Very Dissatisfied<br>2=Dissatisfied<br>3=Neutral<br>4=Satisfied<br>5=Very Satisfied |
| 15. happiness | General feeling or rate of one's happiness based on the above aspects | 1=Very Dissatisfied<br>2=Dissatisfied<br>3=Neutral<br>4=Satisfied<br>5=Very Satisfied |

### *3.3. Conceptual Model*

The model of this study has three layers in order to mimic the neural networks. The input layer has 14 nodes or factors affecting the happiness, these include: physical movement, income level, activeness on social medial, dining habits, sleeping habits, satisfaction on government leadership, rate of support from family members, interaction with new people, friends support, education level, kind of relationship involved in, and health. And we let a vector of these variables be X. We also have one hidden layer and one output layer; the output layer has five nodes (levels of happiness). The motivation of having five nodes for output variable happiness is because of aspect of multi-level logistic regression, that is, the variable happiness has more than two levels in this analysis. We denote the probability distribution of these levels of happiness with y. This model involved softmax activation function in the output layer. The choice softmax function in a multinomial output is well explained by Jurafsky and Martin [8]. It takes the form;

$$\sigma(\vec{z}_i) = \frac{e^{Zi}}{\sum_{i=1}^{k} e^{Zj}} \quad (1)$$

σ = softmax, z= input vector, $e^{Zi}$= standard exponential function for input vector, standard exponential function for input vector, k= number of classes in the multi-class classifier, $e^{Zj}$=standard exponential function for output vector.

### *3.4. Multinomial Logit as a Neural Network*

From the conceptual model described above in section 3.3, hidden layer form the core of a neural network because this is where much of the mapping is done. Inputs variables are weighted at this stage and there is a bias involved in this link. Basically, each hidden unit take weighted sum of inputs, apply non-linearity function, and link to output. Therefore, each hidden unit has a parameter weight $W$ and a bias scalar $b$. The weights form a weight vector denoted by $_{Wi}$ and vector of bias $b_i$. The output in the j$^{th}$ hidden node is taken to be h.

### *3.5. Training a Multinomial Neural Network*

The objective of training in NN is to learn parameters $W$, $b$ for each layer and other hyper-parameters that makes $\hat{\boldsymbol{y}}$ close to true value $y$. Key steps and a loss function are needed to model the distance between hidden layer and system output.

$$h_j = \mathrm{g}(\sigma) \sum_{i=1}^{\infty} W_{ij} X_i b_j \quad (2)$$

Where g(σ) the activation function, $W_{ij}$ and $b_j$ are the weights and bias in the $J^{th}$ node respectively. $X_j$ is a vector of input variables.

Just like the hidden layer, the output layer has a weight matrix $U$. The activation function applied in output layer is the softmax function which takes the form defined in equation (1). The final output for our network has below equations; the input variables vector X, the output a probability distribution y, which is parameterized by weights W and U and bias vector b.

$$h = g(Wx + b) \quad (3)$$

$$Z = Uh \quad (4)$$

$$y = softmax(Z) \quad (5)$$

#### *3.5.1. Data*

Data was randomly split in to two sets; 70% was used in training and 30% was used in testing the model. The levels of happiness turned out to be four: dissatisfied, neutral, satisfied and very Satisfied, Multinomial Levels of Happiness. Let X be vector of 14 variables discussed. The multinomial levels of happiness predicted using Neural Network (NN). Which takes the form;

$$Z = w_I X + b_i \quad (6)$$

#### *3.5.2. Parameter Initialization*

To precisely meet the objective of training a neural network model, initial values of parameters W and b must be chosen wisely. In order to solve the problem of vanishing gradient or converging gradient, we randomly initialize weights that are not too large and not too small for the model. This study uses Xaiveir initialization. The model has three layers x, h and y; x is the input layer with 14 nodes, one hidden layer h and one output layer y with 4 nodes. This gives two sets of parameters $W_L$ and $b_L$; where L is the number of layers which is 3 in this case.

The first set has $W_1$, $b_1$, and second set has $W_2$, and $b_2$ and they exist in form of matrices. The biases are set to 0 while the weights $W_{ij}$ are randomized using uniform distribution.

$$Wij = U\left[-\frac{\sqrt{6}}{\sqrt{x+y}}, \frac{\sqrt{6}}{\sqrt{x+y}}\right] \quad (7)$$

Where U is a uniform distribution and x is the size input layer and y is the size of output layer.

#### *3.5.3. Loss Function/Cross-Entropy*

Let y be vectors of C levels representing the true output probability distribution of levels of happiness. The loss function or the cross-entropy loss is defined as;

$$l(\hat{y}, y) = -\sum_{i=1}^{C} y_i \, log \, \hat{y}_i \quad (8)$$

If the level of happiness is i then y is a vector where $y_i$=1 and $y_j$=0 for all i≠j so the sum of this equation will be equal to zero but not for the term corresponding to level k.

$$l(\hat{y}, y) = -\sum_{k=1}^{k} 1(y = k) \log \hat{y}_i \quad (9)$$

$$= -\sum_{k=1}^{k} 1(y = k) \log \hat{p}_i \, (y = k/x) \quad (10)$$

Which leads to,

$$l(\hat{y}, y) = -\sum_{i=1}^{K} 1(y = k) \log \frac{e^{zi}}{\sum_{i=1}^{k} e^{zj}} \quad (11)$$

This is the negative log likelihood. Which upon plugging of softmax function in equation (1) and after simplification we have the following Loss function which is to be minimized.

$$L = -\log \frac{e^{zi}}{\sum_{i=1}^{k} e^{zj}} \quad (12)$$

#### *3.5.4. Gradient Descent and Back Propagation Algorithm*

Using the cross entropy loss function L= $l(\hat{y}, y)$ to map $\hat{y}$ the predicted output to true label y. The aim is to minimize the loss function through gradient descent by finding its partial derivatives using error back propagation algorithm. We have three components; $\partial w^L, \partial b^L$ and $\partial A^L - 1$ . Next is to differentiate the loss function L with respect to weights W of current layer then again with respect to bias ***b*** of the current layer.

$$\partial W(l) = \frac{\partial l}{\partial (W^l)} \text{ and } \partial b(l) = \frac{\partial l}{\partial (b^l)} = \frac{1}{m} \partial Z^{[2]} A^{(1)^T} \quad (13)$$

The last derivative is calculated with respect to A, the output plus activation function. In back propagation with a single hidden layer like in this study, the gradients for output layer are calculated first then middle layer. The list of these gradients are returned in form of matrices. They then give an indication of what small value weights should be increased or decreased such that the loss function L is decreased too.

### *3.6. Testing Network*

In this part of inference, we do not need to perform backpropagation. We only perform forward propagation and return the final output from our neural network using the trained parameters. All this is done using the trained parameters on unknown set of data, this is 30% of the data set aside for testing data. New values or levels of happiness are predicted from this set. Based on the Values in the test set of data and new predicted values, an accuracy of the fitted model is obtained using the following metrics; Confusion matrix, Class Precision and F-Scores.

### *3.7. Data Collection and Analysis*

Data was collected from Kenyan youths because according to 2019 census by Kenya National Bureau of Statistics, 75% of Kenyan population constitutes of people below 36 years of age which is approximately 35 Million. Online questionnaire were used to collect information on a target sample of 1,067 Kenyan youths. This comes from a formula to calculate sample size for big unknown populations.

$$n = \frac{(Z^2 + S^2)}{E^2} \quad (14)$$

Where; Z is the confidence interval of 95%, S is the standard deviation and is approximately 0.4998 and for better precision, the error margin (E) of this study was 3% [12]. Data was analyzed using statistical software known as R.

## 4. Results

### *4.1. Response Rate*

This study targeted 1,067 respondents but only 864 youths who responded. This result to a response rate of 80%. For online surveys, questionnaire and interviews a respond rate above 60% is still enough for analysis [4].

### *4.2. Data Demography and Preprocess*

No respondent reported very dissatisfied level of happiness, this turned the levels of happiness from 5 to 4, that is, Dissatisfied, Neutral, Satisfied, and very satisfied. Some variables were transformed using minmax transformation to range between 0 and 1 they include, online hours, movement, meals and sleeping hours. This was to ensure their values are small enough for neural network or machine learning analysis.

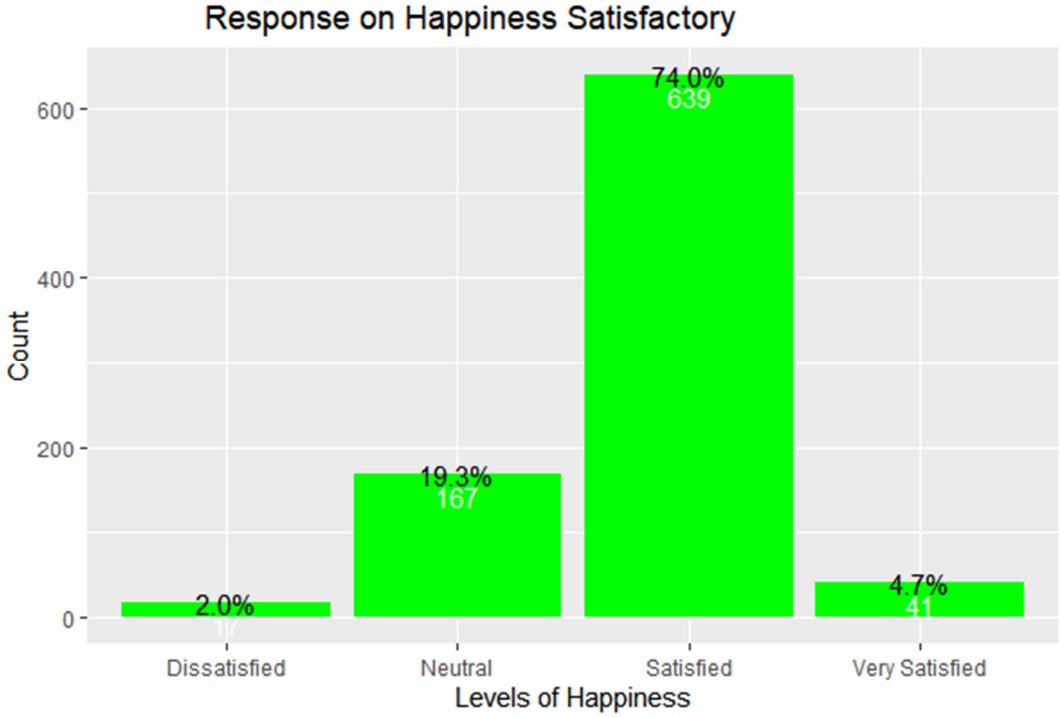



***Figure 2.*** *Showing levels of happiness.*

Most (74%) of the respondents reported to be happy, the category of youths who followed consisted of 19%, and these were neutral about their level of happiness, 4.7% were very satisfied, 2.0% were dissatisfied. No single respondents reported to be very dissatisfied.

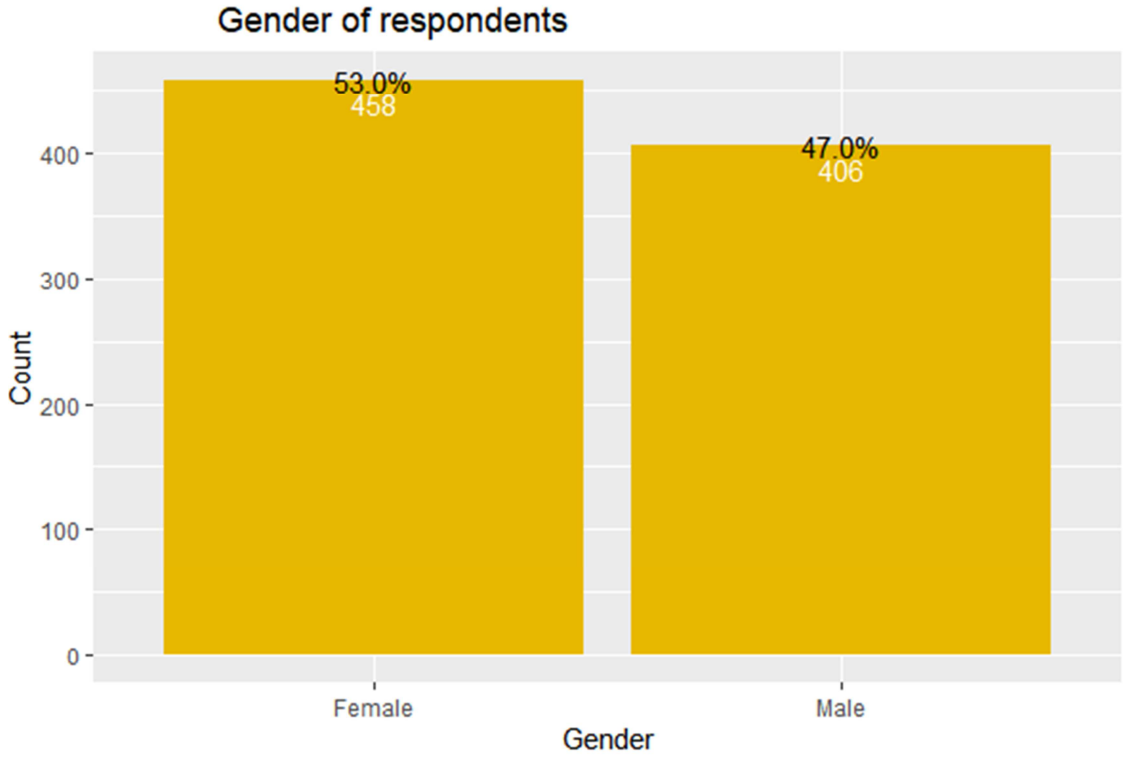



***Figure 3.*** *Gender of the respondents.*

The research comprised of 458 females who formed a portion of 53.0% of the respondents while males ware 406, that is, 47.0%.

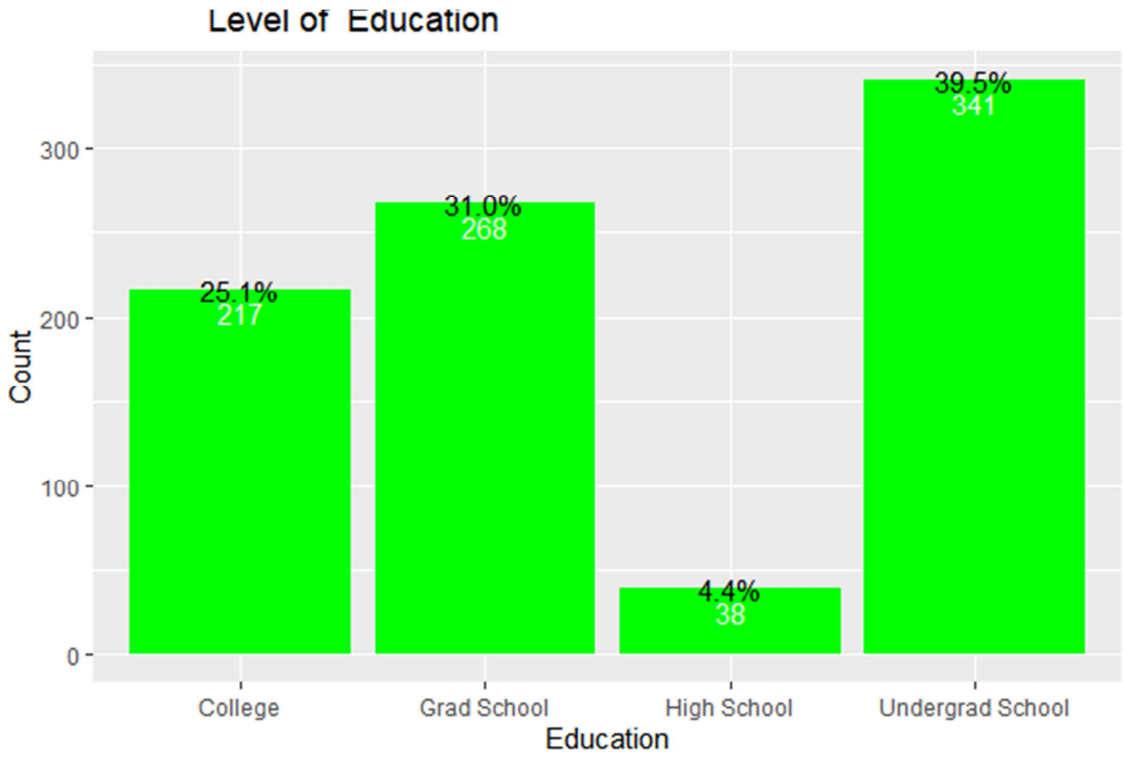
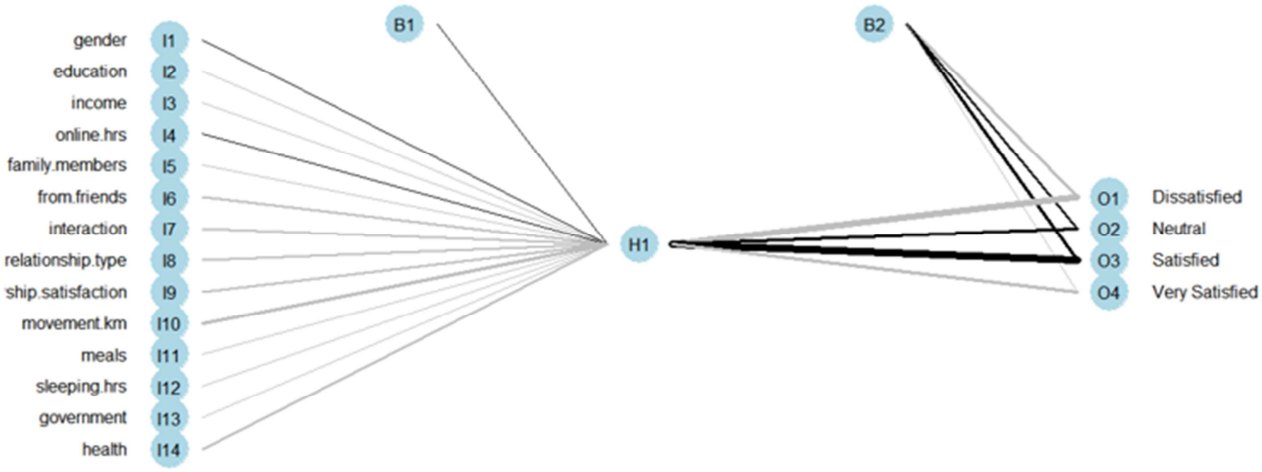



***Figure 4.*** *Level of education of the participants.*

Most of the youths (39%) reported undergraduate as their highest level of education, then 31% attained graduate school, 25% college and finally 4.4% attained High School level.

### *4.3. Neural Network Model*

In fitting a neural network model, the number of hidden layers ought to be small, this resulted in to coming up with four candidate models with sizes of hidden layers from 1 to 4. An evaluation was done and the model with smaller size of hidden layer emerged the best. It resulted into forming a 14-1-4 network as the optimal model for predicting levels of happiness. The network has 23 weights of softmax modelling.




```
a 14-1-4 network with 23 weights
options were - softmax modelling
  b->h1  i1->h1  i2->h1  i3->h1  i4->h1  i5->h1  i6->h1  i7->h1  i8->h1  i9->h1
   0.03    0.31   -0.10   -0.18    0.52   -0.47   -0.93   -1.11   -1.29   -1.21
i10->h1 i11->h1 i12->h1 i13->h1 i14->h1
  -1.92   -0.59   -0.23   -0.17   -1.12
 b->o1 h1->o1
 -1.53  -4.19
 b->o2 h1->o2
  0.77   1.68
 b->o3 h1->o3
  2.05   4.41
 b->o4 h1->o4
 -0.70  -2.17
```

***Figure 5.*** *Model.*

### *4.4. Accuracy Metrics*

The levels of happiness are expressed as factors, this makes the problem to be a neural network classifier, and it classifies level of happiness based on 14 inputs. The model accuracy of classifying these levels were measured by use of Confusion matrix of size 4 x 4 matrix. Accuracy for the matrix was evaluated and compared to weighted accuracy, precision for each category was also evaluated from the matrix. Another metric used was the F-Scores both minor and major scores.

To successfully be more sensitive in this study, the happiness categories in the training set were balanced using the Synthetic Minority Oversampling Technique (SMOTE) and Cluster-based Undersampling Technique. The SMOTE method oversamples the minority classes to generate new cases by copying the existing cases of feature space for each target class and its nearest k neighbors. At the same time cases in the majority classes are removed without replacement to balance the classes. The test set remain untouched.

#### *4.4.1. Confusion Matrix Accuracy*

A confusion matrix is a table that is used to show the performance of a classification model on a set of test data, in this problem, the test set was 30% and its true values are known as they are drawn from the happiness set. However it is unknown by the model. If predicted values of this set are close to its true values then the model is good. That good performance is measured using entries of the matrix to calculate sensitivity, specificity, and precision and recall (F-score) of each category of happiness.

For a classical multi-class problem, accuracy is defined as average number of correct predictions. Let consider the test set used on this study, it comprised of N=260 and level of happiness were four, that is, four classes labelled$C = \{1, \dots, 4\}$

$$\text{accuracy} = \frac{1}{N} \sum_{K=1}^{|C|} \sum_{x:g(x)=k} I\left(g(x) = \hat{g}(x)\right) \qquad (15)$$

Where I is the indicator function which returns 1 if classes match and 0 otherwise.

#### *4.4.2. Weighted Accuracy*

A weighted accuracy is more sensitive as it used available information for each class. Hence, weights $w_k$ are assigned to every class such that $\sum_{k=1}^{|C|} w_k = 1$.

$$weighted\ accuracy = \sum_{K=1}^{|C|} w_i \sum_{x:g(x)=k} I\ (g(x) = \hat{g}(x)) \tag{16}$$

To get a rational argument for a certain combination of weights, all classes are set to have equal weight such that $w_k = \frac{1}{|C|}\ \forall k\ \in \{1, \dots, C\}$.

#### *4.4.3. F-Score*

The F-Score is the harmonic average for precision and recall of each class against other classes. It is simply calculating confusion matrix for every class $c_i \in C = \{1, \dots, K\}$ such that the i[th] confusion matrix consider class $c_i$ as positive class and all other classes with i≠j as the negative class. In averaging precision and recall for larger groups we end up having Macro F-score and for the smallest units we have Micro F-score.

***Table 2.*** *Confusion matrix table.*

| | **Confusion Matrix and Statistics** | | | |
|---|---|---|---|---|
| | **Satisfied** | **Neutral** | **Very satisfied** | **Dissatisfied** |
| Satisfied | 121 | 0 | 13 | 0 |
| Neutral | 0 | 21 | 4 | 2 |
| Very satisfied | 0 | 0 | 8 | 1 |
| Dissatisfied | 0 | 0 | 2 | 1 |
| Overall Statistics | | | | |
| Accuracy | 0.8728 | | | |
| 95% CI | (0.8138, 0.9186) | | | |
| No Information Rate: | 0.6994 | | | |
| P-value [ACC > NIR]: | 6.675e-08 | | | |
| Kappa: | 0.7048 | | | |
| Metrics by Class | | | | |
| | Precision | Recall | | |
| Class: Dissatisfied | 0.2500000 | 0.3333333 | | |
| Class: Neutral | 1.0000000 | 0.7777778 | | |
| Class: Satisfied | 1.0000000 | 0.9029851 | | |
| Class: Very Satisfied | 0.2962963 | 0.8888889 | | |

***Table 3.*** *Accuracy Measures.*

| **Measure** | **Value** |
|---|---|
| Accuracy | 0.87 |
| Weighted Accuracy | 0.73 |
| Micro F-Score | 0.93 |
| Macro F-Score | 0.68 |

A weighted accuracy of 73% was achieved. This is considered as the best accuracy as it measures accuracy based on information available for each class and the normal accuracy is exaggerated. Further, accuracy based on scoring was done and it shows that larger classes were well classified as the Micro F-score was 93%. While the Macro F-scoring of 68% for classes that had low precision of 25% is still good enough.

### *4.5. Variable Importance*

Relative variable importance was performed to find out relationship of explanatory variables with happiness. Use of Neural network in prediction of happiness is advantageous due to use of excess weights than what a classical tool could use. However, the interpretation of effects of specific variable is challenging in any neural network. This study used Olden's connection weights algorithm. It calculate the product of the raw input-hidden and hidden-output connection weights between each input neuron and output neuron and sums the products. Olden algorithm preserves the sign and magnitude of importance values [14]. Basically, these importance values are from summed product of model weights and are not rescaled.

$$Input_X = \sum hidden_{XY} \tag{17}$$

From variable importance of the model, physical activeness leads in affecting levels of happiness positively, a youth who is more physically active is happier than one the ones who were less active. The romantic relationship type was the second most influential factor with people who were married being the most happy and single people being the least happy. The satisfaction level of the relationship type, health status and interaction were also on top five list of factors affecting happiness positively.

***Table 4.*** *Order of variable importance.*

| Rank | Variable Name | Overall Importance |
|---|---|---|
| 1 | movement.km | 18.900952 |
| 2 | relationship.type | 12.6943292 |
| 3 | rship.satisfaction | 11.8665366 |
| 4 | health | 11.0497895 |
| 5 | interaction | 10.9551364 |
| 6 | from.friends | 9.1408691 |
| 7 | meals | 5.8202046 |
| 8 | family.members | 4.6042986 |
| 9 | sleeping.hrs | 2.2878882 |
| 10 | income | 1.8015032 |
| 11 | government | 1.6504819 |
| 12 | education | 0.9998223 |
| 13 | gender | -3.0700476 |
| 14 | online.hrs | -5.1581408 |

On the other hand, Number of hours a youth spend on social media a day affected level of happiness negatively, the more the number of hours one spend, the less happy they are. Gender showed a negative relationship with happiness; Males are happier than the female.

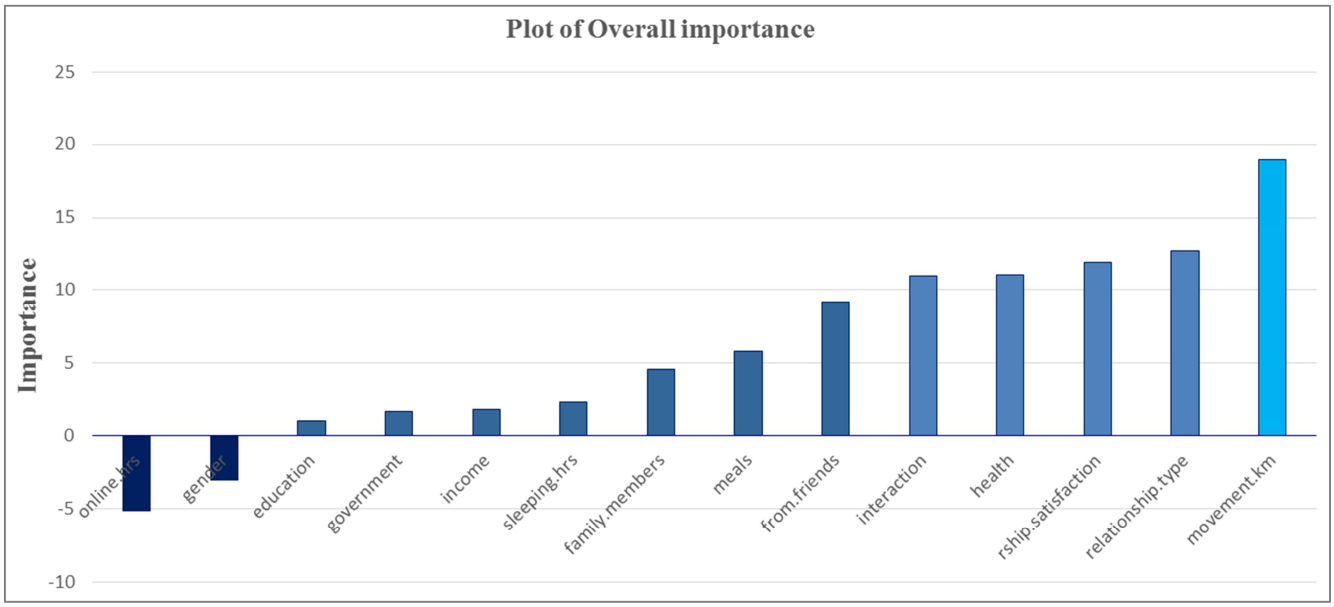



***Figure 6.*** *Plot of Variable importance.*

# 5. Conclusions & Recommendations

## *5.1. Conclusions*

A 14-1-4 neural network model was successfully fitted to classify levels of happiness among Kenyan youths. Multinomial Neural network can be well used to solve multi-classification problems. This project achieved 73% accuracy.

Physical activeness leads in affecting levels of happiness positively, youths who were more physically active were happier than the ones who were less active. Romantic relationship type and satisfaction was the second to positively affect happiness. Health status was the third and physical interaction was the fourth factor to positively affect happiness. Number of hours a youth spend online negatively affects levels of happiness. The relationship of gender to happiness was that males were happier than female youths.

## *5.2. Recommendations*

To increase levels of happiness youths should stay physically active, interact more and spend less hours on social media. A future study on happiness should consider more levels of happiness by using a 10cm graphic rating scale or develop an application to have participants followed up for few days by responding to happiness several times. A hybrid model of neural network and Support Vector machine could be used.

# Appendix: Questionnaire

Dear Respondent,

Hello. My name is Martin Ngari, a student of Masters of Science in Applied Statistics at the Jomo Kenyatta University of Agriculture & Technology (JKUAT). In partial fulfilment of the requirements for the degree, I am required to research an area of my interest. My interest in this study is looking at Happiness among Kenyan youths.

Happiness is a key factor in our lives and it is our responsibility to assess our level of happiness for a better life. I would therefore request you to spare a little of your time to answer this very short questionnaire. The questionnaire has about 16 questions, it takes about five minutes to completely answer it. Please your willingness, patience and honesty in answering questions will be appreciated and I assure you this is confidential. Thank you.

1. What is your gender?

   ⬭ Male ⬭ Female ⬭ Other

2. What is your age? _____

   *(Should be between 18 -35 years)*

3. Want is your current or highest level of education?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Below High School | High School | College | Undergraduate | Graduate School |

4. What is your level of income?

| Scale | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | Below Ksh 20,000 | Ksh 20, 000-ksh 30, 000 | Above Ksh 30,000-ksh40,0000 | Above Ksh 50,000-ksh50,0000 | Above Ksh 50,000-ksh 60,000 | Above Ksh 60,000 |

5. On average how many hours do you spend on social media platforms per day? _____

6. Rate the support you get from immediate family members.

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Very poor | Poor | Acceptable | Good | Very Good |

7. Rate the support you get from friends.

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Very poor | Poor | Acceptable | Good | Very Good |

8. How frequent do you interact with new people physically?

| Scale | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | Never | Very Rarely | Rarely | Occasionally | Frequent | Very Frequent |

9. What is your current type of relationship?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Single | Dating | Engaged | Separated | Married |

10. What is your satisfaction on your relationship above?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Very Dissatisfied | Dissatisfied | Neutral | Satisfied | Very Satisfied |

11. On average how many kilometers do you walk in a day? _____

12. How many meals do you take in a day? _____

13. How many hours do you sleep in a period of 24hours?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Below 2Hrs | Above 2Hrs-4Hrs | Above 4Hrs-6Hrs | Above 6Hrs-8Hrs | Above 8Hrs |

14. How are you satisfied with the top government leadership?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Very Dissatisfied | Dissatisfied | Neutral | Satisfied | Very Satisfied |

15. How do you rate your health well being?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Slightly Good | Moderately Good | Good | Quite Good | Extremely Good |

16. How do you rate your general or overall happiness based on the above aspects?

| Scale | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| | Very Dissatisfied | Dissatisfied | Neutral | Satisfied | Very Satisfied |

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