# The development of a new tool useful to control and limit the spread of pathologies using drug dispensation data

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## Abstract

The literature reports several studies to improve adherence to therapy through the development of new technologies. However, a system which promptly displays the trend of a disease has never been reported. We have created a new tool that can immediately identify the development of a disease and the high-risk areas. During the COVID pandemic, we understood the importance of monitoring the trend of pathology in real-time, on a map.

Through a software named Qlik Sense, we identified the areas with the greatest distribution of anticoagulant drugs. The software geolocated the pharmacies and, when dispensing the drugs, it created a bright spot on the map of the Abruzzo region, Italy, with an intensity proportional to the number of patients who received the drug for the first time.

In this study, we were able to visualize immediately the presence of comorbidities that could worsen the health of patients. The tool created identifies the predominance of a pathology in order to establish correct health policies, and, in the future, it could allow clinicians to monitor patient therapy.

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## Introduction

Looking at the historical moment and its technological progress, it must be considered that, in the coming years, there will be several tens of billions of devices (of any type) connected to the network.[1] This scenario will soon bring great benefits, such as new treatments and the improvement of the quality of life for millions of people.

The role of the patients in managing their own health or healthcare has changed dramatically.[2,3] Recently, the Food and Drug Administration (FDA) approved a new antipsychotic drug that contains an intelligent sensor. When this drug is solubilized in the patient's gastric juices, the sensor communicates with an "intelligent patch" placed on the patient's arm to monitor therapeutic adherence.[4] We are in the presence of the first true "digital drug": a perfect combination of a drug (used for the treatment of schizophrenia, and bipolar disorder) and a technological device.[5]

Technology will innovate the production of drugs tailored to the patient's needs. The development of several medical devices will allow for the continuous monitoring of a patient's health state, and try to identify, in advance, the symptoms or the onset of disease.[6] Drug packs will soon be able to interact with smartphone apps through integrated microcircuits that will send signals every time the patient takes the drug, so both the clinician and the patient will be able to monitor the therapy step by step.[7] It is the innovation of "beyond the pill", that is, services that go "beyond therapy" and that pharmaceutical companies offer patients to simplify access to health.[8-10]

In addition, the FDA approved the first cardiac monitor compatible with smartphones implanted in patients. The Insertable Cardiac Monitor (ICM) is implanted just below the skin and transmits heart rate data to a smartphone application. These data are visualized by the clinicals, highlighting the symptomatic events revealed by the patients.[11]

Therefore, it was necessary to review the concept of Evidence-Based Medicine, (coined by Gordon Guyatt in 1993),[12] which supports decisions on patient care sustained by scientific

evidence and by the use of Artificial Intelligence (AI).[13,14] There have already been significant contributions of AI in medicine, to facilitate the diagnosis of tuberculosis,[15] metastasis of breast cancer,[16] and retinal changes as a result of diabetes.[17]

The innovations described illustrate technologies built in order to monitor patient therapies, but a system capable of promptly monitoring the trend of a disease (looking at the therapies) in a region or nation has never been reported in the literature. The data about the spread of a disease is difficult to extrapolate because it is not easy to obtain. We understood, during the COVID pandemic, the importance of having this information immediately in order to start preventive and efficient health measures. To this end, we focused our attention on drug dispensation data and, thanks to a new software, we identified the exact drug erogation point to understand the predominance (in the region) of the pathology studied in this work - cardiovascular disease. We have considered a class of drugs (Direct-Acting Oral Anticoagulants, DOACs) that are bought by the hospital pharmacy and distributed, through an intermediate distributor, to around 500 pharmacies present throughout the Abruzzo region. In addition, we were able to immediately visualize the presence of comorbidities that could worsen the health of patients affected by cardiovascular disorders. Here, we understood that the erogation drug data contain a lot of hidden important information. When data is collected through a single instrument and well-structured, it allows for a greater understanding of the state of severity of the development of the disease. In summary, we created, for the first time, a digital tool capable of detecting the prevalence of pathology. This study opens new horizons to establish health safety policies immediately, and underlines the importance of drug dispensation data. Typically, this data remained closed in the desk drawer, but we understood that it was an important source of information. For this purpose, we have changed the way of data presentation: no aerograms or histograms, but data displayed on the region map (continuously updated), with greater visual impact, and able to immediately show the possible spread of the disease. Finally, the great advantage of the tool created, is the possibility to load the erogation data of different classes of drugs, so as to highlight, promptly, with a click, the spread of several diseases in a region, and study the treatments introduced.

## Materials and Methods

In order to monitor drug dispensation through pharmacies, we used a program named Qlik SenseÒ, a free downloadable online software. In this platform, we have loaded the topographical coordinates of the pharmacies (data downloaded from Farmadata database), and we have created a map reporting the exact position of the pharmacies in Abruzzo, Italy. When uploading geographic data using the Add Data function (with data profiling enabled), Qlik Sense automatically recognized the names of cities and the exact geographic point (latitude, longitude) of pharmacies. The source used for this data is the ISTAT open data map. The drug dispensation data was extrapolated from a software called GopenDPC, which is used by pharmacies to order the drug (from the intermediate distributor) and dispense it to the patients. The file contained the following fields: patient's fiscal code, medical prescription code, pharmacy name, drug code, drug name, delivery date, drug amount.

## Results

Figure 1 shows the diffusion of patients in therapy with DOACs for six months (August 2018 -January 2019). The tool individuated the exact geographic position of the pharmacy (point of drug erogation), and generated areas with a size proportional to the number of new patients. Day after day, the system updated the data, and we constantly monitored the progress of the pathology, understanding that the disease was concentrated initially in the more urbanized cities.

In Figure 2, we repeated the analysis after six months (February-June 2019), and the trend was increasing in the areas

**Figure 1.** DOACs erogation points in Abruzzo. We monitored in six months (August 2018 -January 2019) the distribution of drugs through the geo-localization of the pharmacies.

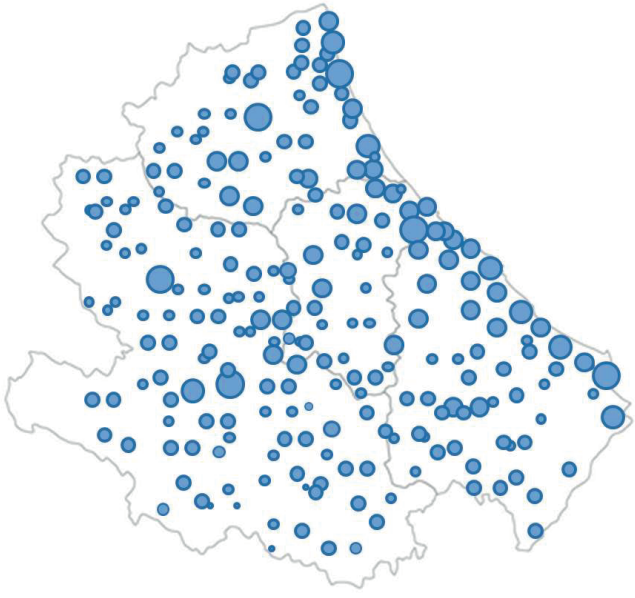

**Figure 2.** DOACs erogation points in Abruzzo. From August 2018 to January 2019 the scenario of DOACs distribution is changed. There was a great concentration in the inner areas.

already identified but, after the winter, the pathology also increased in the internal areas of the region. The sedentary lifestyle, the cold, and the fatter food probably exacerbated cardiovascular problems.

From July to December 2019 (Figure 3), the trend remained almost constant in the region, with a little increase in the disease along the coast and in the inner areas.

At this point, we photographed the trend of cardiovascular pathology in the region, and we decided to verify the coexistence of other pathologies capable of aggravating subjects affected by cardiovascular disorders. We focused our attention on the co-administration of DOACs and hypoglycemic drugs, since diabetes is a factor that can complicate the clinical situation of patients affected by cardiovascular diseases (Figure 4).

We obtained a very interesting result. The presence of diabetes in patients with cardiovascular disease is widespread (black points on the map), and this result, obtained by continuously updating the data, highlights the patients' potential risks. It is important to understand that only a monitoring tool, built on localization of drugs erogation, is able to underline the comorbidities that can degenerate the disease of each patient. In addition, we decided to investigate the behavior of the DOACs erogation during the period under consideration. As can be seen in Figure 5, the four molecules have increased consumption, starting from the second period studied, due to the growth of new patients.

During the period studied, the drug was prescribed to patients from 40 years of age. However, after the winter, the highest consumption was registered starting from 60 years of age, in line with the accentuation of some factors, such as venous stiffening, a diet rich in fats, and a sedentary life (Figure 6).

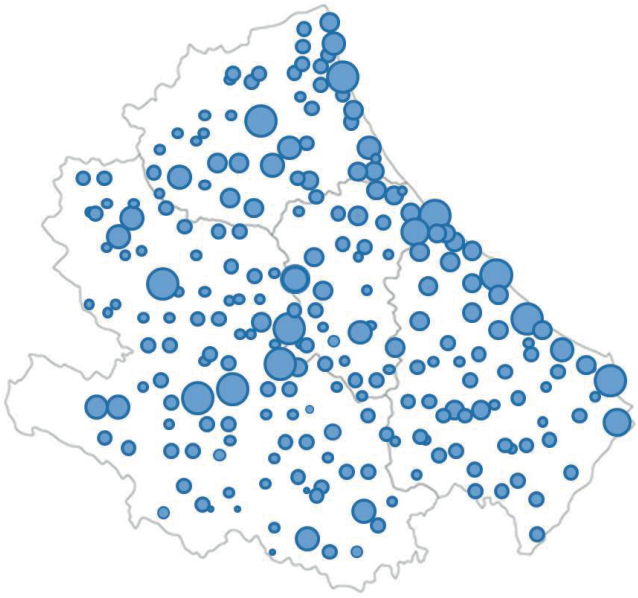

**Figure 3.** DOACs erogation points in Abruzzo. The trend is increased in the cities more populed between July and December 2019.

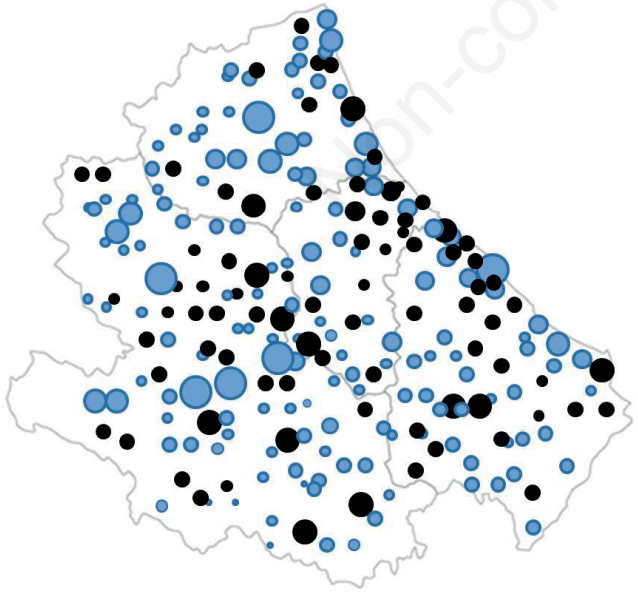

**Figure 4.** DOACs and hypoglicemic agents erogation points in Abruzzo. In the period of study we observed a great diffusion of new patients in treatment with DOACs and drug for the treatment of diabetes (black point).

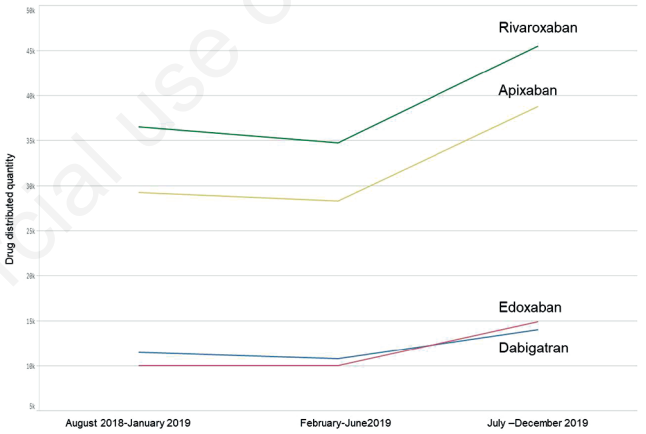


**Figure 5.** Performance of the 4 Direct Acting Oral Anticoagulant agents in the period August 2018-December 2019. The 4 molecules showed similar behaviour in the period studied. Interesting was the surge in consumption after the winter months and rivaroxaban and apixaban showed the greatest consumption.

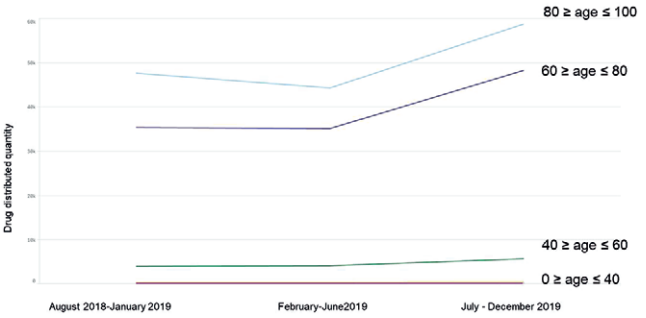


**Figure 6.** Performance of DOACs in different age groups during the period August 2018-December 2019. With the increase in aging phenomena, the use of DOACs has grown after the age of 60. This result is probably due to the presence of other age-related diseases.

In Figure 7 (A-D), we wanted to show, in real-time, the updating of DOACs erogation points in the region. The figure shows a snapshot taken by the monitor. Here, we reported an example of monitoring, and day after day, we followed the development of the pathology through drug consumption, and monitored the inclusion of new patients (through other screens not shown). Of course, the novelty of our tool is the speed with which it displays data in real-time, combining, for the first time, various kinds of information in a single software. The tool created simultaneously connects data relating to population density, the geographical position of pharmacies, and drug erogation, and directly shows a dot on the map full of information (by zooming on the map, more detailed indications are obtained, such as city, patient name, gender, age, therapy, prescriber). In this way, clinicians will easily be able to follow patients through these options in the future.

## Discussion

The advent of new technologies facilitated the patient's use of the internet to obtain information (on their health, pathologies, drugs, therapies) and, through social networks, people have the opportunity to share their experiences and interact in a virtual space with the main stakeholders.

The available data confirm that changes in healthcare must be controlled. Patients not only search for information online, but most of them use the internet to book visits and exams, and communicate with the doctor via e-mail.[18-23] Therefore, in policies about chronic diseases, it is no longer possible to ignore the Internet as a tool for information and education of the population.[24,25]

It is essential to promote the use of digital healthcare models, and provide tools in the management of diseases, in order to guarantee continuity and better quality of care, efficiency, and appropriateness.[26,27] Smart communication and the new technologies available (audiovisual communication, telemedicine, *etc*.) seem to be able to help communication and improve assistance.[28] It is crucial the use of "expert" information systems, (Artificial Intelligence systems) capable of monitoring the diagnostic-therapeutic pathways and improving the appropriateness of care.[29-31] An excellent information system must promptly detect critical situations in order to identify patients who do not follow their therapy, and remind those who do not adhere to it of their treatment.[32] This model of care monitors the patient's adherence to his follow-up, and provides timely alert data to prevent the onset of risks and complications. Digital healthcare technology (E-Health) is able to support the creation of "digital infrastructures"

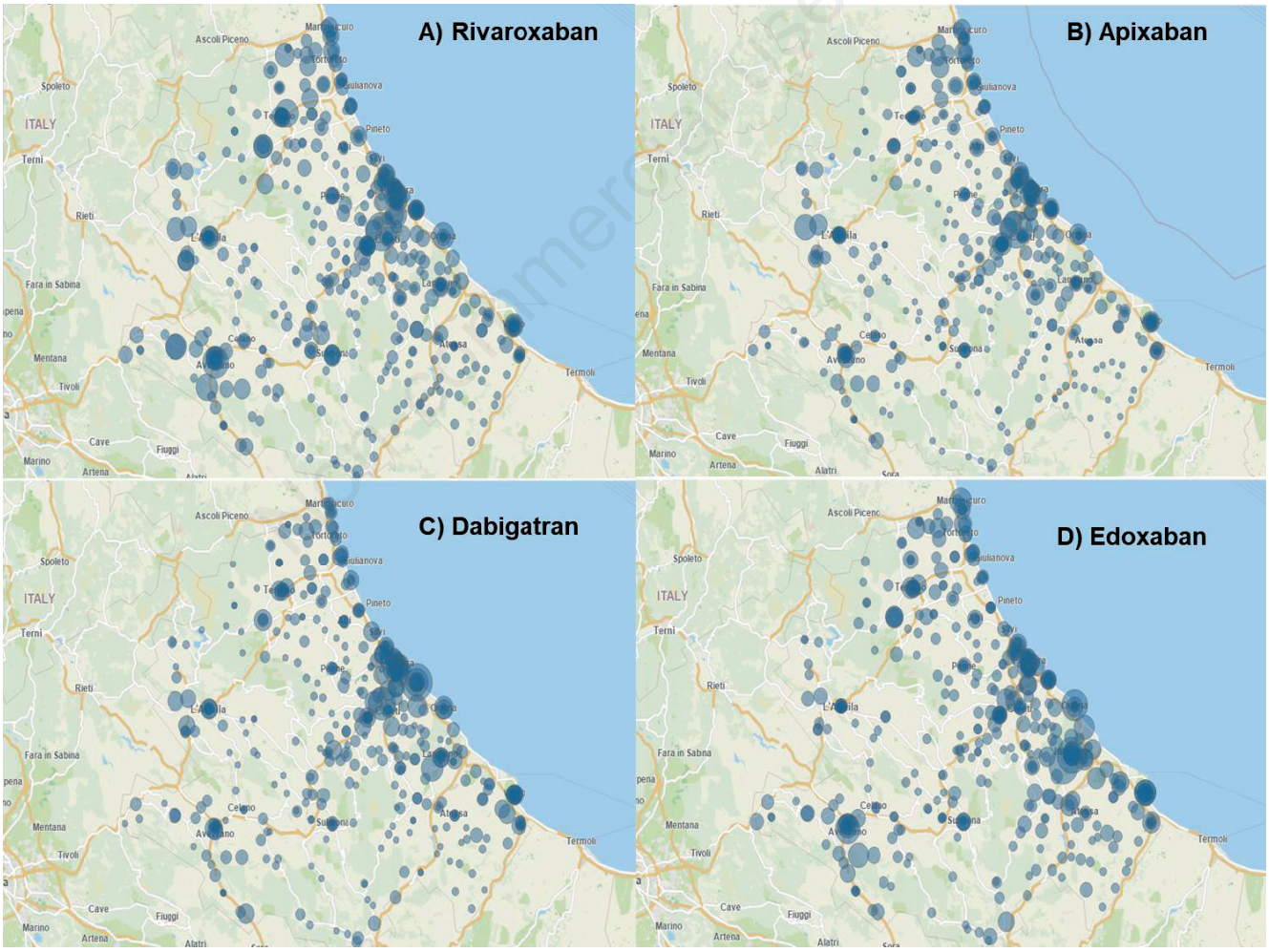


**Figure 7.** A snapshot taken from the PC screen during the monitoring of drug erogation: A) Rivaroxaban, B) Apixaban, C) Dabigatran and D) Edoxaban. Here we have reported an example of monitoring DOACs. Hour after hour the data were updated and, in real time, the size of the areas provided an aggregate result about the quantity of drug erogated and number of patients.

that help and accompany patients in managing their own health through various devices (computers, smartphones, tablets, sensors, *etc*.).[33,34] In particular, the diffusion of mobile devices and the development of wearable sensors represent factors of great potential to support the implementation of new assistance models in order to improve the quality of patients' lives.[35-37] The proposed studies are aimed at personalizing and improving therapies, but the literature reports few studies on prevention made to limit the spread of pathology. During the COVID pandemic, we understood that it is crucial to have available real-time data about disease propagation, and we have always tried to achieve this target by setting up a tool capable of collecting various types of information, in order to turn on or off the risk areas on the map. For this study, we focused our attention on analyzing the DOACs consumption in the region, to analyze the trend of cardiovascular disorders. During the winter, we noted that the disease grew in some areas of the region, probably due to sedentary life, the cold, and a greater amount of food (especially fat). In addition, the system was able to bring out the comorbidities of patients with cardiovascular disease, highlighting the risks for these patients.

## Conclusions

In the future, tools like this could offer clinicians the possibility to check the therapies started and report any interruptions. Finally, this tool could alert clinicians to understand the reasons for treatment discontinuation, and in the case of therapeutic interruptions due to adverse effects, the software proves to be an active pharmacovigilance system, and efficient software that collects useful information in order to build health-related data sets (real-world data), since drugs should never stop being studied.

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