ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #44576

System Engineering a Better Mental Health System

Dr. Paul Lu, University of Southern California Viterbi School of Engineering. Depart of Industrial and Systems Engineering

Dr. Paul Lu is Senior Lecturer and Program Director Master of Science Engineering Managements at University of Southern California. Viterbi School of Engineering, Daniel J. Epstein School of Industrial and Systems Engineering. Dr. Lu has over 40 years of experience in the Aerospace Industry. He focuses on the strategic implementation of technology and innovations, new product development, systems engineering, project and program management, and engineering management.

Recently, he was exposed to the impact of mental illness and witnessed the devastating consequences of people suffering with a mental illnesses. As such, Dr. Lu began to assess the shortcomings of the current system including the lack of breakthrough technologies and innovations in the mental health area.

SYSTEM ENGINEERING A BETTER MENTAL HEALTHCARE SYSTEM:

A Survey of Current Mental Healthcare Systems and Suggestions for Designing Future Large-Scale Mental Healthcare Systems

ABSTRACT

The Mental Healthcare System is in crisis globally. The inability to provide proper and necessary mental healthcare treatment has impacted people economically, financially, socially, physically, and emotionally. The first objective of this paper is to provide insights into the current deficiencies of the Mental Healthcare System illustrating the cause and effects of broken Mental Healthcare systems. The second objective is to offer suggestions for future Mental Healthcare models with reference to John P. Clarkson's System Engineering approach for developing and designing healthcare models and the International Council of System Engineering (INCOSE) Co-Design model. The main thrust is to focus on the Systems, Design, People, and Risk aspects of system designs. The third objective is to provide a survey of current and future technologies (Robotics, Blockchain, and Machine Learning), and innovative applications such as the Metaverse and Connected Mental Health in the mental healthcare industry. The fourth objective is to offer a vision of future of mental healthcare systems with patient-controlled service, modified social contexts, virtual mental healthcare, and partners with the poor. Lastly, introduce a systematic model for designing and developing large-scale enterprises as a roadmap for future developments in mental healthcare systems. This model incorporates Program Management, Project Management, and System Engineering into a three-tier model.

Researchers, practitioners, educators may find the content valuable and useful for open dialogues, future planning, and discussions in system engineering, engineering in society, design of complex systems, public policy, mental healthcare, program management, and project management.

INTRODUCTION

Mental health crisis has global implications. It impacts those suffering from mental health and related issues, family, and friends. The burden of mental health care is a drain to local, national, and global economies. Broken mental health systems impacts communities socially, emotionally, and financially. For instance, the lack of proper mental health treatment leads to unemployment, homeliness, disfunction families, burden on social services, and other undesirable outcomes.

Although many mental health treatment advances incorporating state of the art technologies and innovations have been introduced, the benefits have not been fully realized. In essence, the current mental health system is yielding less than desirable results.

The mental healthcare system is a subset of the extensive and complex healthcare "System of Systems". As such, it suffers and exhibits symptoms of less-than-optimal systems similar to other complex systems in the public and private sectors. One of the factors contributing to this deficiency is gaps in the system that are too complex to solve utilizing the current policies, procedures, and methods - suggesting a change or re-thinking of the current system may be warranted.

A viable approach may be to consider a System Engineering (SE) view of the mental healthcare system as a part of the overall health care system. Developing a future mental health system from a SE approach employing systems engineering tools and techniques, innovative applications of technologies, and a re-envisioning of public policies can bring about a new direction for the mental healthcare system.

This paper is a survey of the current mental healthcare system and offers suggestions for further reviews and pathways to advance the mental health system. The survey offers an overview of the current mental healthcare system illustrating the cause and efforts from a global perspective. This is followed by a review of designing mental healthcare systems as a subset of the overall healthcare system. This assessment is followed by a review of technologies and innovations in mental healthcare. Finally, suggestions and recommendations for further research and pathways for designing and implementing large-scale SE approach for mental healthcare systems.

MENTAL HEALTH SYSTEMS ARE LESS THAN STELLAR

What is Mental Illness?

According to the World Health Organization (WHO), *"A mental disorder is characterized by a clinically significant disturbance in an individual's cognition, emotional regulation, or behaviour. It is usually associated with distress or impairment in important areas of functioning."*[1]

[1] https://www.who.int/news-room/fact-sheets/detail/mental-disorders

The National Alliance of Mental Illness (NAMI) defines mental illness as: *"a condition that affects a person's thinking, feeling, behavior or mood. These conditions deeply impact day-to-day living and may also affect the ability to relate to others."*[2]

The Current Situation

Mental disorders are a major public health problem, and the biggest public health problem among young people in the most productive years of life.[3] According to NAMI, one in five United States (U.S.) adults experience mental illness each year. One in 20 U.S. adults experience serious mental illness each year. One in six U.S. youth aged 6-17 experience a mental health disorder each year. Further, 50% of all lifetime mental illness begins by age 14, and 75% by age 24.[4]

The United States is experiencing the impacts of an inefficient mental health system at the national, state, and local levels. Both public and private sectors mental health services are strained. Hospitals and mental health treatment centers, law enforcement, social services, jails and many other services are overburdened and can not properly support those in need of mental health treatment.

Sharfstean (2023) states:

> *"the overall evidence seems to be that most people in the U.S. with mental disorders remain either untreated or poorly treated, leaving the mental health system with less than stellar reputation and, as a result, has difficulty in receiving additional funding"* [5]

Further, Sharfstean suggests that resolving the mental health needs is simply far too complicated and far too expensive. This view is not an optimistic outlook for the mentally ill, their families and friend, the communities, and for the nation.[6]

Global Implications and Impacts

The direct and indirect cost of mental illness on the economy is estimated to rise to US$ 16 trillion globally by the year 2030. Further, between a quarter to a half of the world population is expected to experience major mental illness in their lifetime.[7] Global healthcare is facing short-term and long-term challenges such as demographic changes, demands for increased quality, limited resources, and cost requirements.[8]

---

[2] National Alliance on Mental Illness (NAMI) https://www.nami.org/About-Mental-Illness/Mental-Health-Conditions#:~:text=A%20mental%20illness%20is%20a,ability%20to%20relate%20to%20others.
[3] Minas, Harry. The Centre for International Mental Health Approach for Mental Health System Development. 37.
[4] National Alliance on Mental Illness (NAMI). https://www.nami.org/mhstats
[5] Sharfstean, Steven S. Despair of Hope. The Future of Mental Health Service Delivery in the United States. 241.
[6] Ibid.241.
[7] Wang, Ying; Byrne, Louise; Bartram, Timothy; and Chapman, Melissa. Developing Inclusive and Healthy Organizations by Employing Designated Live Experience Roles: Learning from Human Resource Management Innovations in the Mental Health Sector. 1974.
[8] Ozturkan, Selcen and Merdin-Uygur, Ezgi. Humanoid Service Robots: The Future of Healthcare? 166.

How Did Mental Healthcare Get to This Point?

There are many factors that contributes to the current short comings of the mental health system. Minas (2012) identified these multiple factors. They are:

- Little understanding of mental health as an important public health and social and economic development issue
- Little understanding that effective and affordable interventions and service models are available
- Mental health is a low political and social priority
- Weak investment
- Weak drive for mental health system reform and development
- Low levels of skill in policy development and implementation
- Weak governance and management arrangements
- Low population "mental health literacy"
- Inadequate infrastructure, facilities, equipment, drug distribution systems
- Shortage of skilled mental health workers
- Geographic maldistribution of available workforce
- Disciplinary imbalance: dominated by physicians and nurses
- Hospital centered
- Undeveloped information systems, with lack of high-quality local information to support planning
- Poorly developed mental health systems research capacity
- No culture of evaluation or continuous quality improvement
- Poorly organized and marginalized consumers, carers, civil society
- Narrow population coverage: wide "treatment gap"
- Very wide gap between best (usually in major urban centers) and worst (usually in poor rural areas) mental health services
- Low and inequitable access (geographic, economic, linguistic, cultural) to mental health services
- Stigma, discrimination, social and economic exclusion
- Mental health training is unattractive for most disciplines
- Inadequate protection of rights, with widespread human rights abuses
- Lack of locally relevant evidence for policy and practice
- Poorly developed advocacy by civil society and groups[9]

Minas propose the mental healthcare system need improvements in order to reduce mental illness related disabilities. Additionally, there is a need to improve social and economic participation, enhanced human rights protections, and reduce poverty.

The objective is to strengthen mental healthcare system governance, leadership, and development capacity by scaling up of mental health services through system development projects involving education/training, research, and knowledge exchange. Additionally, improve

[9] Minas, Harry. The Centre for International Mental Health Approach for Mental Health System Development. 38.

capacity to develop, implement, monitor, and evaluate mental health policy, legislation, financing, human resource development, and service delivery.[10]

A SYSTEM ENGINEERING VIEW OF THE HEALTH CARE SYSTEM

"*healthcare is a complex system—actually system of systems—in which the system's behaviour and performance alter over time and cannot be completely grasped by simply focusing on the individual components."*[11]

System Engineering methods and practices can tackle extremely complex challenges. Typically, practitioners will consider SE tools and techniques in industries such as automobile, aerospace, ship building, construction, and other heavy industries. As the healthcare industry is becoming more complex, SE may be a viable and applicable tool that can contribute to solving the unique and complex challenges in this sector.

Gunray, et al. offers a six-step approach to mapping the current system design and develop improvement strategies. These steps are:

1. Define the problem explains details of a particular challenge in a system, as well as all (re)design requirements necessary to improve the system.
2. Develop the solution describes ways of solving a certain problem in a system and (re)design components to improve the system.
3. Collect the evidence relates to measures utilised to evidence the validity of solution(s) to the problem(s).
4. Make the case explains facts and arguments to improve a system and deliver solutions to the problem(s).
5. Manage the plan demonstrates a detailed proposal for delivering solution(s) to the problem(s) in the system.
6. Agree the scope describes the context and extent of the envisaged (re)design, and the boundary of the system of interest.[12]

According to Clarkson, et al (2018), *"Systems that work do not just happen, they need to be planned, designed and built.' This is the view of the Royal Academy of Engineering. Engineers have long understood that well designed systems can prompt individuals toward desired behaviours, and act to restrain them from undesirable ones*."[13]

Further, the presence of different perspectives from Systems, Design, Risk, and People is necessary to enhance probability of success. Therefore, a clear understanding and appreciation of these perspectives along with the skills to implement risk-based project management can often

[10] Ibid. 40.
[11] Ash, Gunay; Ward, James; and Clarkson, John P. Mapping a Systems Approach to Existing Healthcare Design, Delivery and Improvement Method. 1998.
[12] Ibid. 1999.
[13] Clarkson, John; Dean John; Ward, James; Komashie, Alexander; and Bashford Tom. A Systems Approach to Healthcare: From Thinking to Practice. 151.

make the difference between success and failure. In addition to SE tools and techniques, engineering tools from other engineering disciplines such as software, electrical, and mechanical engineering can further enhance the development and implementation of systems design.[14]

Clarkson, et.al., claims the challenges facing the health and social care systems are considerable with competing pressures from an aging population, increasing numbers of patients with multiple morbidities, new technologies, and the need for increasing efficiencies. The complexity of such systems means that efforts to improve them often achieve only limited benefits and can have unforeseen consequences.[15]

Elliott & Deasley (2007) states: *"Systems engineering has the ability to encourage good behaviour or mistakes, and the difference is the result of the quality of their design, delivery and use. 'Systems that work do not just happen – they have to be planned, designed and built."*[16]

One of the ways to incorporate Systems, Design, Risk, and People into the equation is to consider the International Council on Systems Engineering (INCOSE) Co-Design model. This model illustrates and considers the logical relationships between People, Systems, Design, and Risk into SE designs.[17] The following are the particulars of the Co-Design Model with further definition from the System, Design, Risk, and People's perspective.

The Co-Design Model

(i) People – the understanding of interaction among humans and other elements of a system in order to optimize human well-being and overall system performance;
(ii) Systems – the means to address complex and uncertain problems, involving highly interconnected technical and social entities that produce emergent behavior;
(iii) Design – the identification of the right problem to solve, creation of solution options and refinement of the best of these to deliver an appropriate solution to the problem;
(iv) Risk – the management of what can go wrong (and right), based on the identification, assessment and management of hazards and opportunities present within the system.[18]

System's Perspective

(i) Understand – Who are the stakeholders?
(ii) Organise – What are the elements?
(iii) Integrate – How does the system perform?[19]

Designer's Perspective

(i) Explore – What are the needs?
(ii) Create – How can the needs be met?

[14] Clarkson, John p. What Has Engineering Design to say About Healthcare Improvements? Design Science. Cambridge University Press. 2018. 6.
[15] Ibid. 8
[16] Ibid.9
[17] Ibid.10
[18] Ibid. 10-11
[19] Ibid. 13

(iii) Evaluate – How well are the needs met?[20]

Risk Perspective

(i) Examine – What is going on?
(ii) Assess – What could go wrong?
(iii) Improve – How can we make it better?[21]

People's Perspective

(i) Identify – Who will use the system?
(ii) Locate – Where is the system?
(iii) Situate – What affects the system?[22]

Clarkson, et.al. suggests an integrated approach for the implementation of the Co-Design Model incorporating project management and other engineering tools with consideration of total life cycle of the system. The tools would be used to identify and define the trigger, purpose, team, success metrics, and plans. A life cycle perspective will highlight the importance of defining, designing, implementing, and sustaining the system.

Project management and Other SE Tools

(i) Trigger – Why are we doing this?
(ii) Purpose – What is the purpose?
(iii) Team – Who should be involved?
(iv) Success – What does good look like?
(v) Plan – What should we do next?[23]

Total Life Cycle Approach

(i) Understand – leading to a description of the current system (now), a common understanding of the problem, a consensus view of what the future system might look like (better) and a clearly articulated case for changing the system;
(ii) Design – leading to a clear description of the future system, based on the iterative design of the system architecture with its elements and interfaces, the evaluation through successive prototyping of its likely behaviour, and a plan for its delivery;
(iii) Deliver – leading to the successful deployment of the new system with the levels of measurement necessary to evidence its success, and acceptance that it achieves appropriate value for its stakeholders;
(iv) Sustain – leading to the continued operational success of the new system along with consideration[24]

[20] Ibid. 14
[21] Ibid. 16
[22] Ibid. 17
[23] Ibid. 18.
[24] Ibid. 19

Clarkson, et.al. justifies their SE approach to healthcare by illustrating the value proposition that can be derived. These propositions showcase the benefits of SEs contributions to solving complex system challenges.

Value Proposition of a Systems Engineering Approach

(i) Engineers think about people – a surprise from the health and care perspective that a systems approach is people-focused (people);

(ii) Iteration before implementation – engineers typically iterate to find adequate solutions to challenges before their implementation (systems);

(iii) Design is an exploratory process – engineers develop a variety of potential solution concepts from which the best is then selected (design); exploratory process – engineers develop a variety of potential solution concepts from which the best is then selected (design);

(iv) Risk management is a proactive process – engineers prefer to manage risks proactively to design out faults before they happen (risk); Thinking changes practice, process helps – a systems approach posed as a series of questions has real potential to change behaviour; and

(v) Common sense is not common – while there may be nothing new in a systems approach, islands of excellence are surprisingly rare.[25]

TECHNOLOGICAL ADVANCES IN THE MENTAL HEALTH SYSTEM

There are many current and future technological advances in the mental healthcare system. Although many of these advances offers improvements and benefits, the benefactors are often limited to small pockets within the general population. Going forward, advances should focus on "game changing" innovations that benefits the masses. Further, innovative approaches should be throughout the entire life cycle with consideration for early and accurate diagnosis, appropriate and proper treatment, meaningful education, and viable sustainment programs. The following is a shortlist of technological advances in the mental health system to illustrate current advances and ideations for future innovations.

Robotics

Robots, especially humanoid Service Robots (SR), offer opportunities. In the not so far future, the healthcare system needs to be reinvented to possibly include more humanoid SR in different roles to provide improved assistance and service (Broadbent, et.al. 2010).

Some of the current popular robot tasks are detecting a fall, calling for help, lifting, and monitoring location. Robot functionalities are more important than appearance. Real and perceived benefits may even include allowing offloading human staff of tasks that can allow

[25] Ibid. 20-21

them to spend more time with patients. However, there may be concerns of loss of job to robots.[26]

Blockchain

The healthcare system is applying blockchain technologies in many applications. For example, using blockchain methods to lower healthcare transaction-related costs by improving and automating processes, removing intermediaries, and reducing administrative tasks. Another application is prioritization enabling better data collection, use, and sharing from patients, consumers, and providers through the offer of incentives such as tokens. Blockchain is also yielding indirect benefits such as increasing compliance or preventing fraud. (Mackey, et.al., 2019).[27]

Machine Leaning (ML)

ML can offer enhanced paths for learning patterns of human behavior; identifying mental health symptoms and risk factors; developing predictions about disease progression; and personalizing and optimizing therapies. Despite the potential opportunities for using ML within mental health, this is still an emerging research area (Thieme, et.al., 2020).[28]

There is a significant amount of mental health related data and is continuing to grow exponentially. The growth in data availability alongside with improvements to computing power has led to a surge in research and applications of machine learning (ML) technology.

For instance, there can be targeted efforts on mental health behaviors; opportunities to better understand, detect, and diagnose patients; and assess patient-clinician relationships to improve mental health treatment.

Applying ML can lead to easier and timely access to more objective and scalable mental health data that can save time and cost of the entire system. Further, it can be a tool for more accurate and reliable tool for decision making.[29]

The Metaverse

Trials involving the treatment of psychiatric disorders using therapeutic tools in the metaverse have not yet been reported. However, VR, AR and MR are being used increasingly for the diagnosis and treatment of mental health disorders. [30] There have been applications to Attention Deficit Hyperactivity Disorder (ADHD); Eating Disorders; Anxiety, Phobias and Post-Traumatic

[26] Broadbent, Elizabeth; Kuo, I Han; Lee, Yong In: Rabindran, Joel; Kerse, Ngaire; Srafford, Rebecca; MacDonald, Bruce A. Attitudes and Reactions to a Healthcare Robot. 115.
[27] Mackey, Tim K; Kuo, Tsung-Ting; Gummadi, Basker; Clauson, Kevin A; Church, George; Grishin, Dennis; Obbad, Kamal; Barkovish, Robert; Palombini, Maria. 'Fit-For-Purpose' – Challenges and Opportunities for Applications of Blockchain Technology in The Future of Healthcare. 4.
[28] Thieme, Anja. Belgrave, Danielle. And Doherty, Gavin. Machine Learning in Mental Health: A Systematic Review of the HCI Literature to Support the Development of Effective and Implement ML Systems. 34:1-3
[29] Ibid. 34:8 – 15.
[30] Usmani, Sadia Suhail. Sharath, Medha. Mehendale, Maghana. Future of Mental Health in the Metaverse. General Psychiatry. 2

Stress Disorders; Autism; Alzheimer's Disease; Stress and Pain Management; and Delusion, Psychosis, and Schizophrenia.

In the future, there may be advanced VR versions with more real and life-like encounters. It can mimic a community where you can make new friends, socialize, and maintain relationships. The metaverse can create opportunities for patients to consult mental health professionals by taking the form of 'avatars' in simulated environments. Since the possibilities of virtual simulation are endless, the metaverse is projected to have the potential to create multiple new avenues for the treatment of various mental health disorders (Usmani, et.al., 2022).[31]

Connected Mental Health

Connected mental health (CMH), refers to the use of information and communication technologies (ICT) to support and improve mental health conditions and mental health care. This can lead to unlimited possibilities and opportunities to help overcome the challenges, barriers, and limitations of mental health care. The term connected health is used to "encompass terms such as wireless, digital, electronic, mobile, and tele-health". Connected health is now an established research field (Drissi, et.al. 2020).[32]

For instance, Mobile Therapeutic Attention for Patients with Treatment-Resistant Schizophrenia (m-RESIST) is an EU Horizon 2020-funded project aimed at designing and validating an innovative therapeutic program for treatment-resistant schizophrenia. The program utilizes information from mobile phones and wearable sensors for behavioral tracking to support intervention administration (Seppala, et.al, 2019).[33]

SYSTEM ENGINEERING THE FUTURE OF THE MENTAL HEALTH SYSTEM

'*Psychiatry is on the cusp of major changes. It is time to look at where the specialty has been, where it is now, and to try to imagine its future* (Murthy, 2018).[34]

Going forward, mental healthcare systems need to be re-imagined with a broader multi-disciplinary systems approach. In this future vision, mental healthcare system planners should invite other participants to the table including engineering disciplines.

Planners should consider a "Systems of Systems" approach incorporating Program Management, Project Management, and Systems Engineering. The benefits of a systems engineering approach have been demonstrated on large scale efforts across multiple industries. Designing a mental health care system from a SE perspective can reap similar success outcomes. As one of the goals

[31] Ibid., 3

[32] Drissi, Nidal. Ouhbi, Sofia. Abdou Janati Idrissi, Mohammed. Fernandez-Luque, Luis. Ghogho, Mounir. Connected Mental Health: Systematic Mapping Study. Journal of Medical Internet Research. 2

[33] Seppälä J, De Vita I, Jämsä T, Miettunen J, Isohanni M, Rubinstein K, Feldman Y, Grasa E, Corripio I, Berdun J, D'Amico E; M-RESIST Group; Bulgheroni M. Mobile Phone and Wearable Sensor-Based mHealth Approaches for Psychiatric Disorders and Symptoms: Systematic Review. JMIR Ment Health. 2019 Feb 20;6(2):e9819. doi: 10.2196/mental.9819. PMID: 30785404; PMCID: PMC6401668.

[34] Murthy, Srinvasa, R. Future of Mental Health. A7

of engineering is to make life better for mankind, engineers need to be a part of the design and implementation of future systems. SE methods and practices can serve well to integrate the various disciplines of this extremely complex system.

Applying Systems Engineering to the Mental Healthcare System

As the mental healthcare system is a sub-system of the healthcare system, designers should follow healthcare systems design approaches but focusing on specific issues and shortcomings in the mental healthcare system. Mental health is a subject of interest to all people and all aspects of society. There are a wide range of requirements beyond medical interventions to address mental health needs of the total population. As such all people in the society should be part of the mental health movement [35]

For instance, public policy actions to improve treatment and care for people with mental disorders; empowering people with mental disorders and their families; and create opportunities to build a diverse mental health workforce to deliver psychological treatments. The mission is to develop a collaborative and multidisciplinary team-based approach to mental healthcare by integrating economic interventions with mental health care; use technology to improve access to mental healthcare by providing integrated care for physical health problems for people with mental disorders[36]

Giacco, et.al. (2017) offers four possible views of future mental health systems. They are:

1. Patient controlled service (mental health care will be patient led without coercion);
2. Modifying social contexts (care will target people's social and living contexts to improve their mental health);
3. Virtual mental health care (care will be provided primarily online and become virtual); and
4. Partners to the poor (access to and provision of care will be regulated on the basis of social disadvantage).[37]

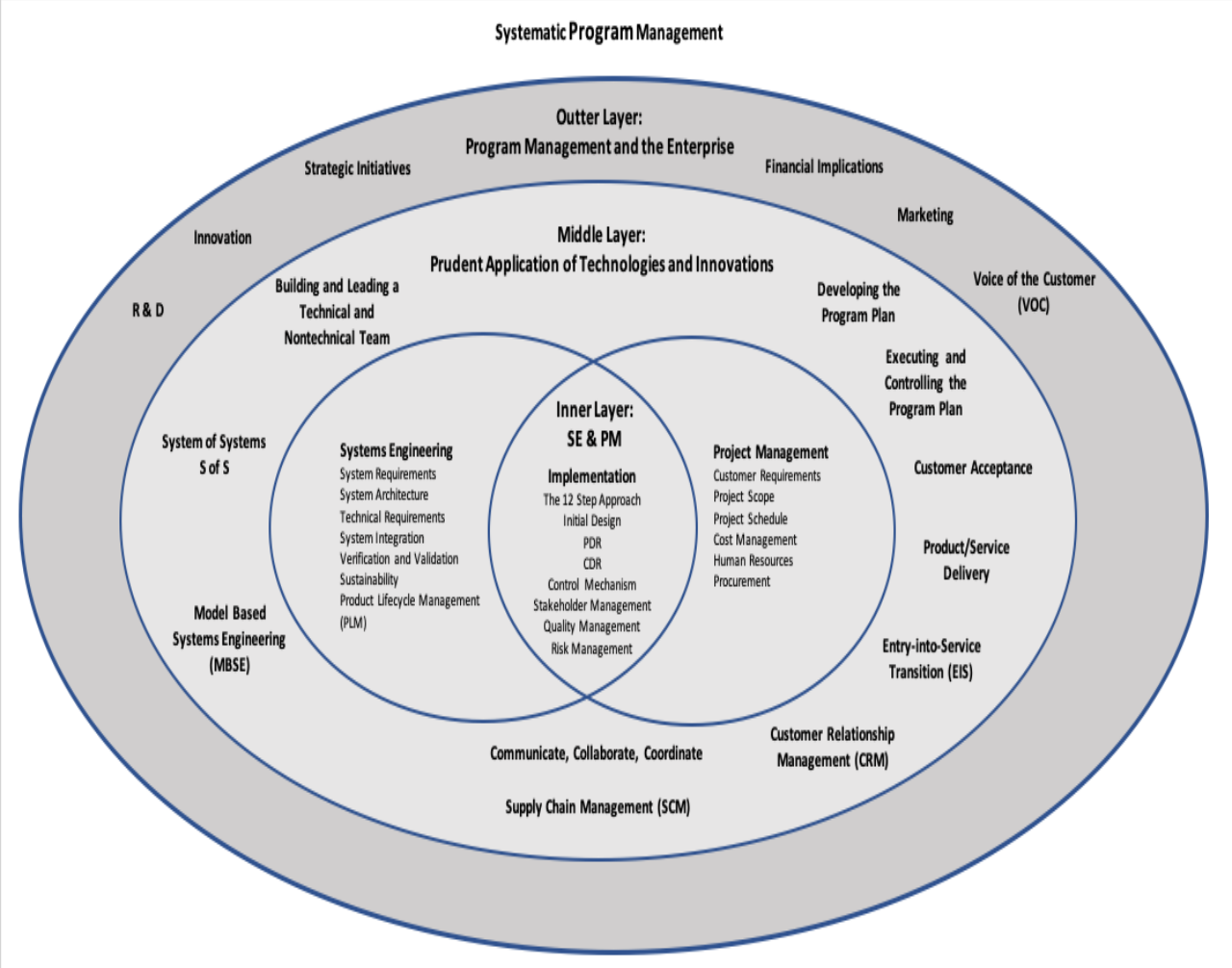
AN INTEGRATED SYSTEMATIC APPROACH FOR MANAGING LARGE SCALE COMPLEX DEVELOPMENT PROGRAMS

Developing, designing, and implementing a future model of mental healthcare system is a massive and daunting task. Developers will need to incorporate and integrate tools and techniques from the medical, public policy, social services, and engineering communities. One of the ways to enable such a massive, large-scale undertaking is to consider a systematic program management approach. In this model, People, Design, Risk, and Systems concerns from various groups and perspectives can be fully integrated in a comprehensive program. This approach not

[35] Ibid. A7
[36] Patel, Vikram; Saxena, Shekhar. Transforming Lives, Enhancing Communities – Innovations in Global Mental Health. 499.
[37] Giacco, Domenico ; Amering, Michaela; Bird, Victoria; Craig, Thomas; Ducci, Giuseppe; Gallinat, Jürgen; Gillard, Steven George; Greacen, Tim; Hadridge, Phil; Johnson, Sonia; Jovanovic, Nikolina; Laugharne, Richard; Morgan, Craig; Muijen, Matthijs; Schomerus, Georg; Zinkler, Martin; Wessely, Simon; Priebe, Stefan. Scenarios for the Future of Mental Health Care: A Social Perspective. 257.

only take advantage of the benefits of program management, but it also compensates for the shortcoming of project management and system engineering. In this model, all stakeholders (people) can have a voice. Designs and planning will stem from the strategic top level all the way down to the detail levels. A System of Systems approach incorporating and provisioning for the various systems will yield a more integrated enterprise. Lastly, risk assessments at all levels can be addressed and managed. The following is work-in-progress illustration of this Systematic Program Management Model. This model has three layers. The outer layer is the enterprise/Program Management Office (PMO) layer focusing on strategic enterprise and PMO initiatives. The middle layer describes the programmatic initiatives and activities. The inner layer shows the systems engineering and the project management disciplines integrated into an implementation plan (see figure 1.1).

Figure 1.1 Systematic Program Management Model for Complex Development Programs (copyrighted)



Although this is a comprehensive model for managing complex programs, this model will need to be vetted and fine-tuned for mental healthcare applications. This effort will be the next phase of this research project. In the next phase the particulars of People, Design, System, and Risk relating to the mental healthcare system will be investigated in detail.

SUMMARY AND CONCLUSIONS

This exercise provided insights into the current Mental Healthcare system. It appears the current system is not capable of providing necessary and proper outcomes due to the complexities and challenges inherent to mental healthcare systems. Further, the current systems are a global economic drain at multiple levels. A potential path to a future system that can better manage the complexities and challenges is to consider a systems approach incorporating system engineer, project management, program management, and tools and techniques from other disciplines in an integrated model. Future models should consider People, Design, Systems, and Risk from a variety of perspectives. Further, seek out innovative applications of technologies such as Robotics, Blockchain, the Metaverse, Machine Learning, and Connected Mental Health. There is a need to re-imagine the future of the Mental Healthcare System. The vision should consider patient controlled service, modified social context, virtual mental healthcare, and partners to the poor. Lastly, consider a systematic program management approach for managing large-scale complex mental healthcare endeavor.

REFERENCES

Ash, Gunay; Ward, James; and Clarkson, John P. Mapping a Systems Approach to Existing Healthcare Design, Delivery and Improvement Method. International Conference on Engineering Design ICED21. 2021.

Barbazzeni, Beatrice; Fritzsche, Holger; and Friebe, Michael. Forecasting the Future of Healthcare Democratization. An Imperfect but Valuable Science. Current Direction in Biomedical Engineering 2021. 7(2) 155-158.

Berg, Thomas A, Marino, Kelsi N, Kintziger, Kristina W. The Application of Model-Based Systems Engineering to Rural Healthcare System Disaster Planning: A Scoping Review. International Journal of Disaster Risk Science (2023) 14:357-368

Broadbent, Elizabeth; Kuo, I Han; Lee, Yong In: Rabindran, Joel; Kerse, Ngaire; Srafford, Rebecca; MacDonald, Bruce A. Attitudes and Reactions to a Healthcare Robot. Telemedicine Journal and e-health, 2010, 16(5) 116-120

Bruch, Joseph Dov; Roy, Victor; Grogan, Colleen M. The Financialization of Health in the United States. The New England Journal of Medicine. 2024. 390 (2). 178-182.

Clarkson, John p. What Has Engineering Design to Say About Healthcare Improvements? Design Science. Cambridge University Press. 2018. 4.

Clarkson, John; Dean John; Ward, James; Komashie, Alexander; and Bashford Tom. A Systems Approach to Healthcare: From Thinking to Practice. Future Healthcare Journal 2018 5(3) 151-155.A

Drissi, Nidal. Ouhbi, Sofia. Abdou Janati Idrissi, Mohammed. Fernandez-Luque, Luis. Ghogho, Mounir. Connected Mental Health: Systematic Mapping Study. Journal of Medical Internet Research. 2020 | vol. 22 | iss. 8 | e19950 | p. 1

Frith, Lianne. Engineering Innovations Focused on Improving our Mental Health. Maker Pro. 2020. https://maker.pro/blog/how-engineering-can-improve-our-mental-health

Geddes, John. Learning from the Global Response to COVID-19 to Accelerate Innovation in Mental Health Trials. World Psychiatry. 2021. 20(3). 358-359.

Giacco, Domenico ; Amering, Michaela; Bird, Victoria; Craig, Thomas; Ducci, Giuseppe; Gallinat, Jürgen; Gillard, Steven George; Greacen, Tim; Hadridge, Phil; Johnson, Sonia; Jovanovic, Nikolina; Laugharne, Richard; Morgan, Craig; Muijen, Matthijs; Schomerus, Georg; Zinkler, Martin; Wessely, Simon; Priebe, Stefan. Scenarios for the Future of Mental Health Care: A Social Perspective. Lancet Psychiatry. 2017. 4. 257-260.

Gubin, Tatyana A; Iyer, Hari P.; Liew Shielene N. Sarma, Aartik; Revelos Alex; Ribas Joao; Movassaghi, Babak; Chu, Zen M.; Khalid, Ayesha N; Majmudar, Maulik D; and Lee, Christopher. A Systems Approach to Healthcare Innovations Using the MIT Hacking Medicine Model. 2017. Cell Systems. 5. 6-10.

Komashie, Alexander; Hinrichs-Krapeis, Saba; and Clarkson, John P. Systems Approaches to Healthcare Systems Design and Care Delivery: An Overview of the Literature. International Conference on Engineering Design, ICED21. 2021.

Mackey, Tim K; Kuo, Tsung-Ting; Gummadi, Basker; Clauson, Kevin A; Church, George; Grishin, Dennis; Obbad, Kamal; Barkovish, Robert; Palombini, Maria. 'Fit-For-Purpose' – Challenges and Opportunities for Applications of Blockchain Technology in The Future of Healthcare. BMC Medicine. 2019. 17:68

Minas, Harry. The Centre for International Mental Health Approach for Mental Health System Development. Harvard Review Psychiatry 2012, 20(1) 37-46

Murthy, Srinvasa, R. Future of Mental Health. Asian Journal of Psychiatry. 28 (2018) A7 - A11

National Alliance on Mental Illness (NAMI). https://www.nami.org/mhstats

National Institute of Health. The Brain Initiative. https://braininitiative.nih.gov/sites/default/files/documents/2-PAGER_brain_initiative_scientific%20advancements_v5_20231106_508C.pdf

Ozturkan, Selcen and Merdin-Uygur, Ezgi. Humanoid Service Robots: The Future of Healthcare? Journal of Information Technology. 12(2) 163-169.

Patel, Vikram; Saxena, Shekhar. Transforming Lives, Enhancing Communities – Innovations in Global Mental Health. The New England Journal of Medicine. 2014. 370 (6). 489-501.

Patel, Vikram. Saxena, Shekhar. Lund, Crick. Thornicroft, Graham. Baingana, Florance. Bolton. Paul. Chisholm, Dan. Collins, Pamela Y. Cooper, Janice L. Eaton, Julian. Herrman, Helen. Herzallah, Mohammad M. Huang, Yueqin. Jordans, Mark J D. Kleinman, Arthur. Medina-Mora, Maria Elena. Morgan, Ellen. Niaz, Unaiza. Omigbodun, Olayinka. Prince, Martin. Rahman, Atif. Saraceno, Benedetto. Sarkar, Bidyut K. De Silva, Maria. Singh, Ilina. Stein, Dan j. Sunkel, Charlene. and UnÜtzer Jürgen. The Lancet Commission of Global Mental Health and Sustainable Development. The Lancet Commision. 392. (2018) 1533 – 1598.

Roesch, Ronald;' Oglof, James R.P,; Eaves, Derek. Mental Health Research in the Criminal Justice System: The Need for Common Approaches and International Perspective. International Journal of Law and Psychiatry 1995. 18(1) 1-14

Seppälä J, De Vita I, Jämsä T, Miettunen J, Isohanni M, Rubinstein K, Feldman Y, Grasa E, Corripio I, Berdun J, D'Amico E; M-RESIST Group; Bulgheroni M. Mobile Phone and Wearable Sensor-Based mHealth Approaches for Psychiatric Disorders and Symptoms: Systematic Review. JMIR Ment Health. 2019 Feb 20;6(2):e9819. doi: 10.2196/mental.9819. PMID: 30785404; PMCID: PMC6401668.

Sharfstean, Steven S. Despair of Hope. The Future of Mental Health Service Delivery in the United States. Journal of Nervous and Mental Disease. 2023 (4) 241-242

Thieme, Anja. Belgrave, Danielle. And Doherty, Gavin. Machine Learning in Mental Health: A Systematic Review of the HCI Literature to Support the Development of Effective and

Implement ML Systems. ACM Transactions on Computer-Human Interaction, 2020. Vol. 27, No. 5. 34

Usmani, Sadia Suhail. Sharath, Medha. Mehendale, Maghana. Future of Mental Health in the Metaverse. General Psychiatry. 2022;35: e100825. doi:10.1136/gpsych-2022-100825

Wang, Ying; Byrne, Louise; Bartram, Timothy; and Chapman, Melissa. Developing Inclusive and Healthy Organizations by Employing Designated Live Experience Roles: Learning from Human Resource Management Innovations in the Mental Health Sector. The International Journal of Human Resource Management. 2023 34(10) 1973 – 2001.