Digital Pills with Ingestible Sensors

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Digital pills contain integrated sensors that allow monitoring of the course of pharmacotherapy through an interaction with the software of, e.g., tablets and smartphones. Such monitoring is of great importance, as low patient compliance (medication opt-out) is a major challenge for all areas of medicine.

digital pill ingestible sensor patent clinical monitoring

1. Introduction

Nowadays, in the modern world the progress of the healthcare system is directly related to the development of digital health tools.

According to the WHO global strategy, digital technologies are connected to the future of world health. Digitalization has the potential to benefit health promotion, maintain global security, and provide services to the most vulnerable groups of the population [1].

Digital pills occupy an important place among the digital health solutions. Digital pills contain integrated sensors that allow monitoring of the course of pharmacotherapy through an interaction with the software of, e.g., tablets and smartphones. Such monitoring is of great importance, as low patient compliance (medication opt-out) is a major challenge for all areas of medicine.

Digital pills improve treatment adherence and efficiency in the field of mental health and behavioral modifications, such as schizophrenia, bipolar I disorder, attention deficit and hyperactivity disorder, drug abuse, smoking, pain, insomnia, and many others. The developers of the digital pills also focus on the treatment of cardiac disorders, diabetes, hepatitis C, AIDS, cancer, tuberculosis, and the monitoring of patients' use of opioid drugs after surgery, and other conditions when admission may be impaired due to the characteristics of the patient's behavior (geriatrics, neurodegenerative diseases, etc.) [2][3][4].

Digital pills have a significant potential for savings in healthcare costs by reducing the need for emergency medical care and the hospitalization of patients. The annual costs of non-compliance range from USD100 billion up to USD290 billion in the US, EUR1.25 billion in Europe, and approximately USD7 billion in Australia. In addition, 10% of the hospitalizations among the elderly are due to treatment noncompliance, with a typical noncompliant patient requiring three additional doctor visits per year, resulting in an annual increase of USD2000 in treatment costs. In

diabetes, the estimated cost savings associated with improving noncompliance ranges from USD661 million to USD1.16 billion. Non-adherence is thus a critical clinical and economic problem [5].

Despite the progress made in this area to date, there are still a number of barriers to the widespread implementation of digital pills into medical practice. They include issues of clinical efficacy, safety, treatment costs, and confidentiality, among others. In addition, the patent landscape for the digital pill with ingestible sensors is not yet well-established. This indicates the need for further research in this area [6][7].

2. Digital Pills with Ingestible Sensors

The development of digital pills is executed by high-tech industries that are evolving rapidly and require innovation from manufacturers. One of the sources of information reflecting the innovation process is the patent documentation.

The value of information, which is formed as a result of the work of patent offices in different countries around the world, is its universality in determining the main technological trends and building trends in market processes, and in analyzing the behavior of specific market participants, their resources, and growth prospects. The universality of patent data is ensured by the unification of standards for the presentation of data on intellectual property objects. The reliability of patent information is ensured by the procedure of the state registration of intellectual property rights. The scope of their legal protection depends on the completeness of the disclosure of information about the objects, as well as on the concretization of the features that constitute the novelty of the results of intellectual property. Therefore, in order to ensure a comprehensive protection of their own exclusive rights, the applicant is forced to detail the important technological aspects of patented development as much as possible. The examination of the patent landscape enables researchers to quantify the intellectual property characteristics.

The developed digital pills, such as Abilify MyCite, allow for the clinical monitoring of the treatment of patients with depression.

In order to improve the scientific and practical approaches to the management of scientific research in the process of digital pills with an ingestible sensor, an analysis was carried out of Proteus Digital Health and Otsuka Pharmaceutical's patent strategy for the digital pill, Abilify MyCite (**Table 1**).

Table 1. Analysis of Proteus Digital Health and Otsuka Pharmaceutical patent strategies for the digital pill Abilify MyCite.

US Patent No.	Patent Expiration	The Title of the Invention, the Owners
7053092	28/01/2022	5HT1a Receptor subtype agonist [8] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)

US Patent No.	Patent Expiration	The Title of the Invention, the Owners
7978064	14/09/2026	Communication system with partial power source [9] Proteus Biomedical, Inc. (Redwood City, CA, USA)
8017615	16/06/2024	Low hygroscopic aripiprazole drug substance and processes for the preparation thereof [10] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
8114021	21/06/2030	Body-associated receiver and method [11] Proteus Biomedical, Inc. (Redwood City, CA, USA)
8258962	25/11/2030	Multi-mode communication ingestible event markers and systems, and methods of using the same [12] Proteus Biomedical, Inc. (Redwood City, CA, USA)
8545402	27/04/2030	Highly reliable ingestible event markers and methods for using the same [13] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8547248	18/12/2030	Implantable zero-wire communications system [14] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8580796	25/09/2022	Low hygroscopic aripiprazole drug substance and processes for the preparation thereof [15] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
8642760	25/09/2022	Low hygroscopic aripiprazole drug substance and processes for the preparation thereof [16] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
8674825	09/04/2029	Pharma-informatics system [17] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8718193	05/12/2029	Active signal processing personal health signal receivers [18] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8759350	02/03/2027	Carbostyril derivatives and serotonin reuptake inhibitors for treatment of mood disorders [19] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
8847766	29/03/2030	Pharma-informatics system [20] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8945005	19/08/2029	Controlled activation ingestible identifier [21] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8956288	06/07/2029	In-body power source having high surface area electrode [22] Proteus Digital Health, Inc. (Redwood City, CA, USA)
8961412	17/11/2030	In-body device with virtual dipole signal amplification [23] Proteus Digital Health, Inc. (Redwood City, CA, USA)

US Patent No.	Patent Expiration	The Title of the Invention, the Owners
9060708	05/03/2029	Multi-mode communication ingestible event markers and systems, and methods of using the same [24] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9089567	28/01/2022	Method of treating cognitive impairments and schizophrenias [25] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
9119554	16/12/2028	Pharma-informatics system [26] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9125939	28/07/2026	Carbostyril derivatives and mood stabilizers for treating mood disorders [27] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
9149577	15/12/2029	Body-associated receiver and method [28] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9258035	05/03/2029	Multi-mode communication ingestible event markers and systems, and methods of using the same [29] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9268909	15/10/2033	Apparatus, system, and method to adaptively optimize power dissipation and broadcast power in a power source for a communication device [30] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9320455	15/12//2031	Highly reliable ingestible event markers and methods for using the same [31] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9359302	25/09/2022	Low hygroscopic aripiprazole drug substance and processes for the preparation thereof [32] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
9387182	25/12/2023	Carbostyril derivatives and serotonin reuptake inhibitors for treatment of mood disorders [33] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)
9433371	15/09/2029	In-body device with virtual dipole signal amplification [34] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9444503	19/11/2027	Active signal processing personal health signal receivers [35] Proteus Digital Health, Inc. (Redwood City, CA, USA)
9941931	04/11/2030	System for supply chain management [36] Proteus Digital Health, Inc. (Redwood City, CA, USA)
10441194	26/07/2029	Ingestible event marker systems [37] Proteus Digital Health, Inc. (Redwood City, CA, USA)
10517507	13/06/2032	Communication system with enhanced partial power source and method of manufacturing same [38]

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As a result of the patent research, the patenting of a pharmacologically active ingredient aripiprazole and the technologies for its production, methods of treatment, as well as pharma-informatics systems and ingestible event marker systems, was established.

US Patent No.	Patent Expiration	The Title of the Invention, the Owners
		Proteus Digital Health, Inc. (Redwood City, CA, USA)
11229378	11/07/2031	Communication system with enhanced partial power source and method of manufacturing same [39] Otsuka Pharmaceutical Co., Ltd. (Tokyo, Japan)

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important that the patent holders have the ability to control the effectiveness and quality of digital pills with ingestible sensors.

Proteus Digital Health is a company creating innovative digital health products and once had a huge valuation of USD1.5 billion. However, the company was unable to complete a USD100 million investment round in 2019. In the bankruptcy proceedings in 2020, a US affiliate of Otsuka purchased the technological assets of Proteus for USD15 million [40].

On the one hand, the rational management of intellectual human capital is extremely important in the development of digital pills. It is noted that the development of the digital pills with ingestible sensors, the Abilify MyCite technology, was expensive, and it was necessary to retain the best specialists. On the other hand, an assessment of medical technology is also very important. The average monthly cost of a generic version of Abilify is USD500 to USD800, according to GoodRx. The original digital pills with ingestible sensors, such as Abilify MyCite, cost more than USD1600.

In order to reduce the unpredictable rising costs of digital pills, it is imperative to perform comparative studies of the clinical effectiveness when discussing new treatment approaches, and to identify clear advantages over the medicines that are already used in clinical practice.

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