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4. Artificial Intelligence, Digital Therapies, and Neuromodulation in the Field of Addiction and Social Work

With the rapid advancement of artificial intelligence (AI) technology, its applications in healthcare and social work have become increasingly widespread, encompassing even the realm of addiction treatment. This chapter sets out to explore how AI, digital therapies, and neuromodulation techniques can provide personalised and efficient treatment plans for individuals struggling with addiction, and to analyse their practical applications within social work and the transformative effects they bring about. It will also delve into the value these developments hold for enhancing the work of non-governmental organisations (NGOs).

In the first section, we will introduce AI's role in identifying and diagnosing addiction, including the use of data analysis to predict addictive behaviours and relapse risks. Following this, we will examine how digital therapies serve as non-pharmacological interventions, leveraging smart devices and software programmes to deliver psychological interventions such as cognitive behavioural therapy (CBT), thereby assisting patients in improving their self-management skills. Furthermore, we will discuss the application of neuromodulation technologies like transcranial magnetic stimulation (TMS), transcranial electric stimulation (TES), and deep brain stimulation (DBS) in addiction therapy. These methodologies show potential in altering neural pathways associated with addiction by modulating brain activity.

The chapter will also analyse how these technologies intertwine with social work, presenting relevant case studies on how they facilitate and enhance the accessibility of treatments and the extent to which patients adhere to them. Social workers can employ AI tools for risk assessments, resource matching, and tailoring individualised intervention plans, while the implementation of digi-

tal therapies and neuromodulation technologies furnishes patients with more adaptable and diverse therapeutic alternatives. Through this exploration, our aim is to furnish professionals with a profound comprehension of the application of AI, digital therapies, and neuromodulation technologies in addiction treatment and social work, guiding future research avenues and practical implementations.

The Role of Artificial Intelligence (AI) in Assisting Addiction Assessment

Clinical diagnosis and assessment of mental disorders, including addiction, primarily rely on the patient's medical history and the physician's interview evaluation according to the international classification of diseases-11 (ICD-11) diagnostic guidelines. However, there are limitations to this approach, such as patients concealing their medical history and subjectivity on the part of the physician. How to objectively assess the pathological abnormalities of addicted patients is the most critical scientific issue for improving the accuracy of diagnosis and assessment and precise intervention in the field of addiction. Chronic drug abuse leads to abnormalities in brain function and structure, manifesting as sensitivities to drug-related cues, attentional bias, increased impulsivity, and decreased inhibitory function, resulting in the vicious cycle of drug use, withdrawal, and relapse.

There are a multitude of objective indicator studies targeting the pathological manifestations of addiction mentioned above. For instance, using drug-related cue stimuli combined with changes in neurophysiological signals can be used for the objective assessment of psychological craving in addicts. Franken et al.(2008) found that the late positive potential in the right central frontal region of the brain of cocaine addicts is significantly correlated with the level of craving. Meta-analysis has found that heart rate changes in marijuana abusers are related to drug cue responses, while our research group previously found that psychological craving in heroin addicts is related to changes in skin conductance, electromyography, and electroencephalography. Ahn et al. (2016) used impulsivity scale assessments and behavioural indicators reflecting the level of impulse inhibition for relapse prediction, employing the least abso-

lute shrinkage and selection operator (LASSO) regression algorithm for classification and achieving an area under the receiver operating characteristic curve of 0.917 in the test sample. Suchting et al. (2019) screened multiple emotional characteristics of cocaine addicts through a generalised additive model, identifying several effective factors for predicting relapse within the next 30 days. Symons and colleagues (2020) at the University of Queensland, Australia compared the accuracy of predicting the relapse risk of alcohol addicts based on medical history characteristics and found that the machine learning model's prediction accuracy (63.06 %) was significantly higher than the physician's clinical evaluation (56.36 %).

Recent studies have shown that through machine learning algorithms for the analysis of multimodal electrophysiological signals, the prediction accuracy of the psychological craving level in addicts can reach 87 %. Single-modal recognition technology has limitations in accuracy and clinical application, and multimodal fusion technology can significantly improve model recognition efficiency. For example, Li et al.(2017) applied stacked autoencoders and long short-term memory-based recurrent neural network models for emotional recognition of mixed physiological signals such as electroencephalography, achieving an accuracy rate of 79.26 %. Shawky et al. (2018) used a 3D convolutional neural network algorithm, improving the accuracy of EEG signal emotional recognition to over 85 %.

The process of addiction includes various pathological manifestations, and a deep understanding of the pathological characteristics behind the information helps to improve the accuracy and precision of diagnosis and treatment. Most of the current multimodal signal integration research comes from existing public databases. Due to the lack of public databases in the field of addiction, there is still a lack of research on the connection between multimodal signals and pathological characteristics of addiction, as well as the application of corresponding deep algorithms. By combining multiple international addiction cohort clinical databases and using multimodal information such as facial expressions, speech, eye movement, electroencephalography, and skin conductance, the accuracy of diagnosis and assessment of addicts can be improved. Furthermore, combining information from voice and image and integrating linguistic text, facial attributes, eye movement, motion, electrophysiology, and

background information with natural language interactive information is expected to provide a more accurate assessment model, representing the development trend and research frontier in this field.

The Application of Digital Therapeutics in Addiction Treatment

Psychotherapy is an evidence-based treatment widely employed for individuals with substance use disorders (SUDs). Recommended psychological interventions for such disorders include motivational interviewing, cognitive behavioural therapy, problem-solving skills, and mindfulness, administered in settings ranging from hospitals to communities and primary care facilities and as pivotal support tools in non-governmental organisation activities. In practice, various behavioural approaches are often combined. Motivational interviewing is commonly used to engage patients in treatment, while cognitive and behavioural methods address dysfunctional cognitions and skill deficits. Therapy can be delivered on an individual or group basis, with the twelve-step programme being the most widely recognised group intervention. Alcoholics Anonymous (AA), for instance, welcomes all who wish to quit drinking, maintaining anonymity among members who share experiences, strengths, and hope to achieve and support sobriety. Motivational enhancement therapy utilises motivational interviewing (MI) to enhance treatment adherence and motivation in patients. Cognitive behavioural therapy encompasses a range of interventions grounded in social learning theory and stress coping theories. From a CBT perspective, substance dependence is a learned behaviour that can be altered through cognitive and behavioural skill acquisition. CBT therapists initially enhance patients' motivation to quit or reduce drug use, subsequently aiding them in identifying high-risk situations for relapse, understanding its consequences, and discussing strategies to manage behaviours related to substance use, thereby preventing relapse and enhancing social skills and stress management. Mindfulness-based therapies are simple and practical and facilitate self-awareness and acceptance in individuals with alcohol use disorder, enabling timely recognition and regulation of negative emotions during the recovery process.

However, psychotherapy is hindered by high professional requirements, costly services, high turnover rates among professionals, and an imbalance between supply and demand for traditional psychotherapy, making it difficult for patients to access specialised care. Patients also confront high levels of stigma, forced abstinence, and scheduling challenges in conventional substance use disorder treatments. Global mental health surveys reveal that only 7.1 % of individuals with SUDs receive even minimal adequate treatment. The Covid-19 pandemic has exacerbated this issue by increasing demand for substances and further obstructing access to care. Integrating information technology into psychotherapy to develop novel treatments for those with substance dependencies could be a crucial solution to this quandary. Researchers have identified dissemination barriers for many evidence-based mental health and substance use disorder treatments, limiting their reach to a broader patient population. For instance, Marsch et al. (2014) found that less than 10 % of individuals with SUDs receive specialised treatment.

Given the limited resources, providing personalised treatment to every patient is unfeasible. AI has introduced numerous new possibilities for delivering mental health services. Digital human-assisted intelligent rehabilitation can enhance the accessibility of targeted and comprehensive treatments. IT significantly contributes to overall health management, making it more autonomous, convenient, and personalised. Many digital interventions developed for mental health, particularly those addressing anxiety and depression, have yielded positive research outcomes and are gaining traction in the tech market.

Interventions based on information technology are emerging as a new approach for self-management and treatment among individuals with SUDs. Over the past decade, a growing body of research has acknowledged the efficacy of technologically mediated interventions for SUDs, offering patients more treatment alternatives. Building upon psychosocial interventions and medication management, researchers in 2016 developed a new computer-delivered behavioural platform called "Take Control", aimed at reducing therapist bias and the costs of conducting clinical trials, while achieving patient retention rates, medication adherence, and placebo responses comparable to those of therapist-delivered platforms. Our research team from the Shanghai Mental Health Center also devel-

oped a community-managed addiction rehabilitation electronic system (CAREs), designed to assist social workers in better managing and serving individuals recovering from substance addiction, which demonstrates high levels of sustained patient usage and acceptability among social workers.

Common digital interventions for SUDs, including alcohol use disorder, involve personalised normative feedback (PNF), brief interventions, and CBT-based interventions. PNF tailors feedback according to an individual's substance use patterns. While extensively studied among young substance users, current evidence does not yet support PNF's long-term efficacy for substance dependency. Brief interventions lasting 15–30 minutes target patients' motivation with personalised advice. A meta-analysis of brief interventions in emergency care settings suggests that brief, non-face-to-face interventions are more effective than traditional ones in reducing alcohol and other substance use. Evidence indicates that low-intensity digital interventions can lead to slight reductions in alcohol consumption among dependent drinkers, with effects persisting for up to six months post-intervention, though there is a dearth of research on the long-term clinical impact of digital interventions on alcohol use disorders. Higher frequency and intensity of interventions correlate with better treatment outcomes for alcohol use disorders.

Internet-based CBT enables patients to access, read, and download online materials by regularly logging onto a web-based therapy platform, mirroring modules of traditional CBT. Kiluk and Devore (2016) randomly assigned 69 patients recruited from outpatient clinics to one of three conditions: (i) treatment as usual (TAU); (ii) TAU plus computerised CBT for alcohol use (TAU + CBT4CBT); or (iii) CBT4CBT plus brief weekly clinical monitoring. Results showed significantly higher treatment completion rates, longer periods of alcohol abstinence, and lower costs for those receiving TAU plus computerised CBT compared to those only receiving TAU. A systematic review concluded that digital CBT effectively reduces relapse rates among individuals with SUDs. Ongoing use of online technologies and smartphone applications following treatment may also have a lasting impact on patients' recovery.

In addition to enhancing intervention effectiveness, web-based mobile interventions enable patients to participate in online addiction treatment services via the internet allowing them to selectively

engage with therapeutic modules or browse social forums. This extends the treatment setting from conventional healthcare institutions to everyday environments, thereby improving service accessibility. For instance, in the United States, only 20 % of individuals diagnosed with alcohol use disorder (AUD) seek treatment at medical facilities; however, further investigation reveals that mild AUD patients demonstrate a favourable receptiveness to online interventions and maintain relatively high completion rates. Web-based interventions prove as efficacious for most mild AUD cases as therapist-delivered treatments in person. These interventions have shown good therapeutic outcomes among alcohol, cannabis, and stimulant users but have had little effect on opioid users. Past research indicates that psychological treatment alone for opioid users, without accompanying medication, can yield adverse effects, necessitating medication-assisted treatments such as methadone, buprenorphine, or naltrexone for this population.

Meta-analyses of adult populations find that brief, web-based interventions for alcohol are more effective for male problem drinkers, and participants aged 55 and above are more likely to adopt low-risk drinking recommendations post-intervention compared to younger individuals. Web-based interventions offer high flexibility and autonomy, enabling users to engage in treatment at their convenience. However, navigating online therapeutic modules can be challenging for some users, with studies indicating lower usability ratings for web-based interventions compared to apps, suggesting limitations in user acceptance.

It is noteworthy that systematic reviews of digital interventions for SUDs indicate that single-dimensional interventions serve as useful adjuncts but are insufficient to fully address patients' recovery needs. Comprehensive interventions are deemed most effective in substance use disorder rehabilitation, particularly when healthcare professionals, social workers, and government personnel collaborate. Despite considering the components and specific implementation strategies of comprehensive interventions, it remains unclear which interventions play pivotal roles in patients' recovery. Meanwhile, providing personalised services to every individual seeking treatment for substance disorders is a key focus for future research.

The Application of Neuromodulation Technology in Addiction Treatment

Neuromodulation techniques, as an emerging therapeutic approach, are demonstrating significant potential in the field of addiction treatment. By directly or indirectly regulating the activity of neural networks in the brain, these techniques can influence circuits associated with addiction. Currently, commonly employed neuromodulation methods include TMS, TES, and DBS. TMS alters the excitability of the cerebral cortex through magnetic fields and has been utilised to reduce cravings and the frequency of certain addictive behaviours. DBS, involving the direct stimulation of specific brain regions via implanted electrodes, shows promise in ameliorating symptoms in patients with drug addiction. TES, as a non-invasive method, has preliminary studies suggesting its positive impact on nicotine addiction and depressive symptoms. With a growing body of research, the clinical evidence base for neuromodulation techniques is expanding, with contributions from research teams across different countries. Although substantial gaps remain before their widespread application in the clinical treatment of addictive disorders, existing evidence points to the potential of neuromodulation technologies in intervening on multiple core pathologic features of addiction disorders.

Craving is one of the core symptoms of addictive diseases, reflecting patients' strong desire for addictive substances or behaviours, and is an important influencing factor leading to relapse behaviour. From the current application research in the field of addiction, psychological craving or drug cue-induced craving are the main observation indicators of various studies. Existing evidence suggests to some extent that various neuromodulations have reduced psychological craving or drug cue-induced craving in addicts to varying degrees. In terms of repetitive TMS, existing systematic review analyses show that multiple high-frequency stimulation interventions on the left dorsolateral prefrontal cortex have a reducing effect on psychological craving in SUDs. Here, there is the most and the clearest evidence for nicotine use disorders, followed by alcohol use disorders. Other SUDs have more limited evidence and only an initial indicative effect. Notably, a large-scale multicentre study found that

the application of high-frequency stimulation using the H4 deep TMS stimulation coil, which is used for stimulate the bilateral insula cortex and prefrontal cortex, significantly reduced the craving levels among individuals with nicotine use disorders, and this stimulation plan has been approved by the U.S. Food and Drug Administration for smoking cessation. Other TMS intervention parameters lack sufficient evidence of improving craving levels among individuals with various SUDs.

In addition, several review analyses suggest that there is an association between the total number of pulses in repetitive TMS and the change in craving. In terms of transcranial electrical stimulation, existing systematic reviews suggest that interventions using transcranial direct current stimulation targeting the dorsolateral prefrontal cortex generally have the effect of reducing the craving level of SUDs, especially with right anodal dorsolateral prefrontal cortex stimulation, but there is still considerable heterogeneity between different studies, mainly reflected in the following aspects: (1) inconsistencies in conclusions between studies on various substances such as cocaine, tobacco, alcohol, and marijuana—comparatively, although there are few studies on methamphetamine use disorders, the evidence is more consistent (four out of five studies showed significance); (2) inconsistencies in conclusions for left anodal dorsolateral prefrontal cortex stimulation. Other TES strategies, such as transcranial alternating current stimulation and temporal interference stimulation, cannot be concluded due to the very limited number of studies that exist. DBS research is currently mainly based on case reports, all targeting the nucleus accumbens for stimulation, with one study combining stimulation of the nucleus accumbens and the anterior limb of the internal capsule. The longest study period lasted four years. All case reports and one small sample (N=12) randomised controlled study have reported a decrease in the patient's craving level after intervention, initially indicating that DBS intervention has the potential to improve the craving of patients with refractory SUDs.

A small number of studies also suggest that neuromodulation can reduce relapse behaviours (relapse to smoking or drinking), but the evidence is limited. In the field of TMS research, existing reviews show that high-frequency parameter stimulation of the left dorsolateral prefrontal cortex can reduce tobacco use in nicotine use dis-

orders, with relatively strong consistency among studies. Research on alcohol use disorders suggests that repetitive TMS has the potential to reduce craving levels, but the evidence is limited; studies on illegal drugs such as methamphetamine and cocaine cannot draw clear conclusions due to a lack of research. The tES technology has shown effects on reducing alcohol and tobacco use in case studies, but there are significant differences in research settings between different studies (intervention plans, number of interventions, intensity of intervention, etc.), and more research is needed to confirm the conclusions. In the research on illegal drugs, there is a significant lack of studies and no clear conclusions can be drawn. In terms of DBS research, existing case reports and limited randomised controlled clinical studies suggest that interventions targeting the nucleus accumbens have positive clinical effects, such as reducing substance use and increasing the proportion of abstinence time, with some studies showing the longest abstinence time continuing for as long as four years. Due to the current small sample size, further research is needed to verify the therapeutic value of DBS.

Conclusion

This chapter comprehensively discusses the applications and potential of AI technology, digital therapies, and neuromodulation techniques in the fields of addiction treatment and social work. With the rapid evolution of technology, these cutting-edge tools offer new perspectives and methodologies for addiction treatment, significantly impacting social work practices. Firstly, AI's role in addiction treatment is increasingly prominent. Leveraging big data analytics, pattern recognition, and machine learning, AI facilitates early identification of addictive behaviours and risk prediction, thereby supporting personalised treatment decisions. AI algorithms not only enhance diagnostic accuracy but also optimise treatment plans, fostering precision medicine. Moreover, AI-assisted digital therapies, such as mobile health applications and online cognitive behavioural therapies provide flexible and accessible treatment options for individuals with addiction, especially showcasing their unique benefits during the Covid-19 pandemic. Digital therapies, as emerging treatment modalities, combine AI technologies with traditional psy-

chotherapy, employing gamification, virtual reality, and other interactive methods to enhance treatment engagement and appeal. They play a pivotal role in delivering psychological education, emotion regulation skills, and social support, thereby improving self-management capabilities and quality of life for individuals battling addiction. By modulating brain activity, neuromodulation technologies, including TMS, DBS, and TES, influence craving and relapse behaviours in individuals with addiction. Research indicates their potential in reducing cravings, minimising relapses, and improving the mental health symptoms associated with addiction. DBS has demonstrated positive clinical outcomes in treating refractory addiction cases, although further studies are necessary to confirm its long-term efficacy and safety.

Within social work, the implementation of AI and digital therapies has not only enhanced service efficiency but also expanded service reach. Social workers can employ AI tools for risk assessments, resource allocation, and the development of tailored intervention plans. Digital therapies equip social workers with innovative means to support clients' mental health and behavioural changes. Nonetheless, the adoption of these technologies also poses challenges related to ethics, privacy protection, and data security, necessitating a collaborative effort between social work professionals and technology developers to ensure responsible use.

In summary, AI, digital therapies, and neuromodulation techniques exhibit great potential in addiction treatment and social work. Future research should concentrate on the integrated application of these technologies, exploring optimal practice models and addressing the accompanying ethical and legal issues. Through interdisciplinary collaboration, we can better harness these technologies to deliver more effective and empathetic care to individuals with addiction, while also driving innovation and development in social work services.

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