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"The Study Of Awareness & Analysis Of Stem Cell Technology Business In The Maharashtra State Of India"

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Abstract: - The term stem cell was coined by Theodore Boveri and Valentin Hacker in late 19th century (Miguel Ramaldo, 2007). Revolutionary works in theory of blood stem cell were conducted in the beginning of 20th century by Artur Pappaenhein, Alexander Maximow, Ernst Neumann.

Stem cells have fascinated both biologists and clinicians for over a century.

Stem cells are special human cells that are able to develop into many different cell types, from muscle cells to brain cells. They have ability to fix damaged tissues. Researchers in stem cells believe that stem cell-based therapies have a potential to treat serious illness such as Paralysis, Alzheimer.

There are two types of stem cells, embryonic stem cells and adult stem cells. For research purpose embryonic stem cells are useful and they come from unused embryos. These can be donated or come from in vitro fertilization. The nature of Embryonic stem cells is pluripotent. That means they can turn into more than one type of cell. Adult stem cells are of two types: Tissue specific stem cells such as the brain, skin and bone marrow and these are more likely to generate only certain types of cells. Induced pluripotent stem cells is the second type of adult stem cells and these can be changed in lab to be more likely to generate embryonic stem cells.

The objective of this research is to study the stem cell technology which is rapidly developing field that collaborate the efforts of cells biologists, genericities and clinicians and offers hope of effective treatment for variety of malignant and non-malignant diseases.

Biology has revolutionized the world of medicine. This discovery of stem cells has come of great interest The study on stem cells has already been exploited in different countries and India is not behind. The stem cell research field has become one of the most practical fields offering exciting career options. Researchers grow stem cells in-vitro. These cells have the capacity to be manipulated to specialize in specific types of cells like blood cells, heart muscle cells or even the nerve cells. Stem cells, the specialized cells, can be implanted in a person. For example, a person with heart disease can be cured by injecting the cells into his/her heart muscle. The healthy transplanted heart cells would then repair the defective heart muscles .

However, people are still very doubtful about career opportunities in biosciences and biomedical science & engineering. It is true that the research scopes in India are quite limited due to various factors like lack of innovative mindset, insufficient funding and most importantly lack proper infrastructure. Still, in recent years, fields like regenerative medicine, stem cell therapy, and tissue engineering, have caught the interest of the Government and Industry, including the VC firms. The VC funding in companies active in regenerative medicine has increased to $807 million in 2016 (Goldman Sachs) from $296 million in 2011. Stem cell banks are getting flourished across India. There are several Indian start-up companies working in the field of stem cells and regenerative medicine very actively.

Another aim of this research is to check the awareness about the advancements in stem cell field to medical professionals, general common people in order to access or capture different career opportunities in this field. Researcher want to know which factors effects on awareness and accepting the facts of stem cell technology.

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Researcher is eager to know and spread a word of mouth which trends, business opportunities are waiting for freshers/youngsters/graduates. So that limited research scope in biomedical science and engineering can be boosted with the help of positive mindset, sufficient funding, good infrastructure and skillful manpower.

Introduction

Stem Cell Definition

(P.K., 2006.)[1], Stem cells are cells of the body (somatic cells) which can divide and become differentiated.

(Stem Cell Biology, n.d.), Stem cells are a specific type of cell capable of evolving into many different types of specialized cells within the body.

(Shiel, 2017), One of the human body's master cells, with the ability to grow into any one of the body's more than 200 cell types. Stem cells are homogenous cells that are characteristically of the same family line. They hold the ability to split all over life and give rise to cells that can become highly specialized and take the place of cells that are lost.

So, in simple words,

"Stem cell is a cell having a unique property to develop into special cell type in body and such stem cell can be used in future to replace cell or tissue that have lost due to disease".

Macular degeneration, spinal cord injury, stroke, burns, heart disease, diabetes, osteoarthritis and arthritis, such disease can be treated using stem cell.

Types of stem cells

According to National Institute of Health, broadly there are three types of stem cells[2]:

Adult Stem cells/Non-embryonic/tissue stem cell

- Adult stem cells main function is to maintain or repair tissues in which they are found.
- Adult stem cells have been identified in many organs and tissues including brain, bone, marrow, peripheral blood, blood vessels, skeletal muscle, skin, teeth. Heart, gut, liver, ovarian epithelium and testis.
- Adult stem cell are more specific than embryonic stem cells.
- These are undifferentiated stem cells.
- These stem cells are found throughout the body after development
- Ability to divide or self-renew indefinitely and generate all the cell types of the organ from they originate.
- Adult stem cells are not controversial like embryonic stem cells, because the production of adult stem cells does not require the destruction of an embryo.

[1] Wikipedia,the free encyclopedia

[2] National Institute of Health,Stem cell basics, Reffered on 22 March 2020,updated on April 08, 2015.

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- **Clinical Significance**: Adult stem cells are used for many years to successfully treat Leukaemia and related bone/blood cancers utilising bone marrow transplants.

Embryonic/Pluripotent stem cell

- As name suggests these type of stem cells is derived from embryos. Mostly embryonic stem cells derived from embryos that develop from eggs that have been fertilized in vitro (IVF clinic) and donated for research purpose with the concept of donor.
- Though embryonic stem cells have tremendous potential to treat many diseases their use remains controversial because of their derivation from early embryos.
- Human embryonic stem cells are useful in Cell replacement therapies, Clinical applications, for drug discovery, to cure genetic disorders, to repair DNA damage, for clinical trials.
- There is ethical debate because of the nature of stem cell research, harvesting of embryonic stem cell.
- Opponents of ESC research counter that an embryo is a human life, therefore destroying it is murder and the embryo must be protected under the same ethical view as a more developed human being.[3]

Induced Pluripotent Stem cells-iPSCs

- These type of stem cells are derived from adult stem cells.
- They share characteristics with embryonic stem cells in that they can become any cell type in the body.
- These type of stem cells offer a unique chance to model human disease and are already being used to make new discoveries about premature aging, congenital heart disease, cancer, and more.

- Induced pluripotent stem *(iPS) cells* are cells that have been bring out in the lab to convert tissue-specific cells, such as skin cells, into cells that behave like embryonic stem cells. IPS cells are critical tools to help scientists learn more about normal development and disease onset and progression, and they are also useful for developing and testing new drugs and therapies.
- While iPS cells share many of the same characteristics of embryonic stem cells, including the ability to give rise to all the cell types in the body, they aren't exactly the same. Scientists are exploring more about these cells. Researcher's experience is going on to find out the alternative way to create iPS because of which they can be used as a source of cells for further treatments.

[3] (Perrin2, 2014)

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Literature Review

(Jee Leng LYE, 2015), says that different education programme on stem cells should be implemented in order to improve knowledge, awareness of them and to encourage positive attitude among them about detail study of stem cells. To study stem cell is now very important in nursing care, specifically in undergraduate nursing students and for those who will be part of it like health providers and teachers. This study shows that there is need to promote stem cell knowledge and its applications and so that to create awareness and to keep inform about the progress in this field. Proper knowledge of this technology can empower the future nurses to gain more knowledge and therefore improve the holistic approach towards nursing and which impact in quality of life of many patients.

(Parika K Chitroda, 2017), have published a study regarding awareness of stem cell among dental professionals, this study put a light on reality that very few practitioners have an idea about treatment through stem cells. Very few of them have attended, workshops, conferences, seminars to enhance their knowledge in treatments using stem cells. And large no of dental professionals agreed that dental professional associations should regulate the use of stem cell and regenerative dentistry whereas many were not sure of it.

According to this study there is need to spread knowledge about different applications , storage, banking related to dental stem cells among dental professionals.This study strongly emphases on the focus on knowledge up gradation about advances in applications, storage, banking and guidelines related to dental stem cells.

(Shaban, 2018), says that after completion of graduation, training program should be introduced in order to acquire knowledge, attitudes, and practices so as to fit recently advanced concepts in healthcare. In order to improve current medical innovation and evidences and to get educated in Umbilical cord blood collection and any current technologies, educational program should be incorporated, or students approach should be towards attending conferences, seminars in order to get themselves aware about the same.

(Amisha S Amin, 2016), stated that nurses have poor knowledge on umbilical cord stem cell therapy and importance of it, there is a need to educate every stakeholder of therapy. The researcher that the staff nurses' have poor knowledge on umbilical cord stem cell therapy and there is a need to e ducate the staff nurses on the same aspect through on job training.

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(Ryuma Shineha, 2018), conclude that, the certification or education program should be run to enhance education for academic members and thereby contribute to quality medical treatments and potential protection. Awareness about regenerative medicine social responsibility and regulatory framework is required among scientists, such as those regarding its benefits, potential accidents, abuse, and other social consequences. Accordingly, training programs for scientists are essential.(Tan C. Keat1*, 2016),says that there is a high knowledge on stem cells among medical professionals in Klang valley, but the level of self–perceived knowledge is still need to improve as a medical professional in order to guide patients for the treatment.

(Conroy, 2016) **,** focused on the education about stem cell to public, pressure for effective regulations and rigorous research in field of regenerative medicine. Stem cell tourism exists in South East Asia, Russia, and Eastern Europe. Perception about stem cell therapies in the mind of experts and public is different, many patients motivated for cure and excited by hope. (Farhin Katge, 2017), according to this research the awareness among dentist about stem cell is quite good and they have generic knowledge about it, but the sources, types, applications of stem cells understanding is less. But the data shows dentist are very keen to get themselves updated for upcoming trends, and this can be done by talking or brainstorming in seminars, academic journals and conferences. DSC hold vast potential, so having detail knowledge of this one is important or necessary.

(Goomer, 2014), explain the importance of making people aware about the health benefits of stem cell from primary teeth. Parents are not aware about retaining primary teeth and its preservation for future applications. Very first parents goes to paediatrician for treatment or counselling, so to create awareness or to guide them properly professional are expected to have holistic knowledge about it. So that medical professionals can motivate patients for cryopreservation of first teeth.

(D, 2016), after preservation of umbilical cord blood and extraction of stem cell out of it, these stem cells can be effectively use to treat a variety of blood and bone marrow diseases, blood cancer, metabolic disorders, and immune deficiency. Researcher found poor information about the stem cell, obstetrician can play a key role in educating them about the benefits, usage and applications of stem cell.

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(Moni Tuteja, 2015), inadequate knowledge and utility of UCB makes lay person and doctors at risk to the marketing strategies. More than 50% of doctors and more than 80% of the people do not know about the use of cord blood for transplantation. Around half of the lay persons (42 %) and doctors (37 %) thought that umbilical cord blood can be used to treat any genetic disorder including Duchene muscular dystrophy and mental retardation. More than 15 % of the doctors thought that umbilical cord blood can be used to treat thalassemia in the same child. Soothe publicity done by commercial businesses like cord blood banks that cord blood is a biological insurance for the child is misleading and should be discouraged. With the help of obstetricians and the paediatricians by providing the correct information to would be parents to help them in taking a correct decision will make things easier. And for this the awareness and proper knowledge about the emergent technology to the professionals like obstetricians and the paediatricians should be there.

Pharmaceutical-

(W.Pouton, 2015)**,** express his opinion about the applications of stem cell technology in pharmaceutical sciences that ,stem cell technology is used to gain mature human cells has the potential to provide much improved cell culture models. In addition PSCs can provide human cells for, replacing defective cells or cells that have been lost due to damage or disease. His team is focussed on developing improved models of brain disease, particularly in relation to neurodegenerative diseases such as Parkinson's and Alzheimer's diseases. (Corona, 2016), in the article named "Medicine, pharmacy students show support for Sickle Cell Center", Students from the UIC College of Medicine and College of Pharmacy are facilitating the Sickle Cell Center at the University of Illinois Hospital & Health Sciences System to recognize its value in the Chicago community. Being students they could not do much for them due insufficient skills, donation of some amount for research was significant to them. With the help of External funding support to the treatment developments and research initiatives that the canter's researchers and physicians are involved in, Gordeuk said. According to one of student the students' donation will improve the quality of life for more than 600 adult and nearly 200 paediatric patients.

(Alnajdy), In "Perception of pharmacist in the era of pharmacogenomics, gene and stem cell therapy" this new technology is going to impact the pharmacy business and the type of services the pharmacist going to offer to patients. It is very important and essential to pharmacist to involve in this process to incorporate these new technologies into practice. In

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this assessment of knowledge of students and pharmacists about these technologies and their views, expenses and recourses are the most common obstacles they talk about as most of them. Faculty members are also in opinion of integration of such topics in the curriculum. According to author, pharmacists look like not have enough knowledge about these topics. Authorities should conduct lectures, can give printed materials and online access to research materials can lead the education and importance of the technology among the pharmacists and students. (Mao, 2015)**,"** stated in his article, Regenerative medicine: Current therapies and future directions", propose directions for current and future regenerative medicine therapies. Stem cells, whether isolated from adult tissue or induced, will often require tight control over their behaviour to increase their safety profile and efficacy after transplantation. Second, the creation of large engineered replacement tissues will require technologies for further process. Thirdly, creating a preorganisation environment within the patient may dramatically improve outcomes of regenerative medicine strategies in general. A better understanding of the patient's health affect regeneration will likely also be important for advancing the field in many situations. (Dori L. Borjesson, 2011),"The regenerative medicine laboratory: facilitating stem cell therapy for equine disease", emphases on the emerging field of equine regenerative medicine with an importance on the use of mesenchyme stem cells (MSCs) for orthopaedic diseases. The practices in laboratory Current laboratory in regenerative medicine reflect those in the human field. Though, the translational use of autologous and allogeneic MSCs for patient therapy is currently permitted in human medicine. So, the upcoming trend should be aware to all aspirants in medical education because of this promising field.

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(CIRM, 2011), High school students get creative in California stem cell labs, according to the discipline or by combining the discipline (engineering, chemistry, social sciences, ethics, music or other academic fields) sponsored summer program encourages the most creative high school students to spend time working in a stem cell lab. By focusing on young faculty, graduate students, masters and undergraduate students, ensuring that California has the scientific talent to fill biotech jobs and create the next generation of stem cell therapies. Programs like this reaches even additional down that pipeline, making sure promising high school students get the experience they need to go to college and earn science degrees. By encouraging smart young people in California to bring fresh ideas into the stem cell research field," said Alan Trounson, CIRM President. So, they are not only supporting the next generation of stem cell scientists, they are promoting the kind of innovative thinking which will leads to novel breakthroughs in science."

(UNIVERSIT)**,** One of the best idea to promote the awareness of stem cell research and therapies by providing proper training, laboratory based learnings or by providing them an internship to the graduates. By giving them initial foundation level training students can be engaged to patients direct query solving process or interactions activities and through this students can share their knowledge and expertise with communities.

(Joshi, 2015),stated in research “Awareness and Attitude of Physicians in Academia towards Human Stem Cell Research (HSCR) and Related Policies in Rajasthan, India”, Medical society is the merely perfect way to endorse the importance and benefits of stem cell research, and it would be to raise the awareness by spreading the success stories in Indian journals, giving information regarding its uses in clinical practices. There is a consents among health professionals that it should be part of the programs for medical, dental and paramedical graduates, as health professionals in their academic career are responsible for developing and evaluating training programs, designing curricula and assessing resident doctors, researching and implementing innovations in the medical field and dealing with policy and accreditation issues. Authentication of institutions involved in stem cell research should be recognised and the activities should be verified.

(Medicine), “Unique Research Opportunities for Medical students”,

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Stem cell biology is a unique field of medical study with the potential to necessarily change our thoughts and treatment of human diseases. MD students should get motivated to explore the research opportunities and should participate in the related activities.

Factors affecting on acceptance of stem cell technology:

(Herberts, 2011), [21], study protocol, location and cost are the main obstacles and effects on the acceptance by stakeholders.

Market potential, upcoming business trends:

Currently following areas define the market for stem cell products:

- Basic Research
- Regenerative medicine
- Drug testing and development

Stem cell product sales worldwide:

- Primary antibodies to stem cell antigens
- Bead-based stem cell separation systems
- Fluorescent-based labelling and detection
- Stem cell protein purification and analysis tools
- Tools for DNA and RNA-based characterization of stem cells
- Isolation/characterization services
- Stem cell culture media and reagents
- Stem cell specific growth factors and cytokines
- Tools for stem cell gene regulation
- Stem cell services and mechanisms for in vivoand in vitro stem cell tracking
- Expansion/differentiation services for stem cell media and RNAi
- Stem cell lines

- **Key report findings include:**
- Market size determinations, with 5-year projections (2016-2020)
- Year-over-year analysis of stem cell grants, patents, clinical trials, and scientific publications

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- Stem cell funding sources, trends, and amounts (domestic and international)
- Stem cell research applications, including priorities by segment
- Relative demand for stem cell products, by stem cell type
- Breakdown of stem cell product categories
- Competitive analysis of leading stem cell research product companies
- Online trends for stem cells, including Google Trends and Google Ad words
- Social analytics for stem cells, including activity on Twitter, LinkedIn, Facebook, and more
- Communications strategies for accessing the marketplace
- End-user survey of stem cell scientists

(Railton, 2019),In “What are stem cells and why are they important?” brief about the stem cell in therapy, current therapy working, ethical issues and current research in stem c ells. To treat type I diabetes and heart diseases stem cell is contributing. Additionally, stem cell in drug development and drug testing are the major element which can make another business trend. In recent years, treatments through stem cell can be done in separate clinics.

(Catharine Paddock, 2016),Eye lens regeneration from own stem cells: 'a paradigm shift in cataract surgery', This is the most successful work which represent a new approach in regenerative medicine and through which human disease can be treated and may have a good control on regenerative therapies by harnessing the regenerative power of own body.

- **Emerging Areas Of Stem Cell Research**

A. Induced Pluripotent Stem Cells (iPSCs)
B. Cord Blood Stem Cells
C. Dental Pulp Stem Cells
D. Adipose-Derived Stem Cell Storage

- **Best Stem Cell Related Business ideas for the Future-**

A. stem cell therapy clinic
B. stem cell research centre

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C. Distribute chronic wound cell therapy products
D. Produce stem cell anti-aging products
E. Manufacture cancer cell therapy products
F. A cell regenerative clinic
G. Become a stem cell scientist
H. Organ repair or replacement lab
I. Epigenetic Drug Discovery and manufacture
J. Manufacture 3D organ printers
K. Set up a cell-based screening business
L. Open a biomaterials company
M. Start a specialty biopharmaceutical company
N. Develop pro-healing medical devices
O. Manufacture regenerative veterinary medicinal products
P. Open a tissue engineering company
Q. Distribute regenerative medicinal products
R. Produce laser-assisted bioprinting machines
S. Distribute human amniotic tissue grafts
T. Start a stem cell related blog
U. Open a stem cell processing center
V. Start an apple stem cell extract business
W. Sell stem cell nutritional supplements
X. Buy stem cell stocks and ETFs

(Krishna, 2019), he identified an opportunity in the medical tourism which led him to co-found a company called Planet Hospital. He focuses on to begin his own medical tourism business. Vipul was also a part of social organisations. He latter realise the need for better stem cell research in India.

As stated by YES Bank, the Federation of Asian Biotech Associations (FABA), the top five players in the Indian private sector space in stem cells currently are Reliance Life Sciences, Life Cell, Cryobanks India, Stempeutics and Trans-Scell Biologics. Indian companies are more engrossed on stem cell banking and research.

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Here Vipul's business strategy differs - he focuses on the therapy aspect.

The Indian Government has been quite positive in endorsing work in stem cells, especially in clinical trials, basic research and creating applications. The Department of Biotechnology invested in stem cell research for 5 year.

Vipul, is neither a scientist nor a technologist. He admires himself a serial businessperson who happened to see stem cells as the future of healthcare.

ReeLabs has already initiated a step towards med claim cover to stem cell therapy and looking forward to popularizing stem cell banking at government hospitals across the country. So, according to Dr. Abhijit, stem cell industry has likely to increase medical tourism in India.

Global Stem Cell Banking Market – Segment Analysis is as follows:

By source- Stem cell banking market is segmented into placental stem cells, adipose tissue-derived stem cells, bone marrow-derived stem cells, human embryo-derived stem cells, dental pulp-derived stem cells, and other stem cell sources. The placental stem cells share holds the most important segment and are likely to have the highest growth rate, owing to the overall rise in the number of placental and cord banks worldwide, particularly in the US and Europe combined with growing public awareness on the potential of therapeutic with stem cells.

By service- Again the market is segmented into preservation and storage, analysis, processing, collection and transportation. Along with processing sector collection and transportation services are also gaining motivation to hold the sustainable share in the market. The preservation & storage share is anticipated to be the fastest growing segment, owing to the growing adoption of stem cell banking services in significant countries coupled with the high market penetration of stem cell banking services.

By bank type- The market is divided into private and public stem cell banks. Private stem cell bank dominant the market segment because of high revenue made by private stem cell banks. But, the number of public banks present are more than private banks.

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Application Insights:

On the basis of application, the market has been segmented as personalized banking applications, research applications and clinical applications.

Global Stem Cell Banking Market– Competitive Analysis

Players in this market are adopting strategies such as mergers and acquisitions, partnerships, and regional expansion to stand out as sturdy entrants in the market. New product launches along with increased focus on R&D are other ways the leading players improve their market presence.

Dubai Healthcare City has proclaimed an increase in stem cell banking services with the opening of CryoSave Arabia's laboratory that can store a million samples and is the only private facility in the region licensed to collect, process, test and cryogenically store stem cells.

LifeCell Internationalis the India's largest stem cell bank which is expanding into diagnostics and tissue therapeutics. LifeCell moved from a private stem cell bank to a public bank.

Business Line(April,2012),[26]"Stem cell market all set to grow". There is potential for fast growth and global players will enter the market through mergers and acquisitions, says a study by YES Bank and the Federation of Asian Biotech Associations (FABA).

Due to stem cell therapy growing, it is attracting several organisations and industry to invest, create and commercialise promising technologies. The global stem cell therapy market was pegged at $21 billion in 2010. It is projected to grow to $60 billion by 2015, the study pointed out.

The market for stem cells will include specific products, services and technologies to aid in diagnosis to cure.

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(Dr Abhijit Bopardikar, 2013), 'Stem cells industry has potential to boost medical tourism in India', **'Stem cells industry has potential to boost medical tourism in India',** In a recent interview with BioSpectrum, Dr Abhijit Bopardikar, director, ReeLabs spoke on various issues including the controversy surrounding the industry, his company's operations, market opportunities, regulations among other things: The real issue is that people don't know that what kind of technology is accepted by the regulations and what is not. Proper mindset before availing the treatment is very necessary. Where there is lacking? Lacking is in the awareness about the convenience/ availability and limitations of treatment to the general public. It leads to the mistreatment by the dishonest elements who have in reality nothing to do with the stem cells. Unfortunately, the law stops at the guidelines level itself.

In review of literature chapter researcher has given review of papers, government reports, newspaper, bulletins, magazines, websites,etc. To maximise awareness, holistic approach, perception among medical professionals through laboratory training, certification or education programs, conferences, seminars is very important in view of further progress in this field and to penetrate the same thing to the common people, medical professionals are the first/faithful contact person to them to gain maximum authentic information.

Since, there is potential for fast growth and global players are entering the market through mergers, acquisition and collaborations. Pharmaceutical industry- drug development and testing, by service- medical tourism, preservation, counselling, analysis, processing, extractions, medical insurance, finance sector has potential to grow fast, laboratory development for research, Collections, transportation, manufacturing, cell regenerative clinics are the emerging business through this technology.

So, study of awareness to the medical professionals, general people, and investigation & realization of upcoming business trend in Pune and allied area is the aim of this study.

Research Methodology:

Parameters	**Particular**
Research Design	Descriptive
Research Methodology	Survey
Research Instrument	Structured questionnaire & Interview
Field Work	Pune and allied area

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Scope of the Research Study

Universe of Study		Doctors. Medical Student and common people in Pune and allied area		
Stratification Variable		Common general people, doctors, medical students		
Statistical Tools		ANOVA table, F-Test.		
Primary Data Source	*Category of Respondent*	Doctors	Medical student	Common general People
	Targeted Sample Size (Total :900)	300	300	300
	Sampling Method	Convenience Sampling		
	No. of Primary Questions Asked	38	30	38
	Valid Response For Data Analysis (Total : 738)	249	244	245
Secondary Data Source		Journals, Books, Conference Proceedings, Magazine, Articles etc		

Stem cell banking had gained immense importance in the medical world. Stem cell once introduced into the damaged tissues help to regenerate and repair them.. Because of the good level of awareness, people were opting to bank their children's cord blood Stem cells just like biological insurance. The Indian Stem cell banking market was mainly dominated by private players like LifeCell International, Cryobanks International India, Cryo Stemcell Karnataka, Reliance Life Sciences etc and few not so popular public Stem cell banks like Jeevan Stem Cell Blood Bank. The private Stem cell banks are growing their services and now on track of storing adult Stem cells from dental tissues, menstrual blood, cord tissue, and fat tissue thus increasing their customer base. To explore the full benefits of Stem cell technology, the Indian government was required to develop regulatory framework with proper procedures and guidelines. Besides the inherent social, legal and ethical issues, some of the key factors that affected the Stem cell banking business were ineffective logistics, shortage of skilled professionals and lack of good infrastructure. Thus, it remained to be seen if Stem cell banking would evolve to emerge as a viable business in the Indian healthcare sector.

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The scope of the study is limited to medical professionals, people and patients in Pune and allied area.

Rationale of the study

Stem cell technology has the potential to treat diseases. The growing interest in stem cell research and therapy decrees the development of forceful regulations and oversight along with steps to enhance public knowledge and awareness. There is need to take special efforts to promote the benefits of stem cell research and therapy.

(Mittal, 2013), Principles of stem cell research should be followed during research and therapies. E.g. Principles of essentiality, of voluntariness, informed consent and community agreement, of non-exploitation, of privacy and confidentiality, of precaution and risk minimization, of professional competence, of accountability and transparency, of maximization of public interest and distributive justice, of public domain and the principle of totality of responsibility and compliance.

Objective of study

The present study will be conducted with the following objectives:

1. To study the stem cell technology – Process, Preservation Techniques, Policies.
2. To study and analyse the awareness of Stem Cell technology among customers.
3. To Identify and study factors affecting acceptance of Stem Cell technology.
4. To assess the market potential for Stem Cell business.
5. To find out different opportunities arising out of Stem Cell business.
6. To frame the business development strategies to enhance the new business sector to have customer satisfaction.
7. To study the upcoming trends in business with stem cell technology.

Research Hypothesis

A hypothesis is a statement of tentative supposition or a possible solution to a problem based on experience or judgment or documentary evidence.

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1. There is no association between source of knowing about steam cell technology and residential location of doctors.
2. There is no association between awareness of the potential therapeutic applications with stem cells and medical practice type of doctors
3. There is no association between opinion of doctors as how stem cell technology can help to Increase understanding of how diseases occur and experience of the doctor
4. There is no association between opinion of customers as which source of steam cells is most useful and age of villager
5. There is no association between status of using stem cell technology for customer or for his/her family member and customers profession
6. There is no association between rating for affordability of cost associated with stem cell-based treatment adoption and family income of customer
7. There is no association between rating for Government of India Policies for stem cell-based treatment adoption and MBBS study year of medical students
8. There is no association between opinion about availability of expert doctors for stem cell-based treatment adoption and gender of medical students.

Testing of Hypotheses

Hypothesis 1 -

- H_0 : $\mu = 0$, There is no association between source of knowing about steam cell technology and residential location of doctors

- H1 : $\mu \neq 0$, There is association between source of knowing about steam cell technology and residential location of doctors

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

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ANOVA

How you came to know about stem cell technology?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3.508	3	1.169	6.496	.000
Within Groups	42.476	236	.180		
Total	45.983	239			

From above table, we get Significance value <0.05. We can reject the null hypothesis and accept the alternate hypothesis.

Inference:

There is association between source of knowing about steam cell technology and residential location of doctors. This indicates that residential location is one of the factor which affect on the gaining knowledge about latest developments. Because of lack of resources, the recent updates are not easily communicated to them.

Hypothesis 2 -

H_0 : $\mu = 0$, There is no association between awareness of the potential therapeutic applications with stem cells and medical practice type of doctors

H1 : $\mu \neq 0$, There is association between awareness of the potential therapeutic applications with stem cells and medical practice type of doctors

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

ANOVA

Are you aware of the potential therapeutic applications with stem cells?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.003	3	.001	.031	.993
Within Groups	7.730	236	.033		
Total	7.733	239			

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From above table, we get Significance value >0.05. We can accept the null hypothesis and reject the alternate hypothesis.

Inference:

There is no association between awareness of the potential therapeutic applications with stem cells and medical practice type of doctors. This indicates that the doctor with any specialization can avail or pursue the knowledge or information about the stem cells. Ultimately general practitioner doctor is the first consultant for any patient, so there should not any relation between which degree doctor have and the doctor update himself, herself on latest technology in medical field.

Hypothesis 3 -

H0 : $\mu = 0$, There is no association between opinion of doctors as how stem cell technology can help to Increase understanding of how diseases occur and experience of the doctor

H1 : $\mu \neq 0$, There is association between opinion of doctors as how stem cell technology can help to Increase understanding of how diseases occur and experience of the doctor

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

ANOVA

Stem cell technology can help to Increase understanding of how diseases occur

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	28.366	3	9.455	5.232	.002
Within Groups	426.530	236	1.807		
Total	454.896	239			

From above table, we get Significance value <0.05. We can reject the null hypothesis and accept the alternate hypothesis.

Inference:

There is association between opinions of doctors as how stem cell technology can help to Increase understanding of how diseases occur and experience of the doctor. This indicates that the doctor's expertise makes him/her towards analysis of disease like how the disease does occurs and the necessary treatments planning get stronger. But the young doctors are

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also more inclined towards the gaining more information or updates about the latest technology and research happening in the world.

Hypothesis 4 -

H0 : $\mu = 0$, There is no association between opinion of public as which source of steam cells is most useful and their age

H1 : $\mu \neq 0$, There is association between opinion of public as which source of steam cells is most useful and their age

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

ANOVA

As per your belief, which source of steam cells is most useful? -

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.142	2	1.071	1.459	.234
Within Groups	179.854	245	.734		
Total	181.996	247			

From above table, we get Significance value >0.05. We can accept the null hypothesis and reject the alternate hypothesis.

Inference:

There is no association between opinion of public as which source of steam cells is most useful and their age. This indicates that the opinion of public regarding SC is not dependent on the age. If the results and benefits are positive of any technology / treatment/ research anyone is always ready to gather information about it and ready to avail the treatment which can cure the diseases and can support the research as well.

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Hypothesis 5 -

H0 : μ = 0, There is no association between status of using stem cell technology for customer or for his/her family member and customers profession

H1 : μ ≠ 0 , There is association between status of using stem cell technology for customer or for his/her family member and customers profession

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

ANOVA

What is your status of using stem cell technology for yourself or for family member?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	9.402	5	1.880	2.320	.044
Within Groups	196.110	242	.810		
Total	205.512	247			

From above table, we get Significance value <0.05. We can reject the null hypothesis and accept the alternate hypothesis.

Inference:

There is association between status of using stem cell technology for customer or for his/her family member and customer profession. The educated class with corporate jobs are more aware or say more towards future and contingency and emergency planning opt for such treatments, they think they must have plans and readiness for everything. While those wealthy and rich but are businessman or entrepreneur which has almost similar mix of educated or just had mud level education are more risk taking and don't bother much on contingency planning refrain from availing such services.

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Hypothesis 6 -

H0 : $\mu = 0$, There is no association between rating for affordability of cost associated with stem cell based treatment adoption and family income of customer

H1 : $\mu \neq 0$, There is association between rating for affordability of cost associated with stem cell based treatment adoption and family income of customer

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

ANOVA

How do you rate affordability of cost associated wth stem cell based treatment adoption?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	2.668	3	.889	.915	.434
Within Groups	237.203	244	.972		
Total	239.871	247			

From above table, we get Significance value >0.05. We can accept the null hypothesis and reject the alternate hypothesis.

Inference:

There is no association between rating for affordability of cost associated with stem cell based treatment adoption and family income of customer. This indicates that the adoption of the treatments and preservation off stem cells directly relates to the cost associated with it. Basically, stem cell therapy is a treatment that treats non-serious to life-threatening disorders, by utilizing stem cells. Stem cells can be procured from various different sources and are utilized to treat more than 80 disorders including degenerative disorders. But the cost of SC preservation and transplant is not affordable to all income groups. Those who can afford with their family income, goes with the preservation option.

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Hypothesis 7 -

H0 : μ = 0, There is no association between ratings for Government of India Policies for stem cell based treatment adoption and MBBS study year of medical students.

H1 : μ ≠ 0 , There is association between ratings for Government of India Policies for stem cell based treatment adoption and MBBS study year of medical students

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

ANOVA

How do you rate Government of India Policies for stem cell based treatment adoption?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	1.177	4	.294	.422	.793
Within Groups	170.839	245	.697		
Total	172.016	249			

From above table, we get Significance value >0.05. We can accept the null hypothesis and reject the alternate hypothesis.

Inference:

There is no association between ratings for Government of India Policies for stem cell based treatment adoption and MBBS study year of medical students.

Hypothesis 8 -

H0 : μ = 0, There is no association between opinion about availability of expert doctors for stem cell based treatment adoption and gender of medical students

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H1 : μ ≠ 0 , There is association between opinion about availability of expert doctors for stem cell based treatment adoption and gender of medical students

We would like to test above hypothesis at Level of Significance = 0.05

We study ANOVA table and F-Test.

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ANOVA

How do you rate availability of expert doctors for stem cell based treatment adoption?

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	.219	1	.219	.274	.601
Within Groups	198.137	248	.799		
Total	198.356	249			

From above table, we get Significance value >0.05. We can accept the null hypothesis and reject the alternate hypothesis.

Inference:

There is no association between opinion about availability of expert doctors for stem cell based treatment adoption and gender of medical students. This indicates that gender of medical students and opinion the expert's availability for SC transplants and treatments or research does not link with each other. The opinion on the expert availability doesn't change with the gender of the medical student. Everyone has their own opinion irrespective of the gender.

Findings:

1. Physicians:

Importance of improving knowledge and information about the therapeutic and research potential of stem cell to Physicians: The medical fraternity seems to believe that one of the ways to promote the benefits od stem cells research would be to raise awareness by publishing success stories in newspaper, journals, giving information through physicians regarding its uses in clinical practices. Physicians acknowledge the public health benefits of promoting Stem Cell Research in India.

The study suggests that doctors who were the respondents in the survey are all aware about the basic, generic, specific knowledge about the stem cells. They are updating the knowledge about the same time to time by attending different seminars, conferences based on stem cells and its applications and advancements in the field.

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According to the author of the thesis, these doctors or practitioners are capable to guide common people for basic information or the very first guidance. So that doctors can contribute in the program of creation of awareness among the common people.

The residential location is one of the factors which effect on the gaining knowledge about latest developments. Because of lack of resources, the recent updates are not easily communicated to them.

The doctor with any specialization can avail or pursue the knowledge or information about the stem cells. Ultimately general practitioner doctor is the first consultant for any patient, so there should not any relation between which degree doctor have and the doctor update himself, herself on latest technology in medical field.

The doctor's expertise makes him/her towards analysis of disease like how the disease does occurs and the necessary treatments planning get stronger. But the young doctors are also more inclined towards the gaining more information or updates about the latest technology and research happening in the world.

2. Common people

Expected mother/parents of children's studying in elementary school: The study throws light on less than desirable knowledge (knowledge deficit) in the subjects who claimed to have heard about stem cells and knew about stem cells. It is high time that the message needs to be passed for the benefit of larger population and larger good. A concerted effort can take this issue forward. In future, we may see a day when noncommunicable diseases are tackled effectively and efficiently with stem cells research and application.

3. Medical Students

The level of stem cell awareness amongst medical students did not depend upon their education stage. Many students were aware of stem cells but still there is lack of acquaintance from the curriculum. Probably due to public commercial resources and stem cell banking services, the awareness about the umbilical cord stem cells is high. Though the awareness level about the stem cells is high but the general knowledge about the stem cell was very poor. Even so the level of knowledge is low but the perception towards the SCR is high. The

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primary data analysis shows that students were interested in gaining knowledge about stem cell research and this led to the suggestion that possibly this topic could be added to the syllabus. And hence students would be able to gain more proper information about the stem cells that just gaining it from commercial resources.

There is no association between ratings for Government of India Policies for stem cell-based treatment adoption and MBBS study year of medical students.

There is no association between opinion about availability of expert doctors for stem cell-based treatment adoption and gender of medical students. This indicates that gender of medical students and opinion the expert's availability for SC transplants and treatments or research does not link with each other. The opinion on the expert availability doesn't change with the gender of the medical student. Everyone has their own opinion irrespective of the gender.

The study and survey suggest that majority of the student's respondents are from District place and metro city and majority of them are studying in first year of MBBS. Male and female students have contributed almost equally in respondents.

4. Medical Professionals Awareness

   Altogether, there is a very high degree of awareness o stem cells among medical professionals like doctors, medical students, consultants in medical field. But being a medical practitioner, the level of perception or perceived knowledge is still inadequate.

5. Indeed, it is important that health professionals should update themselves with the knowledge of stem cells. Stem cell treatments, therapy is an emerging modality and it is believed that it would be one of the greatest untapped resources currently available for the preservation and treatment of many diseases. Researcher suggest that a common man can be educated and motivated to store their children stem cell. When the professional would have expertise in it then only common man can explore more through them and could be motivated to store the cord blood stem cells and avail the different treatments for diseases occurs in future.

6. Affordability & acceptance:

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The study suggests that, the adoption of stem cell technology for treatment is directly relates to the costs associates with it. Basically, stem cell therapy is a treatment that treats non-serious to life-threatening disorders, by utilizing stem cells. Stem cells can be procured from various different sources and are utilized to treat more than 80 disorders including degenerative disorders. But the cost of SC preservation and transplant is not affordable to all income groups. Those who can afford with their family income, goes with the preservation option. Almost 50% of People are quite aware about the uses of stem cell treatment over diseases like Parkinson's, Alzheimer's, cancer, diabetes or heart disease and are acceptable as well, but the availability of doctors for treatment is still a thing which makes people hesitated towards treatment.

7. Profession

The educated class with corporate jobs is more aware or say more towards future and contingency and emergency planning opt for such treatments, they think they must have plans and readiness for everything. While those wealthy and rich but are businessman or entrepreneur which has almost similar mix of educated or just had mud level education are more risk taking and don't bother much on contingency planning refrain from availing such services.

8. So, the study suggests that profession of individual also matters while availing such treatments exactly like financial income, education and awareness towards the technology.

9. Majority of respondents in the survey was in 31-40 yrs. age group and <31 yrs. old. Seeking more and more knowledge and updating about recent trends and technology is more in this age group. Internet is the major source of gaining knowledge of this age group. Creating awareness through social media platform and internet will be effective in this case. Since these respondents are more in private jobs so the contingency planning is the thing where these people more focused in. So that they could afford it if they have planned for

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contingency or opt for it in insurance and many people would like to use it as an when required.

10. Market Overview: According to the report "Stem Cell Market Size Worth $17.9 Billion by 2027 | CAGR: 8.2%: Grand View Research, Inc." by Grand view research dated 2 March 2020 at 9:35, the global stem cell market size is expected to reach USD 17.9 billion by 2027, expanding at a CAGR of 8.2%. In recent advancement it has been proved that tissue engineering has the potential to draw attention to the treatment of several chronic disorders. And addition to this automation in adult and cord blood processing and storage is expected to drive market growth significantly.

11. Adult stem cell segment occupied the maximum share in 2019 and same is expected to maintain across the period and this is due to the properties like long term renewal, low rejection rate, and less ethical concerns.

12. Regenerative medicine segment is also moving towards the huge que for regenerative medicine products.

13. Cell acquisition, allogenic therapy also gaining attention to occupied a major revenue share through cancer treatment and graft-versus-host response in organ or tissue transplant.

14. Active participation of main companies, extensive government funding and increasing research have contributed to the largest market share in North America.

15. The Asia Pacific region is expected to grow at a profitable pace owing to strong product channels in regenerative therapies and large patient population.

16. Osiris Therapeutics Inc; BIOTIME, INC.; Celgene Corporation; STEMCELL Technologies Inc.; and Cynata are some of the key players operating in the stem cells market.

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17. The key players are undertaking strategic initiatives to maintain their market share. They are keen to seek investment from other bodies and also collaborate with other pharmaceutical giants. This is set to enhance market growth over the forecast period.

16. Following are the few business opportunities which can be helpful for youngsters:

Stem cell preservation banks, stem cell therapy clinic, stem cell research center, Distribution of chronic wound cell therapy products, Production of stem cell anti-aging products, Manufacturing cancer cell therapy products, a cell regenerative clinic, an organ repair or replacement lab, Epigenetic Drug Discovery and manufacturing, Manufacture 3D organ printers, a cell-based screening business, a biomaterials company, a specialty biopharmaceutical company, pro-healing medical devices, Manufacturing of regenerative veterinary medicinal products, a tissue engineering company, Distribution of regenerative medicinal products, Produce laser-assisted bioprinting machines, stem cell labs, a stem cell related blog writing, a stem cell processing centre, an apple stem cell extract business, Sell stem cell nutritional supplements, Buying stem cell stocks and ETFs,etc

There is no association between ratings for Government of India Policies for stem cell based treatment adoption and MBBS study year of medical students.

There is no association between opinion about availability of expert doctors for stem cell based treatment adoption and gender of medical students. This indicates that gender of medical students and opinion the expert's availability for SC transplants and treatments or research does not link with each other. The opinion on the expert availability doesn't change with the gender of the medical student. Everyone has their own opinion irrespective of the gender.

The study and survey suggest that majority of the student's respondents are from District place and metro city and majority of them are studying in first year of MBBS. Male and female students have contributed almost equally in respondents.

On the basis of the conclusions drawn which is obtained from the data analysis based on the survey and discussion held with the medical students, doctors and general people and literature review carried out, a few recommendations are presented as below:

Recommendation 1 Education Program

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Research and academic institutions and educators should encourage to participate by hosting public talks and other activities and events in their community in order to educate the general common people aware and familiar with the concept.

Recommendation 2 Knowledge Upgradation

Medical professionals like specialist doctors, general physicians should attend the seminars and conferences based on such latest/emerging technology so that they could grab more knowledge and percolate the same in common people or patients in order to consult them properly.

Recommendation 3 Graduate training Program

A graduate training programme is a way of bridging the gap. Graduate training programme ease candidates into the world of work and give them the skills necessary to become part of the larger team. So, the youngsters who do not have the background of this field to grab the employment, there should be the graduate training program.

Recommendation 4 Motivation to Patients/General People

Testimony is something that shows the experience of someone which does exist and true in nature. Since this research or technology is still emerging, common people need an example to believe on. Testimony of success stories of successful treatments should spread among the people. So that awareness would increase and patients will feel ease while opting for this process of treatment.

Recommendation 5 Information hub for about the process and counselling for people.

General physician is the first person to whom aa patient or family meet first time. That is why it is necessary that general physicians should be aware about the concepts of emerging technology so that they can guide their patients. Addition to this medical professional can start an information hub wherein people can get all information about the emerging technology. And all the counselling can be done with the help of experts or doctors on virtual or physical platform.

Recommendation 6 Simplicity in treatments and availability of expert doctors.

It has been observed in this study that affordability and availability of expert is the major concern as far as the treatments are concern. Medical students can generate their interest in this field and can guide to patients and make the process simplified. As medical students would get the expertise in the field can continue the treatments for patients.

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To make experts available and reduction in the cost of treatments is very important part of this emerging technology.

Recommendation 7 Funding for the treatments and research

Cost associated with this treatment is very high. Government should give full support for stem cell research in terms of funding. Insurance companies generally do not pay for stem cell treatments, they may pay for your consultation with the doctor and other associated costs that are incurred during the procedure. As far treatment is concern there should be insurance coverage so that we can encourage people to avail such treatments.

Recommendation 8 Policy Reformation in clinical research perspective

The increasing global interest in stem cell research & therapy commands development of a strong regulation and oversight along with steps to boost public knowledge and awareness. Embryonic stem cells should be obtained from embryos remaining from infertility procedures after the embryo's progenitors have made a decision that they do not wish to preserve them. This decision should be explicitly renewed prior to securing the progenitors' consent to use the embryos in ES cell research.

Persons considering donating their excess embryos for research purposes should be afforded the highest standards of protection for the informed consent and voluntariness of their decision.

Special efforts should be made to promote equitable access to the benefits of stem cell research.

Intellectual property rules for stem cell research should set conditions that do not restrict basic research. It is essential that there be a public that is educated and informed about the ethical and policy issues raised by stem cell research and its applications.

Future Scope

The present study was focused on to the study of awareness of stem cell technology and identification of the business opportunities arising out of it. Specifically, Pune and allied area was the locational limitation of this study. The study can be further conducted for different district or for Maharashtra state as well, where researcher can analyze the awareness of stem cell technology and business aspect associated with it.

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In addition to above, the future research work can also be carried in investigating, potential business opportunities and role of in bio medical, chemical and logistics industry for supporting the growth and reach of stem cell technology and facilities across geography.

Another scope for future research is to compare and analyze the present scenario of stem cell technology with various reports in order to investigate realities of the technology as well as the to advocate a comprehensive recommendation to Government for increasing awareness and providing ease in treatments related to Stem cells.

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