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Pharmacogenomic Advancements For The Management Of Diabetes Mellitus

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ABSTRACT
Pharmacogenomics (PGx), likewise perceived as pharmacogenetics, is a branch about pharmacologyor genomics. It is an ongoing abstention that examination the results about genomic, yet hereditary variety about the assimilation, digestion, working effectiveness, antagonistic responses of pills between the ethnic body, in this way the improvement of advance medications have been incorporated. The PGx thought has been proposed since 1950s, alongside the primary reason for distinguishing significant hereditary forms up to desire to fix ailment between people. As of now PGx is the former decision as a result of coordinating genomic records into clinical practice and offering therapeutic choice help. PGx inquire about indicated amazing accomplishments for different sickness. Among them, Diabetes is a most plentifully influenced by quality inconstancies. Diabetes is infection characterized dependent on hyperglycemia. There are monogenics of diabetes where characterizing the hereditary reason dramatically affects treatment with patients having the option to move from insulin to sulfonylureas. Be that as it may, most of diabetes is type-2 diabetes. Until this point in time, clinically significant pharmacogenomics has to a great extent been restricted to extreme eccentric antagonistic medication responses, to variety in sedate digestion, and to treatment result in malignant growth chemotherapeutics where the physical transformations drive the decision of focused intercession. In this review article, we concentrate on pharmacogenomics in type-2 diabetes and utilize this not exclusively to layout the ongoing advances in the field however to address the difficulties that are confronted while thinking about hereditary qualities of treatment adequacy and symptoms in like manner complex illness status of diabetes.
Keywords: Diabetes; Pharmacogenomics; Antidiabetic; Pharmacogenes.

1. INTRODUCTION

Diabetes Mellitus is an issue with your body that causes blood glucose (sugar) levels to ascend higher than ordinary. This is additionally called hyperglycemia. There are various kinds of diabetes (Type-I, Type-II) and a condition called gestational diabetes, which occurs during pregnancy. On the off chance that you have diabetes, your either body doesn't make enough or insulin; it can't utilize the insulin it makes quite well, or both. Diabetes mellitus (DM) could be a confusion happens due to metabolic issues is most successive all around. The most sign of DM could be a manifestation in blood that is a result of improper exocrine organ hypoglycaemic operator emission or low insulin-coordinated cultivating of aldohexose by target cells.[1]
Diabetes is joined by danger of cardiovascular, fringe vascular and cerebrovascular ailments. A few pathogenetic forms are associated with the improvement of diabetes, including demolition of pancreatic beta cells that lead to brought down affectability of insulin action.[2]

The hereditary examination concerning pharmacogenes, for example, medicate processing catalysts (Phase I and II), treatment transporters (Phase III), fix receptors identified with show impact, lessens interindividual variations about medication poisonous quality.

Cytochrome P450 (CYP P450) is a superfamily chemical segment concerning a progression of isoenzymes encoded through CYP gene. It is the significant catalyst responsible for drug metabolism, which can radically utilize endogenous atoms then the exogenous mixes. As of now, 80% medications are used through CYP450 inside the body (CYP1A2, CYP2B6, CYP2C9, CYP2C19, CYP2D6, CYP2E1, and CYP3A4).[3]

Diabetes, in the same way as other complicated maladies, is analyzed dependent on a limit, being accomplished in a regularly disseminated characteristic.[4]There are numerous options why a person's blood glucose can transcend this threshold>7 mmol/L.[5]

In the course of the most recent 20 years, an expanding number of monogenic types of diabetes have been distinguished, which are regularly still not known. Monogenic types of diabetes can have extraordinary reaction to focused diabetes medications and speak to vigorous models for pharmacogenomics in the diabetes center .[6,7] Be that as it may, while it is enticing to accept that as we acquire information on diabetes etiology, we will subgroup type-2 diabetes into discrete subtypes, we have to perceive that genuine sort 2 diabetes is to be sure a polygenic malady. [8]Later hereditary investigations have built up that there are likely a huge number of basic hazard variations that add to type-2 diabetes risk, and the contribution of uncommon or low recurrence variations, while separately of huge impact, don't contribute significantly to the general predominance of type-2 diabetes. [9]

Mechanism

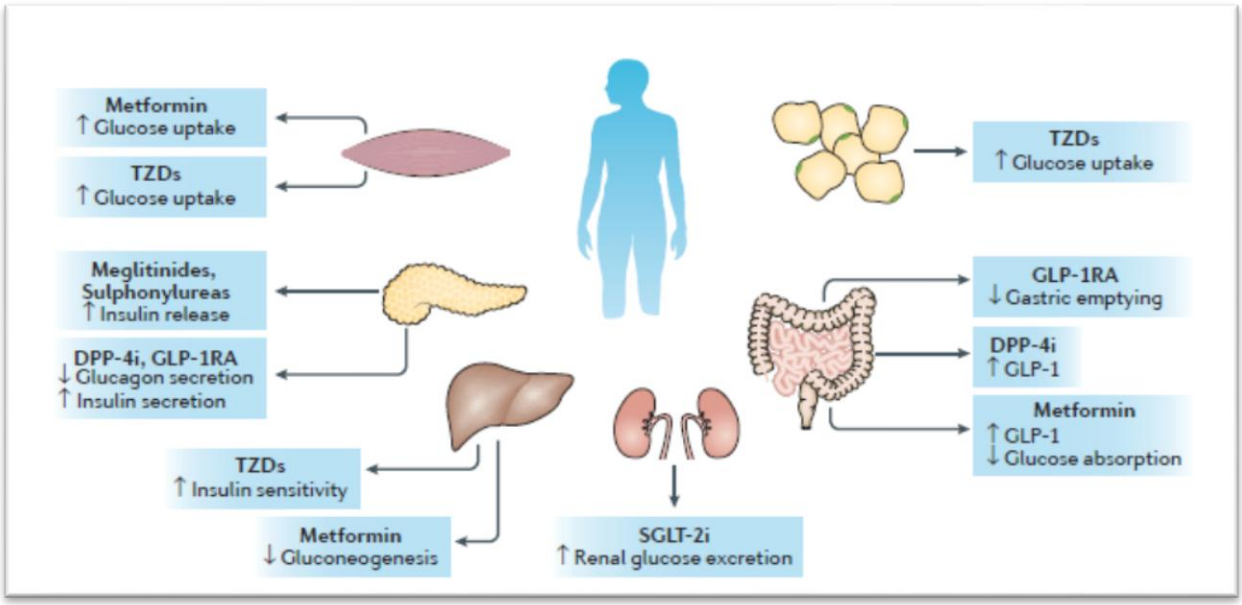

Fig. 1: Mechanism of antidiabetic drugs

Significance of Pharmacogenomics[10]

Genome-wide affiliation research (GWAS) regarding drug responses include 3730 publications or 89897 special SNP-trait associations are recognized according to GWAS catalog by 2019 January 31, inclusive of the genetic biomarker because of Clopidogrel (CYP2C19), Pegylated-interferon (IFNL3) and Carbamazepine (HLA-B 1502) etc. The study related to the genetic mechanism regarding individual variants within therapy clarification helps within result; inclusive of reduce the unpredictable toxicity on the improvement related to immediate drugs.(11) In accordance, sufferers have the necessary remedy effect, after amongst conformity together with maximize the benefits and safe for patients.[12]

The Multifactorial Aetiology of T2DM

The Multifactorial Etiology of T2DM: T2DM is a complex metabolic infection portrayed by higher glucose level coming about because of practical hindrance in insulin emission, insulin activity or both. Both insulin obstruction and secretory inadequacy emerge through the interaction of hereditary and natural hazard factors. Genome-Wide Association Studies (GWAS), which have grilled all the basic hereditary variations (minor allele recurrence >5%), have distinguished >120 T2DM hazard loci. High-throughput sequencing thinks about, which could hypothetically analyze every one of the variations in the genome, or if nothing else the area that encodes proteins, have likewise empowered the revelation of uncommon variations at GWAS-recognized loci and novel loci for T2DM. Hence, such regular variations with little to direct impacts and uncommon variations with generally huge impacts could represent –some percent of complete danger of creating T2DM and affirm its tendency as a complex metabolic syndrome.[13]

Epidemiology

Type-I polygenic disorder is that the most typical style of the polygenic disorder is expected to be seenin individuals with lower age teams. Around 20-79% have been concern 285 million individuals were having disorder worldwide within the survey of 2010, around 438 million individuals is predicted to have the similar disorder by 2030.[14]The prevalence of Type-I polygenic disorder is rising in each flourished nations. 80-95% of Type-I disorder is predominant in developing countries.

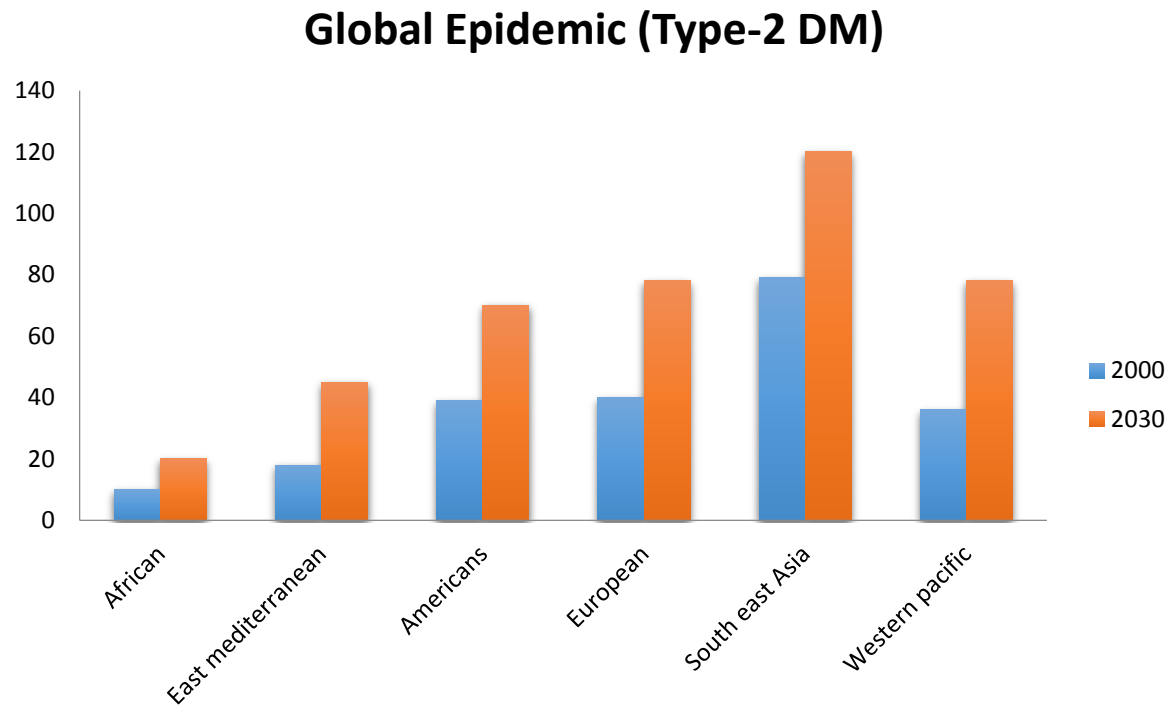

Fig. 2: Global epidemiology of Type-2 Diabetes

As per ICMR - INDIAB, a national diabetes study, currently India has 63 million people living with diabetes. which represents the world's second largest diabetes population after China. This is expected to progress over 100 million by 2030. Maximum population with diabetes (>90%) have Type-2 diabetes.[15]

Pathophysiology

Polygenic disorder could be a long lasting disease, wherever there is destruction of hypoglycaemic agent manufacturing exocrine gland beta cells. Once there is transplantation of exocrine gland from two donars to chronic diabetic, two recepients within the absence of

immune suppression is difficult because of elevated heterogenecity of exocrine gland lesions of beta cells that are quickly wiped out, then production of huge insulitis by victimization infiltrating T-lymphocytes that measures associate in nursing amnesic response reaction. Type a pair of polygenic disorder, because of hypoglycaemic agent resistance, abnormality of hypoglycaemic agent production and current exocrine gland beta cell failure ends up in hypoglycaemic agent inability that could be a characteristics feature of Diabetes Mellitus.[16,17]

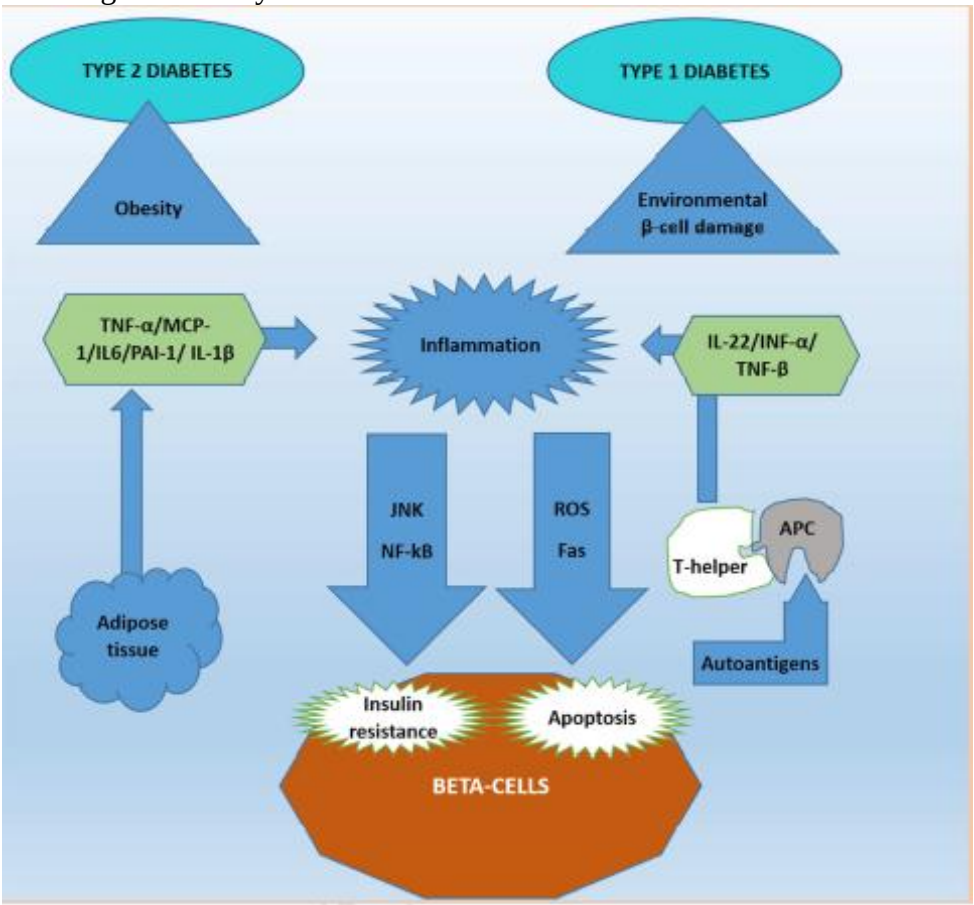

Fig. 3: Pathophysiology of diabetes

Etiology

*Auto immune response:*It is communicated as a result illness, wherever the beta-cells of exocrine organ are gradually destroyed by the body's very own framework that diminishes hypoglycaemic operator generation. Inside the improvement of Type-I issue and hereditary inclining factors are significant, anyway the exact connection stays obscure.

*Genetical factors:*Researchers began with eighteen hereditary positions are chosen as IDDM1-IDDM18, that are related with Type-I issue. The IDDM1 district contains the Human corpuscle antigens that figure proteins known as significant natural phenomenon progressed. During this area, insusceptible reactions are encountered by these genes.[18]

Environmental factors: Because of abrupt stress like Associate in Nursing infection wherever the beta-cells of exocrine gland falls below 5-10%.Coxsackie infections are a group of enteric infections that target the enteric tract closes falls up in the pulverization of hypoglycaemic operator producing exocrine organ beta-cells. [19]

Management

Objectives, which has in dealing with patients with polygenic issue, are to kill the indications or to avert the creating hazard factors incorporates power per unit territory and glycaemia,

regulation of lipids that diminishes large scale tube-formed structure risk and stoppage of smoking and keeping up acetylsalicylic corrosive therapeutic consideration.[20,21]

General management of diabetic patient's education:

• Illness method treatment possibility.
• Food arranges.
• Physical activity arranges.
• Awareness of given prescription for polygenic disorder.
• Observance of glucose levels.
• Psychosocial problems.
• improving life patterns

Medical Nutrition Therapy: patient is recommended to stick to proper diet plan. Physical tasks should be embraced more while working on dietry plan. The diet should embrace 50-55% carbohydrates, 24 % fat, fiber.[14,22]

Type-1 diabetes[(23)]: Insulins are the primary option to manage kind one polygenic disorder taken up by injections and hypoglycaemic agent pump. Insulins are of 3 types; speedy acting, long acting and intermediate acting. Some hypoglycaemic agents like regular insulin, hypoglycaemic agent isophane, and hypoglycaemic agent glulisine, hypoglycaemic agent lispro, hypoglycaemic agent as part. Some long acting insulins are glargine, detmir. Pramlintide inj. could be an artificial version of a chemical free internal secretion that is amylin provided by beta-cells and afew Hypertension receptor blockers, acetylsalicylic acid and sterol reducing medication are used. Artificial exocrine gland could be a control system agent delivery. It is coupled with a continuous monitor of aldohexose to hypoglycaemic agent pump. The device that tranfers correct quantity of hypoglycaemic agent mechanically once the monitor specifies the necessity for the pump.[24]

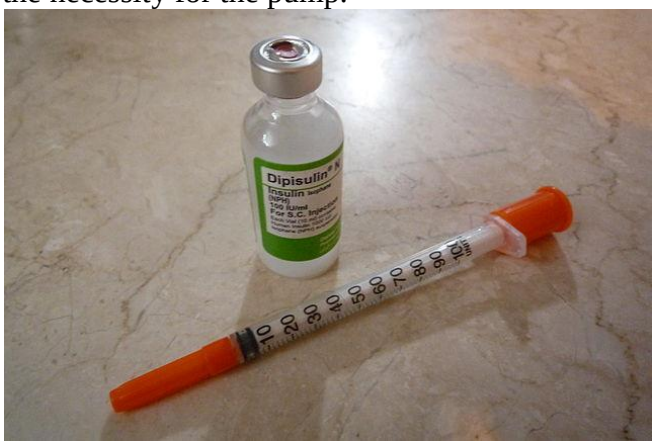

Figure 4: Insulin injection

2. LITERATURE REVIEW:

2.1 Pharmacological therapy: Oral hypoglycemic agents are helpful within the treatment of kind a pair of DM and hypoglycaemic agent additionally embraces in it and people agents are listed below in given table. The most aim is to correct disorder like resistance to hypoglycaemic agent and skipping hypoglycaemic agent secretion and given together with an appropriate diet and changes in manner. They revealreduction in weight, ameliorates glycaemicinterventionsincreaseglycaemic.[17,25]

SR No.	Type of drug	Drug generic	Brand name
1	Sulphonylureas	Glimepiride, Glipizipe, Glyburide	AMARYL, DIABETA, GLYNASE GlUCOTROL
2	Biguanides	Metformin	GLUCOPHAGE
3	Thiazolidinediones	Pioglitazone	ACTOS, AVANDIA
4	Alphaglucosidae inhibitors	Acarbose	PRECOSE, GLYSET
5	Meglitinides	Nateglinide	PRANDIN, STARLIX

Combinations of medicine medication with antidiabetic drug to treat diabetes:

- Metformin+Sulphonyl ureas-decrease in HbA1C (0.8–1.5%) than drug alone.
- Metforminimprove glycaemic management limit changes in weight hypoglycaemic agent necessities.
- Metformindecreased concentration of HbA1C & improve hypoglycaemic agent sensitivity.
- Metformin+α-glycosidase inhibitors-decrease in HbA1C
- Metformin+Glifozins are employed in combos currently daily to treat Type-I disorder

2.2 New inventions developed in activity diabetes:

This category of medicine embrace SGLT-2 Inhibitors , DPP-4 Inhibitors, Amylin mimetics, GLP-1 mimetics, twin PPAR agonist.

GLP-1 mimetics (or) agonist:

Hormone like amide (GLP-1) is mainly employed in the treatment of Type-I disorder that are given by injection to manage aldohexose level there by stimulating aldohexose dependent secretion of hypoglycaemic agent. [26]

SR No.	Name of drug	Brand Name
1	Exenatide	BYETTA
2	Liroglutide	VICOZA
3	Lixisenatide	LYXUMIA
4	Albiglutide	TANZEUM

DPP-4 inhibitors (Gliptins):

It is a replacement category of oral diabetic medication that facilitate in decreasing obesity moreover as reduce glucose level. These are generally prescribed for Type-1 DM patients.[17,27]

Amylin analogues or agonist:

These injectables are employed in treating each kind one a pair of polygenic disorder and are taken prior to meals. They inhibit the discharge of hormone whereas ingestion lowers the pace of food removal from the abdomen. Pramlintide acetate is that the category of drug accessible in United States of America that is run by connective tissue injections.[17,28]

SR No.	Name of drug	Brand name
1	Sitagliptin	JANUVIA
2	Vildagliptin	GALVUS
3	Saxagliptin	ONGLYZA
4	Kinagliptin	TRADZENTA

SGLT- a pair of inhibitors:

Selective atomic number 11 aldohexose transporter-2 is employed to treat Type-1 DM, which leads to lower urinary organ aldohexose leading to associate in nursing hyperbolic quantity of aldohexose, which can be excreted within the body waste.[29]

SR No.	Name of drug	Brand Name
1	Canagliflozin	INVOKANA
2	Empagliflozin	JARDINCE
3	Dapazliflozin	FARXIGA

Dual PPAR agonist :

Nuclear receptor PPAR γ are employed to cut back symptom combined with metabolic syndrome a pair of polygenic disorder. It absolutely was the most target of fibrate medication that could be a category of amphipathic chemical group acids.[17]

SR NO.	Name of drug	Brand name
1	Clofibrate	ATROMID-S
2	Gemifibrozil	LOPID
3	Bezafibrate	BEZALP
4	Fenafibrate	TRICOR

Targeted Cells Therapy:

Beta-Cells Targeted Therapy[30]:These days, diabetic medications are generally center around the beta-cellssenstizations to deliver insulin mostly to bring down blood glucose. In any case, these prescriptions convey undesirable symptoms, which lead to investigations of other elective medicines. As of late, specialists take a treatment, which actuates beta-cells recovery by utilizing various types of cells. Analysts have confidence in the capacity of beta-cells recovery through pancreatic progenitor cells trans-separation in the pancreas. Pancreatic cells, for instance, ductal epithelial cell and acinar cell are picked as the most significant cells for beta-cells recovery as a result of heredity just as their separation tendency. In any case, it is dubious to the later examinations applying naming analyses of the ductal heredity that neglect to demonstrate duct derived beta-cell development.[31]

Stem Cells Targeted Therapy[32,33,34]:Restrictions of trans-separation of pancreatic progenitor cells have incited to investigations of elective beta-cells source, for instance, early stage foundational microorganisms (ESCs). The primary issue of this option is the utilization of human undeveloped cell during the embryonic stage. This raises the moral issue, without a doubt, turns into an impediment. To conquer this constraint, instigated induced pluripotent stem cells (iPSCs) were created through physical cell core reinventing. IPSCs coordinate hereditarily with most patients, in this way anticipating safe responses Recent examinations detailed conventions, which altogether yielded beta-cells, which express comparably to beta-cells secluded from human. After introducing it into mice induced with diabetes, inside about fourteen days, new derived beta-cells comprised of stem cells discharged insulin in light of increased glucose and keeps up the glucose level in normal range.[35,36]

Bone marrow stem cells (BMSC) used to supplant harmed beta-cells, yet it delivers low degrees of insulin.[37]

Human placenta-derived MSC (PD-MSC) likewise seeked researcher because of their capacity to deliver insulin. Information uncovered a huge reduction of glycosylated hemoglobin in the study comprising of 10 diabetic patients, and the degrees of insulin was greater than those earlier medications. Moreover, no advancement of reactions, for example, liver harm, fever and resistant dismissal, and the cardiovascular and renal capacities were improved.[38,39]

2.3 Recent gene Therapeutic Approaches:

Gene Therapy: more often our immune system attacks on foreign substances. However, it may sometime get active on pancreatic beta cells. This subsequently, shoots up the glucose amount in the body.So, hurdle being faced in the treatment for replacing or fixing the degraded cells by immune system other then the beta cells can be overcome by introducing the replicated cells in the pancreas and can feed the insulin need to the body. As of now,

popular strategies, for example, lentivirus, adenovirus and AAV just as nonviral systems are utilized for insulin quality conveyance into various tissues, for instance,adipocytes, pancreas,muscle and liver. Strangely, intestinal cells for example, enteroendocrine K-cells indicated numerous similitudes with pancreatic beta cells, it produces glucose-subordinate GIP agonists, and contains prohormone convertases which are urgent for genius insulin handling. Therefore, numerous analysts endeavored to control K-cells in vitro to create and discharge insulin; be that as it may, the implantation of these cells neglected to securely turn around diabetes.[40,41] These highlights make AAV vectors as the best contender for quality treatment.[42,43,44]

3. CONCLUSION:

Diabetes mellitus is a great danger no longer only regarding the patients, however additionally because of their family and neighborhood. Various ways concerning diabetes need to remain investigated possibly at initial stages then managed accurately according to manage its development or complications. While, the multiple drawbacks associated with the disease are difficult to be controlled with one particular drug taken at a time. Therefore, advancements in the therapeutic strategies are key for a potential intervention of this disease.

The PGx thought has been proposed since 1950s, along with the main purpose of identifying important genetic versions upto expectation to cure disease between individuals. Currently PGx is the preceding preference due to the fact regarding integrating genomic archives within scientific selection support.

Recent studies reveals that there are numerous strategies while dealing with gene therapy and stem cells as therapeutic targetsThe presence regarding less costly high-throughput genomic applied sciences has accelerated our capabilities concerning the multifactorial element regarding T2DM. Diabetes research over affected person stratification, more findings from properly powered pharmacogenomic research are expected in imitation of complement mean ethnical genetic discoveries to facilitate more efficient antidiabetic medicine discovery programs.

4. REFERENCES:

[1] Zhou, Kaixin, et al. "Pharmacogenomics in diabetes mellitus: insights into drug action and drug discovery." *Nature Reviews Endocrinology* 12.6 (2016): 337.

[2] Tan, Sin Yee, et al. "Type 1 and 2 diabetes mellitus: A review on current treatment approach and gene therapy as potential intervention." *Diabetes & Metabolic Syndrome: Clinical Research & Reviews* 13.1 (2019): 364-372.

[3] Olefsky, Jerrold M. "Prospects for research in diabetes mellitus." *Jama* 285.5 (2001): 628-632.

[4] Stratton, Irene M., et al. "Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study." *Bmj* 321.7258 (2000): 405-412

[5] Type 2 Diabetes Mellitus What Is It? [Internet]. 2018. Available from: https://www.health.harvard.edu/a_to_z/type-2-diabetes-mellitus-a-to-z

[6] Florez, Jose C., et al. "TCF7L2 polymorphisms and progression to diabetes in the Diabetes Prevention Program." *New England Journal of Medicine* 355.3 (2006): 241-250.

[7] Pearson ER. Pharmacogenetics in diabetes. Curr Diab Rep 2009;**9**:172–181pmid:19323963

[8] Moore AF, Florez JC. Genetic susceptibility to type 2 diabetes and implications for antidiabetic therapy. Annu Rev Med 2008;**59**:95–111pmid:17937592

[9] Piero, M. N., G. M. Nzaro, and J. M. Njagi. "Diabetes mellitus-a devastating metabolic disorder." *Asian journal of biomedical and pharmaceutical sciences* 5.40 (2015): 1.
[10] Franks, Paul W., Ewan Pearson, and Jose C. Florez. "Gene-environment and gene-treatment interactions in type 2 diabetes: progress, pitfalls, and prospects." *Diabetes care* 36.5 (2013): 1413-1421.
[11] Mannino, Gaia Chiara, and Giorgio Sesti. "Individualized therapy for type 2 diabetes." *Molecular Diagnosis & Therapy* 16.5 (2012): 285-302.
[12] Surendiran A. Pharmacogenomics of Type 2 Diabetes Mellitus [Internet]. Vol. 1, Clinical & Applied Health Sciences. 2017. Available from: https://www.researchgate.net/publication/320616791
[13] Vakharia, Monali Pradeep, et al. "Pharmacogenomics of Metformin-A Way to Personalised medicine." *International Journal of Pharmacology* 5.2 (2016): 55-61.
[14] Zheng, Yan, Sylvia H. Ley, and Frank B. Hu. "Global aetiology and epidemiology of type 2 diabetes mellitus and its complications." *Nature Reviews Endocrinology* 14.2 (2018): 88.
[15] Burden of NCDs and their risk factors in India (Excerpted from Global Status Report on NCDs-2014).
[16] KC, Haritha Yadav, and Venkat Rao. "Pharmacogenomics in diabetes mellitus: Pathway to personalized medicine." *Helix-The Scientific Explorer* 2.6 (2013): 215-220.
[17] Deepthi, B., et al. "A modern review of diabetes mellitus: an annihilatory metabolic disorder." *J In Silico In Vitro Pharmacol* 3.1 (2017).
[18] Zhou, Kaixin, and Ewan R. Pearson. "Insights from genome-wide association studies of drug response." *Annual review of pharmacology and toxicology* 53 (2013): 299-310.
[19] Khandelwal N, Dhundi SN, Yadav P, K PP, Year Scholar F, of Rasashastra D, et al. Prevention and management of Diabetes Mellitus in Ayurveda. Vol. 1, Asian Journal of Biomedical and Pharmaceutical Sciences. 2011.
[20] Spécialistes, Union Européenne Des Médecins, et al. "The 3rd EFLM-UEMS Congress."
[21] Bailey, C. J. "The current drug treatment landscape for diabetes and perspectives for the future." *Clinical Pharmacology & Therapeutics* 98.2 (2015): 170-184.
[22] Rubinstein, Adolfo L., et al. "Abstract P445: Prevalence, Awareness and Control of Diabetes Mellitus in the Southern Cone of Latin America." (2013): AP445-AP445.
[23] American Diabetes Association. "Diagnosis and classification of diabetes mellitus." *Diabetes care* 27 (2004): S5.
[24] KC, Haritha Yadav, and Venkat Rao. "Pharmacogenomics in diabetes mellitus: Pathway to personalized medicine." *Helix-The Scientific Explorer* 2.6 (2013): 215-220.
[25] Stumvoll, Michael, Barry J. Goldstein, and Timon W. van Haeften. "Type 2 diabetes: principles of pathogenesis and therapy." *The Lancet* 365.9467 (2005): 1333-1346.
[26] St Onge, Erin, et al. "The role of glucagon-like peptide-1 receptor agonists in the treatment of type 2 diabetes." *Journal of translational internal medicine* 5.2 (2017): 79-89.
[27] Ou, Shuo-Ming, et al. "Effects on clinical outcomes of adding dipeptidyl peptidase-4 inhibitors versus sulfonylureas to metformin therapy in patients with type 2 diabetes mellitus." *Annals of internal medicine* 163.9 (2015): 663-672.

[28] Adeghate, Ernest, and HubaKalász. "Suppl 2: Amylin Analogues in the Treatment of Diabetes Mellitus: Medicinal Chemistry and Structural Basis of its Function." *The open medicinal chemistry journal* 5 (2011): 78.
[29] Hsia, Daniel S., Owen Grove, and William T. Cefalu. "An update on SGLT2 inhibitors for the treatment of diabetes mellitus." *Current opinion in endocrinology, diabetes, and obesity* 24.1 (2017): 73.
[30] Boughton, Charlotte K., Neil Munro, and Martin Whyte. "Targeting beta-cell preservation in the management of type 2 diabetes." *British Journal of Diabetes* 17.4 (2017): 134-144.
[31] Verspohl, E. J. "Novel pharmacological approaches to the treatment of type 2 diabetes." *Pharmacological reviews* 64.2 (2012): 188-237.
[32] Larijani, Bagher, et al. "Stem cell therapy in treatment of different diseases." (2012): 79-96.
[33] Lee, K. O., S. U. Gan, and R. Y. Calne. "Stem cell therapy for diabetes." *Indian journal of endocrinology and metabolism* 16.Suppl 2 (2012): S227.
[34] Rahim, Fakher, et al. "Stem cell therapy for patients with diabetes: a systematic review and meta-analysis of metabolomics-based risks and benefits." *Stem cell investigation* 5 (2018).
[35] Whiting, David R., et al. "IDF diabetes atlas: global estimates of the prevalence of diabetes for 2011 and 2030." *Diabetes research and clinical practice* 94.3 (2011): 311-321.
[36] Pharmacogenomics review. Available from: https://www.researchgate.net/publication/331703642
[37] Toomula N, Bindu H. Pharmacogenomics- Personalized Treatment of Cancer, Diabetes and Cardiovascular Diseases. J Pharmacogenomics Pharmacoproteomics. 2012;03(01).
[38] Centers for Disease Control and Prevention. "National diabetes statistics report, 2017." *Atlanta, GA: Centers for Disease Control and Prevention, US Department of Health and Human Services* (2017)..
[39] Anjana, Ranjit Mohan, et al. "Prevalence of diabetes and prediabetes in 15 states of India: results from the ICMR–INDIAB population-based cross-sectional study." *The lancet Diabetes & endocrinology* 5.8 (2017): 585-596.
[40] Prasad, Rashmi B., and Leif Groop. "Genetics of type 2 diabetes—pitfalls and possibilities." *Genes* 6.1 (2015): 87-123.
[41] Mohlke, Karen L., and Michael Boehnke. "Recent advances in understanding the genetic architecture of type 2 diabetes." *Human molecular genetics* 24.R1 (2015): R85-R92.
[42] Raghavendra, A. H., et al. "Prevalence of diabetes mellitus in an urbanized village of East Delhi." *National Journal of Community Medicine* 7.4 (2016): 303-306.
[43] Zhou, Kaixin, et al. "Pharmacogenomics in diabetes mellitus: insights into drug action and drug discovery." *Nature Reviews Endocrinology* 12.6 (2016): 337.
[44] Malandrino, Noemi, and Robert J. Smith. "Personalized medicine in diabetes." *Clinical chemistry* 57.2 (2011): 231-240.