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RESEARCH ARTICLE

ASSESSMENT OF INCIDENCE AND PREDICTING THE RISK OF DIABETES MELLITUS IN A RURAL VILLAGE OF TAMIL NADU STATE

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ABSTRACT

A cross-sectional door-to-door home survey was conducted in the village of Nelvoy in Vellore District of Tamil Nadu to assess 9 standard factors governing the incidence and prediction of the risk of Diabetes Mellitus in the village. A structured questionnaire was delivered to a sample of 100 people (65 female and 35 male) in a village with a population of about 1700 people. Sociological, physiological and bio-technical (medical) data was collected and analyzed using statistical methods against standard medical classifications of various factors. The Study reports its findings for each of the 9 factors related to prevalence of diabetes in this population. While 14% of the population of the village of Nelvoy lies in the category of Established Cases of diabetes mellitus, another 9% are already in pre-diabetic stage. Almost half (47%) of the village population are either overweight or obese, with females exceeding males in the overweight/obese category and hence are at high risk of diabetes. Young adults are in the most danger of acquiring diabetes in the coming years.

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INTRODUCTION

Diabetes mellitus is a chronic, non-communicable disease which has become a major global health issue in the past decade. There are two basic types of diabetes. Type 1 diabetes is when the pancreas produce insufficient insulin or no insulin at all. Type 2 diabetes is when the pancreas produces enough insulin but the insulin is not being utilized in an effective manner. Diabetes is recognized as one of the largest global health emergencies of the 21st century. (www.idf.org) The prevalence of Diabetes in India is illustrated in Figure 1. In 2010, 50.8 million people suffered from diabetes, in 2016 65.1 million people do. South Asians are more prone to diabetes than anyone else in the world. The reason for this is due to lifestyle changes, genetic predisposition, nutrition intake and physical inactivity⁽¹⁾. Obesity is said to be one the leading risk factors for diabetes. There are 30 million obese people in India and the count is said to double in the next 5 years. (Misra and Shrivastava, 2013) This study is taken up to identify the risk of Type 2 diabetes in the next 10 years and evaluate the number of people at risk of suffering from diabetes due to obesity.

Scope of Research: Diabetes is a disease that effects different groups of people differently as the risks include age, obesity, environmental factors, genetics or family history, diet, physical inactivity, smoking and ethnicity. These risks cannot be uniformly predicted for a large population. McCarty and Zimmet attempted to make projections of diabetes frequency into the future. However, they did not incorporate projected changed in patterns of urbanization directly into their models. Instead they hypothesized that in general, populations would move toward progressively higher prevalence of diabetes in the future. Such a prediction may be far from accurate. Small scale studies must be conducted at rural/urban locations of each state to be able to predict an accurate trend. Therefore, by creating a model for collecting data with minimal resources, gathering data for epidemiological studies can be initiated. These kinds of cross sectional, descriptive phase study can be used for disease surveillance, outbreak investigation, and identifying risk factors.

This can be used in further research investigation and implementation of disease control. With this background, the purpose of this research is to determine the risk of diabetes in the village of Nelvoy in Tamil Nadu State, analyze each risk factor and thereby establish the preferred measures related to physiological and sociological factors that give rise to the highest risk of diabetes.

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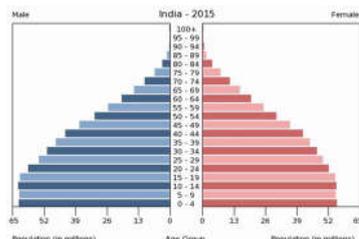
MATERIALS AND METHODS

Risk of Developing Diabetes in the Next 10 Years

The methodology for risk assessment has been developed by Professor Jaakko Tuomilehto, Department of Public Health, University of Helsinki, and Jaana Lindström, MFS, National Public Health Institute (Tuomilehto Jaakko and Lindstrom Jaana). Table 1 sets out the risk ratings against 9 factors as characterized by the Helsinki authorities.

a Quick Test of Blood Glucose Levels that is usually a self-test done at home; and blood pressure in order to confirm the risk of diabetes (a modification to the IFD Questionnaire) and medico-sociological factors like consumption of medicines and family history of diabetes were recorded. Using the questionnaire, the probability of developing Type Two Diabetes within the next 10 years was assessed using Ratings Test designed by Professor Jaakko Tuomilehto, Department of Public Health, University of Helsinki, and Jaana Lindström, MFS, National Public Health Institute as set out in Tables 1 and 2.

Prevalence of Diabetes in India



There are 1.2 billion people in India.

Nearly 50 million suffer from diabetes.

Prevalence is defined as the ratio of number of current cases of disease at a particular point of time to the population at the same particular time (CDC, 2012).

YEAR	Number of People affected by Diabetes	Population of India	Prevalence
2014	50 million	1.2 billion	4.17%
2030	79.4 million	1.46 billion	5.44%

In 2014, the prevalence was 4.17%

In 2025, it is predicted to be 5.44%

Figure 1. Prevalence of Diabetes in India

Table 1. Diabetes Risk Rating Factors

S.No.	Diabetes Factor	Question	Answer	Risk Rating	
1	Age	What is your age?	Under 45 45-54 55-64 Over 64	0 2 3 4	
2	BMI	What is the BMI calculated from weight and height?	< 25 kg/m ² 25-30 kg/m ² >30 kg/m ²	0 1 3	
3	WHR	What is the WHR calculated from circumferences of waist and hip? (Waist circumference is measured below the ribs (usually at the level of the navel))	Male < 94 cm 94-102 cm >102 cm	Female < 80 cm 80-88 cm > 88 cm	Male/Female 0 3 4
4	Physical Activity	Do you usually have daily at least 30 minutes of physical activity at work and/or during leisure time (including normal daily activity)?	Yes No	0 2	
5	Diet	How often do you eat vegetables, fruit or berries?	Every day Not every day	0 1	
6	Medication for BP	Have you ever taken medication for high blood pressure on regular basis?	No Yes	0 2	
8	Blood Glucose	Have you ever been found to have high blood glucose (eg in a health examination, during an illness, during pregnancy)?	0 5	0 3	
9	Family Members with Diabetes	Have any of the members of your immediate family or other relatives been diagnosed with diabetes (Type 1 or Type 2)?	No Yes: grandparent, aunt, uncle or first cousin (but no own parent, brother, sister or child) Yes: parent, brother, sister or own child	0 3 5	

Source: Tuomilehto Jaakko and Lindstrom Jaana, Type 2 Diabetes Risk Assessment Form, Finnish Diabetes Association. Designed by Professor Jaakko Tuomilehto, Department of Public Health, University of Helsinki, and Jaana Lindström, MFS, National Public Health Institute

Data Gathering A questionnaire was developed modeled on the work of the Helsinki authorities as set out in Table 1. The Format used is shown in Appendix “A”. It thus includes calculating risks based on sociological factors such as age and gender; physiological characteristics measured in the form of factors such as Body Mass Index (BMI), Waist Hip Ratio (WHR), and feed-back on their level of physical activity. Measurements included bio-technical (medical) factors such as

The Study was a cross sectional home survey which was started in February 2016 and concluded in April 2016. It was conducted on adults residing in the village of Nelvoy, in the Kaniyambadi Taluk of Vellore District, 14 km south from the city of Vellore. A structured questionnaire prescribed by the International Federation of Diabetes was used to assess the prevalence and risk of diabetes (with a few extra questions relevant to this Survey).

Table 2. Total Diabetes Risk Score

Risk Rating	The Risk of Developing Type 2 Diabetes within 10 Years
<7	Low: estimated 1 in 100 will develop disease
7-11	Slightly elevated: estimated 1 in 25 will develop disease

Sample Size: The structured questionnaire for gathering data was delivered to a sample of 100 people and their physiological characteristics measured in a village with a population of 1700 people. (Ramachandran) The 'questionnaire' format design is shown in Appendix "A". This was based on the risk assessment methodology based on ratings for each factor and total rating as set out in Tables 1 & 2.

Instrumentation The following instruments were utilized to record various questions in the survey.

1. A Glucometer (One Touch Select Simple, One Touch Select test strips, Vital Lancets) to measure blood glucose level
2. Blood pressure machine (Omron Automatic Blood Pressure Monitor HEM-7120) to record high blood pressure.
3. Weighing scale for body mass (weight).
4. A measuring tape (JyotiIND/09/12/309) for height, waist and hip circumference

Important Definitions, Classifications and Standards Used for Analysis of Results

To analyse the results of the Study, the physiological and bio-technical (medical) measurements taken were compared with Standards/Classifications afforded in MedIndia. Net and the Mayo Clinic, USA

- Medical/Health Information Website. MedIndia is stated to be a leading provider of online health information and services to consumers, physicians, healthcare professionals and corporations globally through its websites, applications, and product and service offerings. Independent providers of site analytics have Ranked MedIndia as the top Health website in their Health category in Asia.

Body Mass Index (BMI): It is an index relating weight to height. It is the ratio of a person's weight in kilograms (Kg) divided by his/her height in meters squared (m^2) and shown in Table 3.

Table 3. Body Mass Index Classification

BMI Classification	Value
Underweight	18.5
Normal	18.5-25
Overweight	25-30
Obesity	>30

Table 4. Waist Height Ratio Classification

WHR Classification	FEMALE	MALE
Normal	<0.80	<0.90
Overweight	0.80-0.84	0.90-0.99
Obesity	>0.85	>1.00

Waist Height Ratio (WHR): Ratio of the circumference of the waist to circumference of the hip. This is placed in Table 4.

Blood Glucose Classification: Table 3 brings out the classification of Blood Glucose Levels. Only Post Prandial Values are used for this study that was based entirely on voluntary participation of villagers in the Study and only those who had consumed early morning Tiffin were available and willing to take part in the door-to-door study.

ANALYSIS OF RESULTS

A total of 100 adults were interviewed, of which 35% were males and 65% were females. A test for diabetes using Oneplus Simple Select Glucometer was used to measure Post Prandial values (2 hours post meal) of each adult. The raw data was analyzed using Excel Spread Sheet.

The results from Excel analysis and Charts are shown in Figure 2 and Table 5 it is evident that 14% of the population suffers from diabetes and 7% are pre diabetic.

Diabetes Risk Assessment: The risk of the population was calculated according to the valuations and instructions on the questionnaire at Appendix "A". Figure 2 show that 11% of the sample population is at high risk of developing diabetes in the next 10 years and 8% is at moderate risk.

Age Wise Prevalence of Diabetes: The highest number of diabetics lie in the age group of 55-64 (42.86%) followed by the age group ≥ 65 (35.71%), whereas, the highest number of pre-diabetics are below the age of 45 (57.14%).

Gender-wise Prevalence of Diabetes: Greater percentage of males (64.29%) suffer from diabetes in the village of Nelvoy than females (35.71%) whereas, more number of females are pre-diabetic than males (57.14% as compared to 42.86%). The gender wise distribution of prevalence of diabetes is shown in Figure 3.

Physiological Factors BMI & WHR: Physiological Factors such as BMI and WHR are said to greatly influence the risk of diabetes. These indices determine whether a person is underweight, normal, overweight or obese.

Distribution of Body Mass Index (BMI) in Sample Surveyed: Table 7 sets out the results of measuring body mass and height of the 100 persons surveyed in Nelvoy village

It can be seen that 40% of the male population lie in the Obese/Overweight Category while 53.13% of the female population lie in the Obese/Overweight Category.

Distribution of Weight-to-Hip Ratio (WHR) in Sample Surveyed: Table 8 sets out the results of measuring circumferences of waist and hip of the 100 persons surveyed in Nelvoy village.

It can be seen that 41/100 people are below the age of 45 who are overweight or obese. This shows that the greatest risk to diabetes is to the young adults.

Age affecting the relationship of WHR: Male Population: More than 2/3rds (68.6%) of the male population lie in the overweight/obese category. This trend shows that the population is not following a healthy lifestyle to prevent the future occurrences of the disease.

Table 5. Blood Glucose Level Classification

Blood Sugar Chart Source of Standards: http://www.medindia.net/patients/calculators/blood_sugar_chart.asp			
Category	Fasting Value (mg/dL)	Maximum Value	Post Prandial (mg/dL) Value Two Hours after Consuming Glucose
Normal	70	100	Less than 140
Early Diabetes	101	126	140-200
Established Diabetes	More than 126	-	More than 200

Blood Pressure Classification (Blood Pressure Categories, 2005) Table 6 sets out the blood pressure classifications

Table 5. The Age and Gender-wise Distribution of Demographic Factors that Affect Blood Glucose Level

Demographic Profile	Non-Diabetics (No = 79)		Diabetics (No = 14)		Pre-Diabetics (No = 7)	
	No.	%	No.	%	No.	%
Age Distribution						
<45	50	63.29	2	14.29	4	57.14
45-54	9	11.39	1	7.14	1	14.29
55-64	13	16.46	6	42.86	2	28.57
>=65	7	8.86	5	35.71	0	0
Gender Distribution						
Male	23	29.11	9	64.29	3	42.86
Females	56	70.89	5	35.71	4	57.14

Table 6. Blood Pressure Classification

Blood Pressure Categories Source of Standards: <i>Blood Pressure & Health Standard Mayo Clinic</i> http://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/blood-pressure/art-20050982		
Systolic < 120	Diastolic < 80	Health Category Normal Health
120-139	80-89	Pre-Hypertension Attention to Lifestyle needed
140-159	90-99	Stage 1 Hypertension to Consult Doctor
> 160	> 100	Stage 2 Hypertension Needs Medical Treatment

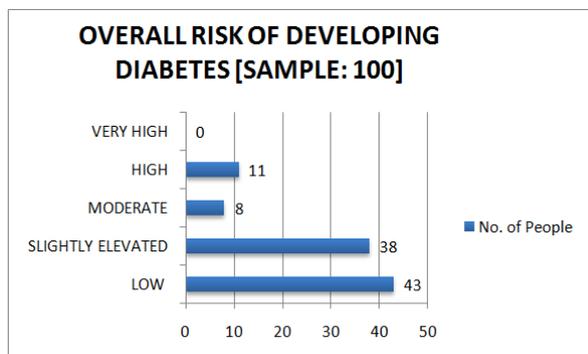


Figure 2. Overall Risk of Developing Type 2 Diabetes in 10 Years in Velmoy Village in Year 2016

Age affecting the relationship of WHR: Female Population: More than 90% of the female population lie in the overweight/obese category. This trend shows that the population is not following a healthy lifestyle to prevent the future occurrences of the disease.

WHR as a function of Glucose: By measuring WHR, 100% of the diabetic population are seen to either overweight or obese and 100% of the pre-diabetic population is also either overweight or obese. It also shows that 77.9% of the normal population is at a high risk of developing diabetes due to being overweight or obese. There was a positive correlation between glucose and WHR meaning that with increasing WHR values, glucose level progressively increases.

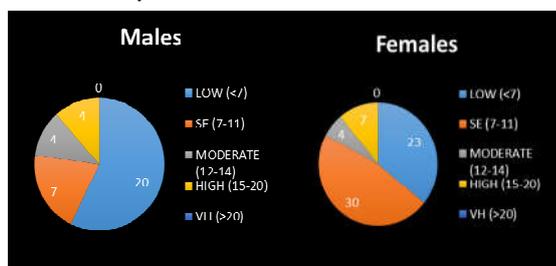
Table 7. Distribution of Body Mass Index (BMI) in Sample Surveyed

Category	Male (35)	Female (65)
Underweight (<18.5)	3	4
Normal (18.5 - 25)	18	26
Overweight (25 - 30)	11	17
Obese (>30)	3	17
Overweight and Obese (%)	40%	53.13%

Table 8. Age-wise Distribution of Weight-to-Hip Ratio (WHR) in Sample Surveyed

WHR	Age			
	< 45 years	45 - 54 years	55 - 64 years	>= 65 years
Normal	15	1	1	0
Overweight	14	6	8	5
Obese	27	4	12	6

Male/Female Assessed Risk



RESULTS:

A total of 11.43% of males and 10.77% of females are at high risk to diabetes. This establishes the fact that males and females have the same risk to diabetes in the village of Nelvoy

Figure 3. Prevalence of Diabetes among Male and Female Population in Nelvoy Village, Tamil Nadu

BMI as a Function of Glucose and Age: A carpet-plot of two variables, BMI and Blood Glucose Levels is shown in Figure

6. Each point on the carpet-plot represents one person's data as reflected and transferred from Excel Spread Sheet. A third variable (age) was included by inspection of running data in the Excel Spread Sheet.

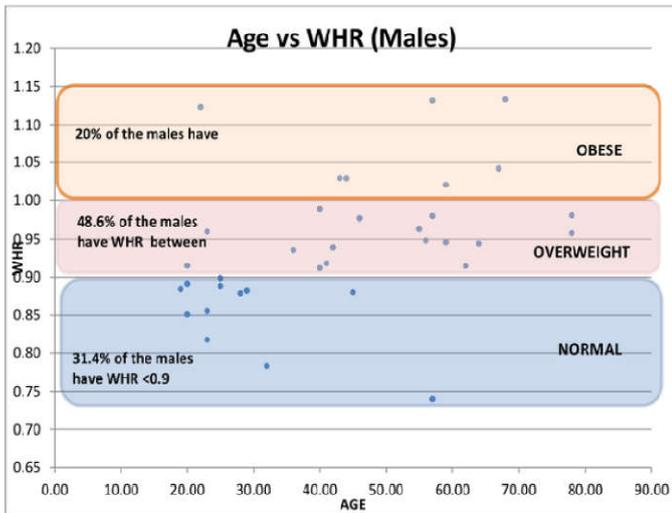


Figure 4. Relationship between Age and WHR in Males (35) of Sample Population of 100

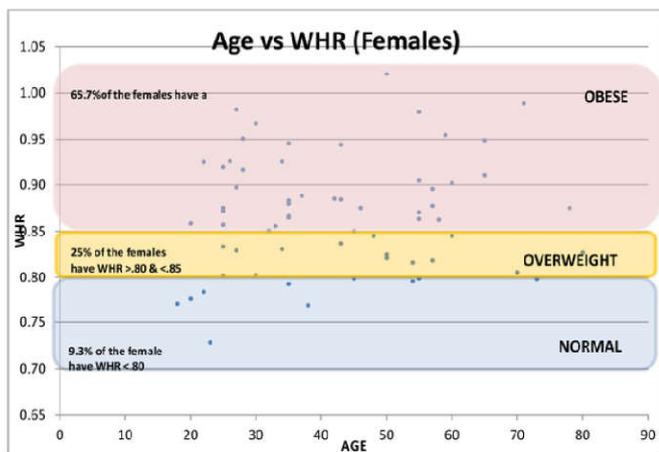


Figure 5. Relationship between Age and WHR in Females (65) of Sample Population of 100

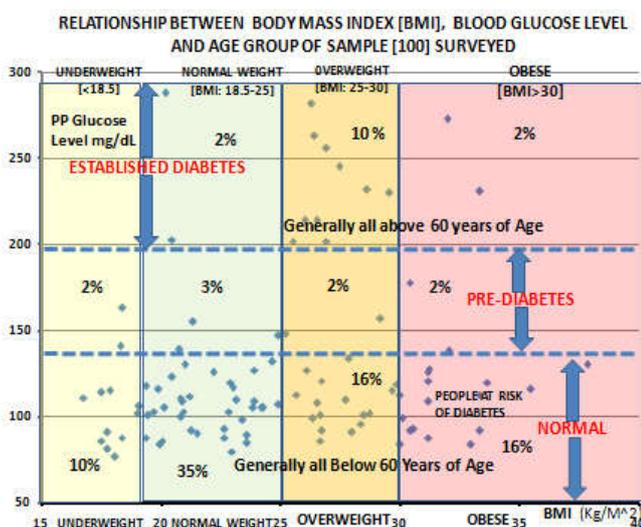


Figure 6. Relationship between Body Mass Index (BMI), Blood Glucose Level and Age Group of Sample (100) Surveyed

Table 9. Comparison of Risk Assessment by WHR and BMI

	Overweight	Obese	Total at risk
WHR	33	49	82
BMI	28	20	48
% Difference	15.10%	59.10%	34%

Table 9. RBC Count of Control Population

Sample	RBC Count
Control 1 (Male)	4.90 x 10 ⁹
Control 2 (Female)	4.03 x 10 ⁹
Diabetic (Female)	5.32 x 10 ⁹

Table 10. Erythrocyte Sedimentation Rate

Sample	ESR
Control 1 (Male)	11
Control 2 (Female)	15
Diabetic (Female)	43

12% of the established diabetic cases are either overweight or obese; 4% of the pre diabetics are the same; and 32% of the normal population is overweight/obese.

Choice between Factors: WHR or BMI? There is a difference of 15% between measure of overweight and 59.1% difference between measures of being obese. *WHR predicts higher prevalence of overweight and obesity in the village of Nelvoy.* This finding is seen in Table 9.

Risk Due to Physical Inactivity: 8 out of the 14 people are physically active in order to control the disease. 6 out of 14 are inactive, which heightens the risk of diabetes.

Risk Due to High Blood Pressure: A correlation between High Blood Pressure and High.

Blood Pressure was attempted using the BP and Blood Sugar classifications as set out in Tables 5 and 6. The analysis was carried out for each of the 4 Blood Pressure categories, age-wise, and the results of this analysis is placed in Table 10 based on Mayo Clinic standard of rating BP as a health standard. Only 19% of the sample population had High Blood Pressure. The Table shows that 7 out of 19 people who have hypertension (high BP) also have hypertension i.e. 37% *hypertensive people have diabetes and hence High Blood Pressure is not the ONLY major contributor to Diabetes and to high risk of Diabetes in Nelvoy Village.*

Risks Due to Family Diabetic History vs. Diabetes:

Analysis of response sheets gives the following results:

- 10 out of 14 people in the sample do not have a risk of family diabetic history.
- People who are non-diabetic without family history: True Negative.
- The people who are diabetic with family history: True Positive
- People who are diabetic without family history: May be True Negative (other risk factors have greater impact)
- People who are non diabetic with family history: May be false negative

Table 10. Correlation between High Blood Pressure and Risk of Diabetes

Blood Pressure Readings Source of Standards: Blood Pressure & Health Standard Mayo Clinic http://www.mayoclinic.org/diseases-conditions/high-blood-pressure/in-depth/blood-pressure/art-20050982			Blood Sugar Readings Source of Standards: Blood Sugar Chart http://www.medindia.net/patients/calculators/bloodsugar_chart.asp			
Systolic	Diastolic	Effect on Health	Number of People	Normal Blood Sugar (70-140)	Early Diabetes (140- 200)	Established Diabetes (> 200)
< 120	< 80	Normal Health	47	43	2	2
120-139	80-89	Pre-Hypertension Attention to Lifestyle needed	34	26	1	7
140-159	90-99	Stage 1 Hypertension Consult Doctor	16	11	2	3
> 160	> 100	Stage 2 Hypertension Need Medical Treatment	3	1	1	1
Total			100	78	100	81

RBC Enumeration: RBC enumeration over a control population and those with likely incidence of diabetes is discussed. Table 9 sets out RBC count of control population. The control population has a normal RBC Count ranging from 4 to 5 x 10⁹. In a diabetic population, the RBC count is higher than in control population. 4.7 to 6.1 million cells/ul (microliter). The normal range in women range from 4.2 to 5.3 million, according to NIH (National Institutes of Health (Reason: Glucose and Sugar easily enters the RBC, therefore, to control the glucose levels in the body, the number of RBC increases dramatically))

Erythrocyte Sedimentation Rate

The control population Erythrocyte Sedimentation rate of 11 and 15 mm/hour.

- Men normal: 0-22 mm/h
- Women normal- 0-22 mm/hcells/ul

The Diabetic Population is more than double the ESR of controls. This could be because the extra glucose in the blood of the diabetes patient is absorbed by RBC and thereby, makes it bulkier

DISCUSSION

Socio-Demographic Factors and Glucose Level This study shows some interesting trends relating to diabetes. From Table 1, it can be concluded that almost half of the diabetic population belongs in the age group of 55-64. On the other hand, looking at the people who are pre-diabetic, about 60% of the people in this group belong in the age group of less than 45 years of age. This shows that young adults are in the most danger of acquiring diabetes in the coming years. The prevalence of diabetes among males was 25.71% whereas in women it was found to be only 7.69% (overall prevalence was 14%). Though it is widely accepted that women are more prone to Diabetes than men⁽¹⁰⁾, there have been studies which may give possible reasons as to why the trend is reversed here. Men are more likely to gain weight and live a sedentary lifestyle⁽¹¹⁾. Assuming this statement to be true, it could explain the above trend.

Risk Assessment Observing the risk assessment of the people in the village, it can be concluded that people who have a BMI greater than 25 are at high risk of diabetes. Therefore it's important for people, especially for young adults (less than 45 years of age), to enhance their physical activity. This will help them keep their BMI in control and substantially reduce their risk of developing diabetes in the coming years. The need for

physical activity is also prompted by the fact that all the people having a high risk score have a waist circumference which is in the high fat range (more than 102 cm for men and more than 88 cm for women). Also notable is the fact that isolated readings of high blood pressure do not necessarily correlate to an increased risk of developing Type 2 Diabetes Mellitus. This can be concluded if we go through the blood pressure readings of people with a high risk score. Most (63.64%) of them have normal or slightly above normal blood pressure

BMI & WHR Almost half of the sample population of the village (47%), have a BMI greater than 25 i.e. they are either overweight or obese. Out of this, 12 people (25.53%) are already diabetic. The remaining is highly predisposed to diabetes due to being overweight. It is also noticed that most of the people who are overweight/obese but have normal blood glucose level are below the age of 60. The probability of these people developing diabetes as they grow older becomes greater. If such a case holds true, then the number of people suffering from diabetes will increase dramatically. Recent studies show that WHR is a better parameter for calculating obesity than BMI. (Noble, 2001) Taking the WHR as a standard, from Figures 3 and 4 it is seen that 68.6% of the males and 93.7% of the females lie in the overweight/obese category. Such a dangerous trend only reconfirms the increased risk of diabetes in this village.

Findings

A summary of findings are reported below based on the Risk Factors prescribed by Professor Jaakko Tuomilehto, Department of Public Health, University of Helsinki, and Jaana Lindström, MFS, National Public Health Institute (Table 1). Prevalence of Diabetes in the sample population of the village Nelvoy is 14% and increasing dramatically. Factor-wise findings of this Study are reported below

1. **By Age:** The highest risk levels were found to be in the age group of 45-64 which fits with the global trend
2. **By Gender:** Men were more prone to diabetes than women. (12% as compared to 10%). Though not a significant difference, this could be because of lifestyle habits, obesity, smoking, environmental Factors.
3. **By BMI:** Predicts that the prevalence of obesity is 48%.
4. **By WHR:** All the members having a moderate-high risk of diabetes had WHR values inclining towards overweight or obesity. Greater than 2/3rds of the male population and nearly 100% of the female population lie in the overweight or obese category. All people suffering from diabetes or prediabetes lie in the overweight/obese category

5. **By Physical Inactivity:** 40% of the diabetic population did not indulge in Physical activity.
6. **By Diet:** Since the majority of the villagers in this rural area consumed farm products viz. vegetables, berries etc this factor was not useful for analysis as a contributor to diabetes
7. **By Blood Pressure:** High Blood Pressure is not the ONLY major contributor to Diabetes and to high risk of Diabetes. 19% were having hypertension and almost all were on medications.
8. **Family History of Diabetes:** Only 28.5% of the diabetic population has a family history of diabetes, the rest of the population may be a True Negative result, in which case the individual did not have the correct data of his family history. It could also mean that other risk factors affected the reason of diabetes.
9. **Awareness of Diabetes** We did not ask responders about their having diabetes so as not to alarm the village as a whole. Hence we are unable to say whether those who had diabetes knew about it

Conclusion

While 14% of the population of the village of Nelvoy lies in the category of Established Cases of diabetes mellitus, another 9% are already in pre-diabetic stage. Almost half (47%) of the village population are either overweight or obese, with females exceeding males in the overweight/obese category and hence are at high risk of diabetes. Young adults are in the most danger of acquiring diabetes in the coming years. It is not known whether Village and District authorities are aware of this trend in Velmoy village and the need to organize widespread campaigns to create greater awareness of the prevailing high risks of diabetes and measures needed to be taken at individual and collective levels to reduce the risk of greater spread of diabetes in the village

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