

# B.Tech Project Report

On

## DIABETES AND NANOTECHNOLOGY

Submitted in Partial Fulfillment for the B.Tech Third Year Core Course on  
Human Geography and Societal Needs (HS202)

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## **Certificate**

This is to certify that the B. Tech project titled “Diabetes and Nanotechnology” prepared by (Harshvardhan Shewakramani, Satya Mishra, Gokul T M, Bobby Kuhikar, Rishabh Jain) is approved for submission for the course on Human Geography and Societal Needs in the Department of Humanities and Social Sciences, Indian Institute of Technology, Ropar.

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## **Declaration**

I hereby declare that the report entitled “**Diabetes and Nanotechnology**” submitted by our team, for the partial fulfillment of the course on Human Geography and Societal Needs (HS 202) in the third year of the B. Tech programme in IIT, Ropar. The work carried out by us under the supervision of Dr. Devaraj. P, Assistant Professor, Department of Humanities and Social Sciences. We further declare that this written submission represents our ideas and other’s ideas or words have been included. We also have adequately cited and referenced the original sources in the case of other’s ideas or words. We have not misrepresented any idea/data/fact/source to the best of our knowledge. Therefore, we affirm that our group has adhered to all principles of academic honesty and integrity .

**Place: Ropar**

**Date: 06-12-2001**

### **Signature of the Candidates**

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### List of Abbreviation

Abbreviation	Stands for
ML Models	Machine Learning Models
AIIDR	All India Institute for Diabetes & Research
DIYA	DIABETES INDIA YOUTH IN ACTION-NGO
NGO	Non-Government Organization
PBA	phenylboronic acid
AuNC	Gold nanoclusters
AuNP	Gold nanoparticles

### Introduction and Objectives:-

#### Introduction:-

Diabetes is a chronic disease that occurs when the pancreas is no longer able to make insulin, or when the body cannot make good use of the insulin it produces. There are three main types of diabetes – Type 1, Type 2 and Gestational.

Diabetes is one of the fastest growing health challenges of the 21st century, with the number of adults living with diabetes having more than tripled over the past 20 years. Among the three types of Diabetes, Type 1 diabetes is the most dangerous as Type 1 diabetes can develop at any age and occurs most frequently in children and adolescents. Over 100,000 children in India are living with Type 1 diabetes. India is listed among the top 10 countries for the number of people under 20 years old with Type 1 diabetes.

Type I diabetes is a chronic condition which is also known as insulin-dependent diabetes. In this condition the body produces little or no insulin. The major problem related to Type 1 diabetes is that people with type 1 diabetes must take insulin daily. If they are left untreated, the excess sugar in the blood can cause severe damage to the body and even be fatal. Type 1 diabetics suffer from conditions (potentially fatal) caused by issues in the management of the disease -- ketoacidosis caused by a lack of insulin in the body and diabetic coma caused by critically low blood sugar. The

mismanagement occurs due to the lack of information on how much accurate amount of insulin is needed at the right time to deal with a person's blood sugar levels or to adjust the insulin level to hit a particular blood sugar level. These conditions reflect the day-to-day challenge that people with type 1 diabetes continue to face: getting the right amount of insulin delivered at the right time to deal with their blood sugar levels.

### **Objectives:-**

- To understand the challenges currently faced by diabetes (Type I) patients and also about the complications of diabetes (Type I). These are some of the questions that we will try to answer.
  - What are the major problems faced by the patients?
  - Can diabetes be predicted at an early stage to pave a path for better treatments?
  - How can the efficiency of the diabetes management system be increased?
  - How can the techniques of glucose detection and insulin administration be optimized?
- To explore the field of nanotechnology in medicine, learn about gold nanoparticles, machine learning and to find an optimal solution for detection and treatment of diabetes (Type I).
- To help people overcome the challenges and create a positive impact on society.

### **Theoretical and Conceptual Aspects of the Problem Selected:-**

#### **Social Aspects:-**

Although awareness of diabetes is increasing in India but still, diabetic people face discrimination and are unfairly treated in our society. In some cases patients try to hide being diabetic owing to the fear of judgment which not only worsens their health but also has a negative impact on their psychological well-being. Some of the social challenges faced by diabetic people are listed below:

- **Social Stigma:**

People diagnosed with type I diabetes often get teased, bullied, abused due to stigma associated with disabilities. This occurs in several parts of India as people tend to associate it with religious beliefs, individual's fault, parents' upbringing and several other baseless reasons. Moreover diabetic people have to face a lot of prejudice about diabetes. These factors eventually lead to depression and the onset of other psychological disorders.



### ■ **Hampered Social Life:**

Diabetic people restrict themselves from getting involved in parties, gatherings, recreational activities due to the fear of being judged and also due to feelings of self blame, guilt and embarrassment. They generally avoid social gatherings and live isolated lives to avoid being treated as abnormal.

### ■ **Employment Complications**

Health-related work limitations in the workplace and absenteeism contributes to work loss and decreased productivity thereby leading to reduced employment opportunities. Furthermore, additional arrangements are required at the workplace due to frequent monitoring of glucose levels and insulin administration, this eventually results in reduced work opportunities.

### **Economic Aspects:-**

Diabetes affects a person's lifestyle and mentality adding these are the economic disparity. Some of these aspects of diabetes are:

- Employment: Diabetic People often find it difficult to find jobs due to Social Stigma and more importantly due to productivity loss often associated with diabetic people
- Education: Data on literacy rate shows that the literacy rate of diabetic people is lower compared to healthy society. This may be due to Higher chances of depression among these people which may adversely affect these people.

### **Psychological Aspects:-**

People suffering from diabetes may have several other health complications. These complications may be present in a healthy person but the probability of occurring in a diabetic person is much higher.

#### **Depression, Anxiety:**

- These complications are far more dangerous than diabetes itself. Major reason for the onset of such health complications is the social stigma. These conditions creep in much easily due to negative feelings of exclusion, self blame, rejection.
- Existing treatment methods of Insulin injection, tablets are not very efficient in the view that the patients who take these treatments sometimes feel the pressure to carry insulin vials with them wherever they go, continuously monitor glucose levels, calculate the exact time for ingestion of medicines and take medicines in fixed amounts which may or may not be the body's requirement.

## Conceptual Aspects:-

- **ML Model:** ML Models being stage 1 of our project consists of Training a dataset containing Diabetes classification Information. As a Model is Trained on a dataset, the computer is actually carrying out regression analysis without explicit coding to represent the data. When the training is completed the model will have a set of parameters learned from training that will help analyze any similar but new data to obtain any conclusions. There are different types of ML Model with different ways of analyzing/perspective of analysis and thereby create a unique set of parameters for representing the data. One of the Most common ML models is **Supervised Learning** which is significant for the learning expected to achieve in this project. Here the model performs regression of training data and uses the obtained parameters to predict the results of test data.
- **Nanoparticles:** Nanoparticles are small particles in size ranging from 1nm to 100 nm. These particles possess excellent optical, electronic and catalytic properties which give a broad range of applications. The most important factor in our project is the efficient drug delivery and real time imaging of Gold nanoparticles along with high targeting. High Targeting is one of the most important features for its usage in cancer treatment as it selectively attaches to the Tumor Particles. Gold Nanoparticles allow real time imaging with the data being transmitted by **Fluorescence**. Fluorescence is the emission of Electromagnetic waves by the excitation of particles inside the most inner electron orbitals. The Toxicity and coalescence of gold nanoparticles are within limits and the efficiency of Nanoparticles have a relation with the size. Nanoparticles with size around 200 nm have the maximum efficiency.

## Methodology:-

### Mode of Inquiry:

Our study uses both quantitative and qualitative methods of data collection and hence we use mixed methods for analysis of data which will eventually help in understanding the depth of the problem as well as help in coming up with efficient solutions.

- Quantitative method - used for diagnosis and prediction of diabetes.

Through extensive review of clinical observations, research reports and datasets from National Institute of Diabetes and Digestive and Kidney Diseases, we collected in depth information of the factors and variables that are useful for early prediction of diabetes. This is based on diagnostic measures and will eventually aid the prognosis stage. The collected data is exhaustive enough for general diagnosis and prediction of diabetes in india. Hence quantitative analysis is used.

- Qualitative method - used for nanotechnology advancements, gold nanoparticles and Type I Diabetes.
  - Nanotechnology and gold nanoparticles in Diabetes -  
Nanotechnology In Diabetes Treatment is part of research on Nanotechnology in Therapeutics. The research is under clinical trials and is performed only on Mice. Even though the body mechanism of mice is similar to human functions, data of nanoparticles in diabetes treatment in humans is still not available. Hence, we analyzed a lot of clinical observation reports and review reports which in turn helped us gather information.
  - Diabetes Type I -  
We carried out collaborative interviews with several experts and professionals of various domains. These included doctors, researchers, PhD students, and the President of **DIABETES INDIA YOUTH IN ACTION** (a NGO). For portraying personal viewpoints and experience of each of the respondents, qualitative analysis was employed here.

### **Application of Research:**

Type I diabetes belongs to a group of metabolic diseases characterized by hyperglycemia (high blood glucose), and can be lethal if not properly controlled. Prolonged exposure, without proper management, may lead to several vascular complications and represents the main cause of mortality and morbidity in diabetic patients.

Presently, our main focus for diabetes management is to optimize the available diagnostic and treatment techniques to ensure adequate blood sugar level, insulin, and glucose level in the blood, thereby minimizing diabetes complications.

Since the research outcomes of the gold nanoparticles will help solve the real-life problem and eventually help achieve the goal of creating a better solution; hence the study can be considered as Applied Research and experimental in nature.

### **Research Design:**

In order to find the type of research design, we shall divide the study into three broad categories and analyze them respectively.

- Context
  - Our research focuses on the domains of Type I Diabetes and nanotechnology wherein, we try to understand about Type I Diabetes, its symptoms, about the risk factors that may lead to diabetes in future (Age, gender, Polyuria,

- Polydipsia, sudden weight loss, weakness, visual blurring loss, muscle stiffness, obesity, Blood Pressure, Skin Thickness, irritability, paresis, itching, alopecia) and also
- about problems faced by patients in terms of convenience, glucose level monitoring & insulin administration (errors may be fatal in worst situations).
  - Purpose-
    - To select relevant major risk factors & variables (gender, Polyuria, Polydipsia, visual blurring loss, muscle stiffness, obesity, irritability, paresis, itching, alopecia) and employ ML algorithm (Random Forest) in order to predict diabetes at an early stage thereby aiding the prognosis.
    - To optimize the treatment techniques by utilizing gold nanoparticle-based glucose sensors that can facilitate frequent monitoring of blood glucose levels and insulin administration by taking into consideration the correlation between two major relevant variables (insulin and glucose levels).
  - Research and Data Sources-
    - Clinical Observations
    - Extensive literature review of past studies in all three domains
    - Collaborative Interviews.
    - Personal experiences via interviews.

Thus, on the basis of above stated categories, we conclude that the study belongs to Diagnostic Research Design.

### **Selection of field Site:**

The geographical sampling unit we considered for data collection was Delhi- the capital of India. Major reason being the alarming healthcare condition.

As per the data analysis by diagnostic chain Metropolis Healthcare, out of the total of 1,37,280 samples tested for Diabetes from January 2019 to August 2020 in their Delhi lab, a whopping 18 percent were found to be suffering from poorly controlled diabetes. Therefore we tried contacting respondents mainly from Delhi and the nearby regions.

This included -

- Research Institute  
(Indian Institute of Technology Ropar) - For understanding current advancements and trends in the field of nanotechnology and gold nanoparticles.
- Healthcare Labs  
(Metropolis Healthcare) - for identifying the condition of diabetes in the field site selected.

- All India Institute for Diabetes & Research (AIIDR) - For gathering relevant data and understanding about the prevalence and condition of diabetes Type I in India
- NGO (DIABETES INDIA YOUTH IN ACTION) - a NGO that aims to de-stigmatize and raise awareness about Diabetes, offers education and provides recreation, empowers the diabetics to understand and take control of diagnosis. Our aim of contacting them was to understand about Type I diabetes in depth, to know about the problems, complications, treatments and diagnosis methods in Delhi.

Hence, we took into consideration a finite universe of study.

### **Selection of Respondents:**

#### **Sampling type:-**

We have chosen respondents subjectively and not randomly because of the need of our research, hence we followed non-probability sampling techniques as we included experience, and the perspective of experts. We followed Purposive cum Snowball sampling.

#### **Respondents:-**

- Diabetes Patient
  - Researchers (medical field and nanotechnology)
  - PhD students
  - Doctors
- **Researchers( nanotechnology field), Diabetic Patient and Doctors:**  
For Researchers, Doctors and Diabetic Patients we will follow non-probability sampling techniques as in this we will include experience, the perspective of Experts of these domains.

We have followed purposive cum Snowball sampling as initially, as these respondents will be only appropriate people to give us the required information we will have 1-2 respondents, and later these respondents have helped pick us more samples with their referrals .

## **Methods of Data Collection:-**

### **Primary Data collection:**

For **Researchers, Doctors ,and diabetes patient** focus groups we have scheduled one on one interactions in online mode using video conferencing software like Zoom, Google Meet, etc.: and for collecting their data we will employ non probability sampling for collecting their data. We have taken their in depth interviews for analyzing the problems and its cure from every angle.

### **Secondary Data Collection**

- **Research Publications of Clinical trials:**

There are many research papers by nanotechnologists and researchers that are available online which tells us about nanotechnology that is being used in treatment of this disease.

- **Healthcare organizations and Websites :**

Data regarding diabetes and its prevalence across the globe is given on the Healthcare organization website. We can get data from the databases of this organization which they share on their website .Using these datasets we can do a lot of experiments and studies on these datasets for our understanding. Also we will easily get a lot of data and statistics available on government healthcare websites.

## **Analysis of Data Collected:-**

### **Quantitative data Analysis:**

For analysis we prepared the data that we have collected from ,electronic health records, hospital databases will be analyzed using **Exploratory data analysis**(i.e finding various correlation and visualization from our dataset). For early stage prediction of diabetes we trained various algorithms like Decision tree, Naive bayes and Random forest algorithm and on comparing them the **Random forest algorithm** proved to be the best model on training .

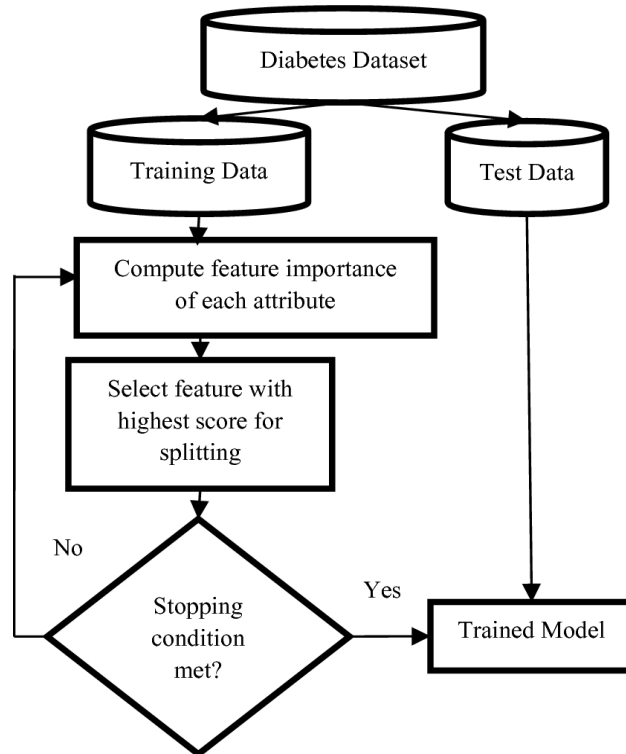


Fig.: 1

### Qualitative data analysis:

For qualitative data that we have collected from nanotechnologists, researchers from the medical field and data from research reports, we have collected perspectives and findings of various researchers in gold nanoparticles. A brief analysis of data collected is given below:

- On discussing with nanotechnologists we find that we need to use gold nanoparticles in clusters. Using gold nanoparticles clusters will increase the drug loading capacity.
- In a discussion with a diabetes patient we came to know about the problems of diabetes patients like where they face problems with current technology used and also came to know about the social stigma they need to go through.
- With the interviews of medical researchers we came to know about the prevalence and some of more symptoms in diabetes. This feedback has helped us in creating a dataset for early stage prediction of diabetes.
- On discussing with nano researchers we also came to know about some more properties of gold nanoparticles problems which we might come across while implementing our ideas.

We will discuss more of our findings from data collected in further sections

## Findings:-

### Data Collected and Inferences

#### Primary Data:-

As mentioned above, our group conducted collaborative interviews with eminent professionals working in the medical field, researchers, PhD students and doctors. Some of the important discussions and excerpts are listed below:

- Interview with Mr. Bhavesh-  
(Associate, Smt NHML Medical College)
  1. What are some symptoms of Type I Diabetes?  
Ans - Type I Diabetes is the condition that arises when the body does not produce insulin by itself and some common symptoms are excessive thirst, more urination, mood swings like irritability, and sometimes patients do experience tiredness.
  2. What are some of the major factors that are responsible for onset of Diabetes?  
Ans - There are several factors that are responsible like diet, type of lifestyle, genetics and in some cases hereditary background also. There have been quite interesting studies about Type I Diabetes. One of the most fascinating ones that I know was that the people who live in countries that are far from the equator region tend to have greater chances of developing Diabetes.
  3. Could you elaborate on the current methods of measuring glucose levels?  
Ans - Most common techniques that patients generally use these days are Home Glucose Monitoring Kits and laboratory blood tests. Home tests are quite convenient but not very accurate.
  4. How is insulin administration done in Type I Diabetes patients? Do these methods have shortcomings?  
Ans - Insulin is generally injected under the patient's skin but the frequency of injections is quite high as the patient might have to take 5-6 injections in a day for the rest of their life. This causes a lot of inconvenience to the patients. Insulin pumps are used in some cases as well but still are not very accurate as there is time lag between insulin administration and glucose monitoring.
  5. Are you aware of the current advancements in treatment of Type - I diabetes and the usage of nanoparticles in treatment of the same?  
Ans - There are clinical trials going on for artificial pancreas and regarding nanoparticles, they seem a promising option too and I believe that



nanoparticles can bring a revolution in the treatment of several diseases not only Diabetes.

- Interview with Prof. Atharva Poundarik-  
(Joint faculty in the Department of Metallurgical and Materials Engineering and Biomedical Engineering, IIT Ropar)
  1. Which are some of the properties that gold exhibits which makes it such an important nanoparticle?  
Ans - Gold has less system toxicity, gold nanoparticles have good conjugation with other materials and good biocompatibility hence it is widely used in the medical domain.
  2. We are planning to make use of ML algorithms and models in early prediction of diabetes. What are your views on the integration of Machine Learning in our project and areas of improvement?  
Ans - It seems a very good idea to me to incorporate new technological advancements in order to predict Diabetes. You may use different models as precision would be a key variable that needs to be considered
  3. What are some of the methods of administration of nanoparticles inside the body?  
Ans - There are multiple methods like intranasal, intramucosal, oral in the form of tablets, subcutaneous injections and skin patches. Amongst these routes, the most suitable one depends on several factors like the type of nanoparticles, treatment.
  4. Any advice or suggestions that you would like to give us?  
Ans - Overall, your group has done impressive research and it's an interesting domain to work upon. In future try to work more onto it as the domains of nanotechnology are quite vast and interesting.
  
- Interview with Miss. Sagarika-  
(PhD Student, IIT Ropar)
  1. What is so fascinating about nanotechnology and nanomaterials?  
Ans - It actually has the potential to improve a lot of current applications across several sectors.
  2. Could you list some of the major problems that the use of nanoparticles in the medical industry possesses?  
Ans - Some of the nanoparticles tend to coagulate after a certain period. This accumulation could become cancerous over time hence elemental nanoparticles (eg - gold) are used as the chances of coagulation are relatively less. Biocompatibility is also an issue as an external particle is being sent inside the body.

3. Is there any major factor that needs to be considered while utilizing gold nanoparticles for treatment of diseases?

Ans - Yes, one should make sure that gold nanoparticles should be freshly made and freshly used as precision is quite important and some properties may be otherwise.

- Interview with Mr. Jai-  
(PhD Student, IIT Ropar)

1. Which properties of gold nanoparticles can be explored for detecting glucose levels?

Ans - Fluorescence and magnetic properties should be explored as gold nanoparticles can be used in sensing and detection using X Rays and MRI (Magnetic Resonance Imaging) scans.

- Interview with Mr. Harsh Kohli-  
(President of DIABETES INDIA YOUTH IN ACTION)

1. How long have you been living with this disorder?

Ans - 29 years, I was 11 years old when I was diagnosed with diabetes and now I am 40 years old.

2. What are the problems you faced in initial days of this disease and how it affected your daily life?

Ans - Social stigma. It's one of the worst things that we need to fight like in workplaces. If I am not feeling well because of the sugar level going down, I am still answerable to the boss for taking a break. Moreover, marriage issues, dating issues, people don't date us due to social stigma and misconceptions like it can spread to other people.

Social stigma impacts kids at a younger age and mainly parents get impacted due to this and in India mostly mothers get affected because they majorly take care of children.

3. Do you experience some mental problems due to this disease like depression, hypertension and stress?

Ans - No, I do not experience any mental problems but yes it's true that diabetes patients are more prone to going into depression. Also, it's about how effectively patients are able to manage their conditions. So it depends on person to person or family to family that he/she takes it in a positive manner or not.

4. What type of symptoms people generally have while they are diagnosed with this disease? (severe,mild,light)

Ans - polydipsia - very thirsty  
polyphagia - very hungry

Polyurea - urine too often.

Loss of weight.

In kids, parents get to know about the symptoms of diabetes by when kids urinate as ants gather around their urine.

5. How do you look forward to effectively managing the intake of carbohydrate, number of insulin that you take in a day?

Ans- For an outsider it might sound like a huge huge task but it is part of our existence and if you research a little bit more we (people living with type I diabetes) need to make 180 extra decisions everyday as compared to a normal person and this is according to a research. These decisions include checking glucose level, counting the carbs which seems difficult initially but people get used to it. But initially it's indeed a struggle.

## Overall Inferences

- Interview with Doctor - Inferences
  - Insulin administration in most of the cases is done through injections which causes a lot of pain and discomfort hence it is necessary to come up with a solution that minimizes the discomfort and is convenient to use.
  - Type - I diabetic patients have to take 2-3 injections every day therefore a long acting solution needs to be proposed in order to minimize the frequency of injections.
  - Insulin administration often witnesses a time lag as the glucose levels continuously change. It is a matter of concern for Type - I diabetic patients as they may suffer owing to this. The problem of time difference between glucose level and insulin administered should be minimized by proposing an effective solution.
- Interview with Expert - Inferences
  - Models for early prediction of diabetes should be reliable and hence the algorithm and model that we propose must have high accuracy values.
  - Several major factors responsible for Diabetes Type I must be considered while developing the model so that solution becomes more reliable and effective.
- Interview with PhD - Inferences
  - According to them, the solution should be such that detection and monitoring of glucose levels can be done effectively to overcome the problem of inaccurate glucose monitoring.
  - Biocompatibility of the solution should be high to prevent the body from attacking the treatment going on which might have severe consequences on the patient's body.

- The solution should be highly consistent and must not vary from one dose to another.
- Interview with President - Inferences
  - Type I Diabetes is not a disease it's a disorder
  - People live with it and not suffer, is it quite analogous to wearing glasses.
  - According to him, Type I Diabetes classical symptoms are polydipsia, polyphagia, Polyurea and we have used these for early Diabetes prediction.
  - Continuous glucose monitoring is still a major question that needs to be solved and our project tries to provide a solution to this problem.

### Secondary Data and Inferences:-

In addition to the interviews, our group carried out extensive literature review of the past studies and clinical observation reports in the domain of Diabetes Type I to get a better understanding of problems and complications that arise due to Type I Diabetes.

1. Prevalence of type 1 and type 2 diabetes among various age groups , race and region has been shown via this graph . This report was published in the National Diabetes Statistics report .

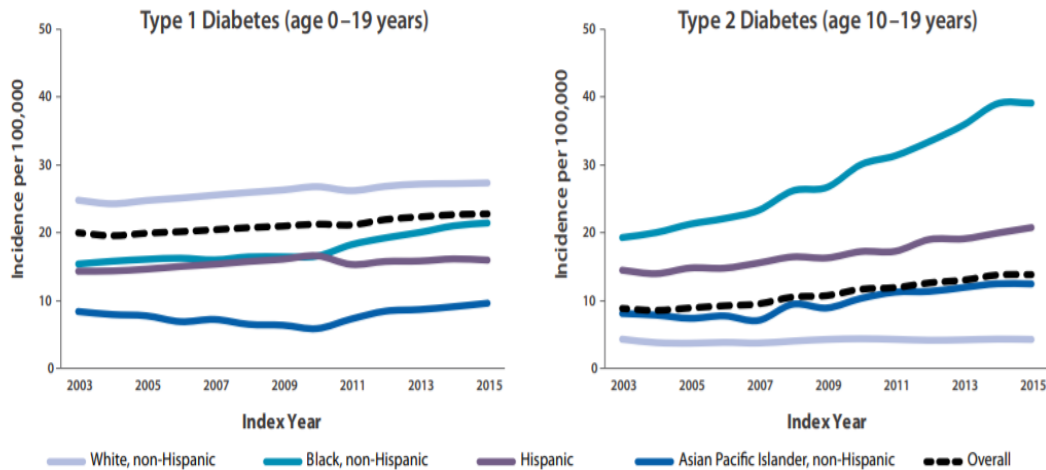


Fig.: 2

2. From the national diabetes statistic report we can see that how from 1999-2016, the age-adjusted prevalence of total diabetes significantly increased among adults

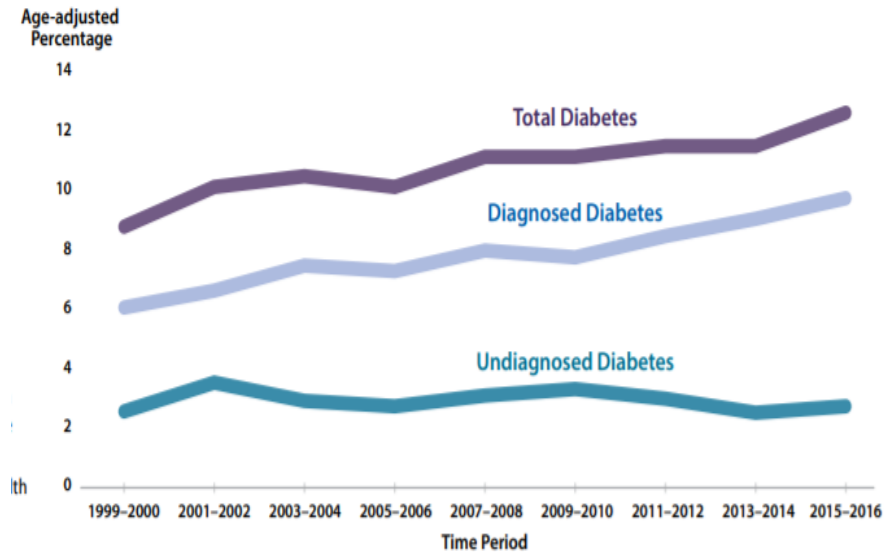


Fig.: 3

- An article published by liebertpub shows that around 60 percent of patients suffering from type 1 diabetes are not satisfied with current technology and diabetes management systems as the whole process is very tiresome for them.
- From the dataset of National Institute of Diabetes and Digestive and Kidney Diseases, polyuria, polydipsia, Abnormal thirst and dry mouth, Sudden weight loss are seen to be the leading symptoms among patients in type 1 diabetes.
- We find some of the treatment of Type 1 diabetes which exists presently and how insulin affects and factors that are taken into consideration to calculate insulin dose .

### Treatment for type 1 diabetes includes:

- Carbohydrate, fat and protein counting
- Frequent blood sugar monitoring
- Eating healthy foods
- Exercising regularly and maintaining a healthy weight
- Taking insulin.

### TREATMENT OF TYPE 1 DIABETES



Fig.: 4

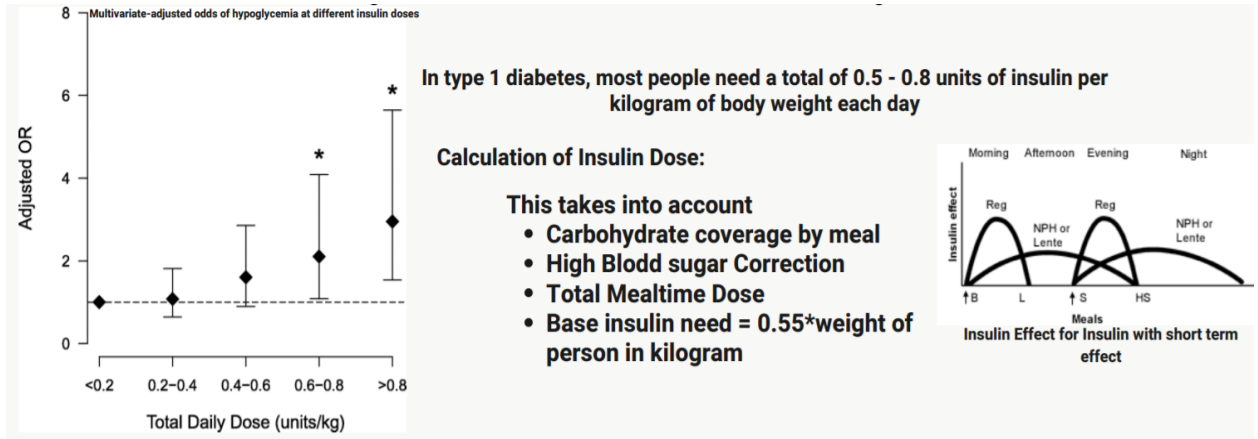


Fig.: 5

6. Scientists at Stanford University in the United States have used nanotechnology to devise a highly specific method of killing cancerous cells. They inserted carbon nanotubes into cancer cells and then exposed the tissue to near infrared laser light, heating up the nanotubes and killing the cancer cells while leaving the healthy cells intact. This works as evidence that we are working in the right direction and gold nanoparticles can revolutionize the treatment of diabetes in future.

## Discussion:-



Fig.: 6

### ASK:

This part of the project relates to the data collection part wherein we conducted several interviews and gathered in depth information about the current scenario and problems of Diabetic people in India. Moreover, additional sources of information were used (Research articles, reports, observation reports). We also contacted a NGO in Delhi which was selected to be the field site, to find the social and economic aspect of the problems faced by Type I Diabetic people.

### IMAGINE:

Through the analysis of data that was collected, we understood how serious the problems related to Type I Diabetes are, hence we imagined to formulate an idea which would decrease the problems with current treatment methods for diabetes and optimize the diabetes management system. The Treatment methods were one of the most important factors in social stigma, thus the solution should be more effective while keeping it more convenient to use.

### PLAN:

At this stage the major objective was to put the imagined ideas to action. The plan was to utilize the Machine Learning algorithms and models for early prediction of Diabetes and the second was using gold nanoparticles for detection of glucose levels and delivery of insulin in the body. The preliminary stage of this plan was to use the Machine Learning Models to predict diabetics. This Stage confirms diabetes in people and will be taken to the next stage where gold nanoparticles were implemented for delivery of

insulin inside the body. The nanoparticles were also made to provide real-time analysis of glucose levels.

### **CREATE:**

We looked into Machine Learning models and several model functioning parameters, variables, factors and dataset to increase the accuracy of the early prediction of diabetes.

For the treatments part, we researched about the different components of the glucose sensor, drug delivery system, detection system, chemical compositions, and chemical reactions that occur. Next, we contacted a few PhD researchers, Professor in IIT Ropar with interest in nanomaterials to explore the possible difficulties and improvements in the predicted nanoparticle treatment. We also contacted a doctor to increase our understanding in the field of Diabetes.

### **IMPROVE:**

With the data collected from researchers and professors on the initial treatment method, the following improvements were suggested. These are:

- Use of non enzymatic glucose sensors: as enzymatic glucose sensors can have considerable batch-to-batch variability in activity and it also requires a constant oxygen level, pH and temperature, as well as frequent recalibration for a reliable readout. To overcome inconsistent enzyme activity we switched to non-enzymatic glucose sensors which had added advantages of improved precision.
- Nanoclusters: These are essentially the clusters of gold nanoparticles with an added advantage of high drug loading capacity thereby providing longer acting formulations. These could improve both the processes of detection of glucose as well as the administration of insulin in the body.



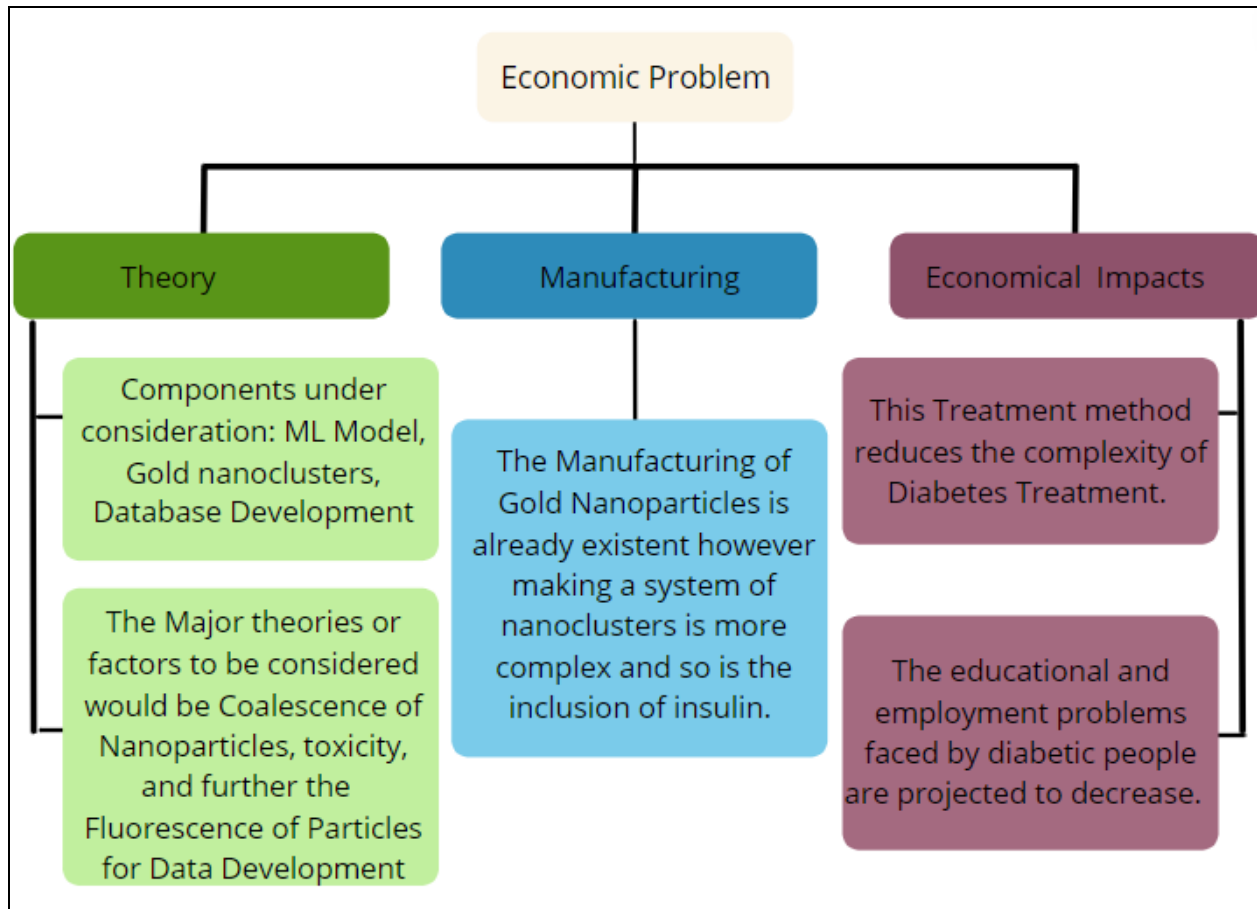


Fig.: 7 Engineering Problem Components

### Engineering Knowledge:

Our project can be divided into two stages-

- Early Prediction of Diabetes
- Gold Nanoparticle Implementation.

#### Early Prediction Of diabetes:-

Here we employed machine learning models to predict the possibility of a person suffering from diabetes. This was done by using ML Models on a diabetes Dataset.

The Broad Objectives of this stage of the project is:

- Dataset Analysis: The Dataset for ML Model Prediction was selected as the dataset compiled by National Institute of Diabetes and Kidney Diseases. The Dataset was very broad ranged allowing generalization to be made from the dataset. The dataset features were then explored.
- Machine Learning: Machine learning Models allow prediction of possibility of diabetes for a person with unseen Medical Situations/Features by proper training.

Training in Machine Learning Model consists of taking into consideration a dataset with Features (Medical Conditions) and modeling it to predict the results by the use of Statistics and Probability.

Different Machine Learning models were also compared (which work on different separation criteria) to explore the different options and conclude with the most optimum Model.

### **Gold Nanoparticle Implementation:**

Gold Nanoclusters are collections of gold nanoparticles clusters that allow efficient drug delivery of insulin and detection techniques. The Gold Nanoparticles exact size depends on the attached molecule size and function. The Gold Nanoparticles can attach themselves to other structures like Insulin. The gold nanoparticle has low toxicity and can be easily removed from the body, thus different from the gold in its natural state.

Gold nanoparticles when bonded to glucose-binding protein also can be used as glucose sensors which allow real time monitoring.

The High targeting ability of Gold nanoparticles has made it an efficient drug delivery option hence can be used for insulin administration.

### **Engineering Design and Prototype:**

The two stages of our project are as follows:-

- Early Prediction of Diabetes
- Gold Nanoparticle Implementation.

By analyzing the problem and exploring the possible ways of implementing our solution we present the following final plan.

- Early Prediction of Diabetes:-

The Early Prediction of Diabetes consists of employing the Machine Learning Model. This Model development consists of the following factors:

Dataset: The data used compiled by National Institute of Diabetes and Digestive and Kidney Diseases and will also collect data from medical hospital databases. This dataset contains measurements relating to Age, gender, Polyuria, Polydipsia, genital thrush, sudden weight loss, weakness, visual blurring loss, muscle stiffness, obesity, Glucose, Blood Pressure, Skin Thickness, Insulin, etc. We used this dataset to prepare a random forest model for early prediction of diabetes.

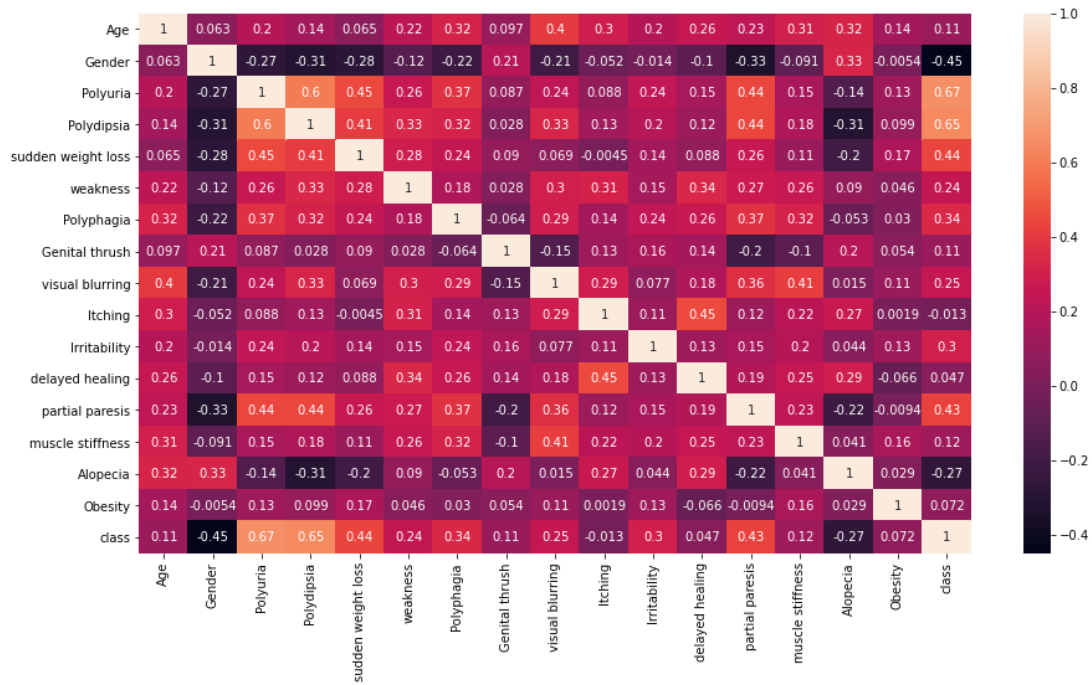


Fig.: 8

This Correlation matrix presents the dependency of the feature used in ML Model with other features.

ML Models:

The dataset was used to train different models like Decision Tree, Naive Bayes and Random Forest Tree. The accuracy of these training models was used to determine the best model among these.

- Decision Tree: Here the data is classified into nodes and subnodes based on a certain parameter.

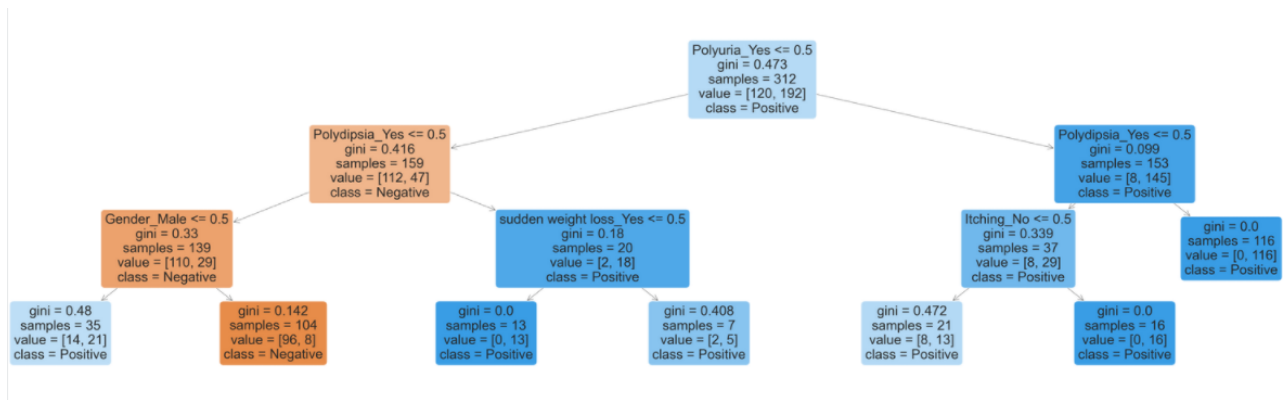
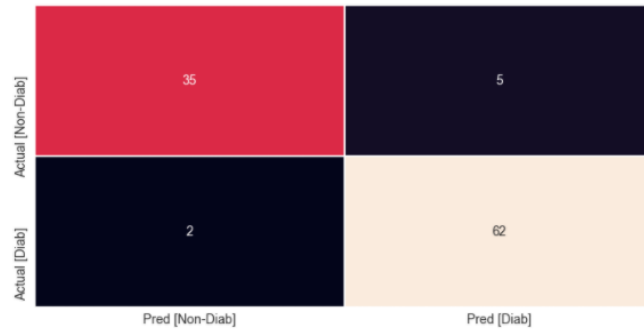


Fig.: 9

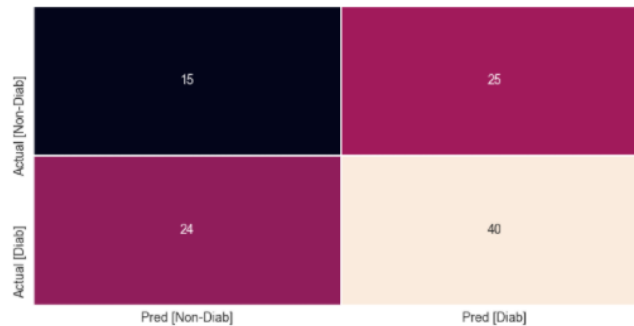
The model gave the following confusion matrix on training and had an accuracy of 91%



	Precision	Recall	f1 - score
Negative	0.95	0.88	0.91
Positive	0.93	0.97	0.95

Fig.: 10

- Naive Bayes: this model uses probability distribution for a person to have diabetes subject to condition that the model parameters are independent. However the dataset features in our dataset have correlation which is a reason for this model to have low accuracy and low prediction as seen in the following confusion matrix. This model gave accuracy of only 88%.



	Precision	Recall	f1 - score
Negative	0.38	0.38	0.38
Positive	0.62	0.62	0.62

Fig.: 11

- Random Forest: This model consists of multiple Decision Tree Models averaged over for better results. The Random forest Tree corresponding to our dataset is:

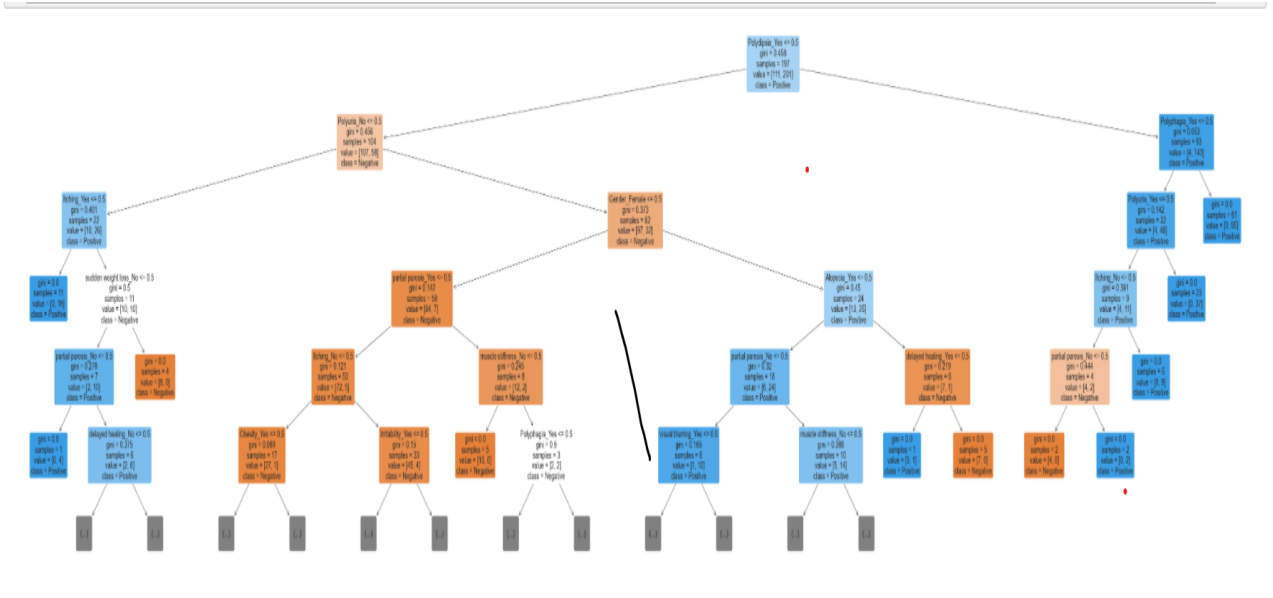
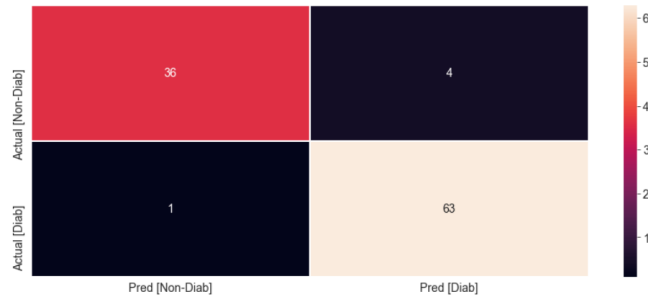


Fig.: 12

The confusion matrix of this model had a clear upper hand over the other models of comparison.



	Precision	Recall	f1 - score
<b>Negative</b>	<b>0.97</b>	<b>0.90</b>	<b>0.94</b>
<b>Positive</b>	<b>0.94</b>	<b>0.98</b>	<b>0.90</b>

Fig.: 13

By comparing the Three Models based on accuracy, recall and Precision the random Forest Model was selected as the most appropriate model for diabetes prediction.

- Glucose level monitoring and insulin administration using gold nanoclusters:- (collection of gold nanoparticles)
  - Glucose level monitoring (Glucose Sensors):-

Nanotechnology holds the key to enable the development of improved glucose sensors that are much more reliable and accurate as compared to the current ones. Hence gold nanoparticle based glucose sensors can revolutionize the existing sensing methods.

Three main types of glucose sensing molecules can be used to engineer these glucose sensors. These sensing molecules include glucose-binding proteins (non-enzymatic approach), glucose-binding small molecules and glucose oxidase (enzymatic approach).

Glucose oxidase approach is not very accurate as it is prone to considerable changes depending on factors such as pH, temperature, oxygen level. This technique requires frequent recalibration in order to get accurate results and good precision. To overcome these shortcomings, a non-enzymatic approach is used.

The non-enzymatic approach provides fluorescent readout and voltammetric signals which take place as soon as the glucose molecule binds to the glucose sensor. These glucose sensors are transcutaneously injected inside the body for monitoring the blood glucose levels. These sensors cannot be taken orally owing to the acidic environment of the digestive system that tends to destroy the glucose sensor.

The working principle is as follows:

- PBA (phenylboronic acid) a glucose-binding small molecule is used for glucose sensing.
- It is a non-enzymatic approach
- It binds to glucose to form cyclic esters
- In association with gold nanoparticles, the displacement of water by glucose in the binding pocket present on the sensor results in a shift of electron density.
- This is measured as fluorescent readout and voltammetric output.

This method is very reliable as multiple glucose sensors can be placed throughout the body owing to small size and thereby this eliminates the dependency on one sensor. These can directly be placed in the bloodstream as well and also doesn't require any battery for operation. No frequent calibration is needed. Overall, it turns out to be a long acting formulation and a reliable method of glucose level monitoring.

- **Diabetes Type I Treatment:-**

Treatment of Diabetes Type I refers to maintaining optimum glucose levels in the body. This term is known as normoglycemia - normal glucose levels. Generally the patient carries out a finger pricking blood glucose using a home kit and then self administers the insulin using an injection. This

traditional method is quite painstaking and brings a lot of discomfort and inconvenience to the patient. The story does not end here, any inaccuracy in administration of insulin may lead to severe complications. To overcome these issues and to make the process more patient friendly, collection of gold nanoparticles called gold nanoclusters can be used.

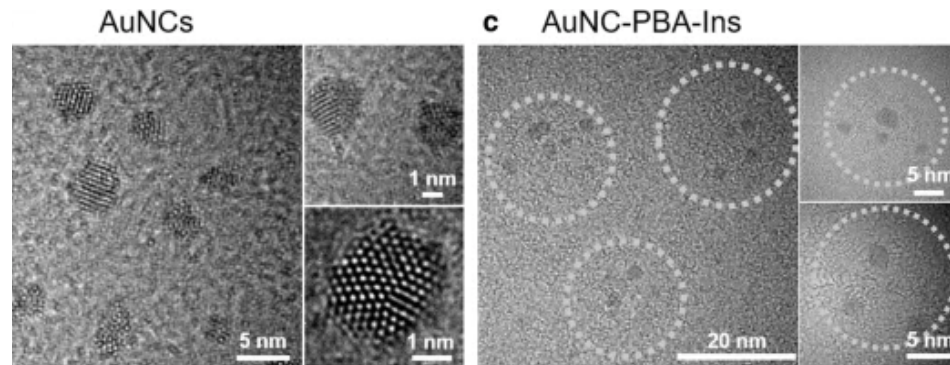


Fig.: 14

- **Preparation:-**

These can be prepared by the reaction of  $\text{HAuCl}_4$  and  $\text{NaOH}$  under specific conditions of pH 12 and intense stirring to achieve homogenous mix. This needs to be maintained at a temperature of  $37^\circ\text{C}$  for a period of 24 hours. Furthermore, it needs to be protected from light. Change in solution color is observed and finally the solution turns brown. Excess chemicals are removed by the process of centrifugation.

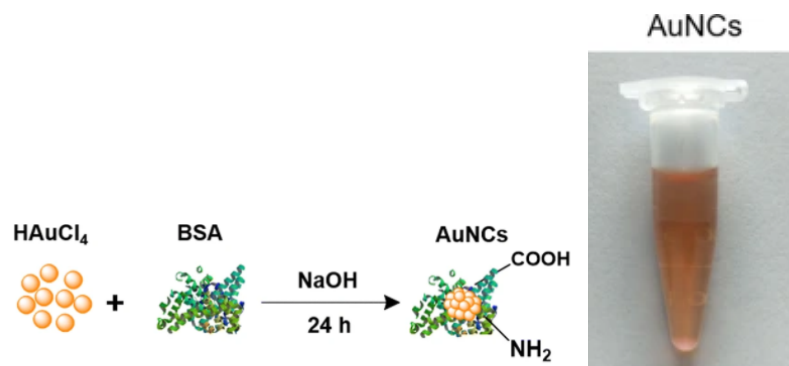


Fig.: 15

- **PBA addition:-**

Activation of  $\text{COOH}$  groups present by maintaining the solution at room temperature. Reaction between  $-\text{NH}_2$  and  $\text{COOH}$  takes place, this is followed by resting the solution for 15 - 20 hours. Finally excess chemicals are removed by the process of centrifugation.



Fig.: 16

- **Grafting of Insulin:-**

It is done by the reaction that is followed by the addition of insulin onto the PBA added gold nanoclusters. This happens at room temperature and takes about 24 hours for completion. Hence, AuNC-PBA-Ins are obtained.

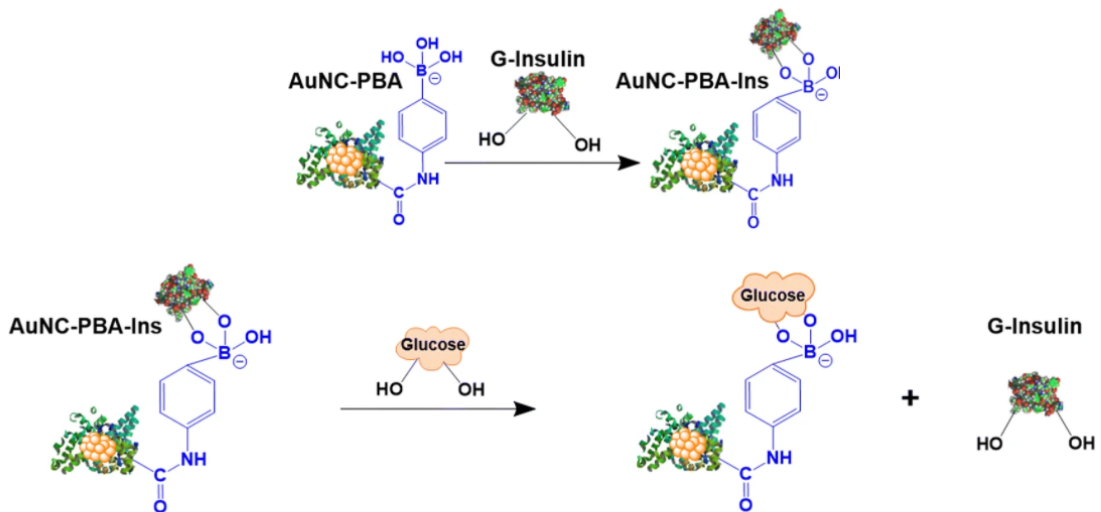


Fig.: 17

The product obtained is very sensitive to glucose levels and therefore effectively maintains the blood glucose levels by releasing insulin (as shown in the image above) as per the body needs and overall helps maintain normoglycemia.



## **Conclusion:-**

Diabetic People suffer from multiple social, psychological and economic problems. The Social stigma present towards the diabetic people degrades the mental condition of these people leading to lower education rates and employment opportunities. These problems also consist of the treatment and lifestyle difficulty associated with the use of Insulin.

Diabetic Patients also need frequent blood sugar analysis to calculate the carbohydrate intake and time to inject insulin.

These problems can be eradicated by the use of Gold nanoclusters. These allow real Time analysis along with efficient drug delivery. The imaging system and detection from the Gold nanoparticles allow visual presentation of the glucose levels. Gold nanoclusters are used for insulin administration. Thereby, optimizing the diabetes management system.

Through our project:-

- **integrating Artificial Intelligence for efficient early prediction of Diabetes**
- **using several ML algorithms for accuracy comparison**
- **highly accurate model - 96% accuracy**
- **non-enzymatic approach - sensor to provide a fluorescent or voltammetric readout using gold nanoparticles (detection)**
- **utilizing gold nanoclusters for insulin administration**
- **(nanoclusters are collections of nanoparticles)**

## References:-

<https://www.liebertpub.com/doi/10.1089/dia.2014.0062>  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3751743/>  
<https://www.nature.com/articles/nrd4477#Sec4>  
<https://jnanobiotechnology.biomedcentral.com/articles/10.1186/s12951-015-0136-y>  
<https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4478103/>  
<https://www.kaggle.com/uciml/pima-indians-diabetes-database>  
<https://www.niddk.nih.gov/health-information/diabetes/overview/what-is-diabetes>  
<https://www.healthline.com/health/diabetes>  
<https://www.who.int/news-room/fact-sheets/detail/diabetes>  
<https://pubmed.ncbi.nlm.nih.gov/26583784/>  
<https://scialert.net/fulltext/?doi=pjbs.2020.959.967>  
<https://news.mit.edu/2013/nanotechnology-could-help-fight-diabetes-0516>  
<http://diya.org.in/>  
<https://www.hindawi.com/journals/jdr/2021/6612063/>  
[https://www.researchgate.net/publication/270911309\\_Recent\\_Advances\\_in\\_Nanotechnology\\_for\\_Diabetes\\_Treatment](https://www.researchgate.net/publication/270911309_Recent_Advances_in_Nanotechnology_for_Diabetes_Treatment)  
<https://www.sciencedirect.com/science/article/abs/pii/S1549963412001852#:~:text=Nanomedicine%20aims%20to%20provide%20novel,patients%20with%20insulin%2Ddependent%20diabetes.>  
<https://www.longdom.org/open-access/nanomedicine-current-trends-in-diabetes-management-2157-7439.1000137.pdf>  
<https://www.pcdsociety.org/resources/details/nanotechnology-and-the-future-of-diabetes-management>

## **Annexure: Questionnaire**

### **Interview with doctor Mr. Bhavesh**

- What are some symptoms of Type I Diabetes?
- What are some of the severe complications of Diabetes Type I?
- Could you elaborate on the current methods of measuring glucose levels?
- How is insulin administration done in Type I Diabetes patients? Do these methods have shortcomings?
- Are you aware of the current advancements in treatment of Type - I diabetes and the usage of nanoparticles in treatment of the same?

### **Interview with Prof. Atharva Poundarik-**

- Which are some of the properties that gold exhibits which makes it such an important nanoparticle?
- We are planning to make use of ML algorithms and models in early prediction of diabetes. What are your views on the integration of Machine Learning in our project and areas of improvement?
- What are some of the methods of administration of nanoparticles inside the body?
- Any advice or suggestions that you would like to give us?

### **Interview with Miss. Sagarika-**

(PhD Student, IIT Ropar)

- What is so fascinating about nanotechnology and nanomaterials?
- Could you list some of the major problems that the use of nanoparticles in the medical industry possesses?
- Is there any major factor that needs to be considered while utilizing gold nanoparticles for detection and treatment of diseases?

### **Interview with Mr. Jai-**

(PhD Student, IIT Ropar)

- Which properties of gold nanoparticles can be explored for detecting glucose levels?

### **Interview with Mr. Harsh Kohli-**

(President of DIABETES INDIA YOUTH IN ACTION)

- How long have you been living from this disorder?
- What are the problems you faced in initial days of this disease and how it affected your daily life?

- Did you experience any side effects due to treatment? If any pls elaborate briefly.
- What are the complications you experienced due to this disease and also what complications you experienced after the treatment?
- Do you experience some mental problems due to this disease like depression, hypertension and stress?
- How much of your expenses goes in treatment of this disease, do you think the treatment is costly and time consuming?
- Anyone in your family also suffer or suffer from this disease?.
- What type of symptoms people generally have while they are diagnosed with this disease? (severe,mild,light)
- Any physical changes?
- Are you doing something extra to be good in health like exercise, meditation or yoga?
- How do you look forward to effectively managing the intake of carbohydrate, number of insulin that you take in a day?
- How much insulin do you take in one day? Do you take that daily or in a particular day cycle?
- What do you use, insulin pump, injections or tablets?
- What other methods are available to take the insulin shots?
- Can eat every type of food?
- Have you tried any other treatments like homeopathy or ayurvedic? If yes then does these treatments help you in going better or it gone worse?
- Do you check your glucose level regularly?.
- What type of other diseases come along with type 1 diabetes?
- How often do you visit a doctor's clinic?
- The healthcare patient analysis shows that the North Zone has a comparatively higher percentage of diabetic people while the healthcare charges for diabetes is higher in the North East zone. What according to you will be the reason for this?