Textile materials for transdermic therapy in neurocognitive disorders

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ABSTRACT – REZUMAT

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Neurocognitive disorders are a group of conditions that affect already developed cognitive abilities such as memory, learning capacity, perception, attention, and language. Excluding delirium and amnestic disorders, dementia is currently the seventh leading cause of death, with ten million new patients diagnosed annually. Patients with dementia, especially those with Alzheimer's disease, sooner or later develop neuropsychiatric symptoms that, along with the disease itself, place a significant burden on caregivers and society. Developing alternative methods of drug administration compared to traditional routes (oral, intravenous, intramuscular, inhalation) is essential to increase patient compliance and quality of life. Transdermal drug delivery via patches has become a convenient alternative to other administration routes, evolving from basic patches that simply store and release an active substance to smart and personalised patches that can incorporate sensors and various technologies, allowing them to adjust drug release according to the patient's needs in real time. However, challenges related to precise drug release, adhesion stability, and uniform diffusion control still remain. Unfortunately, for neurocognitive disorders, there are few patches available on the market, highlighting the need for further research. This paper aims to analyse neurocognitive disorders, from symptoms to new approaches using medical textiles in the form of medical patches for transdermal drug delivery.

Keywords: *Alzheimer's disease, dementia, medical textiles, transdermal patch*

Materiale textile pentru terapie transdermică în tulburările neurocognitive

Tulburările neurocognitive reprezintă un grup de afecțiuni care influențează abilitățile cognitive deja dezvoltate, precum memoria, capacitatea de învățare, percepția, atenția și limbajul. Excluzând delirul și tulburările amnestice, demența este în prezent a șaptea cauză principală de deces, cu zece milioane de noi pacienți diagnosticați anual. Pacienții cu demență, în special cei cu boala Alzheimer, dezvoltă mai devreme sau mai târziu simptome neuropsihiatrice care, alături de boala în sine, reprezintă o povară semnificativă pentru aparținători și societate. Dezvoltarea unor metode alternative de administrare a medicamentelor, comparativ cu cele tradiționale (orală, intravenoasă, intramusculară, inhalatorie), este esențială pentru a crește aderența pacienților la tratament și calitatea vieții. Administrarea transdermică a medicamentelor prin intermediul plasturilor a devenit o alternativă convenabilă la alte căi de administrare, evoluând de la plasturii de bază, care doar stochează și eliberează o substanță activă, la cei inteligenți și personalizați care pot încorpora senzori și diverse tehnologii, permițând ajustarea eliberării medicamentului în funcție de nevoile pacientului în timp real. Cu toate acestea, rămân în continuare provocări legate de eliberarea precisă a medicamentului, stabilitatea adeziunii și controlul difuziei uniforme. Pentru tulburările neurocognitive există puțini plasturi disponibili pe piață, ceea ce evidențiază necesitatea unor cercetări suplimentare. Această lucrare își propune să analizeze tulburările neurocognitive, de la simptome până la noi abordări care utilizează textile medicale sub formă de plasturi medicali pentru livrarea transdermică a medicamentelor.

Cuvinte-cheie*: boală Alzheimer, demență, textile medicale, plasturi transdermici*

INTRODUCTION

Neurocognitive disorders represent a group of disorders that affect mainly ones already developed cognitive abilities such as: memory, learning capacity, perception, attention, language. They include delirium, amnestic disorders and dementia.

According to official data from the World Health Organization in 2021 approximately 57 million people had dementia worldwide, over 60% of whom live in low-and middle-income countries. Every year, there are nearly 10 million new cases. Dementia results from a variety of diseases and injuries that affect the brain. Alzheimer's disease is the most common form of dementia and may contribute to 60–70% of cases.

Dementia is currently the seventh leading cause of death and one of the major causes of disability and dependency among older people globally. In 2019, dementia cost economies globally 1.3 trillion dollars, approximately 50% of these costs are attributable to care provided by informal careers (e.g. family members and close friends), who provide on average 5 hours of care and supervision per day. Women are disproportionately affected by dementia, both directly and indirectly. Women experience higher disability-adjusted life years and mortality due to dementia, but also provide 70% of care hours for people living with dementia [1].

Patients with neurocognitive disorders develop, sooner or later, behavioural and neuropsychiatric symptoms, such as depression, anxiety, aggression, psychosis. There is an increased necessity in research for alternative ways of administering medication in order to treat these symptoms. Not only do they affect the independence and quality of life of patients, but they also have a big impact on the life of the caregivers, who tend to develop psychiatric symptoms themselves, such as depression and anxiety, as a response to high levels of stress. This only increases the need for institutional care, posing a great burden on individuals and society.

NEUROCOGNITIVE DISORDERS. DEMENTIA

Delirium represents an acute decline in cognitive function, attention and state of consciousness. It is a common disorder in the elderly, but depending on the etiology (substance abuse, surgical interventions, acute infections, metabolic alterations, withdrawal, medication-induced etc), it can also affect young people [2, 3]. It has an acute onset (hours, days) and may be completely reversible with the right causal treatment.

Amnestic disorders are a group of neurocognitive disorders due to other medical conditions, substance induced or of unknown etiology, with memory impairment as the primary complaint. The prognosis of amnestic disorders is variable, depending on its etiology: it can be reversible, but if it involves brain damage, the lesions become permanent.

Dementia is a term used for multiple neurodegenerative disorders, characterized by loss of cognitive function, memory impairment and a loss of skills and abilities needed to perform daily activities. There are different types of dementia: Alzheimer's dementia (responsible for most cases of dementia), vascular dementia, Lewy bodies dementia, dementia related to other diseases (Parkinson disease, HIV, Prion disease, Huntington disease etc). Usually, Alzheimer dementia coexists with other forms of dementia (vascular dementia or Lewy body's dementia), pure syndromes being less common.

Vascular dementia

Vascular dementia is the most common form of dementia after Alzheime's disease. Depending on its physio pathological mechanism, it can be classified into four subtypes: multi-infarct dementia, post stroke dementia, subcortical ischemic vascular dementia and mixed dementia [4, 5]. Patients can develop, at some point, neuropsychiatric symptoms.

Management focuses mainly on prevention and treatment of the risk factors for cerebrovascular disease: hypertension treatment with antihypertensive medication, especially with angiotensin-converting enzyme (ACE) inhibitors may protect against further cognitive decline in vascular dementia [6].

Hyperlipidemia can be treated using statins, which also have shown to decrease cognitive decline [7, 8]. Diabetes treatment and antithrombotic medication can also be used for influencing cardiovascular risk in dementia. Cholinesterase inhibitors such as donepezil and galantamine may have some beneficial effects on cognition. Donepezil in dose of 10 mg has the best influence on cognition in combination with galantamine 16–24 mg, but also tend to be associated with more adverse effects than placebo. Also, the beneficial effect is unlikely to be of clinical importance. The evidence for rivastigmine is less certain, further research is needed. Although the effect is modest, but in the absence of any other treatments, people living with vascular dementia may still wish to consider the use of these agents [9].

Dementia with Lewy bodies

Dementia with Lewy bodies may account for up to 20% of all dementia cases. Apart from cognitive decline, it also involves neuropsychiatric symptoms such as: early and persistent visual hallucinations, disturbances of consciousness, neuroleptic sensitivity, and motor features Parkinson-like [10]. Both donepezil and rivastigmine are recommended as first-line treatments for dementia with Lewy bodies. The use of galantamine is unclear, and the NDMA receptor antagonist memantine is well tolerated in patients with Lewy body dementia, but evidence for its efficacy remains mixed [11, 12].

Alzheimer dementia

Alzheimer's disease is the most common cause of dementia. It places a significant burden on both individuals and society. It involves irreversible cognitive and memory decline, to the point where a person is unable to carry out daily activities and loses independence.

The main characteristic of the disease is progressive memory loss, especially of episodic memory, with long-term memory only initially preserved.

Neuropsychiatric symptoms are also present or may develop over time (hallucinations, seizures, paranoia, etc.) [13].

Diagnostic and investigations

There are two types of screening tools with high sensitivity and specificity that can be used to diagnose cognitive impairment. The Montreal Cognitive Assessment (MoCA) is widely used neurocognitive dysfunctions. It is easy to use, patient-friendly and lasts several minutes. It tests memory, attention, orientation, language, executive functions etc. A score of 25 points or lower is considered abnormal. For dementia detection it has a sensitivity of 91% and specificity of 81%. The Mini Mental State Examination (MMSE) can also be used for dementia detection. A score of 24 or less is considered abnormal. It has a sensitivity of 81% and specificity of 89%. Blood tests are usually carried out to rule out other causes of dementia (thyroid stimulating hormone, thiamine, vitamin B12, metabolic panel, full blood count etc.). Brain imaging should be obtained. Magnetic resonance imaging (MRI) shows diffuse cortical atrophy, as well as focal atrophy of the medial temporal lobes. A positron emission tomographic scan (PET) can

show reduced metabolic activity, especially in the parietal and temporal lobes [14].

Treatment

Three main inhibitors are approved for mild to moderate forms of Alzheimer disease: *rivastigmine, donezepil and galantamine*, with similar tolerability. Rivastigmine recommended dose is 3.6 mg twice a day. It also comes in form of a patch, with the recommended dose of 9.5 mg/24 hours patch. Donepezil normal treatment dose is 10 mg/24 hours and Galantamine 16–24 mg XL/24 hours. The most common adverse effect of AChE inhibitors are digestive problems, such as diarrhea, vomiting, nausea, abdominal pain. In case of intolerance at one AChe inhibitor, patients may switch to another [15].

Memantine is an antagonist for the N-methyl-D-aspartate (NMDA) receptor that slows neurotoxicity by binding to open calcium channels. The usual treatment dose is 20 mg/24 hours. It should be used with caution in patients with balance disorders, cardiac problems and liver dysfunction. Guidelines and different studies recommend at the moment a combination treatment between an AChE inhibitor and memantine. Donezepil and memantine showed better outcomes for patients with moderate and severe Alzheimer's disease [16, 17].

A systematic review revealed that supplementation with B complex vitamins can delay cognitive decline. Vitamin D supplementation has not been conclusive [18]. Other research found that Ginkgo biloba may slow cognitive decline especially in patients with dementia and neuropsychiatric symptoms [19]. Quercetin, a very popular flavonoid found in fruits and vegetables has shown interesting anti-inflammatory properties and neuroprotective effects.

Unfortunately, it has extensive digestive absorption and metabolism, lowering its efficacy in dementia [20]. The use of saffron in Alzeimer's disease improves cognitive function, and according to systematic reviews and meta-analyses, there is no difference between saffron administration and AChE inhibitors with memantine [21].

MEDICAL PATCHES FOR NEUROCOGNITIVE DISORDERS

Most medications available for neurocognitive disorders have many side effects that reduce patients' tolerability to treatment (digestive problems such as nausea, vomiting, abdominal pain, diarrhea, pain, etc.), as summarised in table 1.

Transdermal patches represent a rapidly growing market as a reliable delivery system, with more consumers seeking an easy, non-invasive way to take their medications. Transdermal patches are topical medications or products that attach to the patient's skin using a skin-friendly adhesive. The active formulation is then absorbed through the skin and enters the bloodstream. Compared to other drug delivery methods, such as oral or intravenous administration, transdermal patches offer several benefits that improve drug efficacy and patient compliance. They

Table 1

TRADITIONAL WAYS OF ADMINISTERING DRUGS

Drug administrations	Side effects
Oral route	Difficult for patients with neurocognitive disorders and swallowing problems requires high dosages, first pass metabolism
Intravenous or Intramuscular route	Possible pain, infection site
Inhalator route	Difficult to adjust the right dosage

are non-invasive, easy and painless to apply, provide controlled and consistent therapeutic dosages, and avoid the first-pass effect, where the drug is metabolised before reaching systemic circulation. Due to these advantages, transdermal patches have become an increasingly popular delivery method for both pharmaceuticals (such as nicotine, fentanyl, buprenorphine, and others) and nutraceuticals for OTC or recreational use (including CBD, caffeine, Vitamin B12).

Medical textiles, in form of transdermal patches have gain much popularity in recent years, because they are patient friendly, less invasive, easy to apply and don't require digestive absorption. A transdermal patch is usually made of four layers (figure 1) consisting of: a backing layer, which is the external layer of a patch, protecting it from the environment, usually made from polyethylene, a drug layer, which contains the pharmacological active substance, a rate controlling membrane layer, which controls the rate at which the drug is released into the system. An adhesive layer is used to attach the patch to the skin. For neurocognitive disorders there are few patches commercially available and are described in table 2.

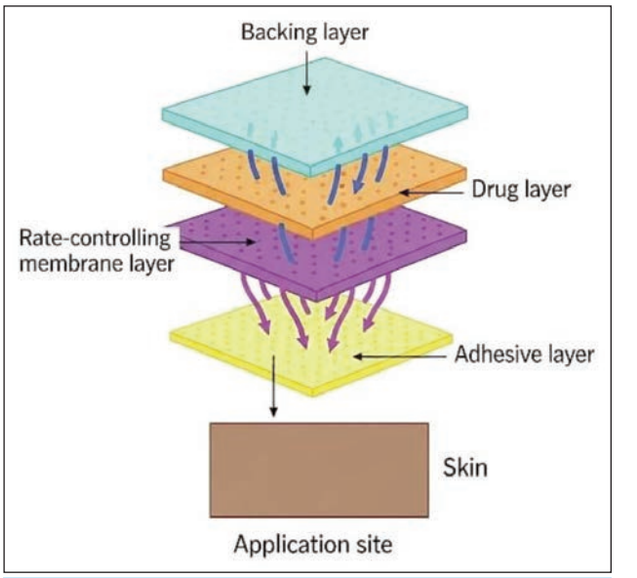

Fig. 1. Transdermal patch structure

Table 2

COMMERCIAL TRANSDERMAL PATCHES	
Transdermal patch name	**Description**
Rivastigmine	In the form of 4.6 mg/24 hours or 9.5 mg/24 hours, has superior tolerability and safety profile compared to oral capsules. It was approved in 2007 and is the only patch available for Alzheimer's dementia.
Rotigotine	A A non-selective dopamine agonist patch, is used for Parkinson's disease treatment, as well as, to treat the restless leg syndrome.
Asenapine	One atypical antipsychotic medication, was approved as a transdermal patch, being the only available patch for schizophrenia and bipolar disorder treatment.
Methylphenidate	A central nervous system stimulant patch is used to treat attention-deficit hyperactivity disorder (ADHD), improving focus and reducing impulsive behaviour.
Nicotine	One of the oldest patches on the market is used for smoking cessation.

The next generation of patches are matrix patches, which contain a solution or suspension of the active ingredient within a polymer or textile pad held in direct contact with the skin. Later, patches combined the drug and adhesive in a single layer. These patches are lighter, thinner, more flexible, and more comfortable to wear, improving the properties of the patches [22].

MEDICAL TEXTILES FOR DRUG DELIVERY

Medical textiles can be designed to gradually release therapeutic agents via diffusion, and some are being explored for their potential to help patients with psychiatric or neurological conditions. These drug-eluting textiles can be divided into three categories: 1. transdermal delivery, where drugs are administered through the skin; 2. controlled-release systems, fabrics designed to dispense medication at precise, sustained rates; 3. clinical applications, used in wound care, tissue repair, and cancer treatment [23–27].

Whether embedded within the fibre or applied as surface coating, the drug is gradually released over time through a diffusion process that follows Fick's law of diffusion. The rate of release depends on key factors such as the fibre structure, the concentration of drug and type of polymer used.

Natural and artificial polymers, chitosan and alginate are preferred due to their biodegradability, biocompatibility and low cost. Fabric characteristics such as thickness and air permeability play an important role in determining functional performance of transdermal delivery systems [23, 27].

Thickness is a decisive factor in ensuring comfort, durability and adaptability, especially when considering the anatomical part and surface area of application. Thicker fabrics are advantageous for prolonged therapeutic delivery, supporting extended wear durations [23], while thinner ones exhibit superior conformability to skin contours, preferred for thin-skinned regions like facial [28].

Air permeability is a critical parameter, essential for maintaining skin integrity during extended wear, as it facilitates moisture exchange and helps prevent maceration [23, 28–37]. On low permeability, the risk of bacterial growth is higher due to the perspiration accumulation, in contrast, whereas excessive permeability can destabilize the drug reservoir by accelerating moisture loss [37, 38]. Open structures, support increased drug loading capacity due to their volumetric porosity, while denser structures act as diffusion-regulating barriers, promoting controlled release profiles [27].

Knitted fabric structure significantly influences both wearer comfort and the controlled release of therapeutic agents. Among these, single jersey structures exhibit inherent elasticity and recovery due to their intermeshing loop configuration. This structural flexibility provides natural conformability and excellent skin contact during movement, making them suitable for application involving sensor integration [36]. In contrast, interlock structures offer superior dimensional stability, with minimal curling effect and smooth surfaces on both sides enhancing patient comfort against sensitive skin [23]. The high surface area promotes uniform coating adhesion for drug carriers. Within laminate hybrid system [28], knitted substrates provide comfort and flexibility while functional membrane controls drug diffusion rate. Double-layer knitted structures represent a good solution for wound care applications. Their unique configuration, independent knitted face and back layers connected by loops or yarns, allows for strategic material pairing: hydrophilic inner layers (cotton, viscose) absorb excess exudate while hydrophobic outer layers (polypropylene) direct liquid movement away from wounds. Open channels designed within double-layer structures guide therapeutic substances across wound surfaces with even distribution, while components maintain moisture and deliver medication effectively [23, 37, 38]. Furthermore, cellular structures demonstrate a greater drug-loading capacity compared to plain configurations. Their open architecture accommodates more drug-loaded microparticles [23, 28], making them suitable to be used for compact patch design.

Material selection for transdermal and wearable therapeutic systems must find the balance between natural fibre that offers biocompatibility and comfort, with functionalities provided by synthetic alternatives [23, 25, 26, 37]. Key considerations in fibre selection

include skin compatibility, long-wear comfort and structural stability to support active pharmaceutical compounds [33].

As natural fibre choice, cotton is valued for its inherent absorbency, which aids in perspiration management. Its breathability prevents skin irritation while hypoallergenic properties are beneficial for sensitive geriatric skin prone to dermatitis, mostly when it is used in direct contact with skin [24, 26, 33]. Synthetic fibres like polypropylene and poly(4-Methyl-1-Pentene) are lightweight, thereby the pressure on skin is reduced [38]. Their excellent chemical resistance ensures structural integrity throughout extended wear periods, while their hydrophobic nature supports efficient fluid management. Additionally, certain synthetic fibres can be engineered for conductivity, enabling integration of sensors when required [25, 30].

In the field of textile used for mental health support with drug-release there is a grown interest in the form of:

- *Transdermal patches* delivering anxiolytics or antipsychotics.
- *Smart textiles* that respond to physiological signals and release calming agents.
- *Wearable fabrics* integrated with therapeutic sensors or drug reservoirs for on-demand delivery.

Alternative to oral routes of drug administration, transdermal delivery has done a considerable contribution to the treatment of various medical diseases. Currently, most *transdermal patches* with drug-release capabilities are done from woven, nonwoven or coated textiles substrates, typically incorporating adhesive matrix systems, microneedle arrays, or laminated layers composed of polymers such as ethylene vinyl acetate or polyurethane [28, 29].

While knitted textiles are still considered an outgoing field in transdermal drug delivery, they are gaining attention due to their flexibility, moisture management and skin compatibility properties [29]. However, they present constant challenges related to precise drug release, adhesion stability, and uniform diffusion control.

Smart textiles are being actively developed for sensor-based monitoring applications [29, 30]. Knitted fabric configurations are often selected for their comfort, tactile sensitivity and breathability, integrating features such as conductive fibres, hardware pockets, and strategically padded areas to enhance wearability and protect sensitive skin. Although these systems typically do not deliver medication directly, they have an important contribution to mental health care through comfort-oriented therapeutic design.

Wearable fabrics with embedded therapeutic systems can be designed to monitor physiological signals and enable precise, on-demand drug delivery. Integration techniques involve: knitting or weaving conductive fibres into fabric; printing or coating drug reservoirs onto textile surfaces; embedding microfluidic channels for drug transport; designed layered textile architecture that combine sensing, actuation and drug release capabilities [32, 33].

Current research direction in drug-delivery medical textile mainly focuses on several key areas: ensuring biocompatibility and optimal skin adhesion; achieving uniform drug diffusion and accurate dosing profiles; improving durability, washability, and scalability of the textile systems; sensor accuracy for clinical use [34]. The main functionalities of their wearable fabrics are: real-time glucose monitoring and insulin/glucagon release; controlled chemotherapy dosing via microneedles; pain relief through transdermal patches with analgesic reservoirs activated by heat or motion; and sensor-based feedback for stress and comfort-enhancing textile design. The main functionalities of their wearable fabrics are: real-time glucose monitoring and insulin/glucagon release; controlled chemotherapy dosing via microneedles; pain relief through transdermal patches with analgesic reservoirs activated by heat or motion; and sensor-based feedback for stress and comfort-enhancing textile design [32, 33, 35]. In their research on wound healing, Arice and Karpagam [24] revealed that using a drug-carrier coated knitted fabrics can effectively reduce wound-related complications. Selected for their flexibility, breathability and suitability for direct skin contact, these fabrics were evaluated for their performance when coated with synergistic drug combinations. The findings confirm that knitted fabrics can serve as promising platforms for drug delivery in wound care, especially when enhanced with antimicrobial agents. Notably, drug-carrier coated knitted fabric has shown to have greater antibacterial efficacy than the drug-coated fabric. The knitted fabrics was a commercial one made of cotton yarn, chosen for its softness, breathability, and compatibility with wound care applications. Cotton's natural absorbency and comfort make it ideal for biomedical textiles, supporting the effectiveness of antibacterial coatings with antibacterial agents like piperacillin-tazobactam and beta-cyclodextrin.

Known for its stretchability and softness, knitted fabrics can be integrated in article for monitoring mental health, as a sensor platform [30, 32]. Their inherent comfort makes them ideal for long-term wear without causing skin irritation, an essential feature for continuous physiological tracking in psychiatric contexts.

Using conductive yarns, directly knitted into the garment, these textiles can form electrodes or sensor capable to detect signals like ECG (electrocardiogram), EEG (electroencephalogram), and EDA (electrodermal activity). The loop architecture of the knitted fabrics ensures close contact with the skin, enhancing signal reliability even during body movement throughout daily activities. The knitting technology allows to use technique to create customizable design for zonal placement of sensors (tighter stitches, shape-conforming zones, loose stiches, different loop architecture inside the structure).

Drug delivery textiles adapted for mental health support through coated fabrics and nanocomposite layers are study also by Ferri et al. [32]. Knitted fabrics is explored in a hybrid system of knitted with laminated drug-release membranes. The surface topology

and the number of fabric-to-skin contact points are those that can influence drug loading and drug release. Knitted structures with open structure such as honeycomb patterns tend to be ideal to host more microparticles of drugs loading on a bio-functional fabric. Most used method for transdermal delivery is the utilization of electrospun nanofibers with core-shell arrangement that allows different drug distribution in the nanofiber. Cotton and wool are natural fibres, good candidates for insect-repellent and antibacterial activity, functionality added trough a dyeing process or microencapsulation of DEET in polymer shells and subsequent surface treatment of fabrics.

Rumon et al. [36] investigate the potential of knitted fabrics as stretch sensors for monitoring physiological parameters such as respiration and body movement. By using embedding silver-based conductive yarns into the knitted surface, to create functional sensors capable of detecting mechanical strain. The intermeshing loops of the single jersey structure, offers natural elasticity and recovery, making it suitable for motion sensing. When stretched, the fabric translates physical movement (like breathing) into measurable electrical signals. The study provides design recommendations to enhance the sensors' durability and accuracy in practical, real-world health monitoring scenarios.

Komisarczyk et al. [37] developed double-layer knitted fabric and a woven one, intro an arrangement made of hydrophilic fibres (cotton, viscose) and hydrophobic fibres (polypropylene). They explore how liquids move through textile materials, especially when used in medical applications like wound dressings. Knitted fabrics showed strong potential as wound dressings due to their ability to manage moisture and potentially deliver drugs. The research highlights the importance of double layer design of the fabric, combining a hydrophobic layer to guide liquid movement with a hydrophilic layer to absorb excess moisture, features used to maintain a moist healing environment while managing exudate overflow. The smart wound dressing proved to be effective thanks to its components that helped the healing process by maintaining moisture, eliminating bacteria and deliver medication through specially designed open channels. Sasirekha et al. [38] explores the role of knitted fabric as a wound dressing application, highlighting their potential to support healing without the use of traditional antimicrobial agents. In the study it is used a knitted Poly (4-Methyl-1-Pentene) (PMP) fabric, a hydrophobic material that encourages bacterial adhesion. The dressing was fabricated using standard textile techniques manufacturing, a melt spinning PMP into multifilaments approximately 30 µm in diameter, followed by knitting. This knitted structure demonstrates excellent fluid management properties, enabling effective moisture control and handling of wound exudate, while leveraging its hydrophobicity to aid in bacterial clearance.

A wearable knitted patch can be a viable soft solution for mental wellness. As a gentle and effective approach that enables on-demand transdermal drug delivery for conditions such as anxiety, depression, or PTSD can be developed. The design can be built around layered functionality, offering both therapeutic impact and comfort. Key components can include:

1. *Knitted base layer* – made out from breathable, skin-friendly yarns such as cotton, bamboo, lyocell or conductive fibres, meant to ensures softness, flexibility, and long-wear comfort.
2. *Controlled-release drug container* – create a specialized matrix embedded within the knit structure, engineered to store and release medication consistently over time.
3. *Integrated channels* – fine distribution channels designed to guide the flow of the therapeutic substances across the skin surface, with even distribution and targeted absorption.
4. *Embedded smart sensors* – biometric sensors monitor key health indicators such as cortisol levels, body temperature, and heart rate. These readings can trigger automated dosing adjustments, offering responsive care.
5. *Comfort and hygiene characteristics*- designed for sensitive skin, the patch should feature moisture-wicking and antimicrobial properties, ensuring hygiene and irritation-free in wear, even during long use.

The design of the transdermal patch should be focused on the fulfilling of their main functions:

- medication released only when needed;
- enhances therapeutic outcomes;
- reduces reliance on oral medication and improves dosing compliance;
- promotes comfort in wear through its design (soft textures and stretchable structure);
- reusable feature through a washable design and pharmacological load.

Overall, biomaterials are integral to advancing drug delivery, offering diverse applications beyond conventional uses. By overcoming the blood–brain barrier, biomaterials enable targeted drug delivery for neurodegenerative diseases such as Alzheimer's and Parkinson's. Biomaterials have also revolutionised pain management through the development of localised, sustained-release drug delivery systems [39–41]. These systems can be implanted or injected near the source of pain, ensuring that analgesic medications are delivered directly to the affected area, reducing the potential for systemic side effects and dependency [42].

CONCLUSIONS

Medical patches and transdermal drug delivery have recently become a trend in the medical field. Owing to their many advantages over traditional routes, medical patches are increasingly attractive, especially for patients with neurocognitive disorders, who already present challenges in treatment compliance and tolerability. The need for alternative methods of administering treatment has led to developments in the medical textile field: the use of knitting technology, hosting micro particles on bio functional fabrics,

embedding micro particles, and using more natural polymers open new possibilities for improved transdermal drug delivery. The use of smart textiles, which incorporate various sensors and technologies, also offers promising solutions. The main goal is to achieve more personalized treatment, guided by real-time monitoring of patients' physiological and psychological needs, to increase compliance with treatment. Improving quality of life for both patients and caregivers may ease the burden of neurocognitive disorders, highlighting the need for further research and solutions.

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