

Biosensors Applications in Medical Field and Current Developments in Biosensors for Healthcare

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Abstract

The aim of the study "Biosensors Applications in Medical Field and Current Developments in Biosensors for Healthcare" is to find out uses of the biosensors in the medical field and its current practices which have been going across the world. Modern medicine is concerned with finding all the answers to the complex question of the medicine and diseases for which the biosensors are an adequate technology. It has been used not only in hospitals by the hospital bed but also by the common people for home diagnosis of pregnancy as well as the glucose. The methodology that has been taken for this research and is has been discussed about the secondary data type along with the thematic data analysis method. In the results part an in-depth regarding the topic has been discussed with the preparation adequate themes. The themes are based on the importance of the biosensor technology, its current practices and future developments. After this the challenges regarding the use of the biosensor use has been given with help of proper solution of all the challenges that has been discussed.

Keywords

Biosensor, Diagnosis, Disease, Medical.

INTRODUCTION

Biosensor is a type of analytical device that is often used for detecting the chemical substance which combines with the biological component with a device called a physicochemical detector. These are generally used to monitor **disease**, discovery of newly formed drugs, pollution detection and **diseases** that are often caused due to microorganisms and the indicators are tested through the body fluids like the blood, urine and saliva [1]. There are five different types of **biosensors** and those are enzyme based **biosensors**, tissue based sensors, DNA bio sensor and piezoelectric **biosensors** are some types of **biosensors**. In 1956 Leland C. Clark coined the term **biosensor** and the purpose for its introduction was to detect the oxygen. After its introduction it has been used exclusively in the **medical** field both in the curing and in research and development. Currently the **biosensors** have been used in **medical** fields like the home testing of glucose and lactate, in hospital bedside testing, emergency, surgery and dialysis monitoring [2]. These are some of the most known uses of the technology of **biosensors** in the **medical** field and they are used so because of its significance.

Significance of the **biosensors** is like it is highly specific, it is bio compatible, it is economical and it is precise and accurate in its implementation. Due to these benefits it has been used exclusively in the **medical** field whether it is to diagnose the **disease** of the patient or developing the medicines by the pharmacy companies [3]. In this research it is going to discuss the significance of the application of **biosensors** in the field of medicine and its future implications. As the technology has been progressing day by day the technological progress has also been going in the **biosensors** as well. Some of the recent developments are

fluorescent tags to non-materials. Along with the use of the nucleotides, peptides, and molecular imprinted polymers are some of the popular and innovative methods that have been used exclusively over the traditional methods of usage of the **biosensors**. More about these technologies will be discussed in the results section along with its significance and current practices. The future of the **biosensors** technology will also be discussed along with the technological transformation that is required for its effective operation. Its applications in the **medical** field as well as in the pharmacy sector are enormous therefore all of its applications will be discussed in this section of study.

MATERIALS AND METHODS

Research design

Material and method is where the methodology will be discussed that has been utilized for the preparation of this research. The research design that has been utilized for performing this research based on the **biosensors**' application in the **medical** field. The research design that has been used in this research is qualitative research design. Qualitative research design is the type of research design which deals with the research of the topic on a theoretical basis [4]. The research topic is based on the current practices of the **biosensors** technology and its application in the **medical** sector. It needs both concepts and some quantitative data for the purpose of interpretation. Due to these reasons the reason design has been used in the research is qualitative research design.

Research type

The research type that has been used in this research is a secondary research type as due to the importance of the research topic. It is a type of research which includes the

reports and studies of the government as well as the NGOs, trade associations [5]. The research topic does require such a report therefore the secondary research type has been taken for this research. In the collection of the data regarding the usage of the *biosensors* the data of the governmental as well as the nongovernmental organizations becomes important. As it provides the data of an organization's *medical* sector is using the technology of *biosensors* and for different uses. The budget that is allotted for the technological development of *biosensor* will also be obtained from these websites as well. Therefore, the research type that has been taken for the research is the secondary research type.

Data collection and analysis method

In this research data has been collected on the basis of the secondary data collection method as the research has been designed according to the qualitative research designing. A secondary data collection method is the type of data collection where data for a particular research is being collected with the help of journal, media articles, books and surveys which are prepared by other researchers as well as governments. After the collection of the data the next part which comes is the data analysis part in which with the help of different types of data analysis methodology the data is being analysed. For this research the collected data is being analysed with the help of thematic data analysis method. A thematic data analysis is the type of data analysis method which is used to analyse the data with the help of themes which are prepared according to the research topic [6]. In this research the themes will be prepared according to the significance of the *biosensors* as well as its future implications.

RESULTS

Importance of the biosensors in the field medical field

Biosensors are used in many areas like in *disease* monitoring, drug discovery, detection of pollutants like the particulate matter, and others. Its use in the *medical* sector is seen as the most significant as in the *medical* field it has achieved a lot of space like in detection of *disease* as well as in curing.

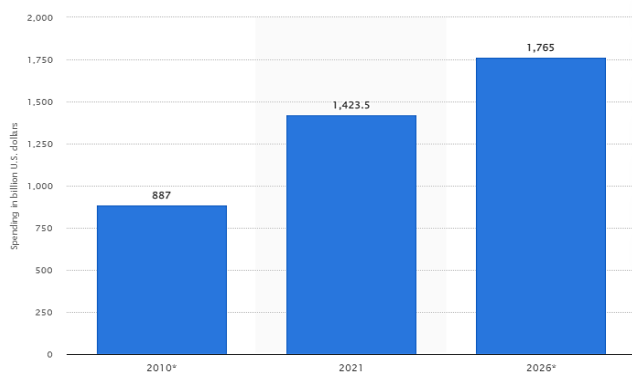


Figure 1: Global spending on the medicine from the year 2010 to the year 2026

For understanding these two aspects, it needed to be understood and those aspects of the *global* spending on medicine and the amount of money which are spent by the people *globally* in the health sector. According to the graph as of the year 2010 *global* spending on the medicine sector was 887 billion US dollars [7]. Which is a significant amount but in the year 2021 it had risen dramatically to the mark of 1423.5 billion US dollars [7]. Many experts suggest that the reason behind this rise is the covid pandemic of the year 2020 and it has been an ongoing pandemic which had not completely; instead the vaccines have been prepared.

The *diseases* which are diagnosed with the help of *biosensors* are celiac *disease*, breast cancer, prostate cancer, and the Hepatitis B virus. After the *diagnosis* of a particular *disease* then the medicine or the vaccines are prepared. Hence, if a particular is not diagnosed properly then only the medicine for that *disease* will be provided. After the pandemic the overall expenditure in the *medical* sector is expected to rise by the year 2026 to 1.8 trillion US dollars as much of this will go towards research and development [7]. Apart from the expenditure towards the medicine a huge amount of money is spent towards the *diagnosis* of a *disease*.

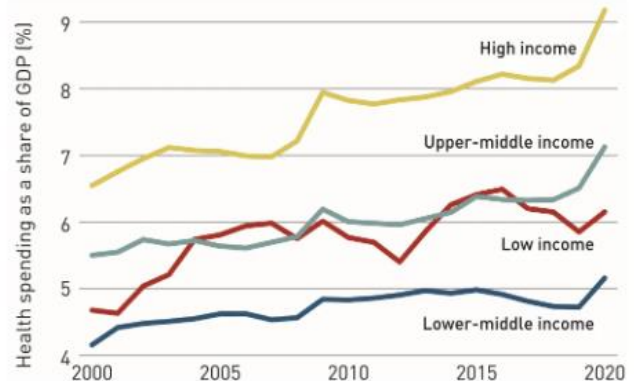


Figure 2: Global healthcare spending from the year 2000 to the year 2020

Health care spending has been increased *globally* whether it is lower-middle income, low income, upper-middle income and the high income countries according to their GDP. Their stats have been shown according to the government's spending towards health care. In this the area where the government spends is preparing a proper *medical* infrastructure, medicine and the *diagnosis* of *diseases*. *Diagnosis* of the *disease* is the crucial part of the *medical* sector. Its significance could be understood with the help of an example as of the year 2023 the *disease* Hepatitis B is present in the countries of Asia, Africa, Middle East and part of South America. The most significant reason behind this is not having the proper testing facilities and the poor *medical* infrastructure in these countries. Most of these countries come under the category of the low income and low-middle income countries and as of the year 2020 the percentage share towards the *medical* sector was around 5% and 6% of the GDP [8]. After the covid pandemic of the year 2020 the

global GDP share towards the *medical* sector has increased drastically which was around 11% of the GDP that is 9 trillion US dollars [8]. Apart from the covid pandemic the *disease* like breast cancer, hepatitis B, diabetes is some of the *diseases* that the world has been affected right before the pandemic and it will definitely require the technology of *Biosensors*. Hence, it can be said that the *biosensors* have been a significant part of the *medical* part and currently there is no other technology that will replace it in near future as well.

Recent developments regarding the biosensor technology and its future implications

Like any other technology the *biosensor* has also developed it with respect to the time that was available and recent trends has been given below. Technology like the nonmaterial based *biosensors*, optical and visual *biosensors*, Quartz/crystal *biosensors*, and the electrochemical *biosensors*. *Nano material based biosensors*, a nonmaterial can be considered as the size of the material with at least the external dimension is approximately 100 Nano meters with the internal dimension is less than 100 nm [9]. *Biosensors* on the other hand are the technology that is used for the *diagnosis* of the *disease* and the *disease* that can be diagnosed up to the extent of the size of the nonmaterial is the nonmaterial based *biosensors*. The term was coined way before because progress has been started in recent days. There are many of the uses of the nonmaterial based *biosensors* and some of its uses are the immobilization of bimolecular, amplification of signal, mediators and the detection of Nano probes.

Optical and visual biosensor, the optical *biosensor* is the most common *biosensor* and it is used in exploiting the interaction of the optical field with the recognition of the bio-element. The *diseases* that are diagnosed with the help of the technology of optical and visual *biosensors* are different types of viruses, toxins, drugs, tumour biomarkers and tumour cells. Using the optical has certain advantages and those advantages are like it has high sensitivity, it is small in size, it is cost effective and it has a high specificity. *Electrochemical biosensors*, an electrical *biosensor* are the type of *biosensors* which are often used for the *diagnosis* of the quality of the food and environmental monitoring [10]. This type of *biosensor* is often used to provide an attractive means for analysing the content of the biological samples with the direct conversion of the biological event to the electrical signals. The best example of the electrochemical *biosensors* is the glucose *biosensors* and the most common type of the electrochemical *biosensors* is the potentiometer *biosensors*, electric *biosensors*.

These are some of the developments that are going on throughout the world in the technological development of *biosensors*. In future as the technology is progressing in the pharmacy as well as in the health sector it is expected to rise further in future as well. Current market size for the pharmacy company is around 28.5 billion US dollars and it is estimated that the revenue will rise further in future to more

than 58 billion US dollars [11]. All of this has been provided below in the figure that has been provided and in this figure the overall revenue is also expected to rise. If the overall revenue is expected to rise in future, it is also sure that the *global* investment will also rise in future. These figures are long term and much of the investment and patience is needed. After the pandemic of the year *global* investment as well as the expenditure towards the healthcare sector has been increased.

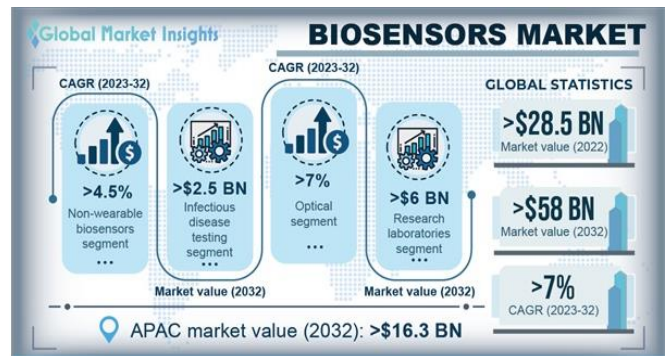


Figure 3: Size of the market of biosensors

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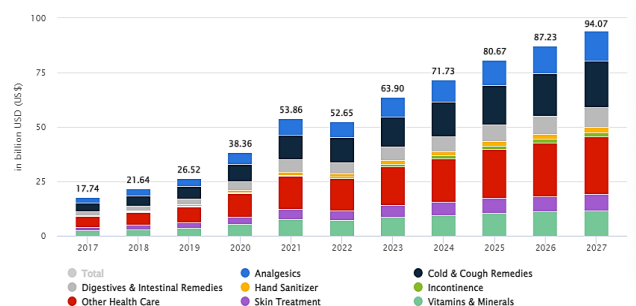


Figure 4: Growth parameter of the healthcare sector

Health care sector has witnessed a tremendous growth and role of both treatment and preparation of the medicines as well as the health infrastructure. During the pandemic when the share of none other companies other than the information technological companies have grown. In the year 2020 the total 38.36 billion US dollar has been generated as revenue

and it includes the analgesics, cold & cough remedies, vitamins & minerals and incontinence [12]. The figure that has been provided above has projected that in the year 2027 the revenue from the overall health care sector will be 94.07 billion US dollars [12]. Therefore, it is very much possible that in the future *biosensors* technology will witness significant changes according to the research and development in this field.

Challenges with the usage of the biosensors in the medical field and its possible solutions

The challenges of using the *biosensor* technology are the many drawbacks which somehow show that the technology is malfunctioning or not performing properly in some of the areas. They will be provided according to the *disease* like in the *diagnosis* of HIV Aids virus is that it requires multiple biomarkers as the viral load and the isolation is quite high. Coming to the next part is the *diagnosis* of Tuberculosis *disease* with the help of *biosensors* requires established biomarkers. In the *diagnosis* of dengue fever the aging and the isolation of the virus pose a serious challenge to the *biosensor diagnosis* [13]. Also the presence of the pre-existing antibodies affects the process of the *diagnosis* of the *disease* with the help of the *biosensors*. These are some of the challenges that are totally related with diagnosing the *disease* with the help of the technology *biosensors*.

In general, the technology of *biosensor* has been facing some of the challenges and those are like the detection limit, detection time and the specificity. Each of them will be explained further below and those have been discussed below. *Detection limit*, a detection limit can be explained as the lowest concentration of an analytic in a particular sample which will detect consistently with the stated probability [14]. While at the same time the detection limit of *biosensors* can be explained as the smallest solute concentration which is used to distinguish with the reasonable reliability of the sample without any analyses. In this performance parameter the *biosensor* does not perform well and hence its detection can be seen as its weakness or the challenges that it has been facing. *Detection time*, the detection time of the *biosensor* also termed as the *biosensor* response time and it can be explained and it is termed as the T90. The detection time of the *biosensors* is also high and therefore it can be considered as one of the drawbacks of the *biosensor* technology [15]. Both of these drawbacks can only be improved by improving the detection time of the *biosensor* as well as removing all the detection limits of the *biosensors*. Then only this technology will become more reliable and more compatible. Regarding the diagnostic challenges of the *biosensors*, viral isolation posed by different types of virus.

DISCUSSION

Biosensors are the technology that was coined in quite earlier but its actual transformation has occurred in the past few decades. Its technological progress has been seen in the countries which are economically developed and they are

using this technology not only in diagnosing the *disease* but also in the detection of the pollutants and the most common among them is the pm 2.5. After the technological transformation *biosensors* have developed some of the technologies and the most popular among them are nonmaterial based *biosensors*. Along with this optical *biosensor* and the electrochemical *biosensors* these are some of the best technological advances which boost the diagnosing process. In the results section a detailed rationale has been provided and it is based on the importance of the *biosensor*, its current practices and its future prospects regarding its technological development. The first figure has provided the details of rising investments as well as expenditure in the field of medicine and after studying those trends it can be figured out that in future there the *medical* sector will witness significant investment. In the year 2026 the *medical* expenditure *globally* will reach 1765 billion US dollars. Sad part of this development is that it has been provided to the developed nations only.

There *globally* the overall GDP rise has shown that the progress regarding the *medical* infrastructure is centred on the high income nation. GDP share growth has not shown immensely in the countries with low income and the low-middle income and moreover the reason is termed as the poor health infrastructure. Whether a country has a poor health infrastructure or good health could be understood with the help of its *diagnosis* process. If any of the country is unable to diagnose a *disease*, then it is very much possible that it will be unable to cure them properly. The next graph that has been provided has talked about the market size as well as the extent of the *biosensors*. Today the *biosensor* is the technology which is used exclusively in the various processes worldwide and its popularity is diagnosing the different types of *disease* with the help of samples that are taken from the bodily fluids. Therefore, the *disease diagnosis* market has become equivalent to the *biosensor* market. According to the *global* statistics, in the year 2022 the market value of the *biosensor globally* was 28.5 billion US dollars and it has been taken separately from the *medical* field. In the future that is as of the year 2032 the overall revenue is expected to reach the mark of 58 billion US dollars which can be seen as a progressive step towards the *biosensors* development program.

In the later part of the results part the growth statistics of the *global* healthcare sector has been explained. Today the *global* health care sector is in a crisis and especially after the pandemic of the year 2020. After the covid pandemic the health budget of most of the nation has been increased. In the budget the expenditure parameters were set towards the making of sanitizers, analgesics, cold & cough remedies, digestive & intestinal remedies, skin care treatment, and other health care areas. According to the projection that has been provided in the graph most of the things that included in the revenue was centred to the products which were somehow centred to the covid pandemic but as the importance of *biosensor* technology to diagnose pregnancy and diabetes it

will also influence the market in future. After that the challenges regarding the *biosensor* have been discussed both in the *diagnosis* process of the company as well as the challenges in general. *Biosensors* technology faces some of the challenges when it is used to diagnose the *disease* like the Dengue, Hepatitis and HIV and all of these has been discussed and from the discussion can be said that viral isolation is the common challenge which is faced by the *biosensors*.

CONCLUSION

Applications of *biosensors* have been centred towards the *diagnosis* of *diseases*, treatments as well as in the preparation of different types of medicines. It has been significantly used in the *medical* field after its discovery in 1956. This research paper has discussed the current developments of the *biosensors* in the *medical* field and those have been covered according to their specific uses. This discussion has been covered in five distinct parts namely the introductory part, the material and methods part, the results part, the discussion and finally the conclusion part. The introductory part has shown the historical development as well as the significance of the *biosensor* in the *medical* field. In the current scenario the technology of *biosensors* is used in the hospitals for the purpose of testing of the glucose, lactate, surgery and dialysis monitoring. With its uses a research and development was also carried out parallels with use of this technology and new types of *biosensor* technology were explored in the market like the electrochemical *biosensors*, nanomaterials *biosensors*, visual or optical *biosensors* and many more. Apart from the healthcare or *medical* use it has also been used in pollution monitoring with carefully examining the particulate matters.

In the next section a brief discussion about the research methodology has been given and according to the research topic the types of research methodology has been used. It has been categorized into four distinct parts namely the research designing part, research type and data collection & analysis. The research design that has been used in this research is the qualitative research design whereas the research type that has been taken is the secondary research type. When it comes to the data collection the data that have been available in the online sources as well as in the offline sources. Such type of data that is used in the preparation of a research paper is termed as the secondary data. Collected data has been used for the detailed and this has been performed with the help of the thematic data analysis. The themes have been prepared according to the significance of the *biosensors* in today's world with wide varied uses. Other themes are based on the future as well as the current developments in the field of data *biosensors* technology.

After this a brief discussion part has been provided with the help of which it has been discussed all the important points, findings and values. Important findings are that there is an increase of the expenditure towards the healthcare sector and if it is then it is probable that it can be predicted that in

future the technology *biosensors* are going to increase. The current market stature for the *biosensors* technology is good and according to the graph that has been provided it will rise further in future. Hence, from this research it can be said that the *medical* field has a wide range of applications of the *biosensor* especially when it comes to the *diagnosis* of *disease*. Current developments have shown that this will improve in future as well.

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