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Innovating Mental Health Challenges to Zero: The Role of Big Data

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I. STRATEGIC IMPERATIVE

Mental health disorder is a major public health concern, affecting millions of people globally. These disorders significantly impact an individual's quality of life and are associated with social and economic burdens. On one hand, the healthcare system faces several challenges in addressing psychological disorders. These challenges include limited resources and a lack of early detection and intervention. On the other hand, mental health conditions are largely stigmatized or overlooked. Some challenges faced by mental health care are highlighted below:

Social stigma: Many individuals are reluctant to seek mental health treatment due to its social stigma. This stigma often leads to human rights violations and discrimination against those with mental health conditions.

Inadequate mental health services: The existing mental health services are insufficient to meet the population's growing needs. Many areas lack sufficient resources, including trained professionals, facilities, and support systems, making it challenging for individuals to access the care they require.

Accessibility gap: A significant gap persists between the number of people in need of mental health care and those who can access it. Barriers such as financial constraints, geographical limitations, and lack of awareness further contribute to this accessibility gap, leaving many individuals without the necessary support and treatment they need.

Mental health is an essential component of overall health and well-being. Psychological disorders can range from mild to severe and have a significant impact on an individual's ability to function in daily life. They are one of the major causes of suicides, the fourth leading cause of death among the population aged 15-29[1]. Psychiatrists even argue that 90% of suicides are due to mental health conditions[2]. Similarly, the Journal of the American Medical Association reports that 50% of individuals with substance abuse have severe mental illness, and 29% of people with mental disorders abuse drugs or alcohol.[3]

[1] https://www.who.int/health-topics/suicide#tab=tab_1

[2] https://www.hindawi.com/journals/sp/2020/2024160/

[3] https://www.helpguide.org/articles/addictions/substance-abuse-and-mental-health.htm#:~:text=According%20to%20reports%20published%20in,least%20one%20serious%20mental%20illness

Besides that, psychiatric disorders can increase the risk of physical health issues, such as heart disease, stroke, and diabetes. Some commonly known mental health conditions are anxiety disorders, including panic disorder, obsessive-compulsive disorder, phobias, depression, bipolar disorder, other mood disorders, eating disorders, etc.

The current situation of mental health is quite grave. United Nations (UN) records show that about one million people suffer from psychological disorders[4]. Likewise, according to the World Health Organization (WHO), one in eight people globally experiences a mental health disorder at present[5]. It also records that the Covid 19 pandemic has exacerbated the existing common conditions such as depression and anxiety further by 25%.

In addition, global healthcare data shows that mental healthcare systems are underserved. WHO notes that countries dedicate approximately 2% of their healthcare budgets to mental health. In middle-income countries, 70% of this budget is allocated to psychiatric hospitals. Lower-income countries have limited affordable psychotropic medicines. Although about half of the world's population suffers from a woeful shortage of psychiatrists, with a psychiatrist-to-patient ratio of about 1:200000 or higher, the situation is further exacerbated by the fact that mental health services are often inadequate or inaccessible in many regions[6]. Along with that, according to the latest Mental Health Atlas 2020, published by WHO, the ratio of deaths per 100000 people is nine. This represents a ten percent decline from 2013. The data for the preceding years are represented in Figures 1 & 2 below.

Figure 1: Gobal median of government health expenditure on mental health

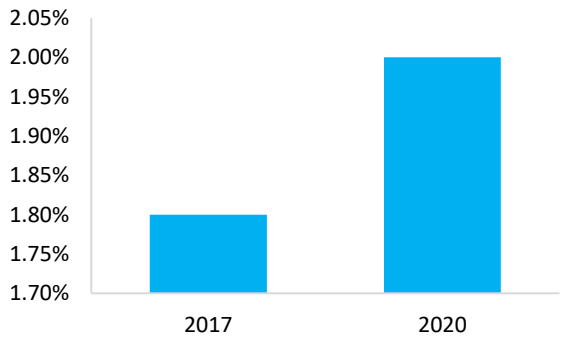
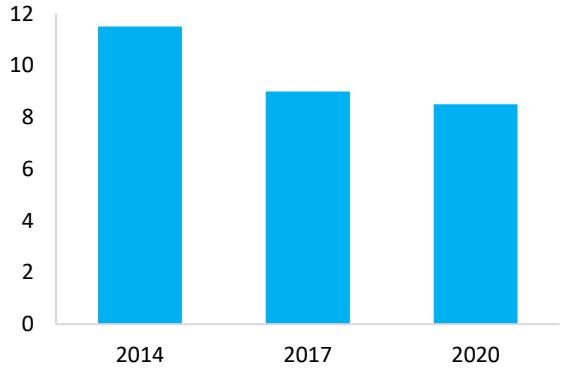


Figure 2: Suicide/100000 people



[4] https://news.un.org/en/story/2022/06/1120682

[5] https://www.who.int/publications/i/item/9789240049338

[6] https://www.who.int/publications/i/item/9789240049338

Moreover, Big Data offers opportunities to overcome these challenges and improve mental health outcomes. This article provides an overview of how Big Data can help address mental health challenges, the current state of Big Data applications in mental health research and practice, and the various types of Big Data sources and methods used in mental health research.

II. BIG DATA

A. UNDERSTANDING THE USE OF BIG DATA, ARTIFICIAL INTELLIGENCE (AI), MACHINE LEARNING (ML), DEEP LEARNING (DL) & NEURAL NETWORKS (NN) IN HEALTHCARE.

Big Data refers to large and complex data sets that are difficult to process and analyze using traditional data processing methods. Big Data typically involves massive volumes of data, diverse data sources, and a variety of data formats, including structured, semi-structured, and unstructured data.

Artificial Intelligence (AI), Machine Learning (ML), Deep Learning (DL) & Neural Networks (NN) are all interconnected in Big Data processing and analysis. Artificial Intelligence involves the simulation of human intelligence processes by machines. This allows them to make predictions, detect patterns, and automate decision-making processes with the help of Big Data. Machine learning is a subset of artificial intelligence that trains algorithms to learn from data and generate predictions without explicit programming. These algorithms are trained on Big Data sets to identify patterns and make predictions based on them.

Likewise, deep learning is a subset of machine learning that trains artificial neural networks to learn from vast amounts of data. This enables them to recognize patterns in data such as images or speech. Neural Networks are computational models that mimic the human brain structure and function, used in Deep Learning to learn from Big Data sets and identify complex patterns and relationships. These technologies are revolutionizing healthcare by enabling advanced image recognition, personalized treatment plans, and real-time disease detection. For example, artificial intelligence is used in medical imaging to detect cancerous tumors. Deep learning is used in genomics to identify genetic variants associated with diseases such as Cancer and Alzheimer's.

B. COMMON SOURCES OF BIG DATA USED IN MENTAL HEALTHCARE

Table: 1

Sources	Pros	Cons
Social Media	• Widely accessible and available. • Natural Language Processing (NLP) frameworks can accurately extract mood and psychological features from textual data on social media platforms.	• Insights not clinically validated. • Prone to bias and noise.
Electronic Health Records (EHRs)	• Useful for developing prediction and surveillance models. • A clinically validated source of information for mental health data analytics. • Longitudinal studies can benefit from the text fields in EHRs.	• Accessibility issues. • Management policies. • Privacy concerns. • Need for resolution of issues at political or institutional levels for researchers to access and use this data source. • Potential legal implications.

The present scoping review, titled "An Overview of the Role of Big Data in Mental Health: A Scoping Review"(2022), provides a comprehensive analysis of the preferred data sources for mental health data analytics. The study primarily focuses on two data sources: social media and electronic health records (EHRs). The review delineates the strengths and limitations of these sources, particularly in interpreting behavior and extracting psychological traits. Table 1 provides a summary of pros and cons of using each source to gather Big Data for treating mental health challenges.

C. BENEFITS OF USING BIG DATA AND PREDICTIVE ANALYTICS IN MENTAL HEALTHCARE

Table: 2

Artificial Intelligence Solution	Features	Benefits
Quartet Health[7]	• Identifies undiagnosed mental health issues • Reduces emergency room visits and hospitalizations by 15% to 25%.	• Cost reduction in mental health care. • Early detection and intervention. • Improved patient outcomes.
Woebot[8]	• Provides support for depression. • Engage users daily. • Affordable cost.	• Increased accessibility to mental health support. • Improved depression scores. • Comfortable interaction with patients.
Crisis Text Line[9]	• Analyzes text messages from individuals in crisis. • Identifies risk of suicide. • Provides contextual information on crisis events.	• Prevents crises by spotting warning signs. • Supports timely intervention. • Provides insights for improving mental health services.
Ellie (Virtual Therapist)[10]	• Observes nonverbal cues and speech patterns. • Identifies signs of PTSD. • Outperforms standard assessments.	• Enhanced detection of PTSD. • Potential to reduce suicide rates. • Improved assessment accuracy.
Awake Labs' "Reveal"[11]	• Wearable band that monitors. • Tracks anxiety levels in people with autism. • Alerts parents/caregivers via an app.	• Early detection and prevention of meltdowns. • Improved management of anxiety in autism. • Support for caregivers and parents.

[7] https://hbr.org/2018/10/ais-potential-to-diagnose-and-treat-mental-illness

[8] https://hbr.org/2018/10/ais-potential-to-diagnose-and-treat-mental-illness

[9] https://www.vox.com/science-and-health/2018/6/8/17441452/suicide-prevention-anthony-bourdain-crisis-text-line-data-science

[10] https://hbr.org/2018/10/ais-potential-to-diagnose-and-treat-mental-illness

[11] https://www.weforum.org/agenda/2016/06/this-wearable-device-monitors-signs-of-distress-in-children-with-autism-and-alerts-their-parents/

III. POTENTIAL APPLICATIONS OF BIG DATA IN MENTAL HEALTHCARE

Big Data has made substantial contributions to both mental health research and practice, with numerous examples of how it has emerged as a game changer in the field of mental health diagnosis, treatment, and outcomes. By utilizing longitudinal data that captures in-depth information about not only mental health issues but also other biological factors, Big Data has the potential to provide real-time information about patients, enabling clinicians to uncover previously undetected issues and intervene early on. The advantages of Big Data are manyfold, as it allows for the identification and resolution of a variety of previously unknown challenges in the field of mental health.

1. RESEARCH-BASED EVIDENCE

The utilization of Big Data in mental health is showing promising results, as highlighted in various studies. One study conducted in the United States focused on using social media, specifically Twitter, to track suicide risk factors in real-time. By analyzing over 1.6 million tweets using Twitter's API, researchers identified 37,717 individuals at risk of suicide. The study found regional variations in suicide-related tweets and established a strong correlation between Twitter-derived data and actual suicide rates, showcasing the potential of social media as a tool for real-time monitoring of suicide risk factors. Also, the ability to gather crucial information on mental health in minutes adds a completely new dimension to the field of mental health. [12]

Another study aimed to predict depression in individuals based on their social media activities using machine learning algorithms. By analyzing 2,500 sentences from a Twitter dataset, researchers measured emotions and accurately predicted depression, highlighting the potential of using Twitter data to identify depression symptoms early on. The study also identified the types of depression, encountered emotions, low state of mind, physical and emotional synchronization of changes, and different categories of early depression symptoms with positive and negative factors.[13] However, the challenges posed by the unstructured nature of data collected from social media require the expertise of specialists proficient in coding languages for effective data filtering[14].

[12] https://www.researchgate.net/publication/257754018_Tracking_Suicide_Risk_Factors_Through_Twitter_in_the_US

[13] https://irojournals.com/tcsst/V3/I1/03.pdf

[14] https://ieeexplore.ieee.org/abstract/document/7724739

In the United States, the NeuroBlu database is utilized by mental healthcare providers to store electronic health records (EHR) data, including information on mental health service contacts, diagnoses, medications, and family history. Researchers have leveraged this database to conduct studies on substance use disorders, major depressive disorder, and anxiety disorders, revealing insights into psychiatric hospitalization risks and antidepressant treatment effectiveness. The database has also facilitated the development of data visualization tools, aided clinical decision-making, and enabled the extraction of clinical information from unstructured EHR data using natural language processing (NLP) applications.[15]

Likewise, a scoping review on machine learning methods for predicting postpartum depression (PPD) found that supervised machine learning techniques outperformed traditional statistical approaches. The review encompassed studies that utilized clinical or hospital data, EHRs, social media platforms, and population data to predict PPD.[16] In another endeavor, researchers developed a mental crisis risk model using EHR data to predict the likelihood of a mental health crisis within 28 days from EHR reports of over 17,000 individuals for 7 years. The model's predictions proved clinically useful in minimizing crisis risks in 64% of cases.[17]

Furthermore, researchers at Georgia State University developed an artificial intelligence program capable of analyzing functional magnetic resonance imaging (fMRI) scans to identify patterns associated with mental health conditions like Alzheimer's disease, schizophrenia, and autism. By training artificial intelligence models on a dataset of over 10,000 people and testing them on over 1,200 individuals with these disorders, the program successfully identified brain activity patterns corresponding to each condition. This breakthrough offers new possibilities for understanding complex mental health conditions and developing more effective treatments.[18]

[15] https://bmjopen.bmj.com/content/12/4/e057227#DC1

[16] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8663566/

[17] https://www.nature.com/articles/s41591-022-01811-5

[18] https://www.futurity.org/artificial-intelligence-brain-imaging-mental-health-disorders-2772212/

2. USE CASE

TABLE: 3

Program Name	Country	Technology Used	Purpose	Description
REACH VET[19]	United States	Big Data analytics, EHRs	Identify high-risk veterans for suicide	Utilizes Big Data analytics on electronic health record (EHR) data to identify veterans at high risk of suicide and provide targeted interventions.
Artificial Intelligence - based Surveillance System[20]	South Korea	Artificial intelligence, CCTV	Crisis detection and response	Implements artificial intelligence-based surveillance and CCTV camera control to identify crisis patterns and respond to suicide attempts.
Mindstrong Health[21]	United States	Smartphone data, machine learning	Detect mood and cognitive changes	Develops a mobile app that utilizes smartphone data, such as typing speed, screen taps, and social media activity, to detect mood and cognitive changes and provide personalized interventions.
LifeSpan[22]	Australia	Data-driven strategy, Statistical Analysis System (SAS)	Suicide prevention	Implements a data-driven strategy, supported by the Statistical Analysis System (SAS), for suicide prevention, aiming to save lives and reduce suicide attempts.

[19] https://www.gao.gov/assets/gao-22-105165.pdf

[20] https://www.ctvnews.ca/sci-tech/seoul-rolls-out-ai-enabled-cctv-cameras-to-stop-suicides-privacy-experts-divided-1.5483358

[21] https://www.nytimes.com/2019/06/17/health/mindstrong-mental-health-app.html

[22] https://www.sas.com/en_nz/customers/black-dog-institute-lifespan.html

Ginger[23]	United States	Big Data analytics, machine learning	Identify patterns in patient behavior	Utilizes Big Data analytics to identify patterns in patient behavior, enabling effective interventions, cost reduction, and improved outcomes.
Spring Health[24]	United States	Machine learning, digital assessments	Personalized treatment recommendations	Utilizes proprietary machine learning to provide personalized treatment recommendations based on digital assessments completed by patients.
Nanyang Technological University[25]	Singapore	Artificial intelligence, fitness trackers	Depression detection through fitness trackers	Develops a system that uses fitness trackers and artificial intelligence to detect depression with 80% accuracy by analyzing heart rate, activity levels, and sleep patterns.

IV. CHALLENGES AND LIMITATIONS OF USING BIG DATA IN MENTAL HEALTHCARE

With the huge potential brought by Big Data to transform the mental health sector, there are several challenges and limitations to using Big Data in mental health that need to be addressed to ensure the ethical and accurate use of this data. These include:

Data Quality: Ensuring the quality of data is a significant challenge while using Big Data for mental health research and practice. Incomplete or erroneous data can lead to incorrect results, and inconsistencies in data collection and recording among different healthcare providers complicate dataset integration and comparison.

Privacy Concerns: Privacy concerns pose a challenge in utilizing Big Data for mental health research and practice. Patients may be hesitant to share sensitive information due to concerns about data privacy and commercial use. Compliance with privacy laws and ethical standards is crucial to maintain patients' trust and protect their information.

[23] https://d3.harvard.edu/platform-rctom/submission/ginger-io-striking-a-balance-between-humans-and-technology-in-mental-health/#:~:text=By%20amassing%20and%20analyzing%20large,a%20user%20may%20need%20help.

[24] https://www.nbcnews.com/news/asian-america/how-three-first-generation-immigrants-are-using-machine-learning-improve-n838136

[25] https://www.euronews.com/next/2022/10/22/scientists-are-using-fitness-trackers-and-ai-to-detect-depression-with-80-accuracy

Potential Biases: Potential biases in data collection and analysis can lead to inaccurate or incomplete results. Underrepresented populations may not be adequately represented in the data, limiting our understanding of their mental health needs.

Data-Generating Process: The use of Big Data in mental health research can be biased if researchers fail to account for data limitations and the data-generating process. Data collected for purposes other than research may not accurately represent the population.

Accuracy and Validity of Conclusions: The accuracy and validity of conclusions drawn from Big Data depend on agile algorithms, timely quality assurance, and updates to account for changes in the data-generating process.

Ethical Considerations: Ethical considerations, such as informed consent, privacy, confidentiality, and potential harm to patients, must be addressed when using Big Data in mental health research and practice. Protecting patient privacy is complex and requires comprehensive measures to be effectively addressed.

Limited Applicability of Artificial Intelligence: Artificial intelligence applications in mental health research have primarily focused on depression, schizophrenia, and other psychotic disorders, limiting their universal applicability to all mental health conditions.

Lack of Transparency: Lack of transparency in sharing information about how artificial intelligence works hampers testing and collaboration among researchers, potentially leading to the premature promotion of ineffective models.

Delays in Evaluation and Assessment: Delays in ensuring the safety and practicality of artificial intelligence can occur if insufficient information and collaboration hinder proper evaluation and assessment of its effectiveness in real-life scenarios.

A. WHO'S SIX GUIDING PRINCIPLES

Understanding the need to transform and adopt the ever-evolving technological advancements for the betterment of humankind, WHO has identified artificial intelligence as a potential tool to enhance healthcare and achieve universal health coverage. However, it has also highlighted the risks and challenges involved, including ethical and human rights concerns. Thus, to address its concerns, in June 2021, the World Health Organization (WHO) released its first global report on the use of artificial intelligence in health and issued six guiding principles for its design and use.

The six principles for the design and use of artificial intelligence in health include promoting human well-being, respecting human rights and dignity, ensuring transparency, promoting safety and security, being

accountable, and fostering trust, solely to ensure maximum output and minimize the risk associated with the use of artificial intelligence in the health sector.

WHO's Six Guiding Principles for Using Artificial Intelligence[26]	
1.	Patients should have control over their healthcare decisions, and their privacy and confidentiality should be protected. They should also receive clear information and give consent before their data is used.
2.	Designers of artificial intelligence need to follow rules for accuracy, effectiveness, and safety in specific use cases. Quality control measures should be in place to improve its use in practice.
3.	The creators of artificial intelligence should be transparent and provide accessible information before developing or using it. Public debates should be encouraged to discuss how it is designed and used.
4.	Trained individuals should use artificial intelligence appropriately, and mechanisms should be in place to address concerns and help those who are negatively affected by algorithmic decisions.
5.	Artificial Intelligence for healthcare should be designed to ensure equal access and use for everyone, regardless of age, gender, income, race, ethnicity, sexual orientation, or abilities protected by human rights.
6.	Continuous evaluation of artificial intelligence applications is necessary to meet expectations and environmental considerations. Healthcare workers should receive training to adapt to artificially intelligent systems, and potential job losses due to automation should be addressed.

The WHO's release of the guiding principles emphasizes the need for a human-centered approach to artificial intelligence research and urges for more international cooperation to guarantee responsible artificial intelligence development and deployment. Similarly, the study is a call to action for stakeholders to promote responsible artificial intelligence research and usage in healthcare, as well as to respect the ideals of openness, accountability, and human dignity in this fast-growing industry.

[26] https://www.who.int/news/item/28-06-2021-who-issues-first-global-report-on-ai-in-health-and-six-guiding-principles-for-its-design-and-use

V. FUTURE DIRECTIONS AND CONCLUSION

The current state of mental health on a global scale is alarming, and it is high time that we focus on addressing these issues. The impact of mental health issues on individuals, families, communities, and societies cannot be overstated. It affects productivity, economic growth, social cohesion, and overall quality of life. Moreover, mental health issues are highly prevalent, with nearly one in four people globally affected by them at some point in their lives.

To address this issue, there is a need for bold and innovative approaches that not only focus on treating mental health issues but also on identifying and preventing them. This requires a multi-stakeholder approach that involves governments, private sector organizations, NGOs, and individuals. Some of the key areas that need to be focused on include increasing access to mental health services, reducing stigma, promoting mental health literacy, and addressing social determinants of mental health.

The potential of Big Data in transforming the mental health sector is immense, but it also comes with significant challenges. One of the biggest challenges is the ethical use of data. Mental health data is highly sensitive and personal, and it requires strict regulations and ethical frameworks to ensure that it is used appropriately. There is a risk of data breaches, misuse, and discrimination of data if proper safeguards are not put in place. The next challenge is the lack of data collection, analysis, and reporting standardization. There is a need for standardized protocols and methodologies to ensure that data is collected and analyzed in a consistent and reliable manner. This will facilitate cross-comparisons of data and improve the quality of mental health research.

Despite the progress that has been made in the mental health sector, there are still significant gaps that need to be addressed. One of the biggest gaps is the lack of access to mental health services, particularly in low- and middle-income countries. This is due to a shortage of mental health professionals, inadequate funding, and weak health systems. Another gap is the need for more research and innovation in the mental health sector. This includes developing new treatments, interventions, and technologies that can improve mental health outcomes. There is also a need for more research on the social determinants of mental health and how they can be addressed.

In conclusion, the challenges of transforming the mental health sector using Big Data are significant, but the potential benefits are immense. It requires a concerted effort from all stakeholders to ensure that data is used ethically, standards are established, and gaps are filled. By doing so, we can move closer to innovating to zero mental health issues and improving the lives of millions of people around the world.