Smart Inhalers: A Digital Step Towards Patient-Centricity

Respiratory infections continue to have the highest incidence rate in Europe. And when asthma is considered, there has been a sharp increase in global cases, morbidity, and mortality rates, as well as being an economic burden over the last 40 years.[1] More than 300 million people have asthma worldwide. These figures demonstrate that despite the efforts of the past few years, the reduction of the incidence of asthma has not been achieved yet.

Connected devices – such as smart inhalers – offer a great opportunity to increase adherence and improve the quality of life of patients.[2]

Increasing life expectancy drives the development of personalised healthcare

Since 1960, the average life expectancy has risen by 20 years. And with the world population aging fast, there will be more than one billion senior citizens in the world by 2030.[3] As life expectancy continues to rise, a growing number of elderly people will suffer from a variety of both chronic and mental illnesses, and physical disabilities. Depending on the disease, they would require long-term medical attention and care. However, hospital treatment may not be the best option which is when the emphasis starts to shift to at-home treatments.

In recent years, home healthcare has been a significant part of the healthcare industry. Technology is setting the stage for some extensive changes in this area. Assistive and monitoring devices as well as mobile laboratories are just a few examples. With these innovations playing such an important role in disease identification, management, and treatment, it is reasonable to assume that they will also aid in improving service delivery and quality of care.[4] The future of homecare looks promising, especially in the case of chronic ailments such as heart failure, Alzheimer's, and COPD. The self-management of health will become more of the norm in the future, driven by an aging population.

Digitalisation has the potential to improve health and care outcomes

It is clear that the digitalisation of healthcare is beneficial. If carefully designed and thoughtfully implemented, digital health has the potential to improve health and care outcomes alike. Health information is fast becoming readily available because of the transfer of digital health data. As a result, higher-quality therapeutic decision-making as well as the mechanism and efficiency quality of health services are improved.[5] The demand for teleconsultation platforms in Europe, for example, has multiplied. Research shows that medical video chat tools are used for tens of thousands of consultations a day.[6] If people are to live longer and better, they will rely on research and technology. The same combination is currently being used to contain the COVID-19 pandemic.[7]

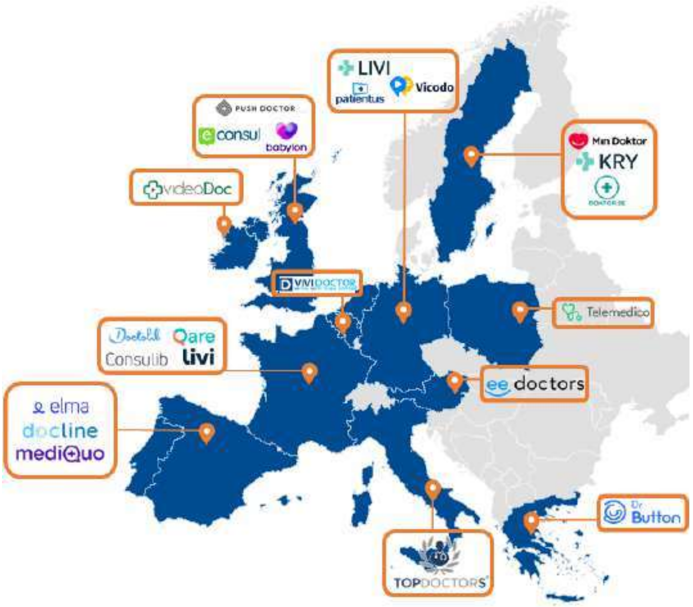

Figure 1 – European Teleconsultation platforms

The fact that digital health is on the rise is unsurprising. Global digital health market revenues in 2026 are expected to account for more than 900 billion EUR. In this context, digital health is defined as both hardware and software applications, Smartphone Apps, telemedicine, and IT systems.[8]

Considering digital health's advantages, it is a common belief that in the long term, digital health will increase efficiency and can therefore save costs. Lowering administrative expenditure, eliminating hospital room expenses and avoidable diagnostic or therapeutic intermediations are just a few examples. Digital health already provides continuous medical education for both physicians and consumers. Increasing efficiency entails not only lowering costs but also improving the quality of services. As a result, digital health has the potential to increase health care quality by enabling comparisons between various services and encouraging a new relationship between the patient and the health expert. Digital health opens up new possibilities for patient-centred care by allowing medical information and personal electronic records freely accessible to users over the internet.

Patient empowerment by using smart devices

The rise of digital health matches the current mind-set of most people: patients are no longer willing to be passive recipients of healthcare services. They want to play a more proactive role in their own healthcare management. Patients may become motivated to take care of themselves more effectively and consistently if they have regular access to their health records.

This mindset is reflected by the use of smartphones or smartwatches to *e.g.*, tracking health data and activity, or monitoring behaviour and heart rate. Wearables and smartphone apps for recording, monitoring, and storing specific health data are becoming increasingly popular. According to the forecast, global

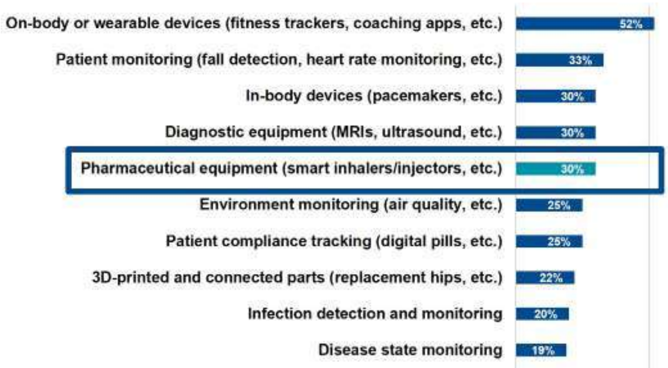

Figure 2 – What type of digital healthcare solutions does your company develop or plan to develop?

sales in the mobile health segment could rise to almost 250 billion US dollars in 2025.[9] But it is not only about smartphones and watches. It is across the spectrum.

Currently, there is a wide range of digital healthcare solutions developed that could offer great opportunities. Smart inhalers are of particular interest and belong to the top-tier for product development and production.[10]

The cost burden associated with asthma and COPD

Poor medication adherence is a major issue in healthcare, especially in the case of chronic diseases. A lack of adherence leads to poor results, which raises the use of health-care services and costs overall. Payers can pass on the financial strain to patients in the form of higher co-payments. The issue of medication adherence is becoming increasingly important in the healthcare industry, resulting in greater costs for the healthcare sector and the pharmaceutical industry.

Adherence is highly variable: Between 30–70% of adults and children with asthma do not take their asthma medication as prescribed by their doctor.[11] Though the factors of poor adherence are diverse, they could relate to the patient, the healthcare system, the therapy, or the disease itself.

A lack of patient adherence is not only an economic burden for the healthcare sector, but also leads to costs for the pharmaceutical industry. The bulk of pharmaceutical profit loss is due to poor medication adherence.[12] Poor patient adherence has a strong impact on pharma businesses, resulting in reduced revenues due to lower prescription intake. The second impact, in terms of brand value depletion, is more long-term.

An analysis on chronic diseases revealed that it was possible to quantify the estimate of revenues lost in a specific therapeutic area. It is essential to mention, that the calculation of losses due to poor adherence is based on revenues that could have been earned, not actually earned. The analysis for respiratory agents in the US revealed that the estimate of revenue lost in this therapeutic area is about 46 billion USD. Extrapolated to the global pharmaceutical market, revenue loss is estimated to be more than $560 billion.[13]

The Smart Inhaler's 4Ps with Win-Win potential

Increasing adherence rates by only 7 percent – *e.g.*, by using smart inhalers that would require *e.g.*, fewer doctor visits and fewer hospital admissions – could translate into a $40 billion pharmaceutical revenue opportunity globally. Most importantly, it will help to improve health outcomes and decrease healthcare spending, giving the pharmaceutical industry enough reasons to continue their development project on smart inhalers helping to save costs and to increase both revenues and patient centricity. The 4P matrix illustrates the potential of smart inhalers.

Major therapeutic classes	US revenue in $ million (2011)	Missed opportunities in $ million	% missed opportunities
Respiratory agents	$ 21,000	$ 46,051	219%
Antidepressants	$ 11,000	$ 23,642	215%
Lipid regulators	$ 20,100	$ 10,330	51%
Oncologics	$ 23,200	$ 2,237	10%
Multiple sclerosis	$ 7,100	$ 1,312	18%

Table 1 Non adherence related missed opportunities in the US biopharmaceutical market by major therapeutics, 2011; Global Research Report"

Precision stands for a more reliable and accurate real-life inhaler technique and adherence information that would be key to support clinical decisions. Penetration can be understood as a remote technology that allows for a better understanding on how patients use their inhalers in real life. Objective data can provide personalised information about a patient's inhaler medication use – to patients themselves, caregivers, and health care professionals. Finally, the real-life usage data can be used to predict if disease control gets worse and even the likelihood of an exacerbation can get identified.

Smart inhalers can help to pave the way to be a win-win situation for users, the pharmaceutical industry, and healthcare providers. Several companies are currently investigating different possibilities to design and manufacture smart inhalers. Some are already commercialised; others are under development. Those companies might have an advantage in using their expertise and existing prototypes for clinical investigations or pilot studies to demonstrate the effectiveness of smart inhalers.

Figure 3 – The 4Ps of Smart Inhalers, Own Illustration

Propeller Health has already illustrated some opportunities for smart inhalers: reduction of hospital admissions, improvement in controller medication adherence, increase in asthma control, and the reduction in rescue inhaler use.[14] This could mean that some patients may well be engaged and motivated by the collection of data related to their medication. The feature might then also increase the market share of a drug where the patient has a choice of medication. In turn, this can lead to improved medication adherence and a reduction in revenue lost to the pharma company. If this can be shown to improve clinical outcomes, then the healthcare payer starts to gain a benefit if this reduces higher costs associated with disease complications.[15]

Flow inhalation measurement technology

It is well known that patients often struggle

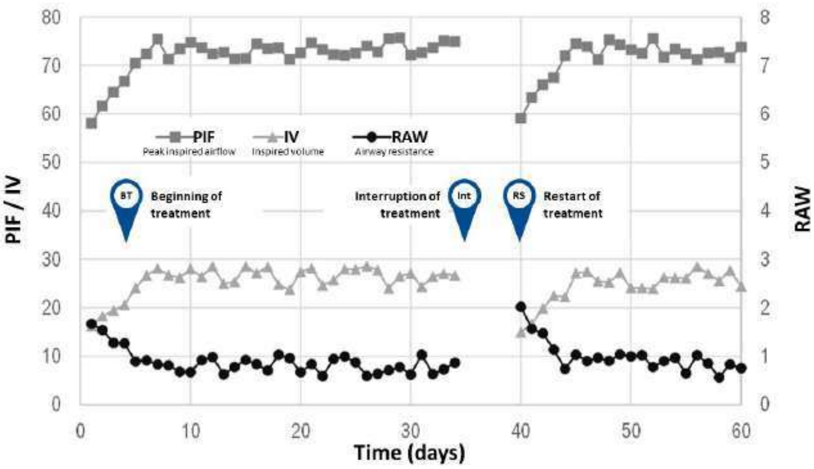

Figure 4 Real time recordings of inhalation flow profile: An imaginary patient case; Illustration by Sensirion

to use their inhaler correctly, resulting in inadequate drug delivery.[16] According to research, the two most common mistakes made while using an MDI are both related to patient inhalation. The first error is related to the coordination between inhalation and triggering the dose release of the inhaler. The second most significant error is not breathing deeply enough. By monitoring patient inhalation airflow, there is a great potential for technological developments to reduce these common mistakes.[17]

The patient's ideal inhalation window can be determined using flow inhalation analysis technology. By measuring the inhaled airflow into the inhaler and recording the moment that the medication is dispensed, it is possible to verify if the drug was delivered during the optimal window of the inhalation process.[18] The inhalation airflow profile can be used to determine a number of parameters that provide data about a patient's inhalation:

- depth and length of inhalation,
- slow inhalation according to instructions,
- lung function and its development over time.[19]

This information can be gained from accurate and measured real-time recordings of the inhalation flow profile, which can be used to determine whether the patient performed the inhalation correctly. Tracking these metrics over time can be helpful for getting guidance on the efficacy of the drug and the progression of the condition as every inhalation is monitored for its accuracy and correct use. Additionally, it could alert a healthcare professional in case of complications as well as being a good resource for patients to improve their adherence.

Summary

In the treatment of asthma and COPD, adding a flow sensor to the drug delivery system is a useful asset. It is a method of giving direct guidance to patients, as well as assisting them in monitoring their illness and increasing adherence.

Adding a diagnostic unit to the drug delivery device that the patient is already familiar with is a powerful tool in asthma and COPD disease management. It is a solution of guiding the patient and providing direct feedback as well as supporting the patient in controlling the disease and increasing adherence. The information collected could be used to anticipate asthma attacks, aid therapeutic decision-making, and improve healthcare resource allocation.

Figure 5 – The potential of a connected device, Own Illustration

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