

■ REVIEW ARTICLE

Impact of Biomedical Engineering on Human & Social Dynamics: A Review on Recent Approaches Through Bioengineering from Recent Past to Post-Covid-19

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ABSTRACT

INTRODUCTION:

The paper aims to discuss the various issues/ problems that people face in day to day life. Using diverse scenarios ranging from mental health issues to common grafting procedures, the author here strives to link these issues to bioengineering and how they are being impacted by modern technology. Most methods and procedures discussed attempt to utilize day-to-day activities and ease of access. The paper has adopted rapid review method. For literature collection, Google scholar database has been used with a scope of specific keywords and time frame of 5 weeks to complete the study.

KEYWORDS | Bioengineering; Healthcare; Mental health; Biotechnology; Tissue grafting; Smart phones, Rapid review.

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INTRODUCTION

The basic idea behind this study through review is to try and link modern day issues and how the solutions regarding them have evolved within the past 20 years. The paper aspires to discuss certain problems that are prevalent within a large section of the society and the ways to solve it that have slowly yet surely, evolved further and further to reach a conclusion. Many complicated issues have been addressed such as tissue grafting, infertility, neurological issues, decellularization, etc. However the paper also attempts to acknowledge the more common issues such as biosensors, mental health disorders, etc. In the end the paper tries to justify the impact of bioengineering and biotechnology on modern world issues, especially in the past 2-3 decades.

METHODOLOGY

Rapid review method has been used in the present study. This method is useful while reaching to conclusion in a short deadline, usually less than 5 weeks. In comparison to other review methods, the rapid review method is speedy and provides a deep outline of related previous researches. Rapid reviews are a form of evidence synthesis that may provide more timely information for decision making compared with standard systematic reviews.” (AHRQ: Agency for Healthcare Research and Quality). The working definition, ‘a rapid review is a type of knowledge synthesis in which components of the systematic review process are simplified or omitted to produce information in a short period of time^{1,2}, is providing the simple details of steps followed

in the review/ research method.

Followed stages in the present review study are given as:

Time frame: ≤5 weeks: The author endeavoured to explore resources available through the time frame of last 2 decades as well as last 3 years to collect literature and complete the study in the time span of almost five weeks.

Research Question: The Narrow question was framed by using PICO model. The question was as following: Estimating the relation of bioengineering advances (Output) in recent times and their applications in medical, societal and human aspects.

Sources and searches: Google scholar search engine was used to collect the literature. The time frame was maintained since 2000 to 2022. It was observed that repeating the searches after one week, the retrieved results were reproduced.

Selection: Inclusion criteria involved various research articles, papers, books and reports on the basis of following keywords/ titles/ concept discussion in their contents.

- A : Bioengineering and society
- B : Mental healthcare and biotechnology
- C : Biomedicine and tissue grafting
- D : Impact of modern technology on tissue decellularization
- E : Environment and biotechnology
- F : Bioengineering utilization for portable apps
- G : Smartphones and bioengineering

Appraisal: The study was rigorous in selection of articles/published literature to follow the limited timeframe of weeks.

Synthesis: The descriptive and analytical summary has been explained in the conceptual manner in chronological order.

Information sources and literature search

To identify potentially relevant studies for inclusion, the following platforms were searched: Google scholar and open access material. Due to time limitation, the search

was limited from 2000 until 2022. The author drafted the literature searches based on the subject knowledge and premonition, which was refined through repeated online searches over the time period of one week. The author focussed inclusion to the specific keywords/ phrases as mentioned above in the ‘selection’ criteria only.

Screening process

The screening criteria were established a priori and author screened the literature search results independently, and discrepancies were resolved through online crosschecking.

Synthesis

To synthesize the descriptive results, the author performed content analysis. Frameworks can be utilized to search for the needed parts of the research question so the author’s own efforts can be used to find out relevant results. The PICO search framework^{3,4} is an adaptable approach to help and consider the question in terms of the following elements:

- P:** Patient/ Population/ Problem
- I/E:** Intervention/ Indicator/ Exposure/ Event
- C:** Comparison/ Control
- O:** Outcome

The research question stemming from this scenario could be phrased in this way:

PICO	Scenario
P (patient/population/problem)	Human beings
I (intervention/indicator)	Medical, societal aspects
C (comparison/control)	Recent times and their applications.
O (outcome)	Estimating the relation of bioengineering advances

Narrow question: Estimating the relation of bioengineering advances (O) in recent times and their applications in medical, societal and human aspects.

The Environmental Aspect and human element

In these modern times, challenges to our environment, global warming and rising temperatures caused by various greenhouse

gases emitted and the drastic changes being brought to our planet have resulted in a huge discussion. The industrial revolution in the 19th century, and the quick breakthroughs experienced in the field of technology within the past 200 years have drastically changed the state of health and welfare of humanity. However, due to improved healthcare, vaccines and prevention of diseases, the population on Earth has skyrocketed to almost 8 billion. For a brief comparison, in 1970, the total number of cars in the world was 250 million, however this number has now reached a sky high 1.4 billion. (This huge number is attained only for passenger cars).⁵ With this steadfast increase in population as well as the reduction in poverty, we have also started using various resources like petroleum, natural gas, water, oxygen, forests etc., at an alarming rate, meanwhile at the same time producing harmful residue such as carbon dioxide, dirty/unusable water and other forms of waste.

A simple observation can be taken from the patterns of Carbon dioxide production across the recent centuries. For example, through modern estimate, the production of carbon dioxide in the 1750 was a meagre 0.01 billion metric tons. However the figure has now increased exponentially to reach an alarming 34.81 billion metric tons in 2020.⁶ Therefore, to deal with this situation lest it becomes too adverse to be stopped, various global measures and protocols have been set up. These protocols and measures are supposed to act as a guideline on the various measures that can be taken to ensure that carbon dioxide production remains at a level where it can be safely dealt with. After a hole in the ozone layer discovered above Antarctica, the Kyoto protocol was brought into effect to prevent any further enlargement of the hole. The efforts have been partially successful, as the hole has now reduced, but the levels of Carbon dioxide production have however continued to reach new heights.⁷ These efforts and methods however, are not going to be successful without the involvement and support of the general public.

Social Anxiety and solutions through technologies

In this modern world, people are readily judged, and are always ready to judge. Such tendencies to evaluate other people and exposure to the same have led to the creation of social anxiety disorder in many people. However in recent times, Cognitive Behavioral therapy, (CBT) has emerged as an effective method to help treat patients with social anxiety. Since a major aspect of CBT involves registering the thoughts of the patient so they can be reviewed/ examined for retrospection. However it is simply not possible for the patient to be able to contact the therapist under all circumstances. Therefore a very simple yet effective conclusion upon brain storming was the development of a simple app that would ensure on the spot communication between the patient and the psychologist/ therapist when needed. This idea took the form of the "Appsiety" app. This allows the patient to record their mental processes and then send this data to the therapist for further reviewing. The app not only provides an easy medium for the patient therapist communication but also allows the therapist to analyse and suggest improvements at all times. The current testing has shown promising results, however further speculation will help analyse better whether the app is perfectly fine or not, and what improvements will help make this idea mainstream.⁸ The environment, human aspects and international scenario also pose challenges⁹⁻¹¹ which are mixed in nature. Attention should be paid to human resources, their relation with the environmental factors, chemical processing¹²⁻¹⁴ and their impacts on human health.

Bioengineering, consumer psychology and its effects

These recent times have seen a boom in the fields of computer science, Information technology and the artificial intelligence. However, Biotechnology is supposed to overcome all of these in terms of sheer financial success. However, the amount of social research and simple data concerning biotechnology is simply not developed enough to lead the field to its full potential. Most of the social studies concerning biotechnology happen to be of qualitative nature, and are restricted to the usual policies concerning

the public such as knowledge and perception of risks etc. It is extremely important to understand and research on how the general public that forms the consumer base will react to and in the long run, affect the consumer market. As technology advances, there are newer and newer inventions emerging from this field, nations have genetically modified food crops and modern polymers extracted from genetically modified microorganisms, newer and better drugs to treat/prevent lethal diseases such as cancer, AIDS, Parkinsons, and various other examples that some time ago would simply have been considered impossible. However the success of these drugs is, in very simple words, driven by customer satisfaction. That is to say, these methods will never make it to mainstream unless and until the customer response for these biotechnological creations is positive. Another incentive on trying to understand why (if in any case) there are any feelings of anxiousness experienced when exposed to these products. The firm/producers can then look forward to coming up with any innovative ways of overcoming any negative emotions/feelings that the customers may experience. The study ultimately aims to understand any existing patterns between the suggested solutions and the existing stereotypes that people usually experience when asked to deal with unknown products of such types. Of course, a study like this¹⁵ that deals with the public in general cannot be expected to negate any doubts caused by personality traits. Therefore in the end it also becomes possible to analyse the underlying traits present in people that may make them more/ less vulnerable about any such decisions.

Biosensors and Identification of Disorders

Across the last century and in recent times as well, we can see computer science coming together with bioengineering in various ways, such as database creations, Human genome project, and many more. Modern times have seen an increasing frequency of psychological disorders such as anxiety, depression and much more. These have been found interlinked with the level of social activity and engaging with the people around an individual. Most of these disorders are diagnosed through

retrospection, i.e., the patient explains to therapist the events/emotions experienced in the past and the therapist attempts to link these to find the causes. However, this method is subject to its own inaccuracies due to the personal subjective bias that the patient might have while explaining this event. Even tactics such as ecological momentary assessment, which involve reporting of any suspected events by the patient himself/herself have been deemed inefficient over prolonged periods of investigation. Patients experiencing depression have often been provided with devices that are able to monitor their bodily signs, however most patients have resorted to stop wearing these within ten days of being administered. The quick development in mobile cameras and processors has led to quick integration of modern facilities to provide even faster and better biosensors.¹⁶

According to a recent survey conducted in 2019, 81% of Americans had smart phones, in people with advanced countries; this number rose to 76%, meanwhile only about 45% citizens had access to smart phones in developing nations.⁸ These ever rising statistics are a simple proof that smart phones have become an integral part of our lives and it now becomes impossible to even imagine the state of various happenings of our daily lives in their absence. The presence of embedded sensors that have access to global network can be utilized to provide a free stream of objective data effortlessly at all times. This is especially useful to note any behavioural issues/discrepancies. According to modern day studies, this data can be further processed to detect the presence of any mental health issues. Utilizing technology to analyse various factors such as the places a person goes to, the amount of time spent in these places, methods of communication, contents of the said communication, etc can be used to diagnose any mental issues such as depression, anxiety etc at an early stage.

The trend of Smartphone related endeavours rise and rise!

However, a trend to be noted is that even though the early 2nd decade of the 21st century proved hopeful for these smartphone based ventures, the demand and boom had

died down in the 2nd half of the decade.¹⁷ Sensing and recognizing the linking between human behaviour and corresponding mental health has heightened the usefulness of sensing the aforementioned stress levels through smartphones. But it is known, no form of research/ innovations is prone to set backs. Therefore there are some issues that persist with this research as well. Most of the patients/ volunteers involved were actually a part of small group all of similar traits (for example, workers in the same organization in the same field). Therefore, some speculation has been found regarding the authenticity of the location feature and its ability to identify anxiety or depression through issues in communication. However some researches in the same field have reached a contradictory conclusion. This may simply be due to the subjective nature of human mind which was not accounted for in the current studies as the experimental groups were homogenous.

These smartphone endeavours, while useful have not yet attained their peak efficiency to detect behavioural issues; however with some time and development in this field, it is expected to improve the situation.¹⁸ Augmented reality is also soon expected to be involved in bioengineering and medical fields¹⁹ due to the great efficiency smartphones are now able to attain.

Decellularization and Tissue Grafting

A recent survey in the USA has determined that around 27000 people die due to the various disorders related to liver every year. Even with the advent of modern technology, orthotopic transplantation is the only viable solution to treat end stage liver failure. However the growing numbers dictate that the demand for this treatment will increase manifold simply due to the ever increasing rates of Hepatitis C. While the number of the sick and negatively affected is bound to increase, the number of eligible people capable of donating their organs will be reduced due to escalating obesity rates and various other disorders. Therefore, many other methods of donation have been suggested as to increase this shrinking donor pool.

However, these methods are not fail proof, in fact, various transplant methods in the past have had to be rejected or simply cancelled as the grafts were rejected by the body and led to eventual casualties. Recent advances in Bioengineering have displayed that transplanting hepatocytes (basic liver cells) holds a more promising way of solving this problem, as has been displayed under various testing conditions and small scale human transplants. But the catch to this success is the fact that these grafts not only have an extremely low efficiency/success rate, but as well that the number of eligible donors is very low. However, not to be discouraged, as more and more studies are suggesting that radiation surgery is going to be extremely efficient in the near future to facilitate liver transplants. Decellularization of entire organs such as heart, liver etc has already been achieved in lab rats. However, in transplantations, decellularization in itself just isn't enough; we have to ensure that proper liver grafts are developed to ensure the transplant isn't rejected and is in vain. Since discarded tissues are also capable of being utilized for these decellularization purposes and there is no lack of such abandoned tissues, it is extremely feasible now to work on this field of research without negatively impacting the current number of available organs up for any transplantation.²⁰ Respiratory disorders are often passed off as cough and not diagnosed, however with modern apps that utilize sound detection to identify respiratory disorders²¹, it shall soon be an issue of the past.

Exquisite, physical and enzyme based research is needed to ensure that decellularization as a process remains stable, as many different factors have to be paid heed too, such as membrane potential, osmotic pressure, etc.²² In these modern times, decellularized tissues have been utilized in various fields involving bioengineering, tissue grafting, etc.²³ However, a special attention must be given to the adverse effects of these processes on the extracellular matrix and the response of host. While the clarity of immunogenicity of tissues in the decellularized state have been thoroughly researched upon and are supported with

concrete evidence, there is a yet a need of clarification for the state of long duration immunogenicity of repopulated neo-organs²⁴ before they can be brought into use for medicinal purposes.

Long run goals and Aspirations in Bioengineering/ Biotechnology

The ultimate goal of all the technological developments that have ever happened has been simple they existed to make life easier and more satisfying. For thousands of years, people have been exercising controls over various parts of their body to utilize them for different tasks. However, certain people are mildly paralysed and experience inability to move certain body parts. The human body surgery and bioengineering are hand in hand since last couple of years. The advances of biotechnology and bioengineering have witnessed a long journey.²⁵⁻²⁸

The recent times have gone through much advancement in the human life betterment and bioengineering. The literature has reflected a transition from the human computer interaction to application of “biomimetic endometrium” and organ bioengineering.²⁹⁻³¹ Whereas the bioengineering learning is significant, the tangible user interfaces, research approaches and technologies are paving way for advanced medical facilities and societal transformation.³²⁻³⁴ Similarly, there are some people who are so much affected by paralysis, that they are simply unable to assert locomotion or movement without any external support. Even to perform tasks deemed normal by most people, they require technological need. Many a times, these people affected by severe disabilities/paralysis are simply unable to communicate with other people through normal means such as speaking, writing or any such conventional activities. Some of the causes of involve stupor, lesions in the brainstem, or any trauma involving significant brain injury. In situations like these, the patients were simply neurologically challenged to exploit any of these neural pathways to achieve communication.³⁵

DISCUSSION

Before the industrial revolution caught on in the 18th-19th century nature's ability to check out human activities was at par with the required level. Simply put, the rate of utilization of resources by humans and the production of waste was low enough for the various forces of nature such as bacteria, plants, fungi and several other living organisms to recycle these waste products, and give back the required resources to the ecosystem. However, with the passage of time, the global economies stabilized and improved consistently, this eventually led to better and better technology so to lead what we observe today, in our daily lives. This development in technology has led to improved health facilities; hugely inflate population which has negatively affected the aforementioned process of recycling these resources. Simply said, the rate of consumption of these natural resources and the rate of production of these pollutants/negative elements to the environment have exceeded the rate at which the previously noted processes could fix it.

Therefore with the help of technology, a new solution was developed Human computer interfaces, equipped with the latest advancement in machineries, these interfaces are capable of receiving messages from the patient, decode them, and then simultaneously transmit them to the needed source. People have breathed a new life into the daily hustle bustle of these disabled people, and with time will help to improve the situation further.^{36,37} Also, the areas of mental healthcare are being supported by bioengineering and other systems. Various examples from recent past³⁸⁻⁴⁰ and after Covid pandemic⁴¹⁻⁴³ are reflecting the active roles of such systems and branches of medicine along with the engineering components. The roles of bioengineering have traversed since slope protection and environment^{44,45} to a diverse medical arena of thermodynamics of cells, microbial activity in natural environment.⁴⁶⁻⁴⁸ How the multifarious scope of biotechnology and bioengineering has intricately affected the society and humans in various sectors of life, the sustainability of environment^{49,50} is being secured by the interventions of bioengineering. At one hand

the research is ongoing in the highly delicate components; cell structures of human body, at the other the areas affecting society at large being taken care by bioengineering.

CONCLUSION

Following observations and findings have been reached on the basis of literature reviewed.

1. The societal aspects including environment, social anxiety and human health at large scale is constantly supported by biotechnology and bioengineering.
2. Decellularization of entire organs such as heart, liver etc., has already been achieved in lab rats. It is extremely feasible now to work on this field of research without negatively impacting the current number of available organs up for any transplantation since discarded tissue can be used for it. A very hopeful field!
3. Smartphone based apps have been somewhat successful in their endeavour of helping in various mental disorders. However more testing is required to ensure transparency in results.
4. Modern interface based devices that enable communication have proven revolutionary in enabling disabled people and helping them connect better with this world.
5. Biosensor based apps may be able to utilize any disorders through simple samples of sound/ chemicals, hence proving extremely useful to diagnose disorders before it is too late.

EVIDENCES

1. Search dates January 2000 May 2022. The author reviewed 50 full text articles, books/ reports and published abstracts.

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- a. Bioengineering and other supportive fields such as biotechnology are going to play a major impact in society and human health issues (studies listed at reference section 7, 8, 9, 14, 16, 17, 18, 36 – 50 are supporting the argument).
- b. Bioengineering will be integrated with more technological opportunities to enhance its current scope of development (07 studies related with bioengineering integration and increasing roles are listed at 5, 6, 10, 11, 12, 13, 19 references).
- c. Bioengineering will be integral in various other complications such as birth giving, recellularisation, clinical neurosurgery etc., (07 research works and studies have reflected the growing roles of bioengineering in intricate medical areas; references listed at 20, 21, 22, 23, 24 ,25, 26 in the reference section).
- d. Bioengineering will help solve issues such as heart tissue regeneration, infertility, neuroscience problems and much more; 09 studies since the recent past and in current times are reflecting the potential roles of bioengineering in human health issues. (27, 28, 29, 30, 31, 32, 33, 34, 35)
- e. Bioengineering will be influential in solving family based mental problems, telemedicine, and in analysing how various people have been affected by the Covid-19 pandemic mentally. (36, 37, 38, 39, 40, 41, 42, 43)
- f. Bioengineering aspires to help fix the environment through analysing soil erosion patterns, water pollution, and the various methodologies possible to prevent them. (44, 45, 46, 47, 48, 49, 50)

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