

PROSPECTING TECHNOLOGIES BASED ON 4.0 INDUSTRY APPLIED TO IMPROVE DIAGNOSES AND TREATMENTS ON ONCOLOGICAL HEALTH AREA

PROSPECÇÃO DE TECNOLOGIAS BASEADAS NA INDÚSTRIA 4.0 APLICADAS PARA MELHORAR DIAGNÓSTICOS E TRATAMENTOS NA ÁREA DA SAÚDE ONCOLÓGICA

TECNOLOGÍAS DE PROSPECCIÓN BASADAS EN LA INDUSTRIA 4.0 APLICADAS PARA MEJORAR LOS DIAGNÓSTICOS Y TRATAMIENTOS EN EL ÁREA DE LA SALUD ONCOLÓGICA

PROSPECTION DES TECHNOLOGIES BASÉES SUR L'INDUSTRIE 4.0 APPLIQUÉES POUR AMÉLIORER LES DIAGNOSTIC ET LES TRAITEMENTS DANS LE DOMAINE DE LA SANTÉ ONCOLOGIQUE

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RESUMO

Este artigo discute como diferentes tecnologias baseadas na Indústria 4.0 (I4.0) podem melhorar o diagnóstico e tratamento na área da saúde oncológica. Trata-se de uma pesquisa de campo qualitativa, exploratória, adotando o método Delphi modificado. Analisou a visão de um grupo de especialistas e apresentou cenários tecnológicos futuros para a área da saúde oncológica, com foco nas tecnologias e ferramentas do I4.0, como Internet das Coisas (IoT), inteligência artificial, robotização, impressão 3D, realidade virtual, realidade aumentada e Big Data. Os resultados mostram que as tecnologias I4.0 são aplicáveis na área da saúde oncológica. Além disso, embora as tecnologias sejam aplicáveis, pode haver diferentes níveis de benefícios para cada uma, variando entre a intensidade do tratamento ou o impacto no pessoal administrativo. Os benefícios aos processos de gestão e, principalmente, aos pacientes, irão variar de acordo com a forma de utilização das tecnologias não invasivas, graus de precisão e confiabilidade. Os especialistas recomendam fortemente as aplicações e apontaram os avanços dos protocolos de tratamento do câncer devido à introdução de recursos das tecnologias I4.0.

Palavras-chave: Indústria 4.0. Tecnologia em Saúde Oncológica. Ferramentas da indústria 4.0. Tecnologias aplicadas à Saúde Oncológica. Apoio ao diagnóstico e tratamento oncológico.

ABSTRACT

This article discusses how different technologies based on the Industry 4.0 (I4.0) can improve the diagnose and treatment on oncological health area. This is a qualitative, exploratory field research adopting the modified Delphi method. It analyzed the vision of a group of specialists and presented future technological scenarios for the area of oncological health, focusing on the technologies and tools of I4.0, such as the Internet of Things (IoT), artificial intelligence, robotization, 3D printing, virtual reality, augmented reality and Big Data. The results show that I4.0 technologies are applicable in the area of oncological health. Furthermore, although the technologies are applicable, there may be different levels of benefits for each one, varying between the intensity of the treatment or the impact on the administrative staff. The benefits to the management processes and, mainly, to the patients, will vary according to the way of using the not invasive technologies, degrees of precision and reliability. The specialists strongly recommend the applications and pointed to the advances of the protocols of cancer treatment because the introduction of I4.0 technologies resources.

Key words: Industry 4.0. Technology on Oncology Health. Industry 4.0 tools. Technologies applied to Oncological Health. Support to oncology diagnose and treatment.

RESUMEN

Este artículo analiza cómo diferentes tecnologías basadas en la Industria 4.0 (I4.0) pueden mejorar el diagnóstico y tratamiento en el área de la salud oncológica. Se trata de una investigación de campo cualitativa, exploratoria, adoptando el método Delphi modificado. Analizó la visión de un grupo de especialistas y presentó escenarios tecnológicos futuros para el área de la salud oncológica, enfocándose en las tecnologías y herramientas de I4.0, como Internet de las Cosas (IoT), inteligencia artificial, robotización, impresión 3D, realidad virtual, realidad aumentada y Big Data. Los resultados muestran que las tecnologías I4.0 son aplicables en el área de la salud oncológica. Además, si bien las tecnologías son aplicables, pueden existir diferentes niveles de beneficios para cada una, variando entre la intensidad del tratamiento o el impacto en el personal administrativo. Los beneficios para los procesos de gestión y, principalmente, para los pacientes, variarán según la forma de utilizar las tecnologías no invasivas, grados de precisión y fiabilidad. Los especialistas recomiendan encarecidamente las aplicaciones y señalaron los avances de los protocolos de tratamiento del cáncer debido a la introducción de recursos de tecnologías I4.0.

Palabras clave: Industria 4.0. Tecnología en Salud Oncológica. Herramientas de la Industria 4.0. Tecnologías aplicadas a la Salud Oncológica. Apoyo al diagnóstico y tratamiento oncológico.

RÉSUMÉ

Cet article explique comment différentes technologies basées sur l'industrie 4.0 (I4.0) peuvent améliorer le diagnostic et le traitement dans le domaine de la santé oncologique. Il s'agit d'une recherche de terrain qualitative et exploratoire adoptant la méthode Delphi modifiée. Il a analysé la vision d'un groupe de spécialistes et présenté des scénarios technologiques futurs pour le domaine de la santé oncologique, en se concentrant sur les technologies et les outils de l'I4.0, tels que l'Internet des objets (IoT), l'intelligence artificielle, la robotisation, l'impression 3D, réalité virtuelle, réalité augmentée et Big Data. Les résultats montrent que les technologies I4.0 sont applicables dans le domaine de la santé oncologique. De plus, bien que les technologies soient applicables, il peut y avoir différents niveaux de bénéfices pour chacune, variant entre l'intensité du traitement ou l'impact sur le personnel administratif. Les avantages pour les processus de gestion et, principalement, pour les patients, varieront selon la manière d'utiliser les technologies non invasives, les degrés de précision et de fiabilité. Les spécialistes recommandent fortement les applications et soulignent les avancées des protocoles de traitement du cancer grâce à l'introduction des ressources des technologies I4.0.

Mots clés: Industrie 4.0. Technologie sur la santé en oncologie. Outils de l'industrie 4.0. Technologies appliquées à la santé oncologique. Soutien au diagnostic et au traitement en oncologie.

INTRODUCTION

Organizations seek to evolve in different ways and for different reasons, whether to improve performance, win new markets, gain competitive advantage, grow or simply to survive. Thus, in recent years, a new concept related to organizational changes has emerged in academic publications in general: the 4.0 Industry, understood as a technological evolution within organizations (Siguaw, Simpson, & Enz, 2006; Fraga, Freitas, & Souza, 2016).

This technology-based evolution proposal produces changes that are perceived by organizations that adopt them in two ways: (i) as natural evolution or (ii) as disruptive innovations. But, regardless of the type of change, in the Internet age, both started to happen at an accelerated pace. In this study the focus is on healthcare organizations, a segment that assumes a prominent economic role. The IBGE 2015 report points out that the health area represented 9.1% of Brazil's GDP (Gross Domestic Product), 6.4% of formal occupations and 9.2% of workers' remuneration (Aires, Moreira, & Freire, 2017; IBGE, 2017; Siemens, 2017; Reis, Pimentel, Machado, & Barbosa, 2018).

Due to the changes resulting from technological advances, tools and knowledge areas, such as Internet of Things, Big Data, 3D Printing, Virtual and Augmented Reality, Cloud Storage, Artificial Intelligence, among others, have become part of the reality in the production of products and in the provision of services. Since then, organizations have increasingly monitored emerging technologies and their use with intelligent systems to increase their levels of quality, performance and value creation (Fraga et al., 2016; Gehm, 2016).

Industry called as I4.0 is a term that originated in Germany and that quickly grew stronger in Europe and in America. The synergistic combination of communication technologies (robotization, transmission, storage, connectivity and processing, miniaturization and more powerful chips), under the empire of algorithms, pose new possibilities and cause great impact on organizations. Such changes have been considered, by the academic and professional realms, as the fourth industrial revolution, giving rise to the term I4.0 (Silva, Filho, & Miyagi, 2015; Fraga et al., 2016).

Notably, the oncology treatment sector has sought support of technological innovations in propaedeutics and in therapy to treat the disease throughout its entire clinical evolution chain. An estimated 600,000 new cases of cancer occur each year for the 2018-19 period in Brazil alone (Silva, 2017). The World Health Organization (WHO) states that practically all families in the world will be affected by cancer, directly or indirectly, since approximately 14 million new cases are estimated per year globally. The WHO estimates that these notifications will rise by 70% until 2018 (UN, 2018).

In this context, scenario design is one of the tools of strategic management, which can be applied to deal with the uncertainties of the future. Through prospecting scenarios it is possible to become aware of the multiple possible futures, to analyze the interdependence that relates the elements to be studied and the possibility of identifying problems that could be ignored by less comprehensive methods (Godet & Dias, 2008; Marcial & Grumbach, 2008).

Prospective models do not intend to predict the future nor do they intend to project trends. Projection is the extension of past trends into the future. Prospecting, otherwise, is the anticipation of scenarios to guide action, using rigorous and participatory methods. Those methods must be built through an adequate strategic planning, which leads the organization to predictable scenarios (Godet & Dias, 2008; Marcial & Grumbach, 2008; Aulicino, 2013).

Therefore, I4.0 has opened up a range of possibilities for healthcare organizations. These possibilities, combined with market uncertainties and development needs, pose a challenge for planning short, medium and long term scenarios. Given this challenge of the arrival of I4.0, what are the technological scenarios for the area of cancer health in the next five to ten years?

THEORETICAL FRAMEWORK

This topic presents a brief review of the theoretical references used in the development of the study and the relationship between I4.0, prospecting scenarios and oncology.

Industry 4.0

The first industrial revolution occurred in the middle of the 1750s, as a result of the mechanization of production, with the introduction of the steam engine. Years later, the arrival of electricity was the second major technological breakthrough, along with the assembly line system, developed by Henry Ford. Both events generated new levels of productivity and large-scale production, so that the period could be classified as the second industrial revolution. The third industrial revolution has brought automation, bringing machines to the world of computing, applying controllers computerized to increase and control performance quality. In the last twenty years, the Internet has been changing the communication environment, narrowing the physical distances of countries and increasing the speed of communication to a level not yet experienced. This advance experienced with the Internet and its correlated digital technologies has been named as the fourth industrial revolution or Industry 4.0 (Arktis, 2015; Mosterman & Zander, 2016; Oberhaus, 2016; Borlido, 2017; Aires et al., 2017; Siemens, 2017).

Big Data is a technological tool for storing and processing large volumes of data. Despite the record of initiatives since the 1970s, they started to gain notoriety from the 2010's onwards. The quick access and the easiness to collect data, together with the appropriate treatment of information, they have offered organizations the ability to make decisions at a high speed (Luvizan, Meirelles, & Diniz, 2014; Silveira, Marcolim, & Freitas, 2015; Cni, 2016; Mazieri & Soares, 2016).

Virtual Reality is a form of interaction between a user and the computer, through the immersion in a three-dimensional environment, which is artificial and created by digital technology. One of the derivations of this technology is Augmented Reality, which can be described as the combination of virtual and real realities through software. In this environment, the user is able to simulate, predict and test actions in an artificial environment, to only then replicate in a real environment (Deloitte, 2014; Cruz, Pinto, & Oliveira, 2017).

3D printing is a cutting edge technology that will accelerate the transformation of the industry. As most companies are just beginning to use this new technology, the pioneers will be able to take competitive advantages for a long period of time. The auto industry has taken on this pioneering role and

has applied 3D printing to test and validate new product designs, thus saving time and reducing errors before starting mass production (Deloitte, 2014; Mendes, Siemon & Campos, 2017).

Artificial Intelligence is observed in intelligent products. They hold the information necessary to execute their own process and they are customized according to the user's needs. Artificial Intelligence and other types of intelligent systems are expected to improve and learn the autonomous learning process (Oyelude, 2017; Saltiel & Nunes, 2017).

Internet of Things (IoT) is the name of the most comprehensive feature of I4.0, the internet that connects people to machines. The term IoT, can also be described as Internet of everything (IoE), based on the fact that the internet encompasses people and machines. IoT is a technological innovation that combines other features of I4.0, as it is based on already consolidated technologies, such as the internet and smart gadgets (Arktis, 2015; Mosterman & Zander, 2016; Galeale, Siqueira, Silva & Souza, 2016).

The combination of IoT and Big Data will generate a huge capacity for collecting and storing data that, when converted into information, will expand on an exponential scale the human capacity to take decisions based on facts and data. This will be an advantage for the health area, considering the large volume of medical data that appears every day (Cni, 2016; Cambricole, 2017).

Prospecting and Analyzing Scenarios

The analysis of future scenarios consists of an internal and consistent vision of the future that, although not certain, may happen. Its specific objective is to make possible the understanding of the various risks that may arise in a given time horizon, as well as the opportunities, helping managers to develop a long-term view (Cardoso, Abiko, Haga, Inouye, & Gonçalves, 2005; Blois, Berdsen, Nunes, Carvalho, & Rasia, 2018; Oliveira, 2018).

Scenarios are ordered perceptions of alternative future environments. Despite having similar objectives, designing scenarios is a different activity from prospecting scenarios, as the projection is the continuation of past trends to the future, while prospecting is the anticipation to guide action, using rigorous and participant methods. Managers must use planning based on possible scenarios (Schwartz, 2004; Marcial & Grumbach, 2008; Aulicino, 2013; Massaroli, Martini, Lino, Spenassato & Massaroli, 2017; Blois et al., 2018).

Prospective studies can be applied for different purposes, the most frequent of which are: (a) decision making; (b) setting priorities; (c) ability to react and anticipate; (d) generating consensus and mediation and (e) communication and education. Beyond these purposes, the studies can be classified according to their scope: (1) holistic or macro, when dealing with a wide spectrum of sectors and areas; (2) the medium level, which covers an area or sector; and (3) the micro, associated with a project or specialized areas/agents. As for the prospecting horizon, it can be classified in the short, medium and long term. Short-term prospects are those that consider periods of one to three years; medium term, three to five years, and long term, ten years or more (Zackiewicz and Salles-Filho, 2001; Cardoso et al., 2005).

Planning through the analysis of future scenarios is considered an effective way to minimize the effects of uncertainties. There are multiple techniques and different research methodologies available to prospect for future scenarios (Zackiewicz & Salles-Filho, 2001; Cardoso et al., 2015; Massaroli et al., 2017; Blois et al., 2018).

Cancer and Technological Advancement

Under conditions considered normal and in healthy people, the cell structure divides in an organized way and the cells follow an ordered pattern of growth and reproduction stages. Cancer is the name given to the set of more than 100 diseases that, in essence, is nothing more than the disordered and abnormal growth of a given type of cell in an organ. Dividing rapidly, these cells tend to be very aggressive and uncontrollable, causing the formation of tumors, which can spread to other regions of the body (Silva, 1998; Oliveira & Benevides, 2004; INCA, 2019).

When a patient is diagnosed with cancer, a series of treatments to cure or palliative care procedures are initiated. Treatments that seek to cure cancer are carried out through surgery, chemotherapy, radiation therapy or bone marrow transplantation. The advancement of technology is an ally to reverse the current scenario of mortality caused by cancer. In 10% of the Brazilian municipalities, cancer already occupies the first position as the main cause of deaths, even ahead of traffic accidents and homicides (Silva, Couto, Chianca, & Dias, 2017; Abrale, 2018; INCA, 2018).

Technology has taken on a very important role for health in recent years. Several technological innovations have been incorporated into the health sector. These innovations impacted the control and the management of the medical service, the benefits of which were noted both by professionals in the field and by patients (Mattos, 2011; Brazil 2016; Muylder et al., 2017; Abrale, 2018).

METHODOLOGY

This part describes the context studied, the type and the method of research chosen, as well as the techniques and methods of data collection and data analysis that was used to achieve the objective of this work.

The methodology chosen for this research has a qualitative nature. Field research was carried out in organizations belonging to the sector of oncology health in Brazil using a structured form. Individuals who provide information to explain a given phenomenon can only be represented by the researcher, who in turn is an instrument for collecting and analyzing the data, in addition to being the spokesperson of the results (Minayo, Deslandes, Cruz, & Gomes, 1994; Mascarenhas, 2012; Vergara, 2016; Silva, Russo & Oliveira, 2018).

As for the purposes of this research, it has an exploratory nature. Researches with this kind dedicate preliminary time to interrogate the research object, the assumptions, the relevant theories, the appropriate methodology, and the research organization as a whole (Minayo et al., 1994; Vergara, 2016).

As for the means of research for the present study, the field research adopted allowed the researcher to have direct contact with the people/organizations studied. This type of research serves as a verification carried out in direct contact with the field of study, in order to support data collection (Cervo, Bervian, & Silva, 2007; Mascarenhas, 2012; Vergara, 2016).

The Delphi Method Modified

When it comes to prospecting future scenarios, the Delphi method can be considered the most suited tool for this function, as it is able to explore the collective experience of a group of experts and, then, present consensus scenarios. The generation of scenarios exists on the blurred frontier between the practice of creative design and strategic forecasting. The prospective results do not indicate one, but several futures. A well-developed scenario can predict the paths, dynamics and sources of change for complex phenomena and provide new materials for consideration (Zackiewicz & Salles-Filho, 2001; Cardoso et al., 2005; Mozuni & Jonas, 2018).

The Delphi method is also a research technique to obtain consensual knowledge. When questioning a panel of experts in several rounds, this technique presents itself as a reliable alternative for research. The debate between experts is one of the main objectives of the Delphi method. Within the process, anonymity is essential to eliminate the effect of influence or even intentional interference with results. Thus, anonymity and the update of the interview script, through feedback, represent the two irreducible elements of the Delphi method (Webler et al., 1991; Zackiewicz & Salles-Filho, 2001; Brazil, 2009; Mozuni & Jonas, 2018).

Xxxx Considering that the Delphi method is based on the collection of data through interviews in a panel of experts, the definition of the selection criteria of these specialists is one of the important stages of the research. Therefore, the criteria that we have applied to form the panel of specialists were: (a) having an academic background in Medicine, Nursing, Engineering, Administration, Computer

Science or Information Systems; or (b) have professional experience in oncology for more than ten years; or (c) act directly with the development of technological tools aimed at the health area.

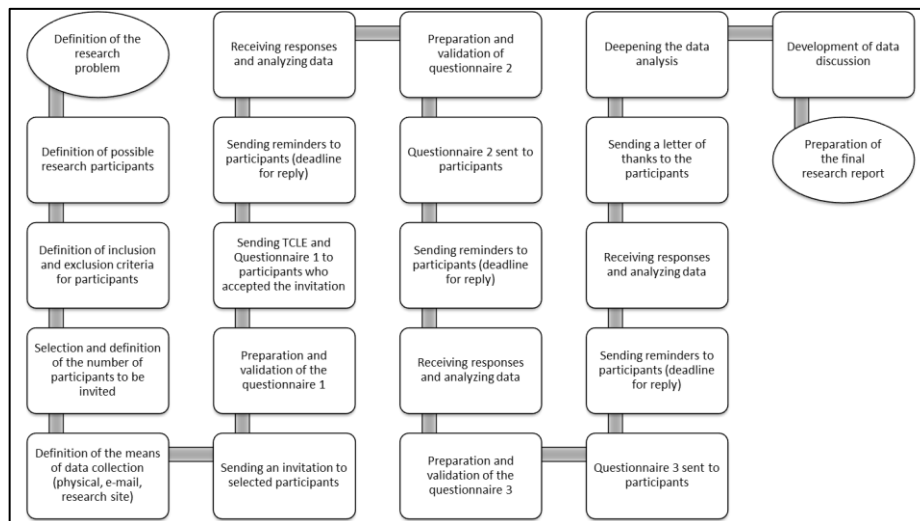
The panel of experts in this research is constituted of sixteen professionals, who work in clinics specialized in cancer treatment, hospitals with cancer care and in companies that develop equipment for the health area in general. 70% of the companies in which the specialists currently work are directly linked to cancer treatment. On the other hand, 30% of the companies in which specialists currently work are directly linked to a Research and Development (R&D) department for equipment to the health area.

It is important to note that the size of the expert panel is not the most important factor. The experts' expertise and their willingness to make a valid contribution and to take reasoned decisions have a higher priority. The Delphi method does not require expert panels to be representative samples for statistical purposes. Representativeness is assessed on the qualities of the expert panel (Mozuni & Jonas, 2018).

Furthermore, the experts selected to the panel are in specialist or in managerial positions. All of them have one thing in common: working directly or indirectly in the area of oncological health. To interview them, the research followed the model presented by Massaroli et al. (2017), in which the research using the Delphi method comprises, in total, 22 steps, as shown in Figure I, applying, if necessary, adjustments to the number of rounds of interviews.

Within the broad universe of qualitative research, the various data sources require the researcher to take a broad look when choosing the method of data analysis. This decision moment can generate tension and possible confusion when defining methodological procedures, since the techniques are, in essence, different, but have points in common, which can raise the researchers concerns. Often, in qualitative research, the three data analysis techniques adopted are content analysis, speech analysis and conversation analysis. Although the data collection and analysis steps are separate within the project, it is acceptable for the researcher to start the analysis simultaneously with the collection phase. (Minayo et al., 1994; Dal-Soto & Suzin, 2017; Schiavin & Garrido, 2018).

Figure I: Stages of the research – by the authors.



Source: Adapted from "Método Delphi como Referencial Metodológico para a Pesquisa em Enfermagem.", by Massaroli, A. Martini, J. G. Lino, M. M. Spenassato D. & Massaroli, R., 2017, *Texto Contexto Enferm*, 26, pp. 1-9.

For the current research, the content analysis technique was applied as the main tool for interpreting the results.

Due to the difficulties of applying the original Delphi method, through several rounds and quantification of the answers by the experts seeking consensus, the most simplified modified method was adopted, only in qualitative analyzes seeking don't lose quality and reliability of the results achieved (see Fig. I) based on analysis of the expert deponents' narratives. This means that the method adopted was a

modified method proposed by Massaroli, A. Martini, J. G. Lino, M. M. Spensato D. & Massaroli, R., 2017 (Pg. 6). In addition, according to the authors (apud cited, pg. 7), “there are no universal guidelines for the conduct of this method, that the achievement of consensus among the participants can be influenced by the conduct of the researcher who manages the development of the technique or, even, that the strongest opinion group can influence so that participants who have a different opinion join their opinion without necessarily representing their position.”

Therefore, content analysis is a qualitative data analysis technique that, in its beginnings, was treated as a way of analyzing and interpreting texts. However, over time, it gained scientific credibility, being improved as an applied technique in several sciences, including the social sciences. When the researcher seeks to privilege individual and group subjectivity, he must adapt the methodology to one capable of achieving greater richness during data analysis. In this sense, for the qualitative research, content analysis is a very suitable methodology (Minayo et al., 1994; Dal-Soto & Suzin, 2017; Schiavin & Garrido, 2018).

The registration unit is an important step in content analysis. It refers to the elements captured through the decomposition of the interviewee's message. During the content analysis, it is possible, for various types of record units, to analyze the content of a message. The words, phrases or sentences and the subject to which the message refers to are examples of registration units. There is still the possibility of combining these registration units in a single search. Together with the registration unit, the researcher will define the context unit, so that he can locate a broader reference, indicating in more detail which context the word or phrase is part of (Minayo et al., 1994).

Content analysis can be divided into three stages: (a) pre-analysis; (b) analysis of the material and (c) treatment of the results and interpretation. It should also be added that content analysis has undergone reformulations in recent years since its first applications. Therefore, content analysis has become a more modern analysis influenced by the use of technology and the processing capacity of computers. The most recent researches may use software that mainly helps the material organization processes and data coding (Minayo et al., 1994; Dal-Soto & Suzin, 2017; Schiavin & Garrido, 2018).

RESULTS ANALYSIS

This topic is dedicated to describing the process of collecting and analyzing the data that was captured during the rounds of interviews.

To collect the data, 32 interviews were scheduled with 16 previously selected specialists. In total, 23 responses were obtained from the interviews concluded successfully. This represents an adherence of 72% of the invitations to interviews sent to specialists and 63% of full participation in the research. The expert panel followed all the terms in the glossary as a research guide and the most frequently cited registration units were: Artificial Intelligence (24), IoT (23), Robotization and Virtual Reality (22), Big Data (21), Telemedicine, and 3D Printing (19).

At the end of the first round of interviews consensus had not yet been reached on the question on which technologies will impact oncology in the next five and ten years. The expert panel pointed out that, among the technologies of I4.0, those that are likely to impact oncology treatments in the next five years are robotization, augmented/virtual reality, IoT, and 3D printing. Expanding the horizon to ten years, the technologies mentioned were Big Data and Artificial Intelligence.

When addressing the processes that will be modified by the I4.0 tools, the first consensus identified was the expectation of the “oncological treatment” stage to be benefited by the introduction of new technologies. All experts cited that the introduction of these technologies will positively influence current treatments. They cited developments in the processes of tumor removal through robotic surgery, total connectivity between instruments and medical records and the introduction of artificial intelligence to support medical decisions.

Regarding the technical skills of the medical team, we had the second consensus, identified in the first round of interviews, since 100% of the experts had the perception that the care team should acquire,

in their academic training, “basic knowledge in TI”, to master the I4.0 tools to be used in cancer treatment.

To the experts, the benefits of introducing I4.0 tools are diverse, including among other things, better communication between hospitals and patients and fastest and most accurate treatments. Among the benefits mentioned, there was an immediate consensus in the first round on the development of drugs 4.0, which is associated with the elimination of side effects.

The experts’ perception was divided regarding the challenges to implement the I4.0 tools. Although there was no consensus, at the end of the first round of interviews, two challenges were mentioned most frequently: the source of investments and the balance between focus on technology and focus on the patient.

Regarding the motivation of the medical team to introduce I4.0 technologies in the treatment protocols, the third consensus was reached. “Saving lives” was pointed out by all specialists as a motivation to adapt knowledge and to use technologies as an additional resource of treatment. Contrary to what happens in other segments, where the introduction of technologies, such as robotization and artificial intelligence, are associated with layoffs (Oberhaus, 2016), in the health sector the perception of the association between new technologies and layoffs is not accentuated.

Another non-consensual point was the development of the medical career due to the introduction of technologies. Experts cited that the knowledge of the various treatment methods, including methods that involve the use of technologies, can be a positive differential in the doctor's career. For the experts, some changes should occur in the profile of health professionals. According to the consensus perception, doctors and nurses, in addition to acquiring “IT knowledge” in their academic formation, should have continued training in the subjects related to IT.

At the end of the first round of interviews, the specialists were encouraged to present their perception for all I4.0 tools, considering a timeline of five to ten years and ensuring that the interview covered all the tools analyzed in this research. Among the experts the consensus was that all seven technologies will be applied in cancer treatment, at some point, within the next ten years. Some, in fact, are already in the implementation phase, while others are still in the sphere of research and development.

The second round of interviews showed 77% adherence. The scripts presented responses aligned with the central theme, with technical arguments and contributing to the formation of knowledge. The consensus record units from the first round were presented as affirmations and discussed at a deeper level in the second round. The technologies of I4.0 were discussed in the face of the time variable, five and ten years, in the face of the variable impact on oncology, in front of health professionals, and, finally, in the face of the challenges for implementation in hospitals and clinics.

The experts consensually pointed out that the set of technologies from I4.0 will positively impact cancer treatment in the next five years through procedures with higher precision, precision that will be a consequence of the advancement of the technology in the field of robotization and augmented reality. After being pointed out by most experts in the first round of interviews, this consensus on robotization, combined with augmented reality, was fully achieved in the second round of interviews.

Moving in the same direction, experts pointed out that Big Data technology will positively impact cancer treatment in the next ten years through the generation of centralized and stored medical records throughout the patient's life. Considering the exponential expansion of the capacity to generate and store data, the experts pointed out that patients' medical data may be centralized in a single database, shared among all medical institutions and it will be used to track pre-existing risk factors and to indicate the best treatment, according to the patient's profile. Medicine based on evidence and Big Data technology will expand the ability to record evidence of oncological advances.

The third consensus reached was in relation to the massive introduction of connectivity in administrative processes, which may, in the next five years, eliminate activities that are currently performed by humans. The experts presented a consensual point of view that jobs such as scheduling appointments, approval of procedures by health operators, delivery of results, confirmation of dates, among others, will suffer great impact of further connectivity. The perception is that the introduction of IoT and increased

accessibility to the Internet, in the society as a whole, will migrate administrative processes to smartphone applications or access via the website.

For the experts continuing education is already a reality in the medical career. The introduction of exponential technologies as part of the treatment will only include one more field of study for the continuous improvement of medical skills. Although there is no consensus as to the starting point in the timeline, five or ten years, the experts consensually pointed out that the professional will be challenged to keep up to date as I4.0 technologies are constantly advancing. Thus, continuing education is the fourth consensus of this research.

When analyzing the advancement of I4.0 technologies from the patient's perspective, the prospect of advancement is better perceived when these technologies offer a positive impact in the cure of the disease or in adding benefits to the patient during treatment. For the experts, a new generation of drugs will be available for cancer treatment in the next ten years. These drugs are named, in this research, as Drugs 4.0. In consensus, the experts pointed out that the advancement of I4.0 technologies will impact the pharmaceutical industry and the R&D laboratories and, as a consequence, the final product of this advance will be more personalized medicines. These medicines will be adjusted to the conditions and specificities of each patient, consequently having less or no side effects.

Still on Drugs 4.0, the panel of experts pointed out, in consensus, that the negative side of this advance is the high cost of research and development. The high cost of research and development can generate barriers to the access to these drugs among the financially disadvantaged social classes, besides restricting investments only to large R&D laboratories.

When analyzing the advancement of I4.0 technologies from the point of view of health professionals, the experts consensually pointed out that having knowledge and mastery of the application of I4.0 technologies can be a positive differential in the medical career. In the first five years, the impact can be enhanced due to the effects of the introduction of the novelty and the absence of trained professionals.

The experts did not come to a consensus on the application of artificial intelligence for decision making in the diagnosis or treatment of cancer. Some experts cite the technology as a good support for the physician decision making. However, they do not believe that this technology will be able to assume a leading role in the conduct of cancer treatment in the next 10 years. Other experts, despite recognizing the importance of the technological advancement, argue that in cancer treatment there is a relationship of trust between the patient and the doctor. Therefore, it is not possible to include artificial intelligence as part of the decision-making process, as artificiality would damage this relationship of trust.

Still on the use of artificial intelligence, some concerns about professional ethics were raised by the experts. These concerns are within the scope of professional responsibility for treatment/patient. The specialists did not present a consensus that the current Brazilian legislation is prepared to regulate the possible medical failures arising from the use of artificial intelligence. Despite understanding that the technical responsibility will always be on the oncologist's shoulder, the experts pointed out that there is a gap regarding new co-responsibilities due to the possibility of errors arising from technology that the current legislation does not yet contemplate.

At the same time, the experts did not arrive to a consensual position about the balance between the focus on the patient versus the focus on technologies. For some experts, technological advances are natural, inevitable and must receive investments proportional to the impacts that cancer generates on the society in general, thus being able to interrupt the continuous advance. For other experts, the patient will always be the center of the treatment, with technology being one of the secondary variables. Despite the disagreement about the central focus of the investments, the experts pointed out that in order to keep up with the expected advances in I4.0 technologies, investments in the training of the physician in the development of new treatments and in the development of new drugs will be necessary.

DISCUSSION OF THE RESULTS

This part of this paper is dedicated to the discussion of the results based on the analysis of the data of the interviews, outlining the scenarios prospected through the consensus of the experts.

The general objective of the study was reached. This research prospected two future scenarios for the area of oncological health: one for the next five years and another for the next ten years. In both scenarios, it was identified that the introduction of I4.0 technologies may generate impacts in the area of cancer health, mostly, positive impacts. Experts have agreed that all I4.0 tools will be part of the oncology sector. The dissent appeared only in relation to the time category, with divergence between the perception of the experts on when each of these technologies will impact the practice in the area of oncological health.

When analyzing each technology and its applicability in the area of oncological health, in the next five years, the experts' perceptions of the I4.0 technologies that will most impact are: robotization, virtual reality, augmented reality, IoT, and 3D printing. The main impacts generated by these technologies will be: (1) the increase in the accuracy of the oncological procedures; the evolution to less invasive procedures; (2) the introduction of more effective and personalized drugs, such as drugs 4.0; and, finally, (3) the change in the entire administrative system for scheduling appointments/treatments, (4) the approval of procedures with health plan operators and, (5) the recording of exam results connected on a large scale network between patients and hospitals, through smart gadgets.

When analyzing the 10-year scenario, the experts' perception was that the I4.0 technologies that will have the greatest impact are Big Data and artificial intelligence. The main impacts generated by these technologies will be on: (1) centralized and shared medical record among the entire network of cancer care; (2) more effective genetic mapping on the possibility of cancer; and (3) the improvement of preliminary diagnoses, through resources of artificial intelligence.

There was a consensus among the experts when they analyzed the changes and adjustments that may be necessary in the academic training of health professionals due to the entry of I4.0 technologies. It was also identified consensus regarding the inclusion of content related to information technology in the curriculum of medical courses. Thus, the new generation of health professionals would already reach the job market with a minimal knowledge base in the new technologies.

Another issue pointed out as a consensus among experts is the training model that should be applied to the theme of technology in the health area. The panel pointed out that continuing education should be applied as the most effective method to keep up with the continuous advances in I4.0 technologies.

Finally, when analyzing the biggest challenges for the introduction of I4.0 technologies in the area of cancer health, the panel of experts presented a consensus on the biggest challenge and a dissent on how to overcome it. The high cost of implementing some technologies is pointed out as the greatest challenge for popularizing these resources within the oncology area, which may restrict the population's access to the benefits of their use. For example, investments in R&D in the search for 4.0 drugs are considered to be high by experts, amounting to billions of dollars a year. Thus, the development of 4.0 drugs may be restricted only to major world laboratories, which, consequently, would monopolize access to the technology and could restrict direct access to those who need it most, the patient.

On the other hand, experts showed dissent on how to overcome the investment challenge. There are two scenarios most indicated by the experts' perception, but there was no consensus on which one is more feasible for the coming years. One of the scenarios presented as a solution is the public-private partnership, using the government to guarantee, through legislation, financial support with exemption of taxes and fees, so that private companies can invest to develop technologies that have an impact in the field of cancer health. In return, the replication of technologies would occur in oncology hospitals in the public network. Another solution designed is the government-university partnership, where investments in research and development would be destined to university researchers, with public hospitals as recipients of the advances achieved.

FINAL CONSIDERATIONS

The experts demonstrated a high knowledge of the oncology theme and a good level of information in relation to the technologies in the health area. They also observed that the technology in the health area is a broad topic, which can be approached from several perspectives: the technology developer, the physician, the hospital management, and the patient. By studying a topic as broad as technology, within an area with great challenges such as oncology, this research touched on issues related to hospital management, research and development and even technical themes on cancer treatment.

It was concluded that, in a way, the technologies of I4.0 are already incorporated by the health area. By focusing within the oncology area, the converging future scenarios for the use of I4.0 technologies as management tools and, mainly, as direct support for cancer treatment, it was found that all I4.0 technologies registered in this study were pointed out in the scenarios prospected by the experts, thus having the consensus that I4.0 technologies are applicable in the area of oncological health.

It is also concluded that, despite the high investment being pointed out as a possible barrier to the implantation of solutions coming from cutting edge technologies, the experts showed consensus that in the short term scenario technologies such as robotization, virtual reality, augmented reality, IoT, and 3D printing will impact the oncology health sector. The main benefits will be the evolution to less invasive procedures, the introduction of more effective and personalized drugs and the implementation of a 100% online and integrated administrative system. For the long-term scenario, the experts' perception was that the technologies of I4.0 that will most impact are Big Data and artificial intelligence. They will bring benefits such as the possibility of an advanced medical record, genetic mapping and application of artificial intelligence in the diagnostic stage.

The Delphi method is suitable for prospecting future scenarios. It was able to explore the collective experience of the panel of experts and support the researcher in the search for consensus among the participants. The prospective results of the experts indicate not just one, but several futures, so that prospecting can be applied as a valuable input for strategic planning.

When conducting a panel of experts in multiple rounds of interviews, the Delphi method proved to be a reliable alternative for qualitative research. The main strengths of the method are the high knowledge of the interviewees and the possibility of improving the content of the interviews throughout the data collection process. The main weaknesses, on the other hand, are the researcher's high effort to maintain the experts' adherence throughout the process and the researcher's difficulty to reconcile multiple agendas with successive rounds of interviews.

Limitations of the Research and Future Studies

It was understood that there are important limitations in the present study. As for the Delphi method, the selection of experts was based not only on the minimum requirements for selection, but also on the accessibility criteria, being defined by the availability of participation in the interview process. Regarding the oncological treatment theme, it is highlighted that this research has a management characteristic and aims to apply management tools and prospect future scenarios. Thus, the present study is limited to the scope of management and does not go into medical studies.

It is important to remember that this study was based on strictly qualitative methods, considered favorable for the achievement of the proposed objectives. However, this characteristic can represent a limiting factor for the measurement of causal relationships between the variables studied. Therefore, it is recommended to produce future studies that explore the statistical causal relationships between the introduction of these technologies and the increase in the cure rate of cancer treatments.

Thus, the present study contributed to researchers in the areas of management, technology and health. Academically speaking, it fills gaps identified in the bibliometric study. Furthermore, when developing a study in the field of strategic planning, through the controlled application of the Delphi method for prospecting future scenarios, this research has continued previous studies on prospecting scenarios.

Finally, some questions emerged from this study and may be addressed in future researches, such as: (a) the prospect of future scenarios for other specialties in the health field, (b) researches on the perception of technologies from the point of view of the patient and (c) a prospecting survey for future scenarios with an expert panel composed only of IT professionals.

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