Robotic Innovations in Support of the Healthcare Workers Against COVID-19 - DIH-HERO Perspective

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Abstract. Coronavirus disease 2019 (COVID-19) has affected the conditions of work in healthcare institutions and the quality of patient care around the world. Emerging healthcare robotic technology may facilitate and improve the overall quality of life, as well as the diagnostics, rehabilitation, and intervention services. This paper reports the lessons learned from actions carried out in the implementation of the DIH-HERO project call across Europe for robotic solutions that support healthcare activities. Conclusion remarks are as follows: *i*) technology pull and the urgent need together accelerate the innovation development and deployment, *ii*) it takes time to establish safety and legal regulations for the deployment of human-machine devices, so the ethical, safety, and reliability aspects of robotic application need to be carefully considered, *iii*) technology adoption depends on the trust of the users to the technology, *iv*) existing robotic technology for prevention, diagnosis, hospital admission, rehabilitation, and intervention is mature enough for the adaptation and deployment, *v*) unskilled general population should be trained for the usage of robotic technology.

Keywords: COVID-19 · Diagnostic robotics · Interventional robotics · Rehabilitation robotics · Robotics supporting healthcare professionals · Robotics supporting patients

1 Introduction

Coronavirus disease 2019 (COVID-19) pandemic has strong negative effects on the quality of patient care and the organizational aspects of work in healthcare institutions. Non-covid healthcare institutions reduced and slowed down the work capacity because of COVID-19 epidemiological restrictions related to the decreasing of the physical interactions of people. The diagnostic services [1, 2] and continuum care for patients with chronic diseases were disrupted and postponed [3], as well as rehabilitation healthcare services [4] and surgical interventions [5]. New measures such as lockdowns, physical distancing, self-isolation, and quarantine have led to an increase in various psychological consequences such as increased anxiety, depression, insomnia, harmful alcohol, drug use, self-harm, or suicidal behavior, etc. [6].

especially in nursing homes where elderly people stay isolated from their families for months. Healthcare workers are particularly exposed to mental challenges as well as to physical efforts, and these facts indicate the need for implementation strategies to reduce their morbidity and mortality (e.g. reducing direct contact with patients, shorter shift lengths, mental health support, physical support).

The pandemic situation caused the urgent transfer to non-contact, digital communication in all spheres where it was possible (human health, healthcare, economy, industries, agriculture, etc.). Due to COVID-19, a new environment is created, in which we need to learn about necessity and challenges in human-human collaboration and interaction, but also in human-machine interaction and collaboration since we are faced with a completely new perspective in the communication. Emerging technologies in robotics can provide the implementation of numerous solutions to support the fight against the

COVID-19 pandemic. Robots can help in organizing the living environment, cleaning, keeping production going in the pandemic scenario, etc. During the COVID-19 pandemic, healthcare robots particularly may play an important role in reducing the spread of COVID-19 infection and providing quality patient care [9]. The current pandemic situation requires the deployment of practical, innovative robotic solutions in the different areas: diagnostic robotics, interventional robotics, rehabilitation robotics, robotics supporting patients, and robotics supporting healthcare professionals. Due to the urgent situation, it is expected that the expansion and adoption of new innovative helpful robotic technologies will encounter fewer barriers than under normal conditions.

This paper provides an overview of the lessons learned from concrete actions that the European network of Digital Innovation Hubs in Healthcare Robotics (DIH-HERO) [10] took across Europe in supporting healthcare workers through robotic innovations and overcoming all the challenges COVID-19 imposed on the community in the previous period.

2 DIH-HERO Open Call – Emerging Scenarios as Key Drivers for Innovations

In April 2020, DIH-HERO announced a call for Financial Support for Third Parties (FSTP) to support small and medium companies in their ideas and activities towards fighting COVID-19. The total call budget was €1 million for up to ten projects, which means 100.000€ per project.

The call was open for only one week. Typically, these types of calls for companies are open for 2–3 months. The call was launched in the second month of the pandemic, during the lockdown, so companies could not prepare a lot in fighting pandemics before the call. The requested duration of granted projects was only 2–3 months. At the end of this short period, companies should have a working prototype validated in clinical settings. Therefore, only those companies that had already had some working solution could fulfill the requirements and on top of that, they should have provided a letter of support from a clinic that was ready to adopt the developed solution at least for testing in clinical environments. Through the DIH-HERO network and with the support of the European Commission, 146 companies from 30 different European countries were mobilized to submit project proposals in such a short time frame.

Consequently, the first lesson learned is that ***the key drivers for innovations are technology pull and the urgent need together***. Throughout history, significant scientific discoveries have occurred during times of global challenges such as wars or pandemics. Although systematic and numerous actions have been made to support innovations and uptake of technology on nationals and EU levels, the technology has been rarely fully prepared to appropriately respond to emergent situations. In conclusion, dedicated measures do not impact the technology uptake and innovations as an emerging scenario does. This may be because of global challenges such as the COVID-19 pandemic affects all aspects of life, not just as a working task, or because technology adopters (such as medical doctors) reduce technology adoption barriers themselves in hopes of resolving problems urgently. Therefore, emerging scenarios often achieve improved communication between technology developers and adopters, and thus match technical innovations with the direct user needs.

3 Safety and Legal Regulation Affect the Robotic Innovation Deployment

Within healthcare robotics, DIH-HERO distinguished five major application domains: diagnostic robotics, interventional robotics, rehabilitation robotics, robotics supporting patients, and robotics supporting healthcare professionals, Fig. 1.

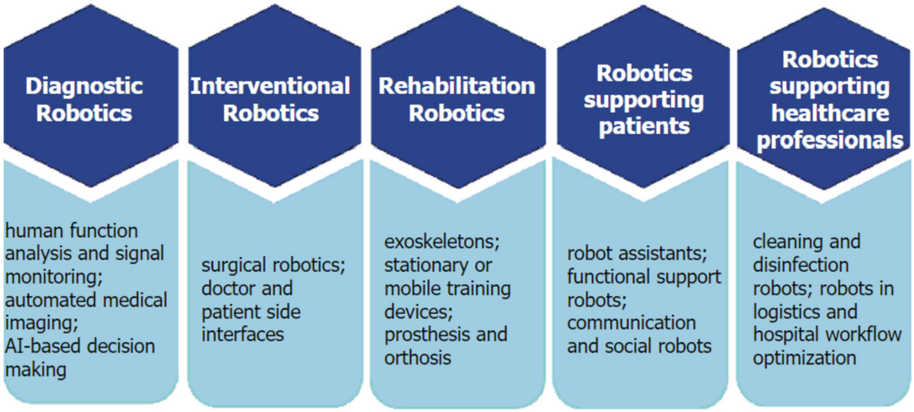


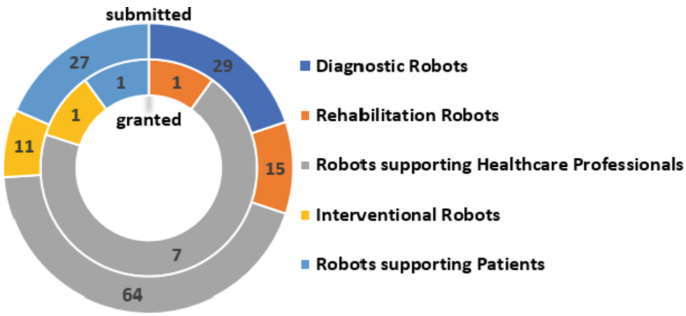
Fig. 1. Five major application areas of healthcare robots

Diagnostic robots are used for human signals monitoring by different sensor systems including medical imagining or micro-nano robots for endoscopy, but also functional analysis and intelligent decision making in diagnostics [11]. Interventional robotics stands mostly for surgical robotics applications, including robotics setups on the patient side (where a robot penetrates a human body) as well as intervention interfaces on a medical doctor's side (e.g. haptics) [12]. The domain of rehabilitation is also considered quite broad - robotics applied to restore health through training and therapy after or during illness (such as stroke or other injuries) or a range of mobile assistive robotic technologies (e.g. exoskeletons, prosthesis, orthosis) [13]. The fourth domain of robots supporting patients directly is considered for robotics solutions that provide direct support and assistance to patients (e.g. bringing the supplies, assisting in motion) but also robots that are used for communication and social interaction [14]. Finally, the robotics solutions which provide support to healthcare professionals are robots that replace healthcare professionals in some tasks such as cleaning or disinfection, assist in hospitals or home logistics including patient transportation [15].

In the scope of the presented DIH-HERO COVID-19 call for projects, project applications that targeted urgent needs at the start of the pandemic were expected such as disease prevention, COVID-19 diagnostics, as well as a few in patient care.

However, the distribution between application domains is presented in Fig. 2. Most of the project applications targeted the domain of robots directly supporting healthcare professionals (64 of 146), and then robots supporting patients (27 of 146), and automated diagnostics (29 of 146).

A



B

	COMPANY	PROJECT TITTLE
7	ACCREA Engineering (PL)	DISInfecting RoboT (DisiRT)
	Akara Robotics (UK)	Disinfectant RObots to Protect Against COVID (DROPAC)
	Jonker-Makis Robotics (NL)	Autonomous mobile disinfection robot SAM-Air
	KELO Robotics (DE)	Autonomous robots for disinfection (ARODIS)
	MetraLabs (DE)	Portable and agile autonomous disinfection robot (STERY)
	PAL Robotics (ES)	Fast Deployment of AVs in Hospitals
	Rubedo Sistemos (LT)	Unmanned Disinfection Solution (UDS)
1	Voxdale (BE)	Robot for Intradermal Drug Delivery (ROB-ID)
1	F&P Robotics (CH)	Autonomous Sanitiser and Assistant Lio
1	Hocoma (CH)	Sensor-based arm and hand functional tele-rehabilitation with Armeo®Senso (Tele-AX)

Fig. 2. A) The distribution of submitted and granted project proposals for DIH-HERO COVID-19 call, B) List of granted projects per application domains

The distribution of submitted and granted projects per application domains demonstrates the priorities of supporting frontline healthcare workers and intention of applicants to stop spreading the disease according to the number of applications in the robotics disinfection. After the submission process had been completed, each proposal was evaluated by the evaluation committee, at least 3 evaluators evaluated each proposal, its potential impact, maturity of the proposed solution, feasibility in the very limited time frame of 2–3 months, and clinical relevance. The evaluation committee also involved clinicians. The result of the evaluation was that only one project per domains intervention, rehabilitation, and support to patients was granted, whereas 7 projects were granted in the domains of robots supporting healthcare professionals. In the area of intervention, the granted project was about intradermal drug delivery, in the area of rehabilitation it was a telerehabilitation device, and in the area of support to patients, it was a personal robot assistant. In the domain of robotics supporting healthcare professionals, there were 6 projects in robotics disinfection and one in logistics. Surprisingly, no diagnostic robotics projects were funded due to different reasons such as difficulties in handling patient personal data and lack of trust of medical doctors for robotized diagnostic solutions.

According to the presented distributions, another conclusion, a lesson learned, was reached: ***robotic technology that requires immediate human-robot interaction cannot be quickly deployed with current safety and legal regulation measures***. So, the society must be better prepared for future emerging scenarios by working on regulations and off-the-shelf technologies in the human-robot interaction preparations which can have a strong benefit in fighting following pandemics in a very short time.

4 Robot Deployment and Impact to the Fight Against COVID-19

Robotic innovations developed within COVID-19 call included the first fully automated standardized intradermal vaccination robot, an upper-limb telerehabilitation setup with data-driven therapy protocols, and an option of semi-supervised rehabilitation protocols, multisensory SLAM robot systems for hospital logistics, a multimodal disinfection robot (spraying, UV lights, ozone), advanced visions systems for human and critical object detections for advanced safety and efficiency in robotics disinfection, etc. A complete overview of the developed technologies is available in the authors previous work [16]. However, the lessons learned in the deployment of robotics innovation in the pandemic scenario resulted in several lessons learned as a foundation for the uptake of advanced technologies in emerging scenarios yet to come.

Technology adoption depends predominantly on the trust of the users to the technology. This becomes evident when facing technology provider priorities in the disinfection robots' innovations (path planning, minimal disinfection time, object detection and recognition, area coverage) with technology adopter key requests (perfect disinfection outcome proven by indicators, reliability of the disinfection process).

Existing robotic technologies are mature enough to be deployed after the period of adaptation and contribute to all phases of the disease treatment – from prevention, diagnosis, hospital admission, intervention, to rehabilitation. The prospective use of robots at different stages of disease treatment is depicted in Fig. 3.

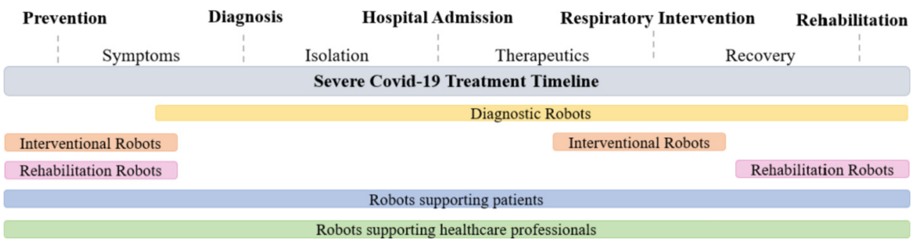


Fig. 3. Prospective use of robots at different stages of disease treatment.

The unskilled general population should be trained for the usage of robotic technology. Although the robotics technology demonstrated maturity for quick deployment in clinical settings and treatment of public spaces, the DIH-HERO COVID-19 experiments highlighted the importance of easy and intuitive commands of advanced technologies and possibly advancements in natural human-machine interaction, for the widespread utilization and general trust in robotic technologies.

5 Conclusion

In this paper, an overview of DIH-HERO perspectives about announced COVID-19 project call for companies is presented. Several conclusions were noticed regarding the realized experience in the call execution. The first remark was regarding the scenario when innovations happen. It was concluded that an emerging scenario, like an actual pandemic, in symbiosis with technological readiness inspires innovation development. The second remark concerns slow safety and legal regulations for the implementation of robotic technology that requires immediate interaction with humans. So, ethical, safety, and reliability concerns need to be carefully considered and exclusive policies for use of the technologies in emerging scenarios should be made. The existing robotic technologies are already mature enough to quickly adapt and contribute to all stages of disease treatment: prevention, diagnosis, hospital admission, intervention, rehabilitation. However, technology adoption depends on the trust of the users much more than the confidence of the technology providers. Finally, robot deployment in everyday living environments and operations with unskilled general population, impose challenges that need to be resolved.

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