## Research and Development Project

# ONCOLOGIA

## Application of AI and ML Technologies for Integrated and Predictive Analysis in Oncology

AlmavivA DIGITALTEC | ALMAWAVE

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# 1. Background

In recent years, the world's digital information has more than doubled, and this trend is set to increase exponentially, generating huge volumes of electronic data, the so-called big data. In parallel, a cultural, technological, and scientific revolution centered on the application of machine learning (ML) using massive databases is currently underway. Artificial intelligence (AI) and machine learning systems are showing, once again, that machines can analyze large amounts of data faster and more efficiently than humans can and, if properly programmed, are able to generate predictive models. Through research and development in AI-related technologies, the cultural paradigm in "precision" medicine, i.e. medicine personalized to each patient, is also expanding. Relevant applications could soon become essential in providing quick responses in very complex, uncertain situations, enabling physicians to free themselves from rote, repetitive work, and rely on assessment and decision-making elements to make the best choices for each patient, including in terms of care. In this sense, AI systems should be considered actual tools like the microscope, stethoscope or electrocardiograph, which developed over time to increase physicians' perceptual capacities with more in-depth biological detection. This goal will be reached when AI constitutes real, constant support for all healthcare personnel, providing a "second set of eyes" in a mode of cultural integration between humans and smart machines, based on the understanding that human cognition will always remain "smarter" than the artificial cognition. The integration of AI with human intelligence will be complete when physicians, equipped with rigorous predictive tools and guidance in clinical choices, can delegate calculations and data operations to machines, focusing on interpreting complex phenomena and possible solutions.

Physicians will continue to guide, supervise, and monitor patients using their own intelligence and typically human qualities such as abstraction, intuition, flexibility, and empathy to apply a conservative and constructively critical approach, while using the enormous potential of predictive AI systems in prognostics through the availability of big data and machine

learning. As an example, Figure 1 shows the integration between studies with traditional methods (in blue) and those conducted with AI and machine learning technology (in green). In medicine, oncology is certainly one of the major disciplines to benefit significantly from an approach that integrates medical activities with AI tools in support of and accelerating the shift toward precision medicine and personalized care. In fact, modern medicine has long sought to provide patients with specific therapies and a treatment plan that considers people's individual needs, in an ongoing attempt to reconcile clinical aspects with quality of life and to also provide answers to social and welfare needs throughout the course of treatment.

The possibilities offered by the digitalization of information and the use of big data as the basis for the AI/ML technologies make it possible to connect the different phases of patient management and, with the appropriate forms and transformations of the available data, to feed clinical research and administrative planning led by local, regional and national health agencies (Regions/Local Health Authorities/etc.).

The organization and processing of large amounts of data and variables can be enhanced by decision support systems (DSS). These are IT tools that rely on data and mathematical models to provide so-called decision makers—from policy makers to physicians to managers, depending on the context—with further information useful for making decisions when performing their activities. This information may be brief (indicators produced by processing several variables) or extended, in the form of analytics in which all the significant logics and patterns behind the returned results are reported. The areas of application are quite varied: from spatial planning—in which the information returned through data processing is cartographic, making planners

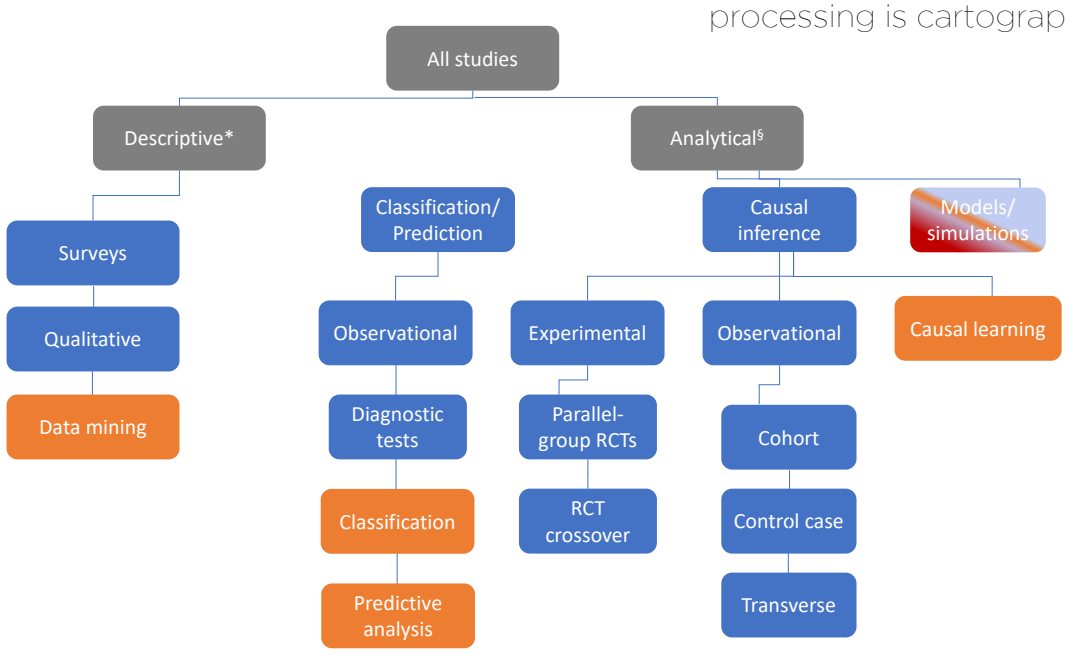


**Figure 1: Traditional and AI-supported study methods**

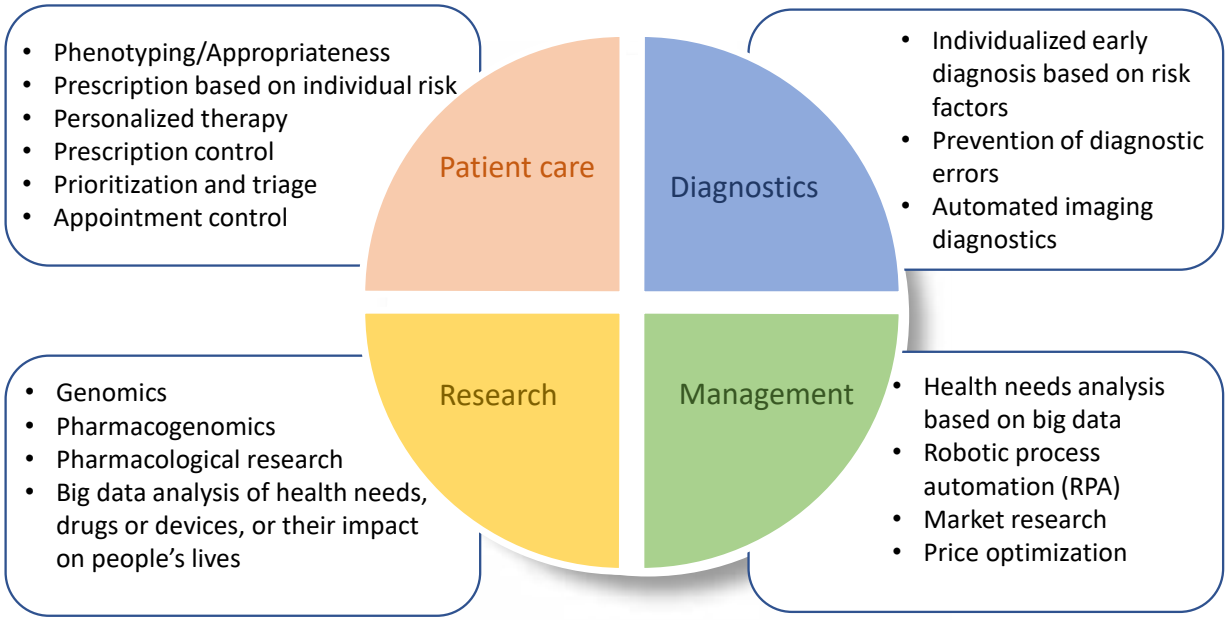


**Figure 2: Traditional and AI-supported study methods**

aware of specific trends for territorial areas and thus providing support when defining new policies—to clinical aspects—where the physician can view data for specific indicators related to the patient's health and, based on these, decide whether and how to adapt the treatment plan. Through DSS, data organized and processed using big data and artificial intelligence technologies are transformed and enhanced into useful information and knowledge for decision-making. In sum, with reference to the possibilities offered by technological development, we see that the availability of new tools at an appropriate level of maturity enables new scenarios and paradigms.

Figure 3 summarizes the different evolutionary stages and enabling technological factors that have led the transformation from traditional medicine to distributed medicine to today's precision medicine, in which the individual patient's genetic, environmental, and lifestyle variables are elements used to evaluate the treatment and prevention of different diseases.

Industrial research and experimental development projects in this field are exponentially increasing applied innovation in medicine and enabling faster progress toward personalized patient care and treatment goals, helping to improve the efficiency and effectiveness of care and the health care system as a whole.

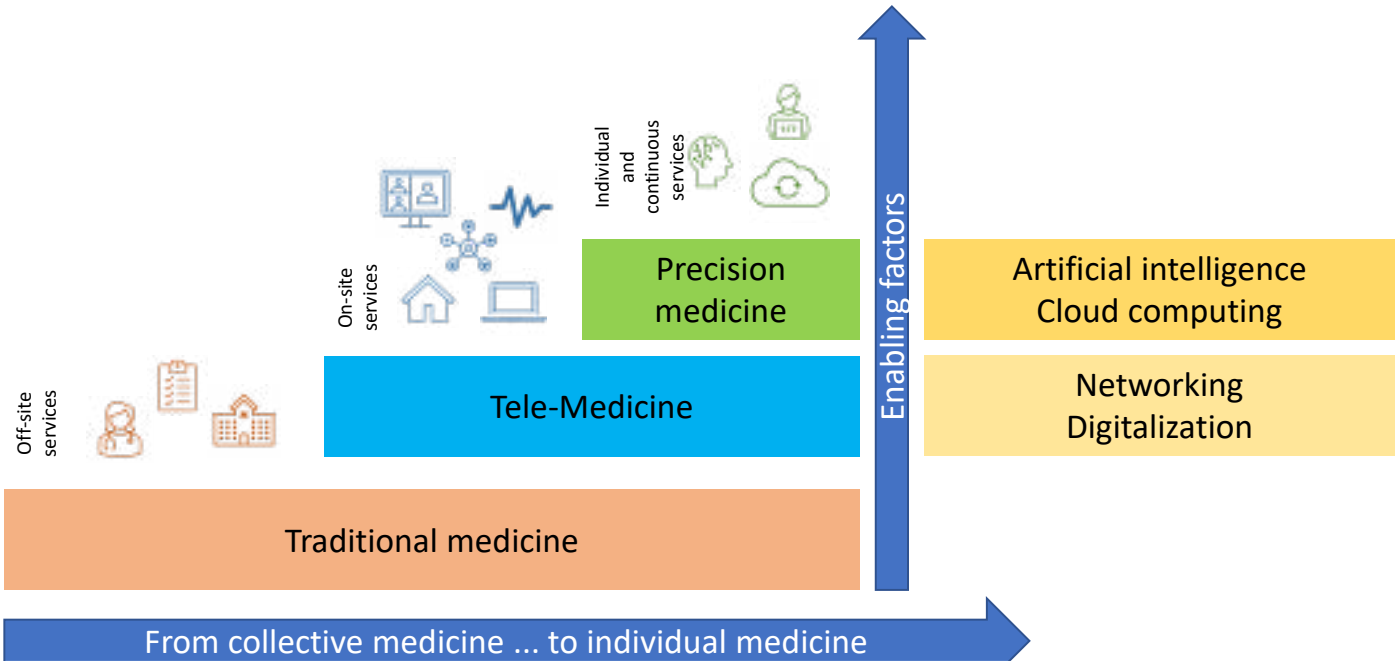


**Figure 3: The evolutionary path of medicine, from traditional to precision medicine**

# 2. The OncologIA Project

OncologIA is an industrial research and experimental development project cofunded by the Apulia Region through the European Regional Development Fund Operational Programme of Apulia 2014–2020, for the application of innovative IT technologies in the field of oncological medicine. This is one of the most advanced specialties to date with a significant service network in which the "precision" approach can ensure crucial differences in outcome. Furthermore, the field of oncology requires access to significant volumes of high-quality data, as well as a large number of potential users. This is a challenging test bed for concepts and applications that are technically and scientifically sound and also easy to adopt by both professionals and the patients themselves. The OncologIA project aims to implement a highly precise modus operandi through the "sustainable" use of artificial intelligence and data, in compliance with the binding regulations governing these applications and their ethical implications. Specifically, the project intends to lay the groundwork for the creation of a cloud-managed framework within which an ecosystem will be created to accommodate different levels of using AI and ML technologies: from predictive and decision-support algorithms in clinical and logistical settings to the establishment of digital health identities (DHI). These represent an evolved, digital model of the real patient, connected through specific sensors and devices, capable of offering physicians an almost real-time "view" of the patient and/or the people in their care. The experimental areas of focus in OncologIA are myeloma—malignant blood cancer—and breast cancer. The project will implement the technology vertically on case studies related to the above-mentioned diseases and general purpose, with a view to extending the scope of application to other diseases or areas, even outside of oncology. In this sense, the scope of technological experimentation may be extended to applying the training of the algorithms on datasets relating to different clinical issues, testing the extent to which the capacity of these algorithms is preserved as the specific clinical issue changes. OncologIA intends to integrate all of the above aspects—from data security to the need to refer to multiple data sources to the construction of decision support systems and predictions in clinical settings—through industrial research and experimental development activities focused on the following technological streams:

- Studying and defining the cloud delivery model: OncologIA intends to investigate the data security aspects of cloud service delivery, and a specific set of features will be developed for each aspect to ensure confidentiality and compliance with privacy regulations (GDPR). In particular, for

the different end users of the services (administration/clinicians/patients/caregivers), appropriate profiling and security mechanisms will be designed to ensure access from different platforms with guaranteed confidentiality and the ability to manage information from IoMT (internet of medical things) devices.

- The "oncology" Data Lake model: within this stream, the goal of the project is to build a system of native information collection, harmonization, and normalization, overcoming the organization silos of oncology network applications, expanding the volume of available information, enabling the effective use of AI algorithms even with data from different sources, and, finally, feeding digital health identities (hereafter DHI) with this information.

- Predictive algorithms in clinical settings: to identify and personalize treatments and care pathways, OncologIA intends to investigate AI and machine learning systems specialized in the medical cases mentioned above.

- Digital health identities (HDI, digital twin): to generalize the simulation process, but also to support the identification of potentially more effective therapies as they are personalized, OncologIA intends to test a "Digital Health Identity" model of the patient, effectively creating a digital twin to provide clinical staff with a complete and integrated picture of the patient's health.

- Predictive algorithms to support territorial health care: OncologIA aims to develop a model of the care process that also considers services offered by territorial health facilities for more efficient and effective logistics, and environmental characteristics that potentially impact patient health. The specific OncologIA project streams are discussed in depth below to describe technological advances and related innovations.

# 3. Innovation in OncologIA

The cloud delivery model
Digital transformation in healthcare also comes through an awareness of the role of data. The volume of digital data is constantly growing, and its value lies in extracting useful and usable information. The model of OncologIA is based on the centrality of clinical data and the ability to reconstruct an individual patient's medical history, as well as aggregating data from different patients in a way that provides tools for treatment and research. To support this data-driven transformation—we could call it a "data revolution"—appropriate technological infrastructure and analytical solutions aimed at building tools for decision support, appropriateness checks, and scenario building are needed. This infrastructure is set to grow exponentially, with the related consequences in terms of the security and protection of sensitive data. A key enabler of this transformation is the cloud, whether public, private, or hybrid. Cloud infrastructures do indeed offer ease of use, configuration flexibility, and scaling, but they can also introduce new data security risks. Security and privacy aspects are central, especially when managing health data. Because of this, the technological infrastructure must comply with current regulations without affecting the possibility of implementing analytical solutions, particularly with regard to those based on artificial intelligence. The innovative potential of OncologIA in this area lies in:

- Implementing an evolved and certified model of credential and access profile management to ensure confidentiality and compliance with regulations;
- Collecting privacy consents, through blockchain techniques for reliable, transparent, and tracked management;
- Creating a hybrid cloud-distributed data lake model for data collection and analysis;
- Using advanced techniques in standard and homomorphic encryption, differential privacy mechanisms, and integration;
- Bringing these aspects together on an enabling platform.

In particular, experimentation with homomorphic encryption techniques is an important aspect in OncologIA. Artificial intelligence algorithms are of fundamental and growing importance, but, as indicated earlier, the type of data processed in health care is extremely sensitive. One limitation of traditional encryption is that the data needed for subsequent statistical processing or to train artificial intelligence models must be decrypted before it is used, as opposed to privacy aspects. In contrast to traditional encryption schemes, homomorphic encryption allows for direct operations on the encrypted data.

Finally, to further increase the level of security and confidentiality sof the information processed, specific techniques of differential privacy—"noise addition"—will be tested by introducing a certain degree of entropy into the dataset, such that the information can no longer be identified or correlated in the event of a "composition attack." In sum, the OncologIA will rely on a cloud-based delivery model to contribute to the technological advancement of data security in clinical health through an integrated model of innovative techniques.

The oncological data lake

Digital data in healthcare continues to grow in volume, variety, and speed, so analytic needs require a data management infrastructure that is efficient, flexible, scalable, and distributed. This scenario embodies the choice of a data lake, which represents a centralized repository designed to store, process, and protect large amounts of data of various types, which may be structured, semi-structured, or unstructured. In this context, the OncologIA project aims to research and develop solutions to implement the processing infrastructure necessary for data management. The data lake is the basis for the analysis and artificial intelligence stages.

In more technical terms, it involves the application of the so-called on-read method, in which the data structure is provided during analysis and not when it is stored. Data management within a data lake involves:

- Data ingestion and storage, i.e. the ability to acquire data in real-time or in batch, and to retain and access structured, semi-structured, and unstructured data in their original format, with a system implemented to define access roles;
- Data processing, i.e. the ability to a) work on previously acquired data to prepare it for analysis with standard procedures, b) implement and engineer solutions to extract value from data using automated and periodic processes, which are the result of the analysis operations;
- Data analysis, i.e. the ability to create models to systematically extract information from data, which can be done in real time or through processes executed periodically;
- Data integration, i.e. the ability to connect applications to the platform to query and extract data in usable formats for specific purposes.

The processing infrastructure must provide the tools to manage the data as described, while focusing on all security and domain aspects related to the health data. With the data lake, the goal of OncologIA is to create a profile of each individual patient

throughout the disease cycle, from the preclinical phase of defining the disease to the design and application of therapy, to evaluation of the results and the endurance of the therapy.

The data, although divided and differentiated in format and content at the beginning, becomes unified through interoperability mechanisms and a standardization process, using the patient as the connecting element, thereby generating the patient's health information according to a "patient-centered" view of the data.

In OncologIA, the adoption of the Observational Medical Outcomes Partnership (OMOP) common data model (CDM) as a reference for data lake design, with appropriate verticals related to oncology, is extremely valuable, applicable to solutions that can also be extended to other healthcare domains.

Predictive Algorithms in Clinical Settings

Oncology is a medical specialty that, given its context, has a strong need for historical and near real-time data to offer increasingly effective, patient-centered care pathways. The development of technology and innovation has impacted this medical field in several aspects: research, tools for treatment and diagnosis, and the type of data and information that can be found and analyzed. In this context, an increasingly crucial role is being played by artificial intelligence. Many, varied experiences and applications are covered in the literature and in clinical practice, especially geared toward designing tools to help assess the compatibility of and among treatments and bringing added value to imaging, both during diagnosis or screening and follow-up.

However, one area with an increasing need for experimentation in clinical health care relates to predictive and prognostic tools within the patient pathway, using different types and forms of data from the most assorted clinical sources (RIS-PACS, LIS, EHR etc.). Machine learning and deep learning models have the potential to provide such tools through their processing capacity.

The OncologIA project fits within this line of research, investigating and testing algorithms that can draw on data from a variety of sources, also understood as steps along the care pathway—from the initial request for in-depth diagnostic investigation and staging and through follow-up—representing a prognostic tool for support clinicians' timely decisions due to the overall, holistic evaluation and consideration of the data.

Specifically, OncologIA intends to develop and test such algorithms at the various junctures of the treatment pathway for monitoring, decision support, and prediction, and to manipulate and transform raw data from multiple sources, such as electronic medical reports and records or documents containing information in unstructured or descriptive form, into usable data through specific data augmentation, data enrichment, and natural language

processing (NLP) techniques. The result is the extension, enrichment, and improved quality of the available datasets. In addition, the ability to process information, characterized by a vast number of variables, makes it possible to construct patient-specific brief indicators, thereby increasing clinical accuracy, i.e. the quality of the physician's assessment, about the specific status of the individual patient, with a view to precision medicine.

In essence, the use of artificial intelligence techniques aims to support the tumor board in more accurately defining the patient's health status at certain junctures of the treatment pathway by constructing additional short diagnostic and prognostic indicators in accordance with the reference diagnostic-therapeutic treatment pathways (PDTA).

With a view to providing tools for medical personnel for medicine that ensures patient-centeredness and benefits from a more varied type of usable data, additional aspects include patient engagement and quality of life assessment (QoL).

OncologIA lays the groundwork for the studying and prototyping physician support tools to automate communication with patients for at-home follow-ups without burdening health care personnel and increasing the "closeness" to patients following contact with the healthcare facility. In this case, the use of artificial intelligence will be the enabling factor to extend the collection of information directly from the patient, automating the administration of patient reported outcome measures (PROMs) and patient reported experience measures (PREMs) through natural language, translating the acquired speech into structured information. Algorithms and predictive tools based on QoL and the related patient-centered view can be built using these data. The use of NLP techniques underlies the use of the voice channel, with the advantage that dedicated devices or other tools are not required, which can be difficult to use, especially for elderly people. Collecting survey results in a structured way will provide clinicians with an overview of the progress of questionnaire administration and participation trends, highlighting any critical issues for individual patients.

In sum, OncologIA aspires to bring innovations to predictive algorithms in clinical settings by: a) experimenting with the potential integration between nonuniform data sources, b) integrating information on potential patient needs and feedback to support healthcare professionals, and c) implementing analysis, monitoring, and prediction tools through a circular mode and continuous discussion with stakeholders according to codesign for technology innovation in healthcare.

Digital Health Identities (DHI)

A digital health identity (DHI) is a virtual representation that uses technology to track and manage the entire lifecycle of patients, from data on their symptoms and health conditions to diagnosis and treatment.

The DHI falls within the family of digital twins, which allow the potential and actual characteristics of people, places, processes, objects, infrastructure, systems, and devices to be replicated in the virtual realm. In general, a digital twin can be designed using various technologies, such as artificial intelligence, augmented reality, and virtual reality.

In medicine, its potential lies in the ability to create extremely detailed and accurate models of patients and also of the diseases themselves, which can help improve the quality of health care and reduce care-related costs. Additional potential includes: simulation and testing of different treatment strategies, early identification of problems, and prediction of patients' needs. In addition, it can be used for training health care personnel, improving the capacity for care.

There are various use cases that can be implemented by creating digital twins in oncology; they can be integrated, and respond to the needs of patients and healthcare professionals. For example, in clinical data monitoring for decision support, DHIs enable medical staff to detect patterns of disease evolution and send alerts to the case manager in the event of abnormalities, as well as providing support in applying any adjustments to the therapy in real time. In terms of diagnostics, DHIs, combined with the computational capability of AI algorithms, can analyze data from a variety of sources, such as clinical data, treatment information, and tumor tissue analysis, thus identifying tumor-specific characteristics and better personalizing the therapy.

In essence, the potential of developing digital twins in healthcare with the creation of digital health identities appears to hold great impact in the structured and integrated return of information from multiple sources, providing medical personnel with a clear, synoptic picture of patients and their conditions, without losing the potential to analyze large masses of data to evaluate general trends.

OncologIA intends to explore and test the potential represented by such digital models, both for patient monitoring and physician decision support. Specifically, through industrial research and experimental development, the goal is to lay the basis for the construction of a complex solution that can develop the following use cases:

- Monitoring: defining a solution that collects both information about prescribed therapies, such as treatment duration and medication dosage, and—through the use of sensors and/or wearable devices—information about patient well-being by monitoring physical activity, sleep, and other activities to be determined with clinical staff. Through these data and the functionality that will be implemented, the application will provide patients with the ability to report any symptoms or side effects medication to monitor their severity and support physicians in assessing whether the therapy needs to be changed. In

addition, the application will integrate data from laboratory tests and follow-ups to monitor the evolution of the disease and the effectiveness of the therapy over time. In this way, greater accuracy in managing postoperative care and more timely management of patient health problems will be ensured.

- Decision support for treatment choices: defining a solution that, through access to patient clinical data and their processing through artificial intelligence algorithms, will provide information on available treatment options, personalized recommendations, and—based on individual data—help physicians with treatment choices. It will have an intuitive user interface, and will be updated regularly to ensure the security and privacy of patient data in addition to state-of-the-art clinical tips.

In sum, the digital health identity (DHI) to be developed in OncologIA represents a profound innovation in the healthcare process. It represents the ultimate in concretizing the concept of "patient centeredness." The DHI can be envisioned as a "digital guardian angel" that complements and empowers the specialized organizational system providing care for the patient. It constantly focuses on the uniqueness of the patient. Trained on large volumes of data, the model also continuously verifies the model fit with the clinical cases to which it is applied and through which it is enriched.

Predictive Algorithms for Regional Health Care.

In addition to impacts on the merits of care, digital technology in health care can also contribute decisively to the method and thus the organizational aspect of care. In health care, aspects of the process impact therapeutic outcomes as much as the treatment.

The OncologIA project aims to integrate tools for monitoring and predicting treatment with those for process and treatment planning, with a view to optimizing resources, logistics, and patient movement based on territorial services and specializations. This opportunity for innovation fully in line with the existing organizational model of hub & spoke oncology networks, and reinforces it through the possibility of processing instantaneous information through AI algorithms.

As noted above, artificial intelligence techniques are able to process and brief different types of data, whether spatial or clinical, in a single algorithm, providing a final indicator that can suggest the best course of treatment in the regional territory.

Specifically, OncologIA intends to test a model to optimize the patient's care pathway, considering logistical aspects (i.e. the patient's home and geographical location of the health care facilities), clinical aspects, (the patient's health status, disease, and treatment pathway), and performance aspects (i.e. the social welfare services provided by the facilities themselves). By optimizing the care pathway, the goal is to streamline the patient's entire treatment process by referring them to the hospitals and facilities with the right services completing the care pathway that are closest to their homes.

The integration of spatial data, clinical-health data related to the specific patient, and performance data from hospitals and other health system entities in the artificial intelligence algorithms in the oncology data lake will feed a recommendation system to support health and social welfare facilities. Specifically, by processing spatial data and the patient's clinical data, the oncology case manager will be supported in identifying the healthcare facilities best suited to the context and specific needs of the individual patient.

By way of explanation, the following are various types of data that may be considered:

- Healthcare facilities in the area and their capacity
- Social welfare facilities
- Medical specialists in the territory
- Services provided per type of specialty
- Techniques used by each facility to manage individual performance
- Environmental conditions in the territorial area
- Clinical pathway of the identified patient
- The patient's clinical data (medical history, diseases, interventions, therapies)
- Services and care needed by the patient.

The impact of such a solution can be enormous. Cancer patients are subjected to periodic, high-intensity therapies carried out at the specific facilities. Patient travel and living arrangements are often the responsibility of family members, caregivers and assistance personnel. Optimizing logistical aspects by increasing the geographical proximity between patient and facilities would allow easier management of patients' daily transfers and improve their overall quality of life. In addition, greater attention to managing access to inpatient and outpatient services and a more efficient balancing of patient loads across the region would strengthen the delivery of clinical and health care services, generally optimizing all resources provided by the health service. With respect to the care pathway, improved logistical and clinical aspects within the cancer patient's pathway would result in greater adherence to care and thus better application of the treatment protocol. Finally, optimizing the distance and amount of travel between home and healthcare facilities would drastically reduce CO2 emissions, resulting in energy savings and environmental benefits to improve the overall sustainability of the region.

In sum, the OncologIA project will provide hospitals and clinical research facilities with innovative tools that, when integrated with monitoring and predicting patients' health status, will enable clinical staff to rely on a logistical/organizational decision support system during care planning.

This possibility will not only strengthen the territorial hub & spoke organization, but the model will also lead to evolution in healthcare networks, in which all healthcare facilities in a territory are valued for their specialized or geographical characteristics, offering an increasingly integrated approach to patient care and an increasingly efficient and effective delivery of healthcare services.

# 4. Conclusion

The rapid, progressive digitalization of different areas of society is leading to the production and sharing of data and information that is revolutionizing our approach to knowledge. This context offers us the opportunity to capitalize on a wealth of information to broaden the ways in which we search for solutions to improve people's quality of life.

Through the availability of data and the ability of machines to process them, various trends can be investigated multidimensionally, that is, investigating a phenomenon in its multidisciplinary complexity and therefore in its relationship with a variety of characteristic variables based on a holistic approach to building knowledge.

The world of healthcare, and oncology in particular, increasingly features multidisciplinary medical teams. In oncology, in fact, we speak of tumor boards (or cancer boards), in which medical teams have a range of specialties, allowing for a broad comparison, an evaluation of all the patient's clinical aspects, and the identification of different viable treatment options. A board in which patients, with their many specifics, are truly at the center.

As highlighted earlier, the use of digital technologies holds tremendous potential in supporting medical and research groups in their respective analyses and decisions. During the pandemic, this opportunity for innovation became a necessity that actually increased the focus on digital medicine solutions.

Almaviva Digitaltec and Almawave fit into this context, with their expertise in IT and complex project management. Their ambition is to create a tool that incorporates medical needs relating to multidisciplinary teams (and thus knowledge) and patient-centeredness, supporting them with the use and processing of large volumes of data through technology, with a focus on security and privacy.

OncologIA was born out of this ambition. Starting from this industrial research and experimental development project, the two Almaviva Group companies intend to build a solution for medicine-oncology—and beyond—that integrates the following features:

a) accommodating and structuring large amounts of assorted health data in different forms (text, images, datasets, etc.) from the most varied sources (hospitals, research centers, private healthcare facilities, social welfare facilities, etc.) through the construction of a specialized data lake oriented around clinical research
b) accessing and processing such data in compliance with current security and privacy regulations through the use of homomorphic encryption techniques

and blockchain technology
c) processing such masses and types of data (from clinical to spatial) for analytical and predictive purposes in both patient care and to organize care in the territory using AI/ML algorithms, thus providing multidimensional and integrated readings as well as decision-support systems d) ensuring a focus on the patient's health status through the construction of his or her digital twin (digital health identity), which monitors the patient's condition and integrates wide-ranging data from other sources in a vision of precision medicine combined with statistical studies. The patient's clinical pathway, and thus the information and data in it, proves to be the key asset to enhance so that medical staff can make the correct decisions in terms of content and timing. Artificial intelligence technologies are an important ally and innovation in the healthcare world. This is due not only to their ability to analyze, process, and evaluate large volumes of data of different types, forms, and sources, providing customized, preventive, and predictive synthesis, but also because they act as a tool for enhancing the information and content of those types of data that are not explicitly numerical or structured.

In this scenario, OncologIA helps to answer to the need for automation in some oncological healthcare processes and patient management, which currently do not exist or are realized through human management. The technological and application experiments in OncologIA will optimize all caregiver and care management to reduce times and give more accurate results, integrating more information and providing better services for patients.
In conclusion, OncologIA fits into the broad evolutionary trend of increasingly important use of ML/AI technologies in clinical settings. Through its industrial research and experimental development, it aims to bring innovation in terms of:

- new opportunities to move beyond the logic of in-house infrastructure needed to deliver these types of services and toward a new cloud and distributed delivery model that ensures adherence to security and privacy regulations
- creation of new models of data cooperation capable of securely aggregating information from varied sources (diagnostic imaging, drug therapies, responses and data provided by patients, analytical laboratories, spatial data, etc.), ensuring consistency with respect to the required processing while respecting confidentiality and data ownership
- modeling and industrialization of the approach adopted in OncologIA to create a framework that can be adapted to multiple clinical domains, creating the conditions to bring the developed solutions closer to a large number of contexts, with the aim of facilitating more

people's and professionals' access to benefits from this important innovation in healthcare.

These elements represent a major challenge, the success of which will make it possible to enrich the care and technology models of health care companies with regard to clinical processes related to diagnostics, healthcare management, and the organization of territorial services.

# The People in OncologIA

The OncologIA project involves the collaboration of a number of public and private entities. The two main organizations in the project are Almaviva Digitaltec S.r.l (proposer) and Almawave S.p.A. (supporter), both belonging to the Almaviva Group. Almaviva Digitaltec (ADT) was established in late 2017 to develop activities based on cutting-edge technologies for central administrations, local administrations, and industry. The company represents the digital soul of the entire Almaviva Group and is characterized by its expertise in the areas of mobile & portals, IoT, GIS, API economy, microservices, containers, big data, and analytics.

ADT is also very active in building a national and local network from an open innovation perspective. With professors from the "Federico II" University of Naples and Almawave, it founded the academic spin-off "Data Jam," which specializes in machine learning and artificial intelligence services and related research and innovation. It has a local presence in the search for talent and innovative solutions by helping to organize Hackathons with the public administration, IT academies, and national and international research projects.

The company is growing rapidly, and has expanded from its Naples office to open offices in Bari, Cagliari, Venice, and Palermo. From late 2017—the year it was founded—to the beginning of 2023, it has grown to 358 employees and expects to hire enough in 2023 to reach 500 employees with the opening of offices in Rome and Milan in late 2023.

Almawave is the leading company in artificial intelligence and natural language analysis. It possesses cutting-edge proprietary technologies and applied services to realize AI's potential in the digital evolution of companies and public administrations. It has an international presence in as many as 29 countries. It has 6 technology labs and more than 400 professionals with strong skills in enabling technologies and major frameworks—big data, data science, machine learning, AI architectures and integration—as well as a deep understanding of business processes. Almawave's mission is to make digital transformation a reality in everyday life through a model of natural experience in human-computer interaction through the advanced use of artificial intelligence. Proprietary technologies enable text and voice interpretation in multilingual mode, multichannel interaction, and data and information analysis with a view to enhancing knowledge and automation. Almawave has in-depth technological knowledge of data science, business processes, and operational contexts and has built Iride®, an advanced artificial intelligence platform that leverages different channels to enhance the customer experience based on a citizen-centered strategy, while enabling cognitive analysis of

all content and natural language interaction with users in over 40 languages (voice and text). Two new companies were added to the Group: The Data Appeal Company, operating with an AI-based product in the world of location intelligence for the tourism, fintech and retail sectors, and SisTer – Sistemi Territoriali, which offers solutions for decision support systems, location intelligence, and big data expertise in the utility and government sectors.

Almawave's solutions leverage products and developments made in its technological innovation laboratories:

- Digital Architecture for AI & Cognitive – designing enterprise architectures that integrate an advanced view of market technologies with client ecosystems, cloud-oriented models, and Almawave proprietary technologies
- Data-driven Transformation & Augmented Analytics – designing solutions for the adoption of new information management models that enable the integration of structured and unstructured data by leveraging state-of-the-art knowledge modeling techniques, AI, and actuarial statistical methodologies
- Open Data & Semantic Web – Application of AI in knowledge and information modeling with symbolic representation or learning techniques and design of data models, including virtual models, to support the creation of new analysis paradigms in open data, linked data, and the Semantic Web.
- Social Media & Web Data Science – Data Science solutions for web and social sources to discover and analyze topics, content, and dynamics of interest, and digital reputation monitoring using the potential of proprietary cognitive solutions to maximize the value of information
- Conversational AI & Engagement – supporting customers in using multichannel and multimodal virtual assistants by refining the proprietary conversational platform to simplify engagement and natural language access to data and processes for creating the best customer experience
- Cognitive Solutions & Smart Process Automation – refining cognitive, proprietary technologies for natural language processing, markets for computer vision, for business process optimization and automation, customer experience improvement and voice of the customer analysis.

The company also collaborates with universities and scientific partners (University of Trento, Fondazione Bruno Kessler, Fondazione Ugo Bordoni, Sapienza University, Politecnico di Milano, etc.) and technological market leaders on the best technologies, methods, and practices to provide new and better services to citizens and businesses.

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