APPENDIX A

The pathophysiology of diabetes mellitus is depicted in figure A.1 below. The onset of diabetes mellitus can be attributed to two factors namely genetic predisposition and environment. Environmental factors like food intake, physical inactivity, and a degraded environment are instrumental in increased obesity which results in insulin resistance. On the other hand, the genetic defect results in β-cell defects which results in deranged insulin secretion. Both cases result in hyperglycemia which leads to β-cell exhaustion and finally culminates into Type-2 diabetes mellitus.

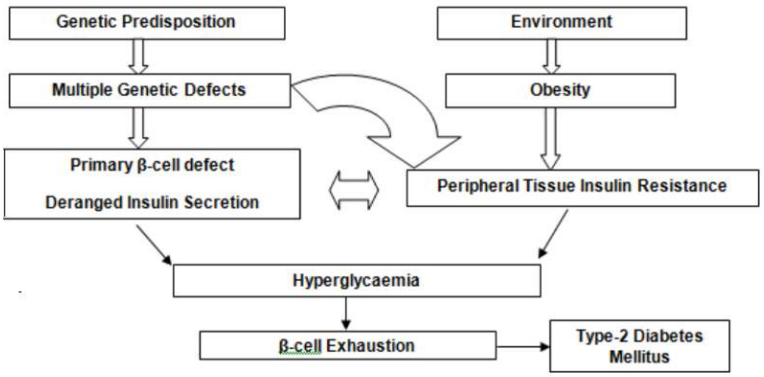

Figure A. 1: Pathophysiology of Diabetes Mellitus

APPENDIX B

Lingo Code for finding central facility:

```
MODEL:
SETS:
!colonies in cluster1;
nodes/Dashashwamedh,Chetganj,Sigra,Kotwali,Chowk,Bhelupur,Khojwa,
Nagwa,Sikraul,Shivpur,Nadesar,Adampura,Jaitpura
/: latitude,longitude,weight;

ENDSETS
DATA:
!declaration of data;
latitude= 25.30678 25.32101 25.31108 25.32453 25.31441 25.30397
25.29378 25.28737 25.35824 25.35951 25.33479 25.32625 25.32783;
longitude=83.01062 83.00146 82.98644 83.01285 83.00995 82.99001
82.9945 82.98376 82.98644 82.9515 82.98913 83.02059 83.01405;
weight= 0.88286 0.70141 1.12969 0.96735 0.49878 0.666 0.76921
1.27803 0.65202 0.92607 0.46711 1.14023 1.44385;


ENDDATA
!objective function;
min = @sum(nodes(i): weight(i)*(@ACOS (@SIN((3.14/180)*(latitude (i)))
*@SIN((3.14/180)*(lat))+@COS((3.14/180)*(latitude(i)))*@COS((3.14/180)*(l
at))*@COS((3.14/180)*(longitude(i)-long)))*6371));

!contstraints;
lat<=30;
lat>=0;
long<=85;
long>=0;

END
```

Solution

```
Local optimal solution found.
Objective value:                              28.83218
Infeasibilities:                              0.000000
Extended solver steps:                                5
Total solver iterations:                            159

Model Class:                                        NLP

Total variables:                       2
Nonlinear variables:                   2
Integer variables:                     0

Total constraints:                     5
Nonlinear constraints:                 1

Total nonzeros:                        6
Nonlinear nonzeros:                    2
```

Variable	Value	Reduced Cost
LAT	25.31931	0.000000
LONG	83.00276	0.000000
LATITUDE(DASHASHWAMEDH)	25.30678	0.000000
LATITUDE(CHETGANJ)	25.32101	0.000000
LATITUDE(SIGRA)	25.31108	0.000000
LATITUDE(KOTWALI)	25.32453	0.000000
LATITUDE(CHOWK)	25.31441	0.000000
LATITUDE(BHELUPUR)	25.30397	0.000000
LATITUDE(KHOJWA)	25.29378	0.000000
LATITUDE(NAGWA)	25.28737	0.000000
LATITUDE(SIKRAUL)	25.35824	0.000000
LATITUDE(SHIVPUR)	25.35951	0.000000
LATITUDE(NADESAR)	25.33479	0.000000
LATITUDE(ADAMPURA)	25.32625	0.000000
LATITUDE(JAITPURA)	25.32783	0.000000
LONGITUDE(DASHASHWAMEDH)	83.01062	0.000000
LONGITUDE(CHETGANJ)	83.00146	0.000000
LONGITUDE(SIGRA)	82.98644	0.000000
LONGITUDE(KOTWALI)	83.01285	0.000000
LONGITUDE(CHOWK)	83.00995	0.000000
LONGITUDE(BHELUPUR)	82.99001	0.000000
LONGITUDE(KHOJWA)	82.99450	0.000000
LONGITUDE(NAGWA)	82.98376	0.000000
LONGITUDE(SIKRAUL)	82.98644	0.000000
LONGITUDE(SHIVPUR)	82.95150	0.000000
LONGITUDE(NADESAR)	82.98913	0.000000
LONGITUDE(ADAMPURA)	83.02059	0.000000
LONGITUDE(JAITPURA)	83.01405	0.000000
WEIGHT(DASHASHWAMEDH)	0.8828600	0.000000
WEIGHT(CHETGANJ)	0.7014100	0.000000
WEIGHT(SIGRA)	1.129690	0.000000
WEIGHT(KOTWALI)	0.9673500	0.000000
WEIGHT(CHOWK)	0.4987800	0.000000
WEIGHT(BHELUPUR)	0.6660000	0.000000
WEIGHT(KHOJWA)	0.7692100	0.000000
WEIGHT(NAGWA)	1.278030	0.000000
WEIGHT(SIKRAUL)	0.6520200	0.000000
WEIGHT(SHIVPUR)	0.9260700	0.000000
WEIGHT(NADESAR)	0.4671100	0.000000
WEIGHT(ADAMPURA)	1.140230	0.000000
WEIGHT(JAITPURA)	1.443850	0.000000

Lingo Code for Traveling Salesman Problem:

```
MODEL:
! Traveling Salesman Problem for the daily inspection and
fulfilment at 12 remote nodes;
SETS:
 NODE / 1.. 13/: U;! U (I) = sequence no. of Nodes;
 LINK (NODE, NODE):
      DIST,! The distance matrix;
         X;! X(I, J) = 1 if we use link I, J;
ENDSETS
DATA:! Distance matrix, it need not be symmetric;
 DIST =   [distance matrix];

ENDDATA

 N = @SIZE(NODE);
 MIN = @SUM( LINK: DIST * X);
 @FOR ( NODE( K):
 @SUM( NODE( I)| I #NE# K: X( I, K)) = 1;
 @SUM( NODE( J)| J #NE# K: X( K, J)) = 1;
 @FOR( NODE( J)| J #GT# 1 #AND# J #NE# K:
      U( J) >= U( K) + X ( K, J) -
      ( N - 2) * ( 1 - X( K, J)) +
      ( N - 3) * X( J, K)
  );
 );
 ! Make the X's 0/1;
 @FOR( LINK: @BIN( X));
 ! For the first and last stop is the central facility;
 @FOR( NODE( K)| K #GT# 1:
  U( K) <= N - 1 - ( N - 2) * X( 1, K);
  U( K) >= 1  + ( N - 2) * X( K, 1)
 );
```

Solution:

```
Global optimal solution found.
Objective value:                              37.25000
Objective bound:                              37.25000
Infeasibilities:                              0.000000
Extended solver steps:                               1
Total solver iterations:                          2731
Elapsed runtime seconds:                          0.40

Model Class:                                      MILP

Total variables:                   182
Nonlinear variables:                 0
Integer variables:                 169

Total constraints:                 195
Nonlinear constraints:               0

Total nonzeros:                   1092
Nonlinear nonzeros:                  0
```

Variable	Value	Reduced Cost
N	13.00000	0.000000
U(1)	0.000000	0.000000
U(2)	5.000000	0.000000
U(3)	9.000000	0.000000
U(4)	1.000000	0.000000
U(5)	4.000000	0.000000
U(6)	8.000000	0.000000
U(7)	7.000000	0.000000
U(8)	6.000000	0.000000
U(9)	12.00000	0.000000
U(10)	11.00000	0.000000
U(11)	10.00000	0.000000
U(12)	3.000000	0.000000
U(13)	2.000000	0.000000

Sequence of Location Travelled:

1-4-13-12-5-2-8-7-6-3-11-10-9

APPENDIX C

Code Used for Conjoint Analysis:

For Conjoint Analysis following syntax was used. The code was run using SPSS Statistics Syntax Editor.

```
CONJOINT PLAN='File Specification'

/DATA='File Specification'

/SEQUENCE=PREF1 to PREF16

/SUBJECT=ID

/FACTORS=QUALITY (DISCRETE)

HOSPITAL_EXP (LINEAR LESS)

SPEND_PV (LINEAR LESS)

WAITING (LINEAR LESS)

DISTANCE (LINEAR LESS)

/PRINT=SUMMARYONLY

/PLOT=SUMMARY
```

- The PLAN subcommand specifies the file containing the orthogonal design.
- The DATA subcommand specifies the file containing the preference data.
- The SEQUENCE subcommand specifies that each data point in the preference data is a profile number, starting from most- preferred profile and ending with the least-preferred profile.
- The SUBJECT subcommand specifies that the variable ID identifies the subjects.
- The FACTORS subcommand specifies a model describing the expected relationship between the preference data and the factor levels. The specified factors refer to variables defined in the plan file named in the PLAN subcommand.

- The keyword DISCRETE is used when the factor levels are categorical and no assumption is made about the relationship between the levels and the data.
- The keyword LINEAR is used when the data is linearly related to the factor.
- The keyword MORE and LESS, following LINEAR, indicate an expected direction of the relationship. Since we expect a higher preference for lower prices (Spend, Expense), the keyword LESS is used for the price.
- PRINT subcommand is used for printing the results of Conjoint Analysis while PLOT subcommand is used for plotting the bar chart for utility for various attributes and levels.

  The Table C.1 lists the response of the test-retest reliability test for the conjoint analysis.

Table C. 1: Test –Retest Response

Respondent 1		**Respondent 2**		**Respondent 3**	
T1	**T2**	**T1**	**T2**	**T1**	**T2**
5	5	4	4	6	6
4	3	5	5	4	1
16	16	15	14	16	11
6	7	6	6	5	5
15	15	16	15	14	14
13	13	12	12	13	13
2	2	2	2	2	2
12	10	13	13	12	15
14	14	14	16	15	12
7	6	7	7	7	4
1	1	1	1	1	7
8	9	8	9	8	8
11	11	11	11	11	16
3	4	3	3	3	3
9	8	10	10	9	9
10	12	9	8	10	10

Cards used for Conjoint Analysis:

Profile Number 1

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
1	High	X<1000 Rs	500<X<1000 Rs	X>30 Min	X<1 Km

Profile Number 2

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
2	Low	1000<X<3000 Rs	X>1000 Rs	X<15 Min	X<1 Km

Profile Number 3

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
3	Low	X<1000 Rs	X<500 Rs	X<15 Min	X<1 Km

Profile Number 4

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
4	Low	1000<X<3000 Rs	X<500 Rs	X>30 Min	>3Km

Profile Number 5

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
5	Low	X>3000 Rs	500<X<1000 Rs	X<15 Min	X<1 Km

Profile Number 6

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
6	Low	X<1000 Rs	X<500 Rs	X<15 Min	X<1 Km

Profile Number 7

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
7	Medium	X<1000 Rs	X>1000 Rs	X>30 Min	X<1 Km

Profile Number 8

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
8	Low	X<1000 Rs	500<X<1000 Rs	15 <X<30 Min	>3Km

Profile Number 9

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
9	High	X>3000 Rs	X>1000 Rs	X<15 Min	>3Km

Profile Number 10

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
10	High	1000<X<3000 Rs	X<500 Rs	15 <X<30 Min	X<1 Km

Profile Number 11

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
11	Medium	X>3000 Rs	X<500 Rs	15 <X<30 Min	X<1 Km

Profile Number 12

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
12	High	X<1000 Rs	X<500 Rs	X<15 Min	1<X<3 Km

Profile Number 13

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
13	Medium	1000<X<3000 Rs	500<X<1000 Rs	X<15 Min	1<X<3 Km

Profile Number 14

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
14	Medium	X<1000 Rs	X<500 Rs	X<15 Min	>3Km

Profile Number 15

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
15	Low	X<1000 Rs	X>1000 Rs	15 <X<30 Min	1<X<3 Km

Profile Number 16

Card ID	QUALITY	HOSPITAL_EXP	SPEND_PV	WAITING	DISTANCE
16	Low	X>3000 Rs	X<500 Rs	X>30 Min	1<X<3 Km

APPENDIX D

Questionnaire for Identifying the Factor Influencing the Quality

Given below are eighteen quality indicator for diabetes care unit in India. A brief description of the variable is also provided for the convenience of the respondent.

To what extent the following indicators affect the quality of Indian Diabetes Care Units measured on a scale of 1-7. Please put a tick mark in the appropriate box:

1. **Quality of care (QOC):** Quality of the care provided by the doctor, nurses and hospital staffs.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

2. **Quality of Investigation (QOI):** It is the quality of investigation carried out in the hospital.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

3. **Cost of Medicine (COM):** Cost related to the medicine prescribed by the doctors in the hospital.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

4. **Length of Stay (LOS):** It indicates the number of days a patient stays in the in-patient-department (IPD).

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

5. **Professional Flexibility (PRF):** The ability of a hospital to increase the number of professional or launch and provide new services.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

6. **Practitioner's Attitude (PRA):** The attitude of the practitioner's towards patients and their attendant.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

7. **Administrative Staff's Attitude (ASA):** The administrative staff's behavior towards patients, attendants, practitioners, and visitors.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

8. **Waiting Time (WT):** This attribute indicates the total time spent by a patient for fixing an appointment as well as taking consultation of the doctor.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

9. **Facility Availability (FA):** Availability of specialized departments and facilities in the hospital like Diabetes Education, Medical Nutrition Therapy, Physiotherapy, neuropathy examination, eye examination and Cardiac Risk Profiling.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

10. **Access (ACS):** Ability of a hospital to admit patients for whom it can provide services with its available resources:

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

11. **Grievance Handling Time (GHT):** Time taken by hospital administration to solve any grievance of a patient :

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

12. **Medical Record Keeping (MRD):** The capacity of a hospital to maintain a proper and detailed record of the patient's case history, and records of lab investigation done.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

13. **Hospital Infection Control (HIC):** Ability to reduce or eliminate the infection risk to the patients and visitors in Out-Patient-Department (OPD) and In-Patient-Department (IPD).

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

14. **Privacy (PRI):** The extent to which a hospital is able to maintain the records of the patients confidential or doesn't disclose the information about patients without their consent.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

15. **Waste Disposal Policy (WDP):** The policy of a hospital related to handling, storage, transportation and disposal of hazardous materials.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

16. **Process Flexibility (PFL):** The process flexibility is a measure of time taken in refereeing the complicated cases to specialized hospital.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

17. **Cost of Consultancy (COC):** The consultant and registration fee charged by a hospital at the time of visiting the diabetes center. Since chronic disease like diabetes requires frequent follow-up visit to the hospital this cost becomes very important.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

18. **Cost of Investigation (COI):** It indicates the cost incurred by patients in the pathological investigation and other special diabetes investigations.

☐	☐	☐	☐	☐	☐	☐
1	2	3	4	5	6	7

APPENDIX E

Research Paper Accepted/ Published in International Journals

- Mishra, V., Samuel, C., & Sharma, S. K. (2018). Lean, agile and leagile healthcare management–A case of chronic care. *International Journal of Healthcare Management*, 1-8. (Taylor & Francis) (Scopus Indexed, Published)
- Mishra, V., Samuel, C., & Sharma, S. K. (2018). Decision of decentralization in a healthcare service–a case of diabetes management. *International Journal of Healthcare Management*, 1-6. (Taylor & Francis) (Scopus Indexed, Published)
- Mishra, V., Samuel, C., & Sharma, S. K. (2018).System Modeling for Forecasting of Diabetes Prevalence, *Indian Journal of Public Health Research & Development* (Accepted, Scopus Indexed)
- Mishra, V., Samuel, C., & Sharma, S. K. (2018). Supply Chain Partnership Assessment of a Diabetes Clinic: A Case Study, *International Journal of Health Care Quality Assurance* (Emerald) (Accepted, Scopus Indexed)

Research Paper Communicated in International Journals

- Mishra, V., Samuel, C., & Sharma, S. K. (2018). Customized Quality Assessment Framework for Diabetes Care, International Journal of Health Care Quality Assurance (Emerald) (Communicated, Scopus Indexed)

- Mishra, V., Samuel, C., & Sharma, S. K. (2018). Patient's Utility for Various Attributes of Diabetes Care Services, International Journal of Health Governance (Emerald) (Communicated, Scopus Indexed)

Research Paper published in International Conferences proceedings

- Mishra, V., Samuel, C., & Sharma, S. K. (2016, December). Visualization of perceived expensiveness of diabetes-Fuzzy MDS Approach. In *Electrical, Computer and Electronics Engineering (UPCON), 2016 IEEE Uttar Pradesh Section International Conference on* (pp. 67-71). IEEE. (Scopus Indexed)

- Mishra, V., Samuel, C., & Sharma, S. K. (2015) Capacity Planning For Diabetes Management-Indian Example. IEOM Society (Scopus Indexed)

- Mishra, V., Rautela, A., Manjunath, B., Samuel, C., Sharma, S. K., & Mishra, A. (2016). Use of Visual Analytics and Durometer in Risk Reduction of Foot Problems in Diabetes. In *CAD/CAM, Robotics and Factories of the Future* (pp. 491-498). Springer, New Delhi.(Scopus Indexed)