ISYS90069
Digital Mental Health
Artificial Intelligence and Mental Health

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Topics for today

- Digital mental health apps/interventions
- AI and mental health:
    - Digital phenotyping
    - Natural language processing analysis of clinical texts and social media content
    - Chatbots
- Ethical and human-computer interaction considerations

Why Digital Mental Health?

- Mental and substance use disorders are a leading cause of disability worldwide.

- One in four people in the world will be affected by mental health or neurological issues at some point in their lives. (WHO 2001)

- Almost half (45%) of Australians experience mental ill-health in their lifetime and 54% of people with mental illness do not access any treatment.

Why Digital Mental Health?

- This is worsened by delayed treatment due to serious problems in detection and accurate diagnosis. The proportion of people with mental illness accessing treatment is half that of people with physical disorders. (Dept of Health Aust. and Black Dog Institute)

- Many affected by mental ill-health do not get the treatment they need due to stigma, living in regional areas, or because of low income.

- Substantial labour cost of mental illness in Australia (estimated to over $12 billion annually).

Why Apps?

- Mental health apps can help to overcome these impediments to treatment and fill in resource gaps.

- Since the development of the first established mental health app circa 2010, around 10,000 mental health and wellbeing apps have been introduced to the market.

- These apps generally serve to complement/supplement rather than completely replace traditional forms of face-to-face treatment.

Types of apps/interventions

- **Teletherapy:** person-person psychotherapy over online chat or video conference
- **Blended:** using an app that is integrated with traditional clinical mental health care
- **Standalone:** the mental health constitutes the intervention

Evaluating Apps

- Only around 1% have been professionally evaluated, as there are currently no enforced standards or regulations.

- Standards and regulation frameworks are however developing:
  - Australian Therapeutic Goods Administration (TGA) "Regulation of Software as a Medical Device"
  - US Food and Drug Administration (FDA) "digital therapeutics"

- Note the difference between apps that employ evidence-based approaches versus apps that themselves have an evidential basis.

Evaluating Apps

- Picking the most suitable app is difficult because of privacy risks, usability concerns, and because apps constantly update and change.

- Users typically rely on the use of star rating systems and reviews in app stores, despite evidence that these evaluation methods can be misleading.

- Need for solid evaluation frameworks: moving away from picking the best-rated app and towards making an informed decision on the basis of clinically-relevant criteria.

- App evaluation frameworks:
  - One Mind PsyberGuide
  - American Psychiatric Association (APA) app evaluation model

APA App Evaluation Model

- Step 1: Gather Background Information
  - What is the business model? If the app is free, then how does it support its own development?
  - Who is the developer?
  - Does it claim to be medical?
  - What is the cost? Does it require in-app purchases to unlock certain features? Is it free?
  - Does it integrate advertising into its usability?
  - On which platforms does it work (e.g., iOS, Android)?
  - When was it last updated? How many updates have there been? What were the reasons for the updates (i.e., security updates; software glitches or bugs; improved functionality or added services)?

APA App Evaluation Model

- Step 2: Risk/Privacy & Security
    - Is there a privacy policy?
    - What data are collected?
    - Are personal data de-identified?
    - Can you opt-out of data collection?
    - Can you delete data?
    - Are cookies placed on your device?
    - Who are data shared with/What data are shared?
    - Are data maintained on the device or the web (i.e., "the cloud")? Both?
    - What security measures are in place? Are data encrypted on the device and server?
    - Does it purport HIPAA compliance? / Does it need to be HIPAA-compliant?

APA App Evaluation Model

- Step 3: Evidence
  - What does it claim to do vs. what does it actually do?
  - Is there peer-reviewed, published evidence about tool or science behind it?
  - Is there any feedback from users to support claims (App store, website, review sites, etc.)?
  - Does the content appear of at least reasonable value?

APA App Evaluation Model

- Step 4: Ease of Use
  - Is it easy to access for the patient at hand (i.e., based on patient diagnosis or other factors)?
  - Would it be easy to use on a long-term basis?
  - Is the app or are features of the app customizable?
  - Does it need an active connection to the Internet to work?
  - What platforms does it work on?
  - Is it accessible for those with impaired vision or other disabilities?
  - Is it culturally relevant?
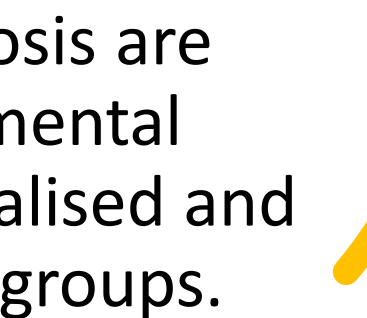
APA App Evaluation Model

- Step 5: Interoperability
  - Who "owns" the data (i.e., patient, provider, developer)?
  - Can it share data with the electronic health record?
  - Can you print out your data?
  - Can you export/download your data?
  - Can it share data with other user data tools (eg, Apple HealthKit, FitBit)?

More on standards and principles for evaluating mental health apps

- "Towards a consensus around standards for smartphone apps and digital mental health": https://onlinelibrary.wiley.com/doi/10.1002/wps.20592

- "Deriving a practical framework for the evaluation of health apps": https://www.thelancet.com/journals/landig/article/PIIS2589-7500(19)30013-5/fulltext
  - "Just as no single best antidepressant or therapy exists, no single best app exists to treat all patients or mental illnesses. Clinical presentation, patient preferences, technology literacy, accessibility, and treatment goals are all important factors that determine the best course of care for any patient. Such factors must be considered when deciding what the most suitable app might be for a patient in any given situation."

What are the examples of mental health conditions with an associated mental health app?

- The two most common mental ill-health conditions associated with mental health apps are anxiety and depression.

- One in three people going to doctors in Australia state that they have either or both of these conditions.

- Beyond anxiety and depression, apps can be found for psychosis, bipolar disorder, PTSD, eating disorders, and others.

- Certain conditions such as psychosis are particularly complex and digital mental health tools for it are more specialised and developed by specialised clinical groups.

How do these apps work to help with a mental health condition?

- Mental health apps generally work in support of therapy and/or medication.
- NIMH classifies mental health apps into six categories based on functionality:
  - self-management
  - cognition improvement
  - skills-training
  - social support
  - symptom tracking
  - passive data collection

How do these apps work to help with a mental health condition?

- Mental health apps span all stages of clinical care provision, including immediate crisis intervention, prevention, diagnosis, primary treatment, supplement to in-person therapy, and post-treatment condition management.

- Mobile apps are a good choice for psychological treatment delivery compared to other platforms due to (i) ease of habit, (ii) low effort expectancy, and (iii) high hedonic motivation.

- Do mental health mobile apps work: evidence and recommendations for designing high-efficacy mental health mobile apps: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC5897664/

How do these apps work?

- Many mental health apps are tailored to the individual through questionnaires that determine the user's needs, strengths and weaknesses.
- Apps provide a toolkit of activities for the user involving:
    - Self-help skills
    - Identification of and support for therapeutic goals
    - Promotion of positive self-talk
    - Reinforcement of techniques used in therapy
    - Cognitive Behavioural Therapy
    - Behavioural Activation
    - Mindfulness
    - Positive Psychology

How do these apps work?

- Apps provide a toolkit of activities for the user involving:
  - Social skills
  - Meditations
  - Relaxation and breathing exercises
  - Connecting users to treatment facilities and therapists
  - Tracking users' moods
  - Identifying triggers for mood disorders
  - Connecting user to similar people suffering similar problems - facilitating therapy through anonymous sharing

Key methods apps employ for depression and anxiety

- Cognitive behavioural therapy (CBT)

- Relaxation

- Mindfulness training

- Mood monitoring

- Features that enable users to self-monitor their mood by periodically reporting their thoughts, behaviours, and actions can increase emotional self-awareness (ESA), which has been found to be implicated in anxiety, depression.

- Increasing ESA, defined as the ability to identify and understand one's own emotions, has been shown to reduce symptoms of mental illness and improve coping skills.

- So let's look at how some of these examples work in more detail …

Virtual Reality

- Virtual Reality (VR) is an immersive computer-generated simulation of a 3D environment or experience that can be interacted with using a headset or other input devices.

- VR can be used as a therapeutic tool for mental health issues such as anxiety disorders, phobias, and post-traumatic stress disorder (PTSD).

- VR therapy allows individuals to safely confront and overcome fears and traumas in a controlled environment, without being exposed to real-life triggers.

- VR therapy can also be used for relaxation and stress reduction, through immersive experiences such as nature walks or mindfulness exercises.

Virtual Reality

- VR therapy has shown promising results in research studies, with some studies reporting similar or even better outcomes compared to traditional therapy methods.

- However, VR therapy is still a relatively new field, and more research is needed to fully understand its effectiveness and potential limitations.

- Some challenges in the use of VR therapy include the cost of equipment and software, as well as potential side effects such as motion sickness and disorientation.

- Despite these challenges, VR therapy has the potential to be a valuable tool in the treatment of mental health issues, providing a safe and immersive environment for individuals to confront and overcome their fears and traumas.

Artificial Intelligence and Mental Health
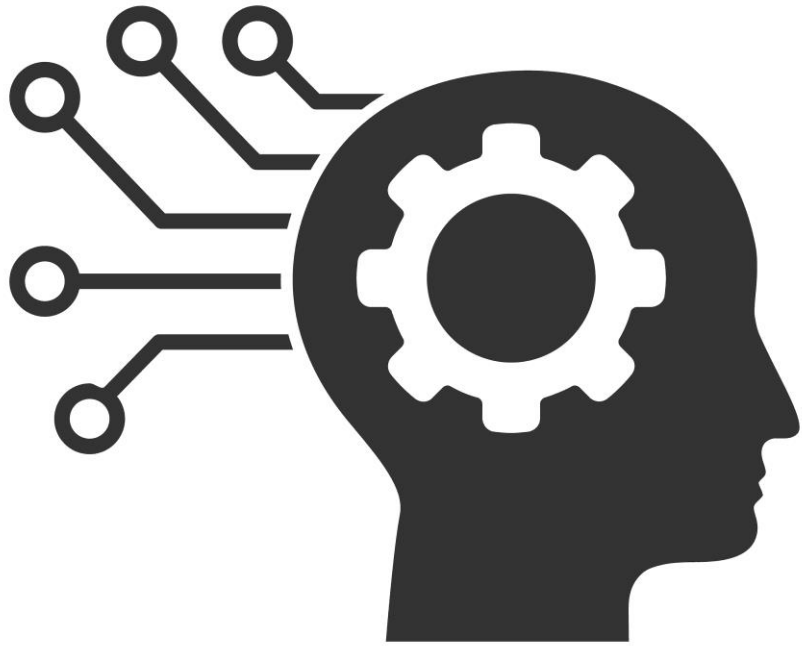
- With the advent of digital approaches to mental health, modern artificial intelligence (AI) (machine learning in particular) is being used in the development of prediction, detection, and treatment solutions for mental health care.

- Although there has been considerable progress in digital health and the application of AI to physical health in general, the adoption of AI in mental health is relatively nascent.

- Topics include:
  - Digital phenotyping
  - Natural language processing analytics
  - Chatbots

Digital Phenotyping

- Our increasing usage of smartphones, wearables and the Internet (particularly social media/networking) has increased what can be termed our 'digital footprint' or 'data exhaust'.

- Digital phenotyping is about mining/analysing an individual's (or group's) digital footprint to gain insights into their mental health.

- Insights of clinical value that could be used to anticipate mental ill-health and inform treatment.

Digital Phenotyping

- The "moment-by-moment quantification of the individual-level human phenotype in-situ using data from smartphones and other personal digital devices":
  - *New Tools for New Research in Psychiatry: A Scalable and Customizable Platform to Empower Data Driven Smartphone Research* (https://mental.jmir.org/2016/2/e16/).

- AKA Personal Sensing.

- 'Phenotype' is a scientific term used to denote an organism's (including humans) naturally observable physical and behavioural characteristics.

- Thus 'digital phenotyping' is the process of measuring or identifying certain (behavioural) characteristics based on an individual's digital footprint.

Smartphone Digital Phenotyping - The Gist

The usage and sensor data from a smartphone can be collected and analysed to infer information about its user.

Two types of information

1. Contextual/Situational
2. Behavioural

The Spiel

Traditional mental health care is resource limited.

Clinical sessions and patient self-reporting can be affected by certain subjectivities in assessments and accounts of behaviour.

Existing clinical practices are inefficient in detecting early stages of mental illness. Standard methods are based on face-to-face interactions and assessments with clinicians, conducted at set times and locations.

Once a clinical therapy session is over, there is no sufficient way to monitor a patient's behavioural patterns in their real day-to-day life.

Continuous smartphone sensing information, unobtrusively collected, can fill this gap, providing value to both patients and clinical care providers.

Movement and Physical Activity Sensors

- GPS, Accelerometer, Gyroscope.

- These sensors can be used to distinguish sedentary and non-sedentary states and to investigate connections between movement and conditions such as depression.

- Some early results suggest that people who are depressed tend to have less spread in the locations they visit:
    - *Predicting depressive symptoms using smartphone data* (https://www.sciencedirect.com/science/article/abs/pii/S2352648319300571)

- The types of locations one visits could also offer mental health insights, though there seems to be little research on this idea.

- One small study found some modest though inconsistent relationships between the time spent in certain locations and mental health; depression and anxiety scores were lower for some people who spent more time in spiritual locations and non-depressed people spent significantly more time at work:
    - *Mobile Phone Detection of Semantic Location and Its Relationship to Depression and Anxiety* (https://mhealth.jmir.org/2017/8/e112/)

Communication and Social Engagement

- Connections between social connectivity and mental health.

- Social media app usage, SMS message counts, calls (incoming, outgoing, answered, unanswered).

- One study found that certain reductions in the number and duration of outgoing calls, as well as number of text messages, were associated with relapses of schizophrenia:
    - *Relationships between smartphone social behavior and relapse in schizophrenia: A preliminary report* (https://www.sciencedirect.com/science/article/abs/pii/S0920996419301082)

- Bluetooth: detecting surrounding Bluetooth enabled devices could be used to determine whether the smartphone user is in a crowded or uncrowded space, surrounded by a lot of people or not:
    - *Validation of a smartphone app to map social networks of proximity* (https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0189877)

Keyboard and Screen Interaction

- An individual's tactile interactions with the screen (typing, pressing, swiping).

- One study showed that both average delays between keystrokes and auto-correction rates (misspellings) correlated positively with a common depression scale:
    - *Predicting Mood Disturbance Severity with Mobile Phone Keystroke Metadata: A BiAffect Digital Phenotyping Study* (https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6076371/)

- In another study comparing two groups, one with depressive tendencies and one without, the depressive group showed longer periods between pressing and releasing a key. This indicates a slower motor reaction time or psychomotor retardation, which is a feature of depression:
    - *Touchscreen typing pattern analysis for remote detection of the depressive tendency* (https://www.nature.com/articles/s41598-019-50002-9)

Opportunities

Tapping into this rich array of sensors in smartphones can be used in two ways in terms of mental mhealth:

1. Development of a digital phenotyping framework to analyse an individual's accumulated smartphone sensing data and converting this analysis where possible into meaningful psychological information, including the prediction/detection of mental ill-health.

2. Provide situational/contextual information about a user (their location, time of day, surrounding), which may be of use in determining relevant real-time digital therapy delivery.

Detect and Deliver

- DETECT = Use of smartphone sensors to detect psychological and situational information about smartphone user.

- DELIVERY = Using this detection information to personalise real-time delivery, via example push notifications, of therapy actions.

- Beyond simply offering and expecting users to visit a website for help, meet them in their situations and dynamically deliver via smartphone relevant therapy directly to their pockets.

- Ecological Momentary Intervention (EMI), Just-in-time adaptive interventions (JITAIs)

- *Making the MOST out of Smartphone Opportunities for Mental Health* (https://people.eng.unimelb.edu.au/dalfonso/articles/most_smartphone_opportunities_mhealth.pdf)

Natural Language Processing for Mental Health Insights

- In line with the idea that the language we use provides a window into our minds, one's words could be analysed with natural language processing (NLP) to infer mental health information about them.

- Sources:
  - Clinical transcripts
  - Social media posts
  - Keyboard / keypad input
  - Voice assistants

Psychosis

- Some early research on NLP and mental health used semantic coherence and syntactic complexity to predict later psychosis development from patient clinical transcripts.

- The use of less complex and more incoherent language predicted (in a small trial group) subsequent onset of the disorder:
  - *Automated analysis of free speech predicts psychosis onset in high-risk youths* (https://www.nature.com/articles/npjschz201530)
  - *Prediction of psychosis across protocols and risk cohorts using automated language analysis* (https://onlinelibrary.wiley.com/doi/full/10.1002/wps.20491)

Depression

- In one study, the Facebook posts of a relatively large patient cohort were analysed to predict, with an accuracy approximately matching screening surveys, depression as recorded in their electronic medical records.

- The researchers found that language predictors of depression include emotional (sadness), interpersonal (loneliness, hostility), and cognitive (preoccupation with the self, rumination) processes:
    - *Facebook language predicts depression in medical records* (https://www.pnas.org/content/115/44/11203)

- Facebook themselves have implemented a system to identify post content that indicates people who might be at risk of self-harm:
    - *How Facebook AI Helps Suicide Prevention* (https://about.fb.com/news/2018/09/inside-feed-suicide-prevention-and-ai/)

Beyond Linguistic Content

- Beyond the natural language processing of text, work on the audio analysis of paralinguistic/acoustic (e.g., volume, pitch and intonation) aspects of speech using AI has shown that such properties of speech can also be computationally analysed to infer mental health information:

  - *Automated assessment of psychiatric disorders using speech: a systematic review* (https://onlinelibrary.wiley.com/doi/full/10.1002/lio2.354)

Chatbots – Key Points

- A chatbot is a computer program that mimics conversation with users via a chat interface, either text or voice based.

- The underlying system can be based on a variety of foundations, ranging from a set of simple rule-based responses and keyword matching to advanced machine learning and NLP techniques.

- Irrespective of the actual intelligence of the responding bot, there is something distinct about the experience of a user entering input and a bot responding.

- There is a range of uses for chatbots in mental health.

Chatbots

- Simple chatbot interfaces providing conversational search engines for digital mental health therapy content.

- Whilst chatbots are far off from being able to satisfactorily emulate human language use and replicate psychotherapeutic dialogue, they can now maintain basic forms of conversation.

- One use of such a chatbot could be to guide users through exercises in a mental health app. Examples of mental health apps that incorporate a chatbot setup are
  - Woebot (https://woebothealth.com/)
  - Wysa (https://www.wysa.io/)
  - Cass (https://www.cass.ai/)

Chatbots

- Another use of such a chatbot could be to initiate a welcoming chat with clients queued up and waiting to chat with a human therapist via online mental health portals such as eheadspace (https://headspace.org.au/eheadspace/).

- Gather clinically useful information by both direct answers and by automatically analysing the language of the responses.

- This information could then provide the therapist with a snapshot about the client with whom they are about to chat.

Chatbots

- Moving beyond simpler chatbots, Replika (https://replika.ai) is one of the more sophisticated examples of a chatbot capable of emulating psychological connection and injecting some emotion into conversation.

- ChatGPT?

- Ultimately however, a chatbot that can carry out a complete psychotherapeutic conversational session and replicate human therapists remains to be seen, if at all entirely possible.

- Such a chatbot goal could perhaps serve as a yardstick of sorts à la the Turing test.

Ethical and human-computer interaction dimensions

- The ethics of app design

- Privacy and confidentiality

- Digital therapeutic alliance

The Ethics of App Design

- Motivated primarily by commercial and advertising interests, many websites and apps incorporate features that are intentionally designed to hook users in, maximising their attention and usage time without due regard for the quality or benefits to wellbeing of this usage.

- Beyond clinical efficacy considerations and also in concert with them, we must be mindful to:
  1. Ensure that the system in general is not detrimental to wellbeing and that features and components of little value or that have a negative impact on psychological health are avoided.
  2. Develop content and features that promote mental health and wellbeing and that users are motivated to use for good reasons

The Ethics of App Design

- An app should encourage and facilitate offline activity outside of the site

- Online activity should be promoted within the site insofar as it is something that is beneficial and inherent to the site/app or can genuinely only be mediated/facilitated by the site/app.

Can these apps pose a risk to patient confidentiality?

- Like any data technology, security and confidentiality are factors that need to be considered.

- Where is the data being stored? What security measures are in place to secure that data?
    - On the patient phone
    - On a remote server

- How can the data be stored to maximise its unidentifiability?

- Digital phenotyping raises these issues to a new level.

- User should have control over their data.

- Trade-off between privacy and help?

- [Are mental health apps better or worse at privacy in 2023?](#)

Digital Therapeutic Alliance

- The therapeutic alliance, the relationship that develops between a therapist and a patient, is a significant factor in the outcome of psychological therapy.

- As mental healthcare starts to increasingly adopt digital technologies and offer therapeutic interventions that may not involve human therapists, the notion of the therapeutic alliance in digital mental healthcare requires exploration.
  - What is the nature and role of the therapeutic alliance in digital mental health solutions?
  - Does the traditional notion of a quality relationship between client and therapist holds true in the digital environment?
  - Do aspects of the traditional therapeutic alliance have digital analogues and what novel aspects emerge in the digital realm?

Digital Therapeutic Alliance

Ways this theme can be explored:

- The standard patient-therapist alliance in the case of telehealth therapy sessions.
- The relationship between a user and their mental health app, including their smartphone.
- The nature of the therapeutic alliance in anthropomorphic digital interventions, including chatbots and virtual human therapists.