New Types of Human Computer Interactions through Digital Healthcare in France

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Abstract - **The Healthcare sector, like all other sectors of our society, is strongly impacted by digital transformations and must tackle huge problems (especially of costs), hoping digital devices help to solve them. We propose to consider it through new uses of Interactive Devices in the scope of Artificial Intelligence (AI) solutions for the improvement of Human Computer Interactions, principally through Telemedicine Platforms in France. First of all, we define our scientific position and the methodology used. Secondly, we present the use of data in telemedicine with data processing and some cases analysis of AI applications in telemedicine. We then analyze the effects of the combination of the two technologies. Furthermore, we consider the impacts of the Covid pandemic with new types of remote interactions, especially for the elderly. We discuss the main challenges of this digital transformation with the risk of a "solutionist" and "technocentric" approach, sometimes forgetting that health is above all based on a human dimension and human interactions. We also outline the question of territories and the integration of telemedicine in the healthcare system. Finally, we give a conclusion focusing on the main challenges undertaken as well as providing some perspectives, integrating lessons of the Covid pandemic. More globally we outline the importance of the digital transformation of the French Healthcare System with new types of human computer interactions both for the resilience of the healthcare organizations, improving care and cure with territorial dimensions, with the new challenges of the Covid pandemic.**

Keywords - Artificial Intelligence; Telemedicine Platforms; Territories; Healthcare; Digital Transformations; France; Covid pandemic.

I. INTRODUCTION

Healthcare is an essential sector in the digital transformations of our entire society, using interactive devices. In the developed countries, Healthcare systems must tackle huge problems (especially costs), hoping digital devices help to solve them and also help to improve the quality of care and their results. It is also the problem of traceabilily of medical acts. An approach may be through uses of interactive devices such as artificial intelligence solutions for the improvement of human-computer interactions through telemedicine platforms [1].

In France, the Isaac's report [2] clearly highlighted the main challenges of this transformation, with digital technology enabling the transition from curative to more predictive medicine. More recently, Villani's report [3] stressed the importance of Artificial Intelligence (AI), particularly in the healthcare sector. The Institute's Montaigne report considers e-Health as a priority project to transform the French Healthcare System [4].

The question of healthcare is linked to the territories, in particular with the subject of social and territorial inequalities in health [5], with the concern of "medical deserts", with issues of traceability of care acts and health pathways, with the possible contributions of telemedicine to improve it and experiment new innovative ways.

This French healthcare system, already in a severe crisis (the question of operating costs having led to hard staff reductions in recent years) has been strongly impacted since March 2020 by the Covid pandemic, imposing in particular the search for new solutions based on digital tools and new uses of data [6].

In this paper, we examine the background of the transformation of the healthcare system and the current context of the development of telemedicine platforms and AI. We clarify the scope and the objectives of the survey that deals with the production and use of healthcare data on telemedicine platforms. Then, we intend to address, through an example, the issue of the AI solutions to implement better Human Computer Interactions in telemedicine. To get a relevant picture of the recent situation, we choose the examples amongst new worldwide trends and French implementations. During teleconsultations, there are no physical examinations, so they seem somewhat like tele regulation and are required to reduce uncertainty in diagnosis. We intend to identify how combining AI and telemedicine may specifically support and improve the process of a remote medical consultation. Finally, we try to bring out the main findings concerning technical approaches as well as other considerations.

The transformation of the French healthcare system has become vital due to the combination of demographic evolution and the epidemiologic transition. With the decrease of infectious diseases that have led to the model of hospital, important changes have been brought with the rise of degenerative diseases and multi chronical pathologies. In this context, the patients are more and more involved in their healthcare pathway. They use search engines to get information on Internet, they share opinions and feelings on social networks, they interact on platforms to obtain medical appointments and they take charge of their healthcare records.

With the implementation of Healthcare Information Systems (HIS) in doctors' offices or hospitals, important volumes of medical data are produced. They gave rise to the

implementation of data warehouses for archiving them in secure ways and managing their use. With multi-chronic pathologies, data for analysis are not only medical parameters but they come from different sources, on issues such as nutrition, habits and behavior, environment, etc. This wide scope of data is produced by the interactions of patients on digital platforms, characterized as social technical devices. Moreover, the chronic patients' healthcare requires the coordination of all the healthcare providers in the hospitals and in the ambulatory system. The different stakeholders have to exchange information for the organization of their patients' healthcare pathways and the monitoring. Medical data are produced and recorded in the different Electronic Healthcare Records (EHR) on proprietary software and in the "*Dossier médical partagé*" (DMP) in France, used till recently as repositories. But the priority is to enable data retrieval and sharing. Healthcare coordination should be based on interactive devices and updated data.

After an introduction (Section I), in Section II, we first define our scientific position and the methodology used. Then, in Section III, we present the use of data in telemedicine and Artificial Intelligence data processing. In Section IV, we consider observations on AI applications in telemedicine through cases analysis. In Section V, we then analyze the effects of the combination of the two technologies. In Section VI, we analyze the consequences of the Covid pandemic on the human computer interactions. After a discussion in Section VII, we give a conclusion focusing on main challenges tackled and perspectives for future works, integrating new uses of data and information and communication challenges.

II. Scientific Position and Methodology

In a research-action approach, this paper associates two researchers, one with a university position and the other with a more consulting position and implication in experimental activities on the deployment of interactive devices, such as AI and telemedicine projects in the territories. Their complementarity allows for a back and forth between theory and practice, by comparing practical results with theoretical issues, to produce knowledge for action.

This work therefore lays in the field of Human Computer Interactions (or Interfaces) - HCI, which corresponds to the analysis of the means or tools put in place so that humans can work with machines, mainly computer tools, by controlling them to develop or improve services in healthcare. We place ourselves in the perspective of analyzing the development of new services for users of our health system (organizations, professionals, patients, etc.) in a dual dimension of care and social perspectives.

There are questions of ergonomics, ease of use and adaptation to the conditions and contexts of use, and ethics, particularly concerning uses of data and societal issues (limiting inequalities) and therefore the ambivalence of these tools: undeniable possibilities for improving care and its quality and traceability, but also risks of technical abuses (technicism) or rationing of care.

We position our research within the interdisciplinary field of information and communication sciences, in the perspective outlined by F. Bernard [7], proposing to articulate the four dimensions of links and relationships (interactions in a systemic dimension), meaning, knowledge and action. We insist on the complementarity of information and communication, stressing both the importance of information to shape organizations and data for their management and development, and also of communication to foster change [8], by promoting cooperative dynamics, articulating the project and storytelling dimensions of all actors [9], both human and socio-technical devices. We propose an approach that we call Information and Communication Organizing Ecosystems (ICOE). The notion of "organizing" was proposed by Weick [10], focusing on processes, and interdependence of interactions, to study human activity by means of "sensemaking recipe" in a set of dynamics to try to grasp the complexity of organizations. For us, information and communication contribute to the shaping and ecosystems, which can be organizations, companies, groups or territories. We thus articulate the approaches of Economic Intelligence and Quality [11], in the wake of Wilensky [12], when he speaks of Organizational Intelligence, without forgetting the innovation dimension in process approaches [13].

In the wake of Goffman [14], we particularly mobilize the notion of situation (situations of activity, management, information, communication, decision, evaluation, etc.) with all the ambivalence of technology [15]. Tensions exist between those who are in favor of new uses of digital technology to improve patient services, such as G. Vallancien [16] and those who fear regression, rationalization may meaning rationing or "uberization" (standardization and precarization of the health professions), such as the National Board of Doctors or *Conseil National de l'Ordre des Médecins en France* [17]. Using the "situational and interactionist semiotics" proposed by A. Mucchielli [18], we analyze situations of activity, also integrating the dimension of emotions and leadership [19] and trust building in complex projects [20]. The aim is to promote new services for patients and healthcare professionals, with the importance of information (data uses) and communication to improve cooperation with a strong territorialization and proximity dimension, with the emergence of new professions such as data scientist or specialists about human data interfaces [21], with specificities in the health sector.

III. The Use of Data in Telemedicine and the AI Data Processing

We intend to examine the use of healthcare data on telemedicine platforms and then, the AI solutions that could improve the processes. The recent trend in new technologies is melding telemedicine with AI. Figure 1 gives an idea of the advance of those two technologies. For getting a comprehensive overview of the context, we can

observe the expected expansion in telemedicine and AI in the twenty next years through the following chart extracted from a study of the English National Health System (NHS).

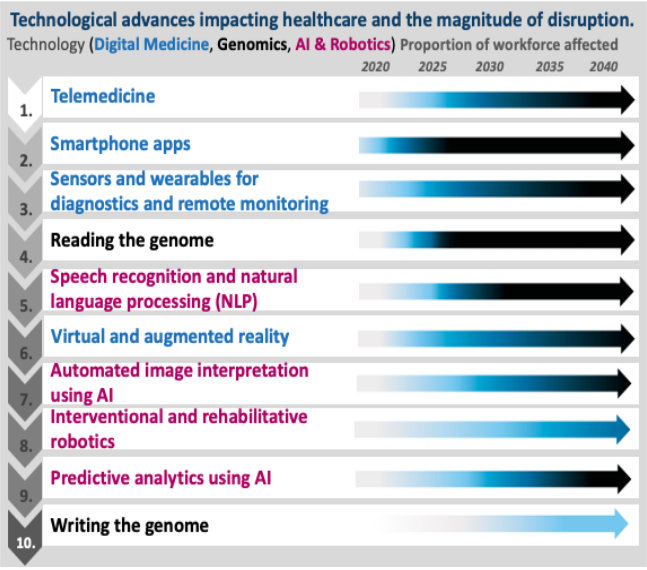

Figure 1. Top 10 digital healthcare technologies and their projected impact on the NHS workforce from 2020 to 2040 [22].

A. *The Use of Data in Telemedicine*

According to the French regulation definition (telemedicine decree: 2010), five situations or types of telemedicine can be distinguished: tele consultation, tele expertise, tele monitoring (for chronic diseases), tele assistance and medical answers for emergency regulation. The types of patients addressed by telemedicine are:

- Every patient in contact with their general practitioner within their healthcare pathway,
- The dependent elderly,
- Patients with chronic diseases: diabetes, heart failure, renal failure, Chronic Obstructive Pulmonary Disease (COPD), etc.
- Outpatients after surgery in hospital.

In terms of technological structure, a telemedicine platform is a connecting device, where the central data repository is related to interfaces. For teleconsultations, there are instantly interactions between the patients and the doctors, who receive measurements and answers, as well as view and analyze patients' health data through a web portal. The portal is customized for the exchanges between stakeholders: patients and professionals, according to the medical specialties. It can be accessed from a computer browser or also from a smartphone on a mobile app with an ergonomic workflow interface. The integration of algorithms for a preliminary analysis of medical data and imaging is now expanding. The platform has to support the entire process chain for providing services:

- The medical appointment, linked to calendaring,
- The collect of the patient's agreement,
- The stakeholders' authentication,
- The diagnosis and medical report,
- The prescription (for drugs, etc.),
- The data recording,
- The billing and payment processes.

Usually, booking a telemedicine appointment is possible through this interface where it can be scheduled. The waiting line may be displayed on a dashboard, and a virtual (space organized as a waiting room for the patients. (Sometimes documents can be exchanged beforehand (questionnaire, measurements, medical imaging, etc.). Recording the National Healthcare Insurance (*Caisse Nationale d'Assurance Maladie*) card is the usual way to check the identity of the patient. Some other forms can be found like the patients' agreement and the eligibility questionnaire. The payment system and the online prescriptions can be supplied through the portal. Additional services consist of the integration of the EHR (Electronic Health Record) for adding data and the report of the teleconsultation, with eventually the telemedicine video record.

The Healthcare Insurance Fund may provide a financial aid to physicians for purchasing the following connected devices: oxymeter, stethoscope, dermatoscope, otoscope, glucometer, electrocardiogram (ECG), doppler device, echograph, device for blood pressure measure, camera, tools for ocular and hearing tests and equipment for breathing functional exploration. As a socio technical device, a telemedicine platform contributes to the transformation of the healthcare system mainly with an extended use of data through Human-Computer Interactions. As there is no physical presence for the patient and consequently no auscultation, the doctors have to secure their medical acts by whatever means possible. Different types of data are needed for improving the general process that includes mainly assessment, diagnosis and medical prescription. Data have to be retrieved and completed for the anamnesis, the medical case history. The diagnosis that is sometimes based on medical imaging requires decision support systems, as prescription too.

B. *AI Data Processing and Solutions*

1) *Machine learning, deep learning:*

With the implementation of EHR in hospitals and the extension of Information Systems (IS) for the healthcare production, medical data began to be mass produced; then, the data management could develop with the creation of algorithms. As data mass production reduces the limitation in the use of statistical rules, AI devices are more and more reliable with deep learning. They were first learning algorithms, with data analysis (neural networks) and the capability for the machine to deduct rules to get a result. AI applications were especially numerous for the analysis of medical imaging, allowing the development of diagnosis support systems, for example in cardiology or ophthalmology, with satisfactory rates of reliability. Genetics is now providing huge amounts of data, which paves the way to the search for predictive models. Thus, AI

solutions strengthen the evolution towards a personalized, preventive, predictive and participative medicine.

2) Mass production of healthcare data:

Human-Computer Interactions increased with the patients' empowerment, developed in France since the March 4th 2002 (Law about *Sickness People Rights and Quality of Health System* with the idea of "Health Democracy"), as they access, more frequently through social technical devices; they not only use various search engines to get relevant information, but mainly digital platforms on computers or smartphones to know the conditions and costs of healthcare, getting on line appointments or healthcare appreciations, discussing on forums, using connected objects or contributing to design innovative products. Data can also be retrieved from the informal exchanges on the social media that have become at the origin of useful information related to healthcare (behavior, habits, ways of living, feelings). In a more global approach towards the determinants of healthcare, information lead to new perspectives in retrieving more data and crossing them to build algorithms that could help to improve the patients' healthcare. The data integrates not only medical, but social, psycho-social information to obtain the signs of any evolution in the living conditions of a person and the risks of degradation.

3) Different uses of AI:

The following figure displays the main uses of AI in healthcare:

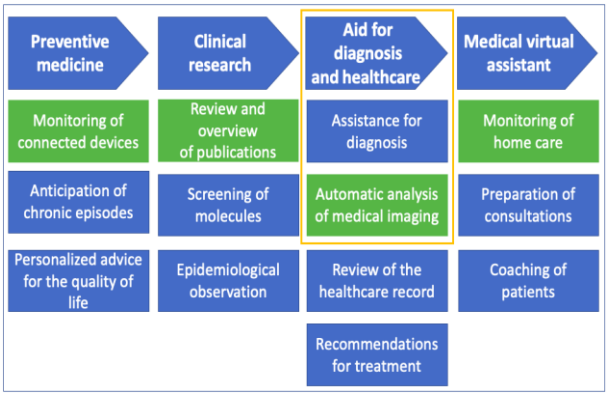

Figure 2. Typology of AI uses in healthcare (the mature uses are pointed out in green) [23].

Through the main characteristic of AI, which is to manage huge amounts of data and provide quick results, we try to clear the applications that would especially enhance the value of the telemedicine process, combining data retrieval, data analysis and the decision support system.

- *Retrieval of the Appropriate Information*: AI applications can retrieve the patients' information automatically, from EHR and other sources. Basically, machine learning can help to analyze clinical data in a patient's EHR to provide patient care recommendations.
- *Automatic Analysis of Medical Imaging:* AI solutions are especially relevant for analyzing huge masses of data from medical imaging. In 2018, DeepMind developed a software using a neural network learning system for detecting ophthalmic pathologies from scanner eye retina imaging [24]. The detection focuses on age-related macular degeneration (AMD), diabetic retinopathy, glaucoma or retinal detachment. DeepMind obtained a precision of around 94% for the AI application it developed. Such AI solutions in medical imaging can provide aid for diagnosis, which helps to secure them.
- *AI Advice for Prescriptions*: Machine learning algorithms may recommend treatment options and solutions for the patients.
  They help the doctors when recommending prescriptions by taking into account the existing ones, checking and validating prescriptions to make sure that the drugs prescribed are compatible with the patient's data.

IV. The Observation of AI Applications in Telemedicine

A. The Analysis of New Trends for AI in Telemedicine

Some applications for telemedicine now use machine learning to help the medical professionals with diagnostic support based on symptoms and patient health data. New trends pivot on the capabilities and benefits of AI in combining high speed data retrieval from very different sources, analysis of huge amounts of data and its results with the decision support system. AI solutions may be used for the patients' orientation, helping to screen patients in telemedicine as they do for emergency calls.

B. Data Collection before a Consultation

Lemonaid Health, an AI application before virtual video consultations: Lemonaid provides video consultations with medical professionals [25]. It uses machine learning at the beginning of the process with the evaluation of the patient's state of healthcare. The patient has to complete a questionnaire online that includes medical history, current medicines, allergies and regular symptoms. An AI model of screening based on the complexity of the case analyzes the information obtained to categorize the patient and orientate him to the suitable healthcare provider. Doctors evaluate the situation, usually during a video consultation available with an assigned healthcare professional.

C. Personalized Diagnosis Support

The telemedicine application Ada Health (Germany): A diagnosis support for telemedicine [25] uses a machine learning AI application to provide personalized diagnosis support. The patient has first to complete his medical profile in an initial survey. A chatbot uses a series of questions to identify possible symptoms.

D. A Case Example of Telemedicine Using AI

1) MédecinDirect: MédecinDirect is a telemedicine platform [26] that provides medical advice and remote consultations through contracts with companies and mutual funds for their stockholders. Facing the increase of the activity in remote medical consultations, MédecinDirect uses AI solutions in order to keep the quality level and to reduce the length of time for providing an answer. They fulfill two major aims: improving the anamnesis and securing both the diagnosis and the prescribed treatment.

2) Analysis Based on the Reasons for the Consultation: The healthcare practitioners have to ask different questions for the clarification of symptoms and to retrieve the patients' medical history, without omitting to get important information. Built on the use of a great number of exchanges recorded on the platform, the analysis aims at standardizing the different healthcare professionals' answers. After the analysis of the major reason for the consultation from natural language, AI solution proposes to the doctor a complete set of relevant questions in order to better define the medical case history. A conversational agent may be integrated into the process of asking questions.

E. Decision Support System

AI is used for creating an inference engine that enables the provision of medical recommendations to doctors for the exclusion of serious risks, for making diagnosis and assisting medical prescription.

Following the publication of Villani's report, the creation of the French "Health Data Hub" (HDH) 2019 is part of the French strategy for IA: improving the accessibility to mass data, the project aims at supporting the development of IA uses. This national platform consolidates French healthcare data from different sources (mainly National Health Insurance, in French Assurance Maladie and hospitals) and in the long run, the project may answer to advanced needs of data for IA techniques and succeed in multiplying the possibilities for data treatments.
A call for projects for the HDH was organized for "The improvement of medical diagnosis by IA"; among the approved projects in 2020, the building of a database of ophthalmological images illustrates the extension of IA uses for designing decision support systems for the healthcare professionals: such services will encourage the development of new types of medical consultations.

The health data hosting by Microsoft is the subject of controversy in a context of discussions about the digital sovereignty.

V. The Effects of Combining Telemedicine and AI Technologies

A. The Impacts for the Doctors

The processes are noticeably different between remote medical consultations and consultations with the physical presence of the patients, and change the relation doctor / patient. Patients reactions are not the same when there exists a "mediator artifact" (computer, tablet, etc.) between medical professionals and patients. This fact explains why some doctors are still reluctant to the practice of telemedicine.

AI and telemedicine are complementary. AI really contributes to securing the whole process of a teleconsultation. First, getting accurate information about the patient's state of health helps the professionals in their assessment. Then, any information improving the decision-making and enabling to confirm the appropriate diagnosis is really valued. Finally, the prescription is much more reliable if the doctors get all the information about the patients' other drugs and prescribed medicine. AI algorithms have to be trustworthy, especially since they are used for healthcare. The use of AI solutions may be time saving for doctors. They can give them more time for doctor-patient interaction. So AI may be a real help for doctors in the teleconsultation process, but some challenges have still to be solved [27]; it introduces a risk due to an insufficient accuracy in the results of AI. Retrieving significant amount of data for the training procedure in order to create reliable algorithms is very important. The data retrieval and their standardization are very important factors facilitating faith in the algorithms created.

B. The New Scopes for the Patients

The development of teleconsultations seems to result not only of recent changes in regulation and of the context of "medical desertification", but also of the patients' current needs.

Some policy holders have access to telemedicine platforms with their healthcare insurance contracts; more patients want to avoid waiting for a medical consultation going to the doctor's office and use such platforms for getting information fast and accurately. With the empowerment for their healthcare, patients are more involved in digital processes, like booking online for medical appointments or filling in information forms before consultations. They also communicate about their patients' experience on social media and forums, so that they contribute to producing data that can be retrieved for AI in healthcare. This observation leads to the questioning concerning the evolution towards digital medicine, with direct access for patients to the information automatically produced by AI, and less human interactions with the healthcare professionals. This will strongly change the doctor-patient relationship, which has hitherto focused on the human dimension of interactions.

VI. The Consequences of the Covid Pandemic on the Human Computer Interactions in Healthcare

The ambivalence of technology and the tensions between technophiles and technophobes are been reduced with the new needs that Covid 19 has brought to the word. In France, according to G. Babinet, the Covid-19 is revealing the low level of digitization in the healthcare system [4].

A. The emergence of the digital medicine

In June 2020, the Montaigne's Institute think tank estimated the potential value creation of e-health in France at between €16.1 and €22.3 billion per year [4]. This economic value creation can be divided into 5 categories of innovations and impacts:

. 3.3 to 4.7 billion through patient empowerment and the prevention of complications, particularly for chronic diseases.

. 3.4 to 4.7 billion through dematerialization and data exchanges, with optimization of the medical time of healthcare professionals.

. 3.7 to 6.4 billion through telemedicine, notably with the use of teleconsultations to limit hospitalisations.

. 2.4 to 3.4 billion through the automation and optimisation of care pathways in both primary care and hospital and at their articulation between these two sectors.

. 3.3 to 4.2 billion through transparency and decision support, by limiting the redundancy of healthcare acts and overpayments.

The health crisis due to the present pandemic has brought out a transformation of both the patients and the doctors' uses.

With the important needs for medical consultations during the lockdown period, the number of teleconsultations exploded. The obstacles to the acceptance of this model of healthcare seem lower. Telemedicine may address the increasing medical needs.

"Video consultation has become part of the daily life of the French," Doctolib says. The health crisis is largely responsible for this, since teleconsultations have really exploded during the confinement: from a total of 100,000 video consultations carried out between the launch of the service in January 2019 and February 2020, the number has risen to 4.6 million, an increase of 4.5 million acts in barely six months. Another revealing figure: in the last six months (February – August), 32,500 healthcare professionals have used Doctolib, compared to only 3,500 before the epidemic, which is almost 10 times less. General practitioners represent 69% of the users of the video consultation, details Doctolib. Next come psychiatrists (7.5% of users), gynaecologists (4%) and paediatricians (3.3%). Although telemedicine is used in all regions, the majority of procedures are currently carried out in Ile-de-France (46.5% of appointments), ahead of the Auvergne-Rhônes-Alpes (10% of appointments) and PACA (8.5%) regions [28].

It may be part of an evolution towards the "smart medicine" with the "all connected", in a convergence between the networks for persons, objects, process and data towards the Internet of Everything (IoE) [29].

A digital revolution for medical practices may really have begun with new habits that are really different from the face-to-face medical singular conference and may change it deeply. The combination of advanced technologies may stimulate the appropriation and extension of the digital medicine, but without forgetting the indispensable human dimension of medicine.

For facing the pandemic situation, in a hasty way, many tools (apps or telemedicine platforms) were provided to the healthcare professionals, mainly free. After this period of exponential expansion in their diffusion then in their appropriation, the uses may now be extended, owing to the existing risk of second wave or other pandemic situations. This may lead to another generation of telemedicine platforms sharing data among multiple users and integrating data from video assessment, patient electronic profile, event logs from connected devices with the Internet of Things (IoT) for improving the remote healthcare management [30].

Such technological developments pave the way to digital and personalized medicine. The concept of 4P Medicine (Leroy Hood, Institute for Systems Biology, 2013) is composed of 4 dimensions: Personalization, especially with the patient's genetic profile, Prevention, with a global approach for healthcare rather than a focus on diseases, Prediction, with the most appropriate medical treatments for the patient, and Participation, involving the patient's responsibility in his healthcare. Another "P" has often been suggested as 5th with Pertinence or Proof of the effectiveness of the medical service rendered to the patients, or even "P" as Pathway, with the evolution towards the management of the patients' healthcare pathways. A new "P" may also be considered with the development of Platforms assembling diagnosis, treatment and clinical trial process and connecting the different healthcare professionals involved [31].

B. An innovative combination of technologies addressing healthcare concerns

AI may be used with the analysis of rare but significant events for detecting the first indicators in order to predict a pandemic. Multiple information sources, including data from the social networks, may be combined in analytical datasets for very complex analysis creating correlations and connections for defining the distinctive features of a viral pandemic model. AI technologies may also help to forecast the needs for medical and nursing staffs, anticipate the situations, and assess the risks for the patients. Furthermore, an AI model using computed tomography may enable to detect the virus through a rapid diagnosis of patients: a recent study showed that the algorithm produced have higher sensitivity compared to the evaluation of the images and clinical data by radiologists [32].

Telemedicine may also help to support emergency care from remote facilities [33]. As the recent pandemic pointed out, telemedicine may be requested to provide medical answers in emergency situations requiring urgent regulation; a mobile telemedicine platform like Nomadeec, developed by Exelus, enables tele-triage, teleconsultation and tele expertise for remote diagnoses and patient orientation decisions. It provides services as elements of a

paramedical check-up, that can be sent to the professionals or video conferences. If the request is not a real emergency, the patient may be orientated to a healthcare permanency. Diagnosis recommendations and decision-making tools are based on AI. Several medical devices can be Bluetooth-connected to the platform for digital capture of vital signs: a thermometer, a blood pressure monitor, an oximeter, a stethoscope, a glucometer, an electrocardiogram device, etc. and the interface displays the relevant data, photos, videos on the same screen. Tele prescriptions are included. Real time transmissions can be sent to hospitals, syntheses, reports and mails automatically generated.

A Covid-19 orientation algorithm has been provided by the Ministry of Health for self-evaluation during the current pandemic. Based on cases study and scientific watch, it integrates severity and unfavorable prognosis factors as variables. The answers to the questionnaire determine the orientation of the patients; the results are presented on a decision map. This process of online questionnaire filling is now proposed by some hospital groups: they ask their patients to fill the form before coming for a consultation or hospitalization. This evolution is a step for more patients' empowerment in the management of their healthcare.

The scope for teleconsultations includes the chronic pathologies follow up. The monitoring of the patients suffering from chronic diseases may also be enhanced thanks to a combination of technologies. It often requires remote surveillance that may be based on the regular data collection from connected devices. With the pandemic, the preparation of a mobile app has been achieved within the scope of the prevention program called "Integrated care for older people" (Icope), implemented by the Gérontopôle in Toulouse. Icope monitor may help for frailty screening: it aims at evaluating and following the elderly person's main functions: mobility, memory, nutrition, state of mind, eyesight and hearing. This program is part of the program Inspire of the World Healthcare Organization (WHO) launched for identifying the aging people who are mostly in risk of chronic pathologies as Alzheimer's disease, atherosclerosis, osteoarthritis, cancer or Age-related Macular Degeneration (AMD); the main goal is to reduce care dependence through targeted and personalized prevention strategies. The elderly persons are encouraged to register their own data. Alerts are automatically generated in case of functional decline or loss; as they are received in the Icope monitoring center, a nurse calls the elderly person and then informs the general practitioner who may plan a teleconsultation or a tele expertise for getting the advice of a geriatrician or of another medical specialist.
AI may be value-adding in the analysis for the patient risk stratification in order to plan healthcare interventions.

HoloLens 2 is an example of extended uses of the virtual reality (VR) with the pandemic: in order to reduce the time spent with contaminated patients, the doctors in the hospitals of the Imperial College Health NHS Trust equipped themselves with Microsoft helmets: the device preserves the human appearance; medical notes or images such as radiographs and scanners can be projected on the visor above the patients; the wearer may interact with the virtual elements through movements or voice; a camera can film and transmit in live the images via a video stream on a platform to a computer located in another room for other doctors, which enables to limit the number of professionals in contact with the patients.

The pandemic circumstances may lead to hasty the appropriation of pioneering techniques that have to be evaluated in terms of security and ethics in order to consider their possible extension over time and their integration in the healthcare management process.

C. Profound changes for the healthcare professionals

Considering the doctor patient relationship, the pandemic leads to a paradigm shift as many consultations may now become digital, particularly if they are related to a prescription renewal or to a chronical disease monitoring.

The health crisis also points out that the medical resources have to be spared; in order to answer to the needs for homecare, it would be important to rely on all the healthcare providers involved.

Recently, the Ministry of Health has recommended to the Regional Healthcare Agencies (in French, "Agences Régionales de Santé", ARS) to organize for the patients suffering from the Covid-19 the extension of the use of tele expertise in different specialties: pneumology, infectious diseases, geriatrics, palliative care, physical medicine and rehabilitation; this evolution may prefigure changes in the medical organization.

The technologies may help to secure the different process for appropriate delegation of tasks. Thereby, the data registration of the patient's medical history and the description of the symptoms before a teleconsultation may be supported by decision aid based on AI tools for being carried out by a nurse or an orthoptist in ophthalmology.

In France, the lockdown period has brought several changes in the healthcare regulation: the nurses are now authorized to practice the remote monitoring called telecare; the midwifes may perform teleconsultations for remote pregnancy monitoring; speech therapists, occupational therapists are now authorized to practice teleconsultations, and psychomotor therapists, remote tele-rehabilitation. Physical therapists may manage telecare for their patients and the remote pharmaceutical monitoring may be planned for fragile persons.

Physiotherapy is considered as important for patients during or after their stays in an intense care unit for the improvement of the functional mobility. The remote respiratory tele rehabilitation gets equal results compared to pulmonary rehabilitation in a follow-up care and rehabilitation unit [34]. The tele rehabilitation process is also a support to develop the autonomy of the patients in order to keep them at home. It might be extended to cases of ambulatory orthopedic surgery, or after a stroke:

teleconsultations could be regularly scheduled with the surgeons or neurologists, and telecare with the physical therapists.

Finally, it was observed that the Covid pandemic and the lockdown period induced anxiety and worsened the suicide risk. Phone, teleconsultations and telecare are considered as means of improving the psychiatric follow up in distress and decompensation situations. Those specific modes of intervention have to be secured and supported by technological tools and data processing, for collecting accurate information at the different steps of the process: before, during and after the interaction with the patients; AI tools are adequate for retrieving the data from different sources and analyzing them.

D. The perspective of breakthrough innovation in the organization of the homecare monitoring

The development of chronic diseases and the increase of the elderly population make urgent some changes in the homecare monitoring. This necessary evolution for healthcare at home should accelerate in order to cope with other pandemic situations.

AI may be an innovative way for adding value in the management of the elderly patients' pathways, for instance with the use of predictive information thanks to the behavioral data recording. Teleconsultations for geriatrics and other specialties (psychiatry, cardiology, dermatology, pneumology, endocrinology, neurology) may be planned with the hospitals and the telecare process may enable to follow up situations remotely in relation with a nurse or another caregiver at the patients' bedside.

Furthermore, technologies may improve a real populational approach, in order to identify the urgencies and priorities with the detection of frailty situations. Developing the teleconsultations and connected devices monitoring may help to avoid hospitalizations. The extension of the telecare may complete the digital medicine with interventions of different healthcare providers.

Sharing the healthcare professional resources on a territory may enable to deal with their rarefaction. Some establishments for the elderly (in French, "*Etablissement d'Hébergement pour Personnes Agées Dépendantes*", EHPAD) experiment their intervention on their territory as an "EHPAD out of the walls" or "EHPAD at home"; such changes offer many opportunities for homecare: portable devices can eventually track vital signs such as blood pressure, heart rate and temperature; healthcare measurements devices might be connected to the EHPAD platform for providing direct information for remote patients monitoring; teleconsultations may be organized with the EHPAD for geriatric evaluation, psycho geriatrics in case of crisis, and monitoring for wounds and pressure sores, palliative care, drug iatrogenic. The EHPAD coordinating doctor may analyze the iatrogenic risks in relation with the general practitioners. The EHPAD occupational therapist may provide specific support to the patients and the psychologist help to reduce the elderly' anxiety or behavior disorders.

The whole remotely digital organization at home may also be improved for many services: an example is the direct delivery of the medicine after their prescription during a teleconsultation.

According to S. Bertezène, "the Covid crisis first exacerbated all the dysfunctions, then there was immense organizational resilience" and solidarity with innovative ways. The territorial cooperation dimension was essential, notably through the CPTS (Health Territorial Professional Communities / *Communautés Professionnelles Territoriales de Santé*) or the GHT (Territories Hospitals Groups / *Groupements Hospitaliers de Territoires)*, including the EHPAD.

S. Bertezène insists on the imperative for less administration and constraints and on the importance of trust in all the actors. She develops the notion of "hidden costs" of bureaucracy, which, if controlled, would allow for salary increases and investments. The resilience of the healthcare system implies restoring meaning and give the means to act as the government has committed itself to do [6].

VII. DISCUSSION

The interactive devices studied (AI, telemedicine) are certainly very promising and should constitute major levers of the digital transformation to make the health system evolve from a purely curative and fee-for-service medicine to a more preventive medicine, as envisaged by the Isaac's report [2]. The Covid pandemic has made these transformations even more imperative.

We have already highlighted in the wake of J. Ellul [15], the ambivalence of technology and the tensions between technophiles and technophobes. In France, the Descartes' country, engineers have always occupied a privileged place, with the risk of technological "solutionism" drifting away from technocentric approaches, with tools too often developed without real consultation with users, whether they are health professionals or patients and their families. The integration of new project management methods (known as "agile", integrating users into the various stages of project development) such as the method for developing trust in complex projects, for instance the Fears - Attractions - Temptations (FAcT)-Mirror method proposed by G. Le Cardinal [20], are interesting approaches. Developing trust is essential to promote resilience of the whole French healthcare system.

New tools also renew territorial approaches to health and in particular those of health inequalities, which can have an individual, social (isolation and poverty) and collective dimension, concerning not only individuals, but the collective dimension of territories, the question of "medical deserts", territories without health professionals, these "medical deserts" being also "digital deserts" [5] with

specific work on AI and rurality, data and weakened territories or smart cities and smart territories.

Another essential aspect is the evaluation of the impact of these new devices and their added value in improving services for both health professionals, patients and their families. This is another area of research we are working to propose, still in an approach based on information and communication issues, a more contributory evaluation by integrating the expectations and emotions of all stakeholders, tool designers, users: health professionals, patients and their families. These patients are gradually affirming their role with the notion of "health democracy" enshrined in the law on "Patients' rights and the quality of the health system" of March 4th 2002.

All these developments imply a new “territorialization” of health management, with an affirmation over the past thirty years of “healthcare interface organizations” (healthcare networks, multi-professional healthcare centers, home hospitalization, etc.) to overcome the barriers between urban medicine and the hospitalization sector, or new territorial groups of urban medicine, with whom there are still challenges of coordination and traceability of acts.

All these digital transformations are also reflected in the affirmation of new coordination professions [35] and also to give meaning to data, not only data scientist but also human data mediation [21]. But if we have outlined the challenges of the digital transformation of the health system through the implementation of new devices, mainly AI and telemedicine, we must not forget the whole human dimension of healthcare, well emphasized by M.J. Thiel, with the suffering and anxiety of illness and the end of life [36].

VIII. Conclusion

With the rise of more uses in telemedicine, we are witnessing a new step in the transformation of the healthcare system, with major challenges to overcome. The Covid pandemic has fostered the evolutions [6].

The digital process in telemedicine is a Human-Computer Interaction, both requiring and producing data. It contributes to the increase of the volume of healthcare data and therefore to the possible development of AI. Telemedicine is based on data exchanges between the stakeholders and data processing. Data collection in this case is even more important than when there is physical presence in a medical consultation. The doctors have to act without any information from the patient’s auscultation. The relevant information must be available, thus the necessity to gather as much data as possible, i.e., recent information, then, to select the required information and to get support when making a decision.

The use of AI strengthens the requirements of the information systems interoperability, as data are collected from different sources where their meaning may be different. Data entered into an AI system should be complete and accurate. A healthcare data normalization engine, curated and versioned data sets for the terminologies could be used. But in order to improve the quality of the available data, especially with large-scale data sources, we would need some of the standardization tools for curating the data that do not yet exist [37],[38]. A standard terminology, such as the Systematized Nomenclature for Human and Veterinary Medicine (SNOMED) Clinical Terms achieves semantic interoperability. Archetypes provide the shared meaning of data with the specifications of its format.

Furthermore, the implementation of AI solutions highlights the complex ethical questions about the use of medical and behavioral personal data, with the upcoming extension to genetics. From an ethical point of view, beyond the patients’ free consent, the use of their healthcare data mandates a differentiated exploitation according to their sensitivity.

The future trends may be the temptations to use AI for services to patients without any human interaction, in answer to their various questions about the seriousness of the symptoms, how to understand, what to do, when seeing a doctor is essential. We have outlined the risk of any only “solutionist’ approach, as medicine is managing human beings and not only materials or connected objects. The challenges are very important and shape the whole future of our society. Health is an essential sector to observe the issues and challenges of the digital transformation of our entire society and new uses of data, with their ambivalence [15]. As productions of new technical devices, they can allow essential and imperative transformations (cooperation based on trust among all the actors) but also with risks of abuses (more controls and bureaucracy). The path to resilience can include some hard stones ...

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