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Algorithmic Management practices in regular workplaces: case studies in logistics and healthcare

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Contents

Abstract

The objective of this study is to understand better the algorithmic management practices adopted by regular workplaces. We investigate the degree of penetration and impact of algorithmic management on work organisation, job quality and industrial relations focusing on the logistics and healthcare sectors. The report focuses in these two sectors because the logistics sector has been at the forefront of digital transformation and has been deploying algorithmic management practices in regular workspaces. Similarly, digital technologies are revolutionising the healthcare sector, and there has been a significant rise in investments in digital health in the aftermath of COVID-19 pandemic. The research has been conducted in two European countries (Italy and France) and two non-European countries (India and South Africa), allowing for a comparative analysis across countries with different levels of development. We show that algorithmic management is widely present in traditional sectors, with benefits in terms of streamlining and simplification of work processes and efficiency gains. The implications of these new forms of work for work organisation and working conditions are also discussed. We show significant challenges in terms of potential deterioration of job quality as well as concerns regarding the strong potential for worker surveillance.

Foreword

This report has been drafted jointly by the European Commission's Joint Research Centre and the International Labour Office. The report is part of a series of four joint publications that together represent the main final outcomes of a 2.5-year joint research project on the changing nature of work at a global level. The project, entitled "Building Partnerships for the Future of Work" was carried out by the two institutions as close implementing partners between January 2021 and June 2023 and was financed by the European Union's Partnership Instrument in collaboration with the European Commission's Directorate-General for Employment and Social Inclusion. In particular, joint research activities were developed under the project's Fact-based Analysis component, aiming to develop new evidence around some specific, and understudied, future of work themes focusing on aspects of relevance to the EU and selected non-EU countries.

More information on the project and its other research findings is available here:

https://www.ilo.org/employment/Whatwedo/Projects/building-partnerships-on-the-future-of-work/lang--en/index.htm

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Executive summary

The rapid pace of the digital revolution and the increase in connectivity at work are transforming and reshaping the world of work. The use of digital tools and the implementation of algorithmic management practices as mechanisms of work coordination, which was typical and predominantly associated with digital labour platforms, are now expanding to regular workplaces. Digitalisation, the digital monitoring of work and algorithmic management - understood as the use of computer-programmed procedures for the coordination of labour input in an organisation – open up new business opportunities, foster efficiency gains and streamline work processes. However, this transformation also presents challenges in terms of working conditions, the potential deterioration of job quality, and a significant risk of worker surveillance.

The direct and explicit application of algorithms and the use of digital tools for work management is contingent upon the standardisation of specific tasks, the level of digital infrastructure development, institutional constraints on the use of technology in the workplace, and the relative labour cost with respect to technology adoption. While this phenomenon is global and continuously evolving, its adoption varies across sectors and countries, adding complexity to the analysis of its potential effects. Given its recent emergence, the extensive and wide-ranging impacts of this phenomenon are not yet entirely understood. Therefore, it is essential to have a comprehensive understanding of its effects on work, workers, the economy as well as society at large, in order to provide evidence-based support for regulations aimed at addressing potentially negative repercussions.

This report adopts a broader conceptual approach to the analysis of algorithmic management practices, considering the use of both specific-purpose and general-purpose digital technologies at the regular workplace. Specific-purpose digital technologies are designed for a specific function, while general-purpose digital technologies have wider applications and can be adapted to different situations. That is, the report considers also the impact of technologies not explicitly designed for work coordination but which nonetheless exert a significant influence on work organisation. In many instances, algorithmic tools are (at least ostensibly) implemented for managing aspects and processes beyond work coordination, yet they have direct and important effects on the organisation of work, task allocation, job quality and industrial relations. This study aims to enhance the understanding of algorithmic management practices prevalent in regular workplaces in the logistics and healthcare sectors. We explore the degree of penetration and impact of algorithmic management on work organisation, job quality and industrial relations. To analyse these implications, given the limited empirical evidence available, we rely upon workplace case studies to examine the impact of new technologies on labour processes. The research has been conducted in two highly developed European countries (Italy and France) and two non-European developing countries (India and South Africa), enabling a comparative analysis across countries with different levels of development.

The logistics sector stands at the forefront of digitisation and deployment of algorithmic management practices in regular workspaces. Algorithmic management software is used to monitor the production flow, coordinate work processes and assess workers' performance. Technologies analysed in this sector include robots employed for picking and storing items for retail orders, algorithmic tools to optimise itineraries of postmen, predictive algorithmic tools to assist companies to forecast their client flows, peak activity, stock requirements or staff planning, as well as mobile hand-held scanning devices. In addition to these specific-purpose technologies, general-purpose digital technologies such as instant messaging apps are also taken into account.

The main motivation behind the introduction of these technologies in the logistics sector in all countries analysed is to increase effectiveness, efficiency and improve the service delivery. The case studies analysed generally exhibit a positive impact on productivity achieved through a simplification and streamlining of work processes. While there is no direct evidence of job losses resulting directly from the introduction of these technologies, it is crucial to note that they may pave the way for future labour displacement by facilitating efficiency gains. The case studies reveal varied outcomes in terms of redefinition of tasks and roles, depending on the specific country context. In Italy and France, technology adoption often gave rise to new roles and training of new personnel, but it did not directly impact organization structure or hierarchy. In South Africa, the implementation of technology did not result in modifications of job roles of existing workers, although workers were provided training to use the technology. This led to a mismatch between occupational profiles and tasks, and there was a sense of frustration among some workers who felt they were being upskilled while there was no proper recognition of their work and remunerations.

Regarding job quality in the logistics sector, the findings are quite diverse, and, particularly for the case studies in Italy and France, inconclusive due to the presence of supervisors during the interviewing process. However, in one of the Italian logistic companies workers reported that the adoption of the technologies led to safer working conditions as it reduced the physical strain, consequently lowering fatigue and stress levels. Work intensification (increase in workload, pace, or demand for a job) is observed in South Africa, and the case studies show the possibility of a similar risk for Italy, France and India. In terms of workers' autonomy, we find evidence of a reduced level of discretion, although human decision-making remains prominent. Further, in South Africa the unions recognized that the technology itself was not the issue; rather, it was the existing management-worker relationships that failed to establish a connection between training in new technologies and the upskilling of workers. There are also differences in terms of monitoring and surveillance of workers. In Italy and France, regulatory safeguards seem to be currently preventing a major impact, while in South Africa and India, worker monitoring and surveillance are already a reality with workers facing some punitive actions in South Africa. Generally, there seems to be a lack of awareness and low level of involvement of trade unions in decisions regarding technological adoption in workplaces in all countries.

Digital technologies have also brought about changes in the health sector. The use of data analytics, mobile applications, digital tools and integrated digital platforms are opening new frontiers in telemedicine, predictive diagnostics and medical assistance generating services for patients, healthcare professionals and healthcare managers. Algorithms and algorithmic management, as part of digital health platforms, are new and may be used for creating efficiencies and improving the accuracy of diagnosis, the planning of the health care system and the coordination of work processes. Among the technologies analysed, we explore Health Information Systems for health care system planning; integrated digital platforms; digital health platforms and dashboards for predictive data analysis, along with general-purpose digital technologies such as WhatsApp and tablets used for coordinating work processes.

Similarly to the logistics sector, the main drivers for technology adoption in the healthcare sector are cost and service efficiency. In the case studies in Italy and France, digital technologies improve work coordination processes, reduce the time spent by doctors and nurses on non-medical tasks, and consequently increase the time dedicated to caregiving activities. In India and South Africa, digitalisation has also improved workflow and health service delivery, providing better control over organisational performance. In both India and South Africa, the adoption of digital technologies is quite high in the private sector compared to the public sector, where it is either in pilot stage (South Africa) or being introduced for certain specific purposes.

The findings on job quality in the healthcare sector show differences between the case studies in Italy and France on the one hand, and India and South Africa on the other. In Italy and France, technology adoption in the cases analysed is mainly on a pilot phase, voluntary, and operates within a clear and structured legal framework, resulting in a generally positive impact on job quality. In India and South Africa the evidence is quite mixed, as in South Africa some of the technologies are in pilot phase, while in India where many of these technologies have been adopted, there are no impacts on job quality as of now. However, there is a potential for the use of these technologies to increase monitoring for both the nurses as well as the doctors in both these countries. The case studies in Italy and France show the potential positive use of technologies that helped in achieving a better organised workload, lower pressure, particularly in the emergency departments, and reduced the level of stress for all healthcare workers. Although all these technologies have the potential to be used for monitoring workers, such practices are not yet prevalent in both the countries. In the case studies in South Africa, there is evidence of constant worker monitoring and performance evaluation, directly impacting workers' payment and access to work. In contrast, in India while the use of digital technologies has made the functioning of employees (doctors and nurses) transparent to the higher management, it is possible that if proper safeguards are not put in place, then in the future the hospitals might increase their control over their performance. A common element, albeit for different reasons, is the limited consultation with workers regarding adoption of digital technology and automation in the hospitals across countries.

The evidence from the case studies show that algorithmic management is already a reality, in all the four countries studied, and is far from homogeneous, as similar technologies yield very different effects. A common element among these tools is that they are implemented and driven by the objective to maximise profit, increase productivity, improve the business model and foster efficiency gains. Another common element in the technologies analysed is that they are either being used already, or embed a strong potential to be used, for the purpose of workers' monitoring and surveillance. In terms of challenges, there are differences between the impact of these technologies on job quality and working conditions in the European and the non-European cases. The case studies conducted in Italy and France show a generally positive impact of the introduction of digital tools on job quality and no immediate evidence of higher level of workers' monitoring and surveillance. This could be linked with the existence of specific legal frameworks for the adoption of surveillance technologies in the workplace or the fact that many of them were still on a pilot phase. There are also differences in the case studies conducted in India and South Africa, with similar technologies and similar types of work. The impact on job quality is far more evident in South Africa than in India and, importantly, there is clear evidence of worker monitoring and surveillance. These differences shows that the impact of algorithmic management in the workplace in regular workplaces appears to be at least partly mediated by the institutional and the regulatory framework in place.

The extensive and pervasive nature of algorithmic management practices in regular workplaces may require additional regulatory measures specifically tailored to address this phenomenon comprehensively. To facilitate future policy discussions on algorithmic management and inform policy decisions, further research becomes imperative to provide robust evidence on the evolving nature of algorithmic management, its expansion and the increasingly apparent consequences it entails.

1 Introduction

Since the 19th century, technology development and forms of surveillance have been key factors in defining the economic model ruling the organisation of labour, capital, social and work life. The development of digital technologies and its adoption marked a significant shift from the industrial economy to the information economy. A key element was the transition from the tangible brick and mortar productions to new intangible assets and investments that made information and knowledge valuable resources. During this course, and along with technological advancements, the ability to process and analyse information became rapidly more critical. According to Zuboff (2015, 2019) we live in an era of surveillance capitalism, wherein every human experience can be transformed into behavioural data and unilaterally appropriated for profit or to influence individual behaviours.

In this new economic paradigm, data and surveillance technologies play a central role in reshaping the organisation of economic activities and workplaces. The widespread use of the internet, the digitalisation process and the datafication enabled by technology has led to the emergence of new companies whose business models collect and leverage data and transform it into new forms of value. Similarly, the change in the business structure and the adoption of new digital tools modify the organisation of work and the workplace from a Taylorist structure of control to new forms of data-driven management and digital surveillance (Baiocco et al., 2022). Zuboff (1988) employs the concepts of automate and informate to describe this process, a dyad unique to information technology, from which the inquiry into new models of hierarchies in the information technology era emerges.

Indeed, the duality that is inherent in information technology, simultaneously automating tasks and generating information about the process, gives rise to a stark contrast between managerial control and horizontal access to information. Burton-Jones (2014) in his review of Zuboff's work, explains that the potential transformative effects of information technology are constrained by three dilemmas: knowledge, authority and technique. Briefly, information technology forces workers to acquire new knowledge (knowledge dilemma). The acquisition and exercise of more and shared knowledge affords power and undermines the incumbent hierarchal structure of authority (authority dilemma). As a result, the technique dilemma arises because managers leverage the information potential of new technologies not for learning or improvement but for control and enforcement. Zuboff (2019) further resolves the tension between hierarchical forms of control and potential emancipating power of technology adoption - in favour of the former - by developing the concept of "behavioural surplus". That is, the surplus value extracted by the datafication of human experiences, which constitutes the economic justification of surveillance and monitoring practices. As the adoption of technology in the workplace increases, so does the level of sophistication of digital monitoring tools, paving the way for the datafication of work processes.

Currently, algorithmic management and digitalisation of work are at the core of the codification and standardisation of labour processes in modern workplaces. They entail the development of digitalisation and datafication procedures, whether directly intended to be used for work coordination or for other purposes that allow to track, record and analyse work operations. This may happen by means of general-purpose ICT and digital tools, artificial intelligence and data analytics programmes, robots or wearables or even workers' personal devices such as personal computers, tablets and smartphones.

Digital labour platforms have been at the vanguard of the use of surveillance technologies and algorithmic management practices (Pesole et al., 2018; ILO, 2021), thanks to both the natural setting they operate in, being entirely in the digital space, and also mostly due to the informal nature of the working relationship that lifted many of the potential restrictions related to the use of technologies in regular working places. Nonetheless, algorithmic management, as well as forms of digital surveillance, are becoming insistently more common in regular working places (Baiocco et al., 2022) raising broader questions on how these management tools affect labour processes, disrupt work organisation and the power balance in the workplace.

The emergence of these new forms of work process coordination enabled by digital technologies creates the need for developing new theories and testing new evidence to help us understand the evolution of emerging industrial relations and power structures in the workplace. Moreover, in addition to the direct influence on work procedures and systems of monitoring and control, a particular feature associated with the use of algorithmic management practices and digital labour platforms is the decoupling of the physical space of the firm and the place of work. This has an effect on the traditional assumption of imperative control (Zuboff, 1988) in the workplace. Indeed, information technology organisations, that are more dispersed, need to develop collateral coordination mechanisms capable of feeding the top-down structure of control to ensure it is effective. For instance, in business process outsourcing (BPO) companies and call centres where work is undertaken in different locations for a particular project, the mode of work organisation was through the use of algorithms, also referred to as 'algocratic' governance (Aneesh, 2009). In this process, work was 'governed through the design of the work process . . . using software code to govern globally dispersed workers through data servers' (Aneesh, 2009: 347). As a result, the use of information technology entirely modifies the physical structure around which workers' self-determination could develop.

The radical transformation of such physical structures has consequences that affect working conditions and can reshape the industrial relations in the digital era. Historically, the labour movement developed as a response to industrial capitalism and for improving the working conditions in the factory, and with the goal of achieving the balance of power between capital and labour. As trade unionism and the labour movement were the response to industrial capitalism and work in the factory, it is important to understand the triggers and the changes in regular workplaces arising from data capitalism. New theory and evidence need to be gathered in this regard.

The relationship between technology, workers' skills and autonomy and managerial control is at the core of the power struggle in the workplace and is a fundamental issue in Labour Process Theory. Braverman (1974) analyses the labour process in light of capitalist production and technology development, and in his revisitation of Marx's theory, he argues that technology is adopted by management in order to control the work process and the worker. In contrast with Smithian theory, he argues that the division of labour entailed by technology and meant to reduce workers to fungible parts of the production system is not a technical requirement, but the economic mandate of the capitalist system. Indeed, Braverman discusses how technology could emancipate workers from routine tasks, allowing workers to progress to more lucrative roles within the production system through proper training and reskilling.

A similar argument could be applied to the use of surveillance tools and algorithmic management practices in the workplace, as discussed earlier. The use of such technologies could be articulated in different ways. One might argue that algorithmic management and surveillance tools have the potential to increase productivity, organise work more efficiently, foster workers' autonomy and improve health and safety. However, at the same time, the economic orientation of such tools, namely, the profitability derived from standardized behavioural data and simplified personalised profiling, may serve as an incentive to use these tools for consolidating control, influencing and replicating behaviours, and reducing uncertainty. Despite the potential for technology adoption to bring about emancipation, employers may choose to prioritise efficiency and profit, resulting in a use of technology that may be in conflict with workers' interest. Bell (2021) argues that when technology adoption goes beyond what is proportionate or necessary; compromises working practices and negatively affects existing levels of control, autonomy and trust, it can lead to counterproductive work behaviours and resistance.

The development of these new tools and algorithmic management practices in the past decade has been largely unaccompanied by regulatory interventions. Legislative initiatives, mostly focusing on digital labour platforms, have started to emerge only in most recent years and forms of workers' resistance have emerged spontaneously, particularly among platform workers (Bessa et al., 2022; ILO, 2021; Scholz, 2016). In this context, algorithmic management practices have the potential to reshape the employer-worker relationships in terms of conflict between labour and capital in the workplace, and the systems of control used to restrain the conflict.

Borrowing Edwards' concept of contested terrain (1979) which delineates different degrees of control to explain workers' resistance to forms of discipline and surveillance, and aligning with the findings of Kellogg et al. (2020), this report contributes to the literature exploring how algorithmic technologies might reshape the control relationship between employers and workers, thereby impacting the organisational dynamics. We examine this by looking specifically at how algorithmic management systems affect work organisation, job quality and workplace relationships.

The objective of this study is to gain deeper insights of the algorithmic management practices that are being adopted by regular workplaces in the logistics and healthcare sectors. We aim to explore the extent of adoption and the impact of algorithmic management on work organisation, job quality and industrial relations. Given the limited empirical information available, we employ workplace case studies to understand the impact of new technologies on the labour process. Specifically, this study seeks to understand, within each sector and country, how algorithmic management systems are embedded in the coordination of work processes at different functional levels within the establishments, and how they affect and influence:

- the business model and the delivery of services, including possible outsourcing and subcontracting, and how this affects productivity;

- the different occupational levels, the organisation of work and the distribution of tasks, as well as the requirements in terms of skills;
- job quality, taking into account the gender dimension to the extent possible;
- digital monitoring and control and related datafication processes;
- industrial relations in the establishment; and also how employer-employee consultation processes affect the introduction of algorithmic management systems.

The research has been conducted in two highly developed European countries (Italy and France) and two non-European countries (India and South Africa), allowing for a comparative analysis across countries with different levels of development. We analyse two sectors of the service economy: logistic and healthcare. The use of algorithmic management in direction, evaluation and discipline functions has been widely documented in the logistics sector in Europe and the USA (Wood, 2021; Dzieza 2020; Delfanti 2019). In the healthcare sector, algorithmic management has proceeded mainly through the introduction of digital labour platforms for the provision of on-location health care services at home, for example to assist dependent persons (Blanchard 2022; Rodríguez-Modroño et al. 2022). Yet, algorithmic management in the healthcare sector, especially beyond digital labour platforms, remains relatively limited, or at any rate less well documented. Being underexplored in the literature and with investments in digital health having expanded in the aftermath of the pandemic, algorithmic management in the healthcare sector is a novel and important field to investigate.

The rest of the report is structured as follows. Chapter 2 introduces the conceptual approach that underpins the development of the case studies, followed by an in-depth discussion of the methodology. In Chapters 3 and 4, the report presents the main findings for both the logistic sector and the health sector in all the four selected countries, respectively. Finally, Chapter 5 provides a conclusion and highlights some of the policy implications.

2 Conceptual approach, methodology and fieldwork

2.1 Conceptual approach

The term algorithmic management was introduced by Lee et al. (2015) to describe the ability of software algorithms to allocate, optimise and evaluate work of a plethora of dispersed workers. According to Mateescu and Nguyen (2019) algorithmic management is a “diverse set of technological tools and techniques to remotely manage the workforce, relying on data collection and surveillance of workers to enable automated or semi-automated decision making”. Wood (2021) proposes a classification of algorithmic management based on the embedded level of automation of the main managerial functions - direction, evaluation and discipline - that draws from the six mechanisms of algorithmic control defined by Kellogg at al. (2020). As defined by Kellogg et al. (2020), algorithms may be used “to direct workers by restricting and recommending, evaluate workers by recording and rating, and discipline workers by replacing and rewarding” (Kellogg et al. 2020, p.36). Furthermore, algorithms could be of different types according to their different functions. Parent-Rochelau and Parker (2021) analyse the effect of algorithmic management on work design characteristics, distinguishing three types of algorithms: descriptive algorithms, used to record past events and analyse their impacts on the present; predictive algorithms, used to foresee the occurrence of future events; and finally prescriptive algorithms, used to identify best possible solution and recommend or implement course of actions.

The original conceptual framework that underpins this research is based on Baiocco et al. (2022) according to which algorithmic management is defined as the use of computer-programmed procedures for the coordination of labour input in an organisation. Baiocco et al. (2022) are particularly concerned with both the organisational and coordination aspects entailed in their definition of algorithmic management and its application by using specific digital tools. This theoretical underpinning is also at the core of the concept of “platformisation of work”, which refers to the use of platforms and algorithms as mechanisms of coordination in regular workplaces beyond digital labour platforms, as a result of the increase in digitalisation and connectivity at work (Fernández Macías et al., 2023). Indeed, Fana and Villani (2023) show that firms with higher level of digital (and process) innovation record higher levels of indirect control (especially related to algorithmic management). The concept of platformisation in Fernández Macías et al. (2023) encompasses three distinct but closely related phenomena: firstly, the increasing use of digital tools at work, secondly, the rise of digital monitoring and surveillance, and thirdly, the use of algorithmic management.

In this report we adopt a revised and expanded approach to capture also the unwitting effects of digital technologies not specifically related to work management, but with potential for digital monitoring and work organisation. We adopt a broad definition of algorithmic management technologies that have a direct or indirect effect on work organisation, and take into consideration two additional elements for analysis in the case studies analysed:

First, digital tools can be used potentially for different purposes as well as the direct and explicit objective of managing work, and we have identified two broad types of technologies and practices within the case studies analysed: ‘specific-purpose digital technologies’, which are designed and developed for a particular function or application, and ‘general-purpose digital technologies’, which, in contrast, have a wider application, can be adapted in different situations and are highly flexible.

‘Specific-purpose digital technologies’ refer to those that are intricately designed and developed and are often tailored for the codification of specific process or to solve a precise problem. Examples include IoT systems, software and robots that are programmed and equipped with tools which are tailored for intended tasks. It also includes applications and software explicitly designed to measure productivity or monitor the workforce – the so-called “bossware” - and systems developed to assist workers during the performance of their tasks, such as specific digital business management applications. In contrast, ‘general-purpose digital technologies’ encompass aspects of general-purpose technologies, and they exhibit wide applicability, adaptability and application across various industries, and high flexibility. They possess the capacity to address and to solve both basic problems and advanced needs of the society, for example information and communications applications, and the potential for innovation across diverse industries. We also discuss various general-purpose digital technologies being used for the management of work on a routine basis, which have implications for working conditions and digital surveillance, such as instant messaging or text editing software.

From both a regulatory and a privacy point of view, incorporating due diligence and privacy by design, and privacy by default principles into all applications development is crucial to mitigate the potential risks associated with the use of such technologies. Crabtree and Lodge (2021) found that there is little evidence of this process being widely adopted, highlighting the challenge of reconciling developer’s technical skills with the necessary competence to understand the impact of development decisions upon privacy. Furthermore, the potential risks linked to the use of technology are strictly dependent on the context and the function in which it operates. Therefore, each system must be rigorously tested against its design and purpose. Utilising general-purpose digital technology to fulfil specific functions in specific contexts can pose substantial risks for both users and workers.

Second, we have observed in this study that technologies do not necessarily have to be conceived and implemented for the purpose of work coordination in order to have even significant effects on work, which has led us to take a broader conceptual approach. Indeed, we show in this report that in many cases, algorithmic tools are (at least ostensibly) implemented for the management of other aspects and processes at the workplace, but also in this case they often have direct and important effects on the organisation of work, task allocation, job quality and industrial relations. This means that, even if these digital tools or algorithmic systems are not explicitly intended to manage work processes, de facto they can be considered as part of, or at least equivalent to, algorithmic management systems that produce effects on work organisation.

In a nutshell, a broader approach towards the analysis of digital monitoring and algorithmic management was adopted in this report, going beyond "the use of computer-programmed procedures for the coordination of labour input in an organisation" in two different ways:

- First, in addition to computer-programmed procedures we also cover general-purpose digital technologies being used for the management of work. The distinction adopted throughout the case studies allows us to gain deeper insights into the implications from a broader use of technology and helps us to understand whether general-purpose digital technology can influence work organisation and its associated implications. For example, we show how Whatsapp groups used in the workplace exert a strong function of control and pressure over workers.
- Second, in addition to the use of algorithmic management for the explicit purpose of coordinating work processes, we show evidence also of other technologies which have other intended purposes, but at the same time have substantial implications for the organisation of work and for digital monitoring within the workplace. For instance, we look into ways through which algorithms used to manage patient flows in healthcare can improve the patient outcomes and can also affect the organisation of work and have the potential to be used for worker monitoring.

2.2 Methodology

Currently, there is little empirical evidence on algorithmic management. Most quantitative data available on algorithmic management practices derives from surveys on the platform (or gig) economy (ILO, 2021; Urzì Brancati et al. 2020; Pesole at al.2018; Huws et al, 2017) or from specific questions added to regular surveys analysing workers' working conditions and health and safety.[1] To our knowledge, only two surveys investigate specifically the use of algorithmic management in the workplace: the AMPWork survey, that collects data on the use of digital tools, digital monitoring and algorithmic management adoption in both digital and regular working spaces in Spain and Germany (Fernández-Macías et al, 2023), and the UNI Europa survey that collects specific information about use, risks and level of awareness associated with algorithmic management practices among trade union members in Europe (Holubovà, 2022). The AMPWork survey provides quantitative evidence regarding the use of digital tools and the nature and prevalence of algorithmic management in an economy and across sectors. However, this data alone is not sufficient to comprehensively understand the phenomenon and its implications on work processes and work organisation and how it impacts social relations in the workplace. Similarly, a survey helps us to capture more common digital tools that are often used in workplaces, and it is difficult to capture industry or sector specific digital tools, which are often used for work processes. To have a nuanced understanding of different aspects of algorithmic management practices in specific sectors, it is important to have complementary qualitative methods and approaches, centred on in-depth case studies. Thus, this study complements the available survey data and contributes to the advancement of knowledge in the field through a case study approach to generate new insights on the workplace dynamics as well as the organisational and structural changes following the adoption of algorithmic management.

1 To name a few, specific questions on algorithmic management procedures can be found in the European Working Condition Survey (EWCS) and the European Company Survey (ECS), both carried out by EUROFOUND, and the European Survey of Enterprises on New and Emerging Risks (ESENER) carried out by EU-OSHA.

There is a long-standing debate about the role and nature of workplace case study research against quantitative analysis. The quantitative oriented scholars tend to reduce workplace case study to a descriptive exercise (McGovern, 2020) with little influence on theory development. Case study research was largely used to find evidence by institutional labour economists, particularly in the United States during the 20's and the 30's, and was harshly criticised by later neoclassical labour economists for the absence of general principles (Boyer and Smith, 2001). In particular, neoclassical labour economists would use theory to draw hypothesis and conclusions to be tested empirically "to discover systematic behavioural tendencies, and comfortably relegate deviations from these tendencies to the "unexplained variation" of the error term" (Boyer and Smith, 2001; p.201).

However, in instances where it is difficult to conceptualise and identify a phenomenon, where taxonomies are absent, such as in the case of new and emerging forms of algorithmic control, and where workplace dynamics may be affected by general-purpose technologies that can easily miss the focus in analysing organisational facts, case study research offers a valuable avenue. Through the intensive observation of workplace interactions and the adoption of new tools, such research can provide theoretical insights that can eventually bridge the knowledge gaps between theory and reality in the workplace. Choudrie and Dwivedi (2005) examined research approaches to investigate technology adoption and found that the case study method is the most commonly used approach when analysing technology adoption issues at the organisational level. In a similar vein, this report uses case studies to have a better understanding of algorithmic technology adoption. This becomes even more crucial when new technologies are changing and shaping contemporaneously both the value chain of production and the dynamics of work organisation. Indeed, data and digital practices are at the same time the means and the outcome of production affecting both the production of capital-labour ratio and the workplace autonomy and control dynamics in the employer-worker relationship.

In this context, Labour Process Theory (LPT) has gained new attention as a valuable perspective for examining the numerous recent changes in work, employment, industrial relations and managerial control. Case study research holds a prominent position within the LPT body of research and is at the basis of several strands of literature over the past decade. Veen et al. (2020) adopt a labour process analysis within qualitative case study framework to unravel the features of capital's control in the food-delivery industry. Gandini (2019) uses LPT to study the managerial and organisation practice of digital labour platform and the process of work commodification by discussing the notions of 'point of production', emotional labour and control. Looking at the impact of algorithmic technologies in different sectors, Cini and Goldmann (2021) and Delfanti (2021) investigated the role of algorithmic technologies in retail, services and manufacturing and Flecker et al. (2013) look at the effects of production reorganisation along global production networks depending, among other factors, on codifiability of information. LPT also offers a unique set of tools to understand the rise of forms of workers agency, including organisational misbehaviour (Taylor and Bain 2016; Contu 2008) and process of solidarity formation and conflictual action (Atzeni 2010; Tassinari and Maccarrone 2020) and the application of new forms of control and value extraction that trigger the emotional performance of workers (Korczynski 2016; Ikeler 2015).

The case study approach that we have adopted in this report contributes to this body of research, and focuses on the use of technology to automate, to some extent, the processes of managerial control and decision-making within the three core managerial functions: direction, evaluation and disciplining of workers, considering the adoption of a wide range of technologies, as long as they influence the coordination of work.

The case studies focus on two sectors, logistic and healthcare. The choice of logistics follows the deep transformation witnessed by warehouses and storages in the last decade linked to digitisation and the deployment of algorithmic technologies in the organisation of both work and the physical space. Logistics could be considered the sector at the forefront of adoption of algorithmic management in regular workplaces. In contrast, in healthcare, algorithms and digital tools have been mostly introduced to improve services for patients (i.e. telemedicine, e-health, etc.) or to assist medical professionals in diagnosis and consultations, with little evidence so far of algorithmic coordination of work. However, the Covid-19 pandemic and the push for an immediate increase in efficiency during the emergency, have hastened a shift that was already underway, increasing the use of digital labour platforms for the provision of care services and the recruitment of medical staff, making algorithmic management in the healthcare sector a novel and important field to investigate.

The original design of this project involved carrying out two case studies per sector (healthcare and logistics) and country (South Africa, India, Italy and France), i.e. a total of sixteen establishments. Each case study was initially conceived to include a number of qualitative, in-depth, semi-structured interviews and field visits in an establishment using algorithmic management for the coordination of work processes, to be complemented by desk research as appropriate. The initial plan was to conduct at least 25 interviews with individuals in different functions and roles in each establishment (total of 200 interviews), including interviews with managers at different levels, union and worker representatives, technology specialists, and workers affected by the technology. As a first step, an outreach phase was conducted to identify two suitable establishments for each sector and each country.

During the outreach phase, the research team encountered a series of challenges and difficulties to identify suitable establishments where the case studies could be conducted. In the initial stages this was partly linked to the use of the narrow definition of algorithmic management practices as explained in the previous section. Furthermore, some of the establishments contacted were particularly concerned about confidentiality and the potentially sensitive nature of the research findings that may emerge from the study. This was particularly relevant for the logistics sector, which has recently been heavily criticised for deteriorating working conditions in both Italy and France. This sector has also been in the spotlight in South Africa and India. Additionally, in South Africa, we had to obtain permission from the National Economic Development and Labour Council (NEDLAC) which is the vehicle for tripartite consultation in the country, and for the case studies in the health and logistics sector, we had to get the ethical clearance from the University of the Witwatersrand Human Research Ethics Committee (HREC). It was agreed with all the participating establishments that their name and details would be anonymised, and for this reason the names of none of the establishments are disclosed in this report.

There were some challenges in accessing workers and managers in some establishments after the initial contacts were made in the outreach phase, which led to a reduction in the number of case studies conducted, compared to the initial plans. Eventually case studies were conducted in five establishments in France and Italy; and six establishments in India and South Africa (see Annex 1 for details on the outreach phase and fieldwork). The technologies considered in the cases selected in the four countries are very different in nature, as well as the degree of algorithmic management. However, all the cases analysed entailed noticeable implications on business models, work organisation, job quality, working conditions and digital monitoring.

The case studies draw primarily from qualitative interviews conducted with an ample range of key stakeholders, as outlined in the summary table of the interviews conducted - with roles and dates for the different case studies - provided in Annex 2. In addition, evidence from the qualitative interviews has been supplemented with information and documentation provided by the establishments. For the interviews, a semi-structured interview guide was designed around a set of core themes and questions to investigate the impact of algorithms and digital solutions on work organisation and working conditions. This framework includes the following main elements: organisation and coordination of work processes; business model and the delivery of services; occupational levels and implications for tasks, skills and productivity; job quality and working conditions; job profiles and skills; industrial relations and stakeholder consultation. The case studies were complemented with additional interviews with a broad range of stakeholders and qualitative data collection across different establishment and sectors, as well as with experts and technologists.

As previously explained, we believe that the case study approach, complemented by desk research and interviews with stakeholders, is the best available method to gain a thorough understanding of the deployment and expansion of algorithmic management systems in regular workplaces. We are nevertheless conscious that this methodology has operational constraints that need to be considered when interpreting the results.

Firstly, as described above the difficulties in the outreach phase have led to the development of fewer case studies than initially envisaged for France, Italy and South Africa. The reluctance of employers to transparently share their experiences and allow access to analyse the effect of algorithmic management practices on workers is, in itself, an intriguing research finding. This likely reflects not only a concern about unduly disclosing information internal to the establishment, but also potentially negative effects at a moment when such potential impacts become a highly topical issue in policy debates.

Secondly, the sample of case studies might be affected by self-selection bias. The large number of rejections by firms to conduct the interviews resulted in fewer options for a balanced and representative selection. It is likely that some of the establishments who decided to participate did so to promote their experience as "best practice", rather than from a neutral perspective. We find that the very fact that this was an incentive to participate is also inherently interesting, for the reasons mentioned earlier. However, even in these cases the access obtained to the establishments and the ample evidence collected in the interviews allows gaining an independent and objective understanding of the situation, including difficulties and challenges. We have therefore included these cases in the study too.

Thirdly, and partly related to the above, some of the evidence may be incomplete or biased and needs to be analysed and interpreted with this in mind. It is worth mentioning that the list of interviewees for each case study was previously agreed with the establishments. Moreover, interview guidelines were shared in advance to reassure the interviewees about the discussion topics. Finally, and perhaps most importantly, certain interviews took place in the presence of the establishments' hierarchy, and interview notes were validated by interviewees before being used for the research. This was particularly the case in Italian Logistics 1. In spite of these constraints, however, it was possible to gather robust evidence and insights in all the case studies conducted. The fact that even in these circumstances it was possible to obtain evidence of a negative impact on working conditions shows the need for further research and the potential magnitude of the challenges.

Fourthly, it proved difficult to ensure a broad range of profiles among the interviewees. In particular, interviewing trade union representatives appeared to be particularly challenging. Most establishments denied their relevance within the scope of the case study. To mitigate this, the research team expanded the interview list by conducting more interviews with workers. In some field sites, even when workers were impacted by technology, they chose not be interviewed due to sensitivity of the issue. As we discuss in the conclusions, this also reflects interesting developments with regard to the implication of workers and trade unions in introducing these technologies and shaping their effects.

Finally, the very nature of the technologies analysed makes it difficult for workers to fully appreciate their impact. As previously mentioned, the algorithmic management systems used in the regular workplace are rarely explicitly and directly used for the purpose of work organisation, and in many cases may be, at least to some extent, invisible to the workers. Since a big part of the information collected in the fieldwork ultimately comes from workers´ responses, this means that our picture of the impact of these technologies may be incomplete. To address this issue, we have tried to complement the worker interviews by conducting additional interviews with various worker profiles, including managers, technology specialists and experts.

3 Algorithmic management in the logistics sector

3.1 Overview of the sector

The logistics sector has been among the most profoundly impacted by technological advancements and economic restructuring over the past decade. In particular, the sector has been at the forefront of the digital transformation, often accompanied by the deployment of algorithmic management practices within regular workplaces. The main reasons for the adoption and implementation of algorithmic management in the logistics sector are closely linked with competitive pressures related to cost efficiency, timely deliveries, and the increased centralisation of control and monitoring through corporate governance structures. The latter appears to be the predominant driver behind the introduction of algorithmic systems (Cirillo et al. 2022). The use of technology for control and monitoring purposes includes wearables worn by operators, sensors, or radiofrequency identification (RFID) tags applied to goods. Moreover, algorithmic management software is utilised to oversee the production processes and evaluate worker efficiency (Gutelius and Theodore 2019). The logistics sector has also exhibited the use of algorithms for recruitment and for coordinating work processes in the warehouses. The deployment of algorithm aims to automate workforce management, encompassing direction and allocation, evaluation and disciplining processes (Wood 2021).

Firstly, for purpose of direction and allocation of the workforce, algorithmic instructions are communicated to workers through handheld or wearable digital devices. Workers, in turn, use scanners to instantly communicate operational details in real-time, while the wearable/handheld devices gather data on their pace and timing in executing tasks (e.g. pick-rate). This information enables central software algorithms to process data on factors such as location, distance, speed, etc., facilitating planning of tasks and directing workers to optimise the processes. Workers often possess limited autonomy to override or engage in discussions with supervisors, as data and algorithms have already defined these instructions in the (perceived) optimal way. Evidence of such practices was documented in warehouses in Italy and the UK (Delfanti 2019; Gent 2018). Furthermore, algorithms are employed for work allocation through management systems automating worker scheduling in the US warehouses, proving effective in managing short shifts and variable schedules (Oort 2018). In a warehouse study conducted in the UK, findings revealed the use of a smartphone app. This app directed delivery workers to check into warehouses at specific times and provided them with a GPS route for deliveries that was irreplaceable by alternative GPS maps for navigation (Gent 2018). Further, the app automatically paid workers upon successful completion of all deliveries, and if workers logged off from the app without completing their delivery duties the payments were withheld.

Secondly, data gathered by the handheld/wearable devices (e.g. pick-rate, breaks, errors, etc.) are used for evaluation purposes. This involves employing software to calculate productivity metrics and generate real-time rankings of worker. These rankings often compare daily performance against individual averages. Managers gain access to information on workers' performance in real-time and receive alerts when performance falls short of algorithm-calculated targets (Delfanti 2019; Gent 2018). These devices provide continuous real-time information on pick-rate, duration of breaks, and peak efficiency of the worker. Factors such as individual speed, productivity (pick-rate), accuracy, and errors are bundled together to assess worker performance (Wood 2021). Given continuous workplace monitoring, this system curtails workers' capacity to make autonomous decisions or deviate from instructions to avoid penalties or being punished (e.g. dismissal) (Todolí-Signes 2021).

Thirdly, while complete algorithmic automation of disciplinary functions in warehouses remains uncommon, these functions are increasingly augmented by real-time metrics and the calculations enabled by algorithms. These metrics and calculations inform and contribute to managerial decisions regarding disciplinary actions, including contract termination or cancelation of work shifts due to inadequate performance. Lecher (2019) documented instances of the automatic dismissal of low productivity workers in a US warehouse, which was executed without supervisor intervention. Nonetheless, he also underscores that human managers can intervene in this process. Similarly, there is evidence of AI-enhanced cameras on vehicles, which are used to monitor driver speed and behaviour, consequently serving as grounds for disciplinary measures, including terminations (Palmer 2021).

Box 1. The Logistic sector in Italy, France, India and South Africa

The logistics sector in France is highly sophisticated and strategic for the country. According to the French government, the logistics industry in France accounts for 10 per cent of the GDP, 150,000 firms, and 1.8 million jobs (four times as much as the automobile industry). Leveraging its four major international gateways (Le Havre, Dunkirk, Marseille, Roissy-CDG) and three vital strategic logistics corridors (Mediterranean Rhône-Saône, Seine and Nord), France enjoys an advantageous position in Europe, reinforced by a robust internal market, infrastructure, and remarkable innovation capacity. French global logistics players are increasingly investing in AI technologies. Moreover, in 2018, the French government launched the French National Strategy on AI (Stratégie nationale pour l'intelligence artificielle). Notably, from 2018 to 2023, the French government has allocated over 1.5 billion euros for AI development within the country, and an additional 500 million Euros from private co-financing invested in the technology sector.

The surge of investments in AI and algorithmic technologies has sparked a debate on the effects of these new emerging digital technologies. Trade unions and French regulatory authorities have put algorithmic management practices under scrutiny (CNIL, 2017; Salis-Madinier, 2021) and recently, workers' mobilisation and protests have emerged against the role of algorithmic management and its adverse impacts on working conditions (Abdelnour and Bernard, 2018). Particularly noteworthy within the logistics sector, these mobilisations have held a significant place (Massimo 2020a; 2020b; Dirringer and Nizzoli 2022).

The logistics sector in Italy is characterised by a relatively high degree of outsourcing (40 per cent in Italy versus 10 per cent in Germany). The largest companies frequently resort to subcontracting, entrusting various warehouse activities to third-party suppliers (predominantly cooperatives). The supply of logistics services is quite fragmented, with a very high number of operators, which are mostly small or medium-sized companies specialising in basic services, such as warehousing. Smaller companies however generate significant turnover and offer a wide array of value-added services, such as order management and preparation, picking, additional processing, inventory management, distribution and returns handling. According to the Observatory Contract Logistic of University of Milan, the logistic sector turnover in 2022 reached 92 billion Euro and 32 per cent of the companies are investing in automation. This is particularly noticeable in warehouses, where advanced sensors and fleets of robots are deployed for internal handling. A smaller proportion of companies are also using data analytics and AI to make real-time predictions and conduct scenario evaluations. An overwhelming majority of the workforce is registered as self-employed: 56 per cent in 2012 and 52 per cent in 2015. Cooperative societies are one of the key actors in this sector, who recruit workers especially for outsourced warehousing activities, namely the couriers and messenger segment (7.4 per cent of enterprises in 2015 versus 6.8 per cent in 2012). Typically, these micro-firms are integrated into the highly internationalised supply chains and may oversee the entire logistics chain on behalf of the client, qualifying as integrated logistics partner or lead logistics provider.

The logistics sector in South Africa is highly sophisticated and advanced, and is classified as a "logistics overperformer" (Ittmann and King 2010: 3) in comparison to countries with similar income levels and those within the sub-Saharan African region. The integration of digital warehouse management systems is a growing trend across South Africa. It encompasses various domains from e-commerce to road-freight and logistics and facilitates precise monitoring of product storage and deliveries, additionally enabling projections of consumer trends. The aggregate turnover for the logistics industry, including warehousing and transport in retail and manufacturing, is estimated to approximate Euro 24 billion (GAIN Group 2020). As digital technologies play an increasingly central role in shaping the supply chain and logistics sector (ibid), prominent industry players have committed significant investments in digital architecture and automation systems as part of their overall consolidation strategy (Imperial, 2021), with implications for the workforce. GAIN Group (2020) highlights the insufficient digital technology skills within the logistics labour force, and they posit that the inevitable adoption of these technologies will likely curtail demand for lower-skilled jobs in the sector, necessitating upskilling to mitigate adverse employment outcomes. According to Barloworld Logistics (2021), the conventional warehouse picker of the past is poised to transform into "a Warehouse Management System (WMS) operator, or machine operator, or technician in the future" (Barloworld Logistics 2021).

In India, warehouses play a crucial role in managing the supply-chain, encompassing various phases from manufacturing to reverse logistics, particularly in the retail sector. Notably, grocery retail accounts for more than 68 per cent of the overall market. The Indian grocery retail market is dominated by small local shops which hold a market share of over 75 per cent, supermarkets, constitute approximately 12-15 per cent of the grocery market and online grocery companies, with home delivery services, have a smaller, but expanding, market share of around 5 per cent. Amidst the flourishing online grocery market, the public sector in India continues to play a significant role in supplying essential household staples. The National Food Security Act (NFSA) 2014 mandates that 75 per cent of the rural and 50 per cent of the urban population be provided with 5 kg of food grains per person per month. Although the basket of groceries distributed through the public distribution system (PDS) is minimal in comparison to the online retail grocery market, the PDS grapples with distinct challenges on account of its scale of operations, including procurement, storage, and distribution. To address these challenges, the government has introduced digital technologies within the PDS, including warehouse management systems, designed primarily for inventory management. Given the substantial operational scale and the challenges encountered, the PDS presents an intriguing context to explore the role of digital technologies and algorithmic management practices within warehouse operations.

Source: own elaboration

3.2 Profiles of case studies

In Italy, the first establishment chosen within the logistics sector (Italian Logistics 1) is a fulfilment centre (FC) that employs advanced robotics technology integrated with algorithmic management capabilities. This company's logistics network utilizes FCs as the first step after a customer makes an order on their website. These FCs serve as expansive warehouses, managing all the logistics processes of the product (e.g., receiving, storing, preparing for shipment, picking, packing, and loading onto trucks) for items sourced from the company's e-commerce platform. The FCs handle a variety of items, including (i) products owned, sold, and shipped by the company, (ii) products owned by third-party sellers but sold and shipped by the company, and (iii) products owned and sold by third-party sellers but dispatched through the company. The selected FC, operational since September 2021, has been intentionally designed to accommodate robotics technology from its inception, therefore a comparison between pre- and post-implementation scenarios is unfeasible. Consequently, both workers transferred from other centres and new recruits were well-informed about the incorporation of robots within the establishment. As of February 2023, the centre employed 1,021 individuals with permanent contracts. Among them, 106 employees were in managerial positions. The workforce comprised of a substantial number of women and non-Italian employees, albeit with a basic command of Italian for safety purposes. The recruitment of warehouse workers is managed directly by the company or through recruitment agencies. While most workers hold permanent contracts, a small proportion of the workforce, engaged during peak periods, operate on short-term or temporary contracts. Many of the workers involved during the establishment's launch phase came from other locations. In the case of the chosen FC, workers were notified about the forthcoming opening of the new establishment, allowing them to voluntarily apply for new roles at the FC.

The second selected establishment within Italy's logistics sector (Italian Logistics 2) is a mail distribution centre owned by a large semi-public postal service. This centre employs 32 employees, mostly with permanent contracts, except for three workers who are on fixed-term contracts. On average, the facility sorts approximately 1,000 pieces of postal mail and 186 packages per day. The centre operated from Monday to Saturday, from 6:00 a.m. to 8:57 p.m., with two work shifts. Postmen are equipped with 2 electric tricycles, 2 endothermal tricycles, and 18 cars to carry out their tasks. This establishment was chosen due to its pilot implementation of an innovative algorithmic technology, known as the dynamic Driven Sorting Mail algorithmic technology (referred to as dynamic DSM technology). Based on the pilot performance, there are plans to expand the utilization of dynamic DSM technology to other sites throughout the country.

In India, the first case study involves a private warehouse (Indian Logistics Private 1) that examines both central and local warehouses of the establishment. Operating on a hub-and-spoke model, this warehouse system comprises a central warehouse and multiple distribution centres serving a radius of 15-20 kilometres. Migrant workers constitute a significant part of the workforce and approximately 20 per cent of workers are women. The second Indian establishment (Indian Logistics Public 2) pertains to the public distribution system, incorporating a chain of warehouses responsible for distributing food grains to retail outlets, subsequently reaching households. In this process, warehouses employ fundamental digital technologies, such as computers, for procurement, stock management, and program administration.

As elaborated in Annex 1, suitable case studies were unfeasible in France and South Africa, thus, the analysis was supplemented by interviews with relevant stakeholders, and interviews with workers and managers in multiple companies.

3.3 Use of digital technologies

The case studies analysed in this chapter demonstrate the use of different types of technologies and algorithmic management practices to improve the work organisation and ensure timely delivery of services. The technologies used differ across the select countries. In India and South Africa, the use of digital technologies is less integrated to systems and supply chains, and there is limited presence of advanced elements like the Internet of Things (IoT), in comparison to Italy and France. Nevertheless, a noteworthy trend in all countries analysed is the substantial adoption of digital technologies aimed at streamlining operational processes such as receiving, stacking, and picking functions. The primary motivation for this adoption is the compelling need to reduce delivery time, largely attributed to increased competition among establishments.

Two broad types of technologies and practices can be identified for the case studies analysed, which are used at different stages of the processes. These are 'specific-purpose digital technologies', which are designed and developed for a specific function or application, and 'general-purpose digital technologies', which, in contrast, have a wider application, and can be adapted in different situations and are highly flexible.

3.3.1 Specific-purpose digital technologies

Robotics: The robotics technology examined in *Italian Logistics 1* comprises both hardware and software components. The hardware component encompasses the physical robots, while the software part incorporates a spectrum of underlying technologies, predominantly driven by algorithms that facilitate the robots' operations. In this chapter, we focus on the software segment, particularly its reliance on algorithmic software, which is utilised to support workers during storage procedures in the warehouse. This aspect is deemed more pertinent as it delineates how robots navigate the warehouse and interact with the workforce. The fulfilment centre (FC) comprises three floors, with approximately 2,000 robots and 20,000 pods operational across two of these floors. The ground floor is dedicated to overseeing reception and packing phases, while the first and second floors house the Robotic Storage Platforms (RSP), where the technology orchestrates stowing and picking operations.

The technology consists of automated guided vehicles (AGVs), which assist workers by facilitating the movement of shelves around the FC for more efficient storing and picking processes. The company's system encompasses three main physical components: mobile shelving units, robots, and employee workstations. Robots are responsible for transporting mobile shelving units to designated stations, where employees follow the guidance of the software and robots to either retrieve items (picking) or place them (stowing). Items are stored on portable storage units, while workers operate from fixed workstations. The technology empowers robots to navigate the RSP and shift shelves by interpreting QR codes affixed to the floor. Subsequently, robots guide pods to the appropriate shelves and, with guidance from the system's updated coordinates to the nearest available position, which is then managed by operators.

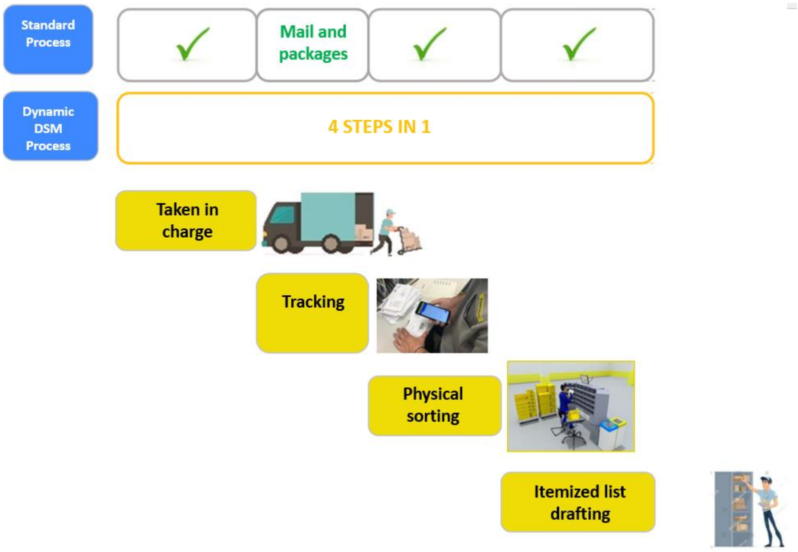
During the picking phase, when an order is registered within the database system, the software promptly identifies the robot closest to the target item and issues directives for its retrieval. Upon reaching the intended location, the robot employs a corkscrew manoeuvre to slide beneath the shelf and lift it using an upward motion. Subsequently, the robot transports the shelf to the designated worker assigned to item picking. This worker operates from a workstation equipped with a computer and a scanner. The computer interface displays the item's image, name, barcode, and precise location for picking. To expedite the process, a focused light highlights the exact bin containing the required item. This illumination aids the worker in swiftly locating the item on the shelf, scanning it, and placing it into a tote. The tote is then routed onto a conveyor system, destined for the packing department.

Conversely, when handling item storage, the sequence is reversed: the designated storage worker operates from their workstation, furnished with a rack accommodating totes filled with items awaiting storage. The worker scans the item and places it within the bin on the shelf. An AI-equipped camera aids the process by indicating the optimal position for item storage.

Distributed system management technology: The dynamic Distributed System Management (DSM) technology, used at *Italian Logistics 2*, features a dynamic routing technology that has been externally developed and subsequently tailored to the needs of the establishment. Though not primarily designed for coordinating work processes, its initial implementation holds implications for the establishment's operations.

The technology is deployed for the last-mile delivery operations and affects the daily work of postmen. Prior to the introduction of the dynamic DSM technology, registered and insured mail items underwent four manual handling phases: (i) acceptance, (ii) allocation, (iii) physical sorting, and (iv) list preparation.

Figure 1. Dynamic Driven Sorting Mail flow



Source: Open Evidence

With the new technology, all four tasks are integrated into a single step: scanning the product encompasses acceptance, allocation, inclusion in electronic itemised list indicating which products need to be delivered i which place, and where the products need to be shelved. The updated dynamic DSM technology version generates itemised lists for both base and business lines simultaneously, strategically designing during the initial taking-in-charge phase an optimised itinerary for the delivery of the products. Thus, by using the dynamic DSM technology, there are no pre-established divisions between base and business lines, as the creation of itineraries is updated and revised until the very last calculation step before being handed over to postmen. Before the introduction of the technology, with the standard process, postmen were in charge of (i) manually partitioning all the mail and packages according to the different delivery areas and priority; and (ii) manually tracing the itinerary to follow for the delivery of mail and packages. Therefore, postmen were supposed to know the delivery area in their scope of work very well, including the single streets and house numbers. Now, these two tasks are carried out directly and automatically by the dynamic DSM technology, which has replaced the standard process. While the technology creates the list of stops, human worker can still add additional stops to the list, if the system failed to register an item. Once the itinerary is created, postmen do not modify it but print it as generated by the technology. However, they retain the autonomy to deviate from the suggested travel route while driving around for the delivery of items.

AI-Powered Route Planning tools: The French logistics sector has witnessed a surge in the incorporation of AI tools in recent years, driven by advancements in machine learning, computing, and big data. Stakeholder interviews reveal that some of these tools, while not directly designed for work coordination, do have work-related implications. In particular, AI-Powered Route Planning tools have emerged as a technology with algorithmic management elements. These tools empower the transport and logistics domains to synthesize information from multiple sources, enabling informed decisions on travel routes. This resource equips drivers with vital insights prior to and during their delivery journeys, as well as when planning future routes. This includes information like road traffic, delivery locations, count and disposition of delivery areas, parking site availability, parked vehicle types, parking zone durations, and parking area attributes. It is imperative to acknowledge, however, that these tools can also lead to extensive monitoring and surveillance of drivers.

Inventory/Warehouse Management Software: In large warehouses in South Africa, inventory or warehouse management software is utilized by the managers on their laptops, and it helps to determine the total number of incoming daily orders, data that subsequently informs department managers and supervisors about staffing requirements for shifts to accommodate these orders. This allows the managers to have a discretion in staffing decisions about the number of workers in a shift, and during weekends and peak times allows them to hire workers through labour brokers.

Mobile scanning app (Scanner): In the South African warehouse a locally-developed mobile scanning app is used. This software integrates seamlessly with the workers private mobile phones, empowering drivers and depot personnel to efficiently scan parcels during loading onto trucks and offloading at depots. The app's functionality extends to parcel categorization based on their intended destinations across the country, effectively sidestepping manual consignment procedures. The electronic repository maintains delivery records, including scanner-validated proof of delivery, while allowing clients online access to electronic documentation. At the same time, the software includes a monitoring component that tracks the amount of time spent by the driver on their tasks. A supervisor is responsible for monitoring drivers' kilometres covered and fuel consumption, with weekly performance review meetings scheduled to discuss their performance targets. This emphasises how digital technology coordinates tracking and tracing along delivery routes, while aspects of performance evaluation and management are partially automated with human intervention and control. In addition, the scanner practically handles everything within the facility. It is used to designate a location. It is used to communicate with a customer to inform them when the parcel that has been dispatched will arrive. It helps the pickers and packers in distinct ways. Pickers employ a scanner alongside an app that instructs them on which items to retrieve from specific warehouse locations. The app provides them with location information, and they proceed to collect the items accordingly. These items are then placed in a tote, which is subsequently transported on the conveyor belt to the packers. The scanner operates efficiently, either reading barcodes on individual items or scanning a QR code on a container that holds multiple items.

Hand-held devices: In *Indian Logistics Private 1* handheld devices equipped with scanners are deployed on the shop floor of both central and local warehouses, aiding workers in efficient storing and picking operations. All three functions - receiving, stacking, and picking - are managed using handheld devices. Task allocation, micro-directions, and work monitoring occur through these devices, facilitating seamless coordination. The handheld device bridges data flow, not only across the three functions but also aids supervisors in real-time to monitor workers.

In the central warehouse, workers begin their shift by verifying their identity through their handheld device. The order allocators assign picking tasks to the workers, who are stationed at a kiosk and use a computer to distribute large orders into smaller tasks based on experience. Using a trolley and handheld device, pickers navigate the warehouse and select items according to system instructions. The handheld device also tracks worker productivity, setting a minimum threshold to be met. In the local warehouse, automated order allocation eliminates the "order allocator" role. Pickers manage multiple orders through a technique called multi-order picking, employing a multi-tiered trolley for up to six baskets. This approach is akin to a simplified traveling salesman problem where each location is visited only once. While central warehouse pickers have a daily pickings target, local warehouse associates are evaluated based on hourly picker productivity, as they perform other tasks beyond picking.

3.3.2 General-purpose digital technology

Instant Messaging applications: WhatsApp Chat groups constitute the linchpin of all internal communication, fostering connectivity across lower-level employees, management, and operations managers and CEOs in both large and small warehouses in South Africa. Workers did not report the use of instant messaging applications through Chat groups in the Italian case studies. This may be due to the relatively higher level of technology adoption, leading them to forego the use of private communication channels. It could also be influenced by the fact that one of the cases concerns a prominent logistics player in Europe, which prohibits workers from using their mobile phones during working hours.

3.4 Business model and work organisation

The main motivation for the introduction of digital technologies in the cases analysed is to enhance the effectiveness and efficiency of the companies' business model and to improve service delivery. All cases reported the use of algorithmic tools to optimize their operations and improve efficiency, reduce costs, and enhance customer satisfaction. Both the South African and Indian cases show the growing demand for track and trace functionality has driven the implementation of digital technologies in the warehouses.

3.4.1 Streamlining work processes to improve productivity

The introduction of specific-purpose digital technologies has helped to standardise the processes in the selected establishments, resulting in a simplification of tasks and better management of the scheduling and allocation of human workers. This leads to increased flexibility as well as productivity and efficiency gains. Indeed, this allocation is preliminarily done automatically and casually by a system retrieving data from either the robotics technology or the deployment of warehouse management systems, which are able to provide an overview of the volume of products stowed and picked in the establishment. Then, the team leader or a manager may decide to adjust the system allocation if deemed necessary on the basis of inbound and outbound volumes. The allocation of workers across the different processes is facilitated by the technology which suggests where to allocate the worker. This, in turn, results in an increase in clients' satisfaction as the items are delivered in a short time, which is the goal for all the establishments analysed. Some of these mechanisms are outlined in box 2.

Box 2. Standardisation of processes and efficiency gains in the logistics sector

- Standardisation in terms of roles and tasks and automation of task assignment: Algorithms are used to empower workflow applications that allow workers or robots to self-check-in parcel tasks.
- Routing and scheduling: By leveraging algorithms, logistics companies can optimize routes and schedules, leading to improved delivery times and cost reductions. This optimization often involves analysing data on traffic patterns, weather conditions, and delivery destinations to determine the most efficient routes.
- Inventory management: Algorithms enable real-time monitoring of inventory levels and provide recommendations on reorder timings and quantities. This proactive approach helps logistics companies avoid stockouts and minimize wastage.
- Quality control: Algorithms are employed to monitor and analyse data from sensors and other sources, facilitating real-time identification of quality control issues. This can help logistics companies identify and address problems before they escalate into customer complaints or necessitate product recalls.
- Predictive maintenance: Algorithms use data from sensors and other sources to predict equipment failures, allowing logistics companies to schedule maintenance proactively. This minimizes downtime and prolongs equipment lifespan.
- Customer service: Algorithms analyse data on customer preferences and behaviours to personalise customer service interactions. This personalisation can encompass product or service recommendations, tailored offers or discounts, and real-time responses to customer queries.

Source: own elaboration

A warehouse worker interviewed explained that the system's automatic allocation of workers to the different tasks, such as stowing, picking and packing, is of great help to their workflow.

> *Thanks to the technology, we do not have to allocate resources across the different processes taking place in the establishment manually. This allows us to save time, which can be spent to make adjustments to the allocation or to carry out other tasks. However, these adjustments are not to be made often, as the technology is sufficiently precise.*
>
> *Italian Logistics 1*, Warehouse Worker 3

According to a General Manager interviewed at *Italian Logistics 1*, the technology is able to provide more accurate data related to productivity, in particular the number of orders to be elaborated and the volumes of items stowed and picked. This data can then be used to manage the workload of warehouse workers. Indeed, the interviewee affirmed that data elaborated thanks to the robotics technology helps to understand the volumes processed in the establishment and, thus, the overall productivity.

> *Thanks to the technology, we have an overview of the inbound and outbound volumes to be processed, which allows us to understand how many workers we need to cover the different processes in different times. This is also key to plan the off-work time of our warehouse workers and to guarantee sufficient coverage during peak times.*
>
> *Italian logistics 1,* General Manager 1

We could not investigate the aspect regarding whether the use of such system increased productivity or not from the interviews carried out at *Italian Logistics 1*. However, according to Cirillo et al. (2022) who also conducted case studies of warehouses, there is evidence of increased productivity, which is associated to increased work intensity, i.e., there is 25 per cent unit stowed per hours, while press sources report that the increase is more than 200 per cent unit picked per hour.

At *Italian Logistics 2*, the increase in parcel volumes urged the need to make postmen's itineraries more efficient. According to the IT specialist the adoption of the dynamic DSM technology led to optimizing long-distance travel times, minimizing vehicle usage, and eliminating redundant tasks, which triggered a significant transformation in internal workflows, resulting in a comprehensive restructuring of worker organization within the centre and substantial reduction in mail delivery processing times. According to the workers' representative interviewed at this establishment, the dynamic DSM technology significantly increased worker efficiency and productivity by giving them greater autonomy over time management. With this technology, postmen have the flexibility to prioritize tasks more effectively, utilizing the time saved. It's worth noting that while postmen now serve a broader territory, the technology hasn't led to additional task assignments.

> *In light of the time saved, postmen can now deliver a higher number of letters and packages, and can do that with more confidence as they do not have to struggle to think about the itinerary to follow. Usually, they are also more lucid as they make fewer efforts in the preparatory phase.*
>
> *Italian Logistics 2*, IT Specialist 1

3.4.2 Impact on jobs and skills

The impact of these technologies on job losses is complex and varies across the different cases analysed. Specifically, the Italian case studies do not reflect work disruption or widespread replacement of human labour with machines, but rather a reallocation of certain labour-intensive tasks to technology, allowing human workers to dedicate more time to higher-value activities and fostering collaboration among colleagues. This aligns with findings from Cirillo et al. (2022), who similarly found no significant labour displacement due to the adoption of automation technologies in a comparable case study. However, it is noted that the introduction of automated guided vehicles (AGVs) did lead to a reconfiguration of specific tasks, particularly those formerly carried out by forklift operators. Notably, this reconfiguration varied across plants, primarily influenced by the level of AGV integration into the work process. Conversely, in France, interviews with stakeholders emphasised how algorithmic management systems in warehouses streamlined monotonous tasks, enhancing operational efficiency and cost-effectiveness. The use of such systems is seen by stakeholders to have disrupted the workplace by making certain warehouse jobs redundant and other engineering and managerial jobs more important.

In the South African context, concerns arose about potential job losses due to the integration of digital technologies. However, a dispatch controller within a South African company shared that they had not witnessed any reduction in employment; on the contrary, there had been a noticeable rise in the workforce, predominantly driven by a significant increase in workers from the labour brokering agency. The company's expansion, coupled with the accelerated growth of e-commerce, particularly during the COVID-19 pandemic, accounted for the increase in employment. The only factor that affected the number of people working was the order sizes, or the "volume" of orders, according to a dispatch supervisor.

The case studies also present mixed evidence in terms of **redefinition of tasks and roles**, depending on the specific country context. In certain instances, the adoption of these technologies has created new specific roles that did not exist before. While no restructuring of the work organisation within the establishment is directly reported in terms of roles, hierarchy, number of employees involved, rules and procedures, there have been considerable changes in the nature of tasks carried out by operators.

In the context of *Italian Logistics 1*, it was pointed out multiple times during the interviews that the deployment of the robotics technology requires specialized teams responsible for interacting and maintaining the robots, with specific roles within robotics sites (e.g., Amnesty Floor Monitors). The development of the new technology necessitated the recruitment and training of new personnel, whose roles were not previously required in traditional establishments.

In France, insights from stakeholder interviews illuminate how algorithmic tools within the logistics sector influence worker tasks and competencies. This impact extends to various dimensions, including:

- Technical skills: The use of algorithmic management tools requires employees to have technical skills to operate and interpret the data generated by these tools. For example, logistics workers need to be proficient in using warehouse management systems, inventory management software, and other similar tools to manage and optimize their work.
- Analytical skills: The data generated from algorithmic management tools provides valuable insights into the performance of logistics operations. As a result, the logistic workers need to have analytical skills to interpret this data and make informed decisions based on the insights gained.
- Communication skills: Algorithmic tools are changing the way logistics workers communicate with each other and with their superiors. For example, some companies use chatbots to communicate with their employees and update them in real-time, necessitating an adeptness in new communication channels.

- Adaptability: The use of algorithmic management tools requires logistics workers to be adaptable and flexible. They need to be able to quickly learn and adapt to new tools and processes as they are implemented.
- Multitasking: Automation of routine tasks are helping logistics workers to become more efficient and productive. As a result, workers need to be able to multitask to maximize their productivity.

In South Africa, the introduction of technology did not entail alterations in job roles or functions for existing workers. While training was provided to familiarize workers with the technology, their roles remained unchanged. Interviews with workers in a large South African warehouse revealed that while job tasks remained largely unchanged, the use of scanners and apps introduced additional steps. A worker noted that "*Whatever I was doing manually is now written into the system*," (*South Africa*, Worker 1). However, some workers expressed grievances about the need to scan and consult the app at each step along the process, which they would have previously handled without the technology. The workers in South Africa also felt that they were not compensated enough for the stress and effort required to use technology, especially the scanner, which had a significant impact on the pickers. One major point of contention was the classification of workers:

> *The complaints we receive from the pickers are that they use machines for scanning and driving the BT forklift, but they are not classified as operators. They are seen and paid as general workers, which is not the case. When you are too slow, you are still accountable. They account for the work they do but they are not getting paid and recognised for what they do, and they are put down*".
>
> *South Africa,* Worker 7

This seems to point towards a mismatch between occupational profiles and tasks and skills level. The shop steward argued that since these general workers operated machinery, including the new BT forklift machines and the scanners, and were held accountable for errors they made due to this technology, they could not be categorised as general workers, a term typically associated with manual labourers only. Further, workers also felt that while they are indeed being upskilled, their efforts are not being recognized or financially compensated for their work. Workers also expressed some frustration over decision-making, as with the use of the app they could not take decisions:

> *The machine will say you can't move that to here without telling me, now I must go via the app. Sometimes I am stressed, I don't even know which option to choose. For instance, there is a new app that they are using at dispatch…. That app is limiting you to a certain number of parcels you can scan into a cage. Once it reaches 50 it does not allow you to scan another box, and you have a lot of boxes still. … So, if you reach 50, let's say it is small boxes when your cage isn't even full, the app does not allow you to fill the cage. So, they are frustrated, why must I stop now, when there is space?"*
>
> *South Africa,* Worker 1

Regarding the technology's impact on workers of different ages or experience, there was some resistance from older employees at *Italian Logistics 2*. There was no differential impact on gender in the Italian establishments. At *Italian Logistics 1,* robots handling strenuous tasks enabled female employees to carry out picking and stowing activities without hindrances or discrimination.

3.5 Job quality

The findings in terms of job quality are diverse and, in some cases, inconclusive due to methodological constraints. In general, there are also significant differences in the case studies in South Africa and India. While, there is clear evidence of a negative impact on job quality in South Africa, and a similar potential of it in the future in India, it is difficult to discuss about the findings on job quality in Italy and France. In the Italian case studies, this may be due to the pilot nature of the *Italian Logistics 2* case and, in *Italian Logistics 1*, the impossibility to interrogate all workers and management about changes given the greenfield nature of the plant and the presence in person of a supervisor during the interviews.

3.5.1 Work intensification

The efficiency gains that are observed can also create the conditions for possible increases in work intensity and eventual labour displacement in the future. However, the final outcome will depend on techno-organizational capabilities of the firm and the type of strategic orientation versus technological adoption, as well as market conditions, industrial relations and other regulatory and political economy factors.

Interviewees reported that the adoption of the technologies at *Italian Logistics 1* have led to safer working conditions by reducing the physical strain on workers, consequently lowering fatigue and stress levels. Workers agreed that the distinction between traditional and robotic establishments is evident in terms of the physical demands placed on employees and, consequently, their levels of fatigue and stress.

> *The Robotics technology eases the work we have to do since robots carry out the heaviest tasks. The workload and the fatigue are significantly reduced, not to mention the time saved thanks to this technology.*
>
> *Italian Logistics 1*, Warehouse Worker 1

Nevertheless, centralised algorithmic control presents a potential for work intensification in Italy and France. In the cases analysed in this study the introduction of the technologies has not directly led to a reduction of working time quality. As already mentioned, Cirillo et al. (2022) found in their case study evidence of increased work intensity, wherein workers reported that they stowed about 25 per cent unit more per hour. Furthermore, their case study for similar warehouses in *Italian Logistics 1* reveal that the elimination of walking for workers removes their ability to control the pace, as they no longer control the arrival of the robot, which can bring about work pace intensification.

Work intensification is clearly observed in the companies in India and South Africa. Moreover, the implementation of algorithmic management for tasks like picking and packing through the hourly productivity rate also adds pressure on workers and significantly impacts their earnings. For instance, in South Africa, workers are forced to go outside the premises to use the toilets and biometrics records are used to monitor when the workers come and go from breaks. They need to pass security and get searched every time they get in and out, even for lunch breaks making the place work as a "prison" as described by one worker. The time spent using the toilet is not paid and, workers reported that time was used as a means of exerting control and workers often received instructions from the inventory clerk, that they had to stay late:

> *And then by five they will tell you that no, you're going home at eight. ... They'll tell you, no, we have a target now we have to work until eight. And it's not like they are begging you or they ask you, nicely, they are telling you that you have to stay up until eight. Because now we have to [make] the target.*
>
> *South Africa*, Worker 2

On the other hand, sometimes workers were let off early, without pay:

> *Sometimes still there's no guarantee you work until late. Sometimes they can chase you [let you off] around 1 o'clock. So, you didn't make anything for a day....You didn't make a rate... You're going home early, they chase you 1 o'clock, but sometimes you work until later.*
>
> *South Africa*, Worker 4

Workers perceived these changes as punishment. Additionally, there existed significant pressure on the pickers, as the main elements of surveillance appeared to be directed towards them.

Work intensification was quite high during peak season in specific times of the year. In the smaller firm in South Africa, the daily target for pickers was set and measured by the amount picked in tonnes and they were constantly under surveillance. The pickup rate was occasionally changed without prior consultation with workers, and the group of workers for the shift were held responsible for meeting the targets, rather than individual workers. A worker noted that:

> *For example, we may normally pick 500 tonnes in a day, but then it increases to 1000 tonnes. They just want to push it, so there must be that target, and that's when it becomes a problem. Because of the approach...you guys are increasing the target but not increasing the staff. They just say 'do it, we will see when we stop', and then we become the problem, and it's a thing of 'you guys don't like to work*.
>
> *South Africa*, Worker 7

3.5.2 Lack of autonomy

In Italy and France some of the technologies analysed have the potential to reduce workers' autonomy, although in contrast with other studies, interviewees' replies did not show this. Both warehouse workers and postmen interviewed in Italy place significant emphasis on worker autonomy. In both cases, it was stressed that the technology simply offers indications and not a binding assignment, hence leaving a wide margin of manoeuvre to workers when carrying out their tasks. Some interviewees emphasized that autonomy could be enhanced as the technology enables engagement in more intellectually challenging tasks. Additionally, according to some interviewees, these technologies do not prescribe orders to workers; instead, they offer "suggestions" and "advice," providing support for their daily activities. At *Italian Logistics 2*, due to its pilot phase, the technology might display some inefficiencies in itinerary planning, prompting postmen to independently make changes to the system's recommendations. Consequently, human decision-making remains essential at this stage.

Nevertheless, it is plausible to argue that the instructions or guidance provided by the algorithmic systems analysed might occasionally be so precise and detailed that they leave minimal to no space for human autonomy. For instance, the light illuminating the bin in *Italian Logistics 1*, which indicates the specific bin for item placement in warehouses offers workers a highly precise direction to be followed. Likewise, it is highly unlikely for a postman to deviate from the route suggested by technology in the case of *Italian Logistics 2*. The contrast with findings on this aspect from other studies might partly result from the way in which interviews were conducted, particularly when supervisors were present, as elaborated in the methodology section. Nonetheless, in *Italian Logistics 2*, the use of technology could potentially reduce employee autonomy due to predetermined delivery routes that sometimes seem counterintuitive – like passing a residence during an initial visit to the neighbourhood only to return later for delivering a package. The increasing use of these technologies has the potential to alienate workers from their decisions, as it curtails their flexibility and independence in deciding how best to achieve their tasks.

In the Indian and South African cases the role of human decision-making also remains prominent. At the *Indian Logistics Private 1*, the value of human agency is acknowledged as a positive contributor to improved outcomes. Consequently, while the process of order allocation within the local warehouse is automated, the order allocator in the central warehouse plays a crucial role by bringing in their tacit understanding of the pickers. Additionally, the warehouse relies on supervisors' tacit knowledge to identify high-performing individuals among pickers, stackers, and receivers for monthly recognition. Although worker and supervisor performance data are available and considered, decisions aren't solely reliant on data. Further, in the context of *Indian Logistics Private 1*, even though management systems can automatically generate worker shift schedules, the company often opts to retain the decision-making authority with human managers and supervisors and does not use the automated function. According to an Indian entrepreneur working on robotics for warehouses, the heterogeneity in size, shape and weight of Stock Keeping Units in an e-grocery warehouse makes it challenging and prohibitively expensive to design robotics-based automation solutions. He opined: "*In a country like ours where cheap labour is available, the only algorithm that works is adding more people".*

3.5.3 Monitoring and surveillance of workers

The technologies analysed create the conditions for monitoring and surveillance of workers, with the possibility to check their performance and compare it against pre-defined algorithmic benchmarks. This, in turn, creates the conditions for a centralisation of knowledge and control as they embed a strong potential to collect a wide range of data to control and monitor workers, thus potentially shifting the power balance within the organisation towards management. The huge potential for data collection and processing of the digital technologies analysed and the fact that there is evidence that such data – including on the productivity of workers and their work schedules for example - is already being used and analysed by managers while remaining largely inaccessible to workers shows the risk of further reinforcement of managerial power that could materialise in the future and negatively affect workers. It is important to note that workers expressed different degree of concerns in this regard. In the Italian case studies in *Italian logistic 1,* workers were interviewed at the presence of their supervisors, while the technology of *Italian logistic 2* was not yet used at its full potential as it is still on a trial phase. In Italy and France, prevailing regulatory safeguards seem to mitigate significant effects at present, while in South Africa and India, worker monitoring and surveillance have already become a reality.

According to the workers interviewed during the case studies in Italy, the implementation of algorithmic technology at *Italian Logistics 1* and the integration of dynamic DSM technology at *Italian Logistics 2* did not directly change the way they used to assess or evaluate workers' efficiency and productivity. Notably, at *Italian Logistics 2*, the standardization of processes appears to have resulted in reduced monitoring of postmen's tasks, as the technology takes over the validation role formerly performed by the Site Manager.

However, when receiving their optimized daily delivery itineraries, postmen at *Italian Logistics 2* now receive specific time slots for each delivery, as determined by the algorithm. While these algorithm-generated timings are intended as guidelines and no direct enforcement exists for postmen to adhere to them rigidly, the conditions are in place for such adherence to take shape and materialise in future. Notably, at *Italian Logistics 2*, the foremost priority is delivering items to recipients, even if this means extending postmen's work shifts. While this aspect is not formally evaluated for performance, the technology does afford the flexibility for this to occur. An HR Manager explained that the technology indeed permits the measurement of productivity indices, yet, as mentioned by the Public Policy Manager, the evaluation criteria are standardised and are similar to those used in traditional FCs.

> *Performance evaluations are done by department and are of qualitative nature, done by managers on the basis of what they see with their own eyes, not by a software on the basis of data produced by an algorithm.*
>
> *Italian logistics 1*, Public Policy Manager

It has been emphasized that these criteria are primarily on work quality rather than the sheer quantity of items processed, with due attention to adherence to safety protocols. Nevertheless, certain discrepancies emerged during the interviews. For instance, within *Italian Logistics 1*, one warehouse worker mentioned the existence of a quantitative daily target pertaining to the number of items to be stowed. Likewise, another warehouse worker indicated that the decision to extend a permanent contract could be at least partly influenced by the data provided by the technology. Additionally, according to the interviewees, supervisors at *Italian Logistics 1* are vigilant and responsive to instances where warehouse workers deviate from safety protocols or commit errors, a trend also reported in Cirillo et al. (2022).

Conversely, the advent of the dynamic DSM technology at *Italian Logistics 2* has resulted in interesting changes in the monitoring and supervision of postmen's activities, as pointed out by the Site Manager. In this context, postmen no longer receive any instruction from their supervisors, a departure from previous practices that spanned their tasks from the beginning to the end of all their tasks.

> *The introduction of the dynamic DSM technology has allowed postmen to begin their daily activities without the foreman's or my supervision. Before, the first activities of the process were monitored, [...] now there is more autonomy and time to carry out other tasks.*
>
> *Italian logistics 2*, Site Manager

However, as explained later in this chapter, while it holds true that postmen might now experience reduced reliance on direct supervisor instructions during task, it could also be argued that a form of indirect monitoring has shifted from the foreman or site manager to the realm of technology. The latter provides specific instructions to postmen, outlining the itinerary which should be followed. This shift has been noted by two postmen interviewed during the field visit, who confirmed that the dynamic DSM technology is replacing a task previously performed manually by them, which had to be approved by their supervisory, namely the creation of itineraries to deliver mail and packages.

In France there is evidence emerging from stakeholder interviews about concerns in terms of increased data collection and monitoring of workers, as shown in box 3.

Box 3. Monitoring and surveillance of workers in France

In France, a case analysed through stakeholder interviews shows how a logistics management software, designed to optimize delivery routes based on factors like nearby drivers or user preferences, can have significant implications in terms of worker supervision and surveillance. This platform is customized to cater to the requirements and objectives of its customers, functioning like an Enterprise Resource Planning (ERP) system for delivery and logistics companies, as well as non-delivery companies venturing into delivery services. The first step in using this tool involves setting delivery times for each day and hour and defining the operational area, which could encompass a neighbourhood, an entire city, or even a region. Subsequently, the dashboard provides a number of options for users to configure their services. Customers can specify services, preferred coverage area, pricing per km/minute/distance, vehicle type, service availability (within time windows), and more. Pricing can be structured per km, base, volume, or weight. Users can have an overview of deliveries in progress, missions completed, ongoing tasks, cancellations, and failures, along with delivery specifics, delivery time and location, status, duration, goods count, environmental impact, and various other metrics. The technology provider does not perform deliveries but sells the software underpinning the dashboard, enabling companies to plan all these aspects.

Each company possesses its own dashboard, while delivery workers are linked to this dashboard through their connected applications. Customers can view the total number of drivers in the company, drivers active in the given month, average earnings per driver for the month, and the previous month's average earnings per driver. The interface allows customers to track the increase in new drivers across multiple months and identifies the top 10 drivers with the most completed missions. The lower section displays the list of drivers alongside their corresponding statistics.

Despite the substantial efficiency improvements and time savings achieved through this system, the tool facilitates continuous worker monitoring through a GPS application. The French National Commission on Informatics and Liberty (CNIL) has dealt with problems pertaining to the geolocation of workers who have company vehicles. The use of GPS systems is only legitimate in the context of organizing work, however many times they remain connected after working hours. This raises several data privacy concerns for employees who feel monitored outside working hours, including weekends. Another CNIL expert recounted instances where their organization received complaints from logistics company employees who arrived on Monday only to receive feedback from supervisors about their weekend activities.

Data regulatory issues extend to the management of logistics chains, particularly cold chains, subject of a complaint received by the CNIL. These chains involve stringent regulatory obligations related to monitoring and traceability, such as maintaining temperatures during the transport. Software packages handle these requirements alongside workers in the chain who scan products at each stage to verify this traceability. However, cases have emerged where post-monitoring information is retained about individuals involved in the chain. Additionally, CNIL has addressed issues regarding algorithmic management software labelled as 'environmentally friendly' that inadvertently gather sensitive data. For instance, CNIL encountered software connected to cars to assess metrics like speed, intensity of acceleration, and braking to sensitize employees to a more virtuous and careful way of driving to reduce fuel costs. However, the software was also being used to monitor the driver in a multitude of ways.

Source: Open Evidence

Conversely, in South Africa, the use of technology has intensified surveillance over workers in the large warehouse. This increased monitoring has imbued workers with a palpable pressure to maintain a specific pace, all the while being subject to monitoring by managers situated outside the shop floor.

> *It's not easy for you to hide yourself. The problem is going to be only if you were maybe a little bit slow the way like maybe when you're driving the reach truck or the BT forklift and then they come and say you are a little bit slow. But the other thing is if the system can tell you maybe today we're a little bit slow as we don't have enough. And if it doesn't have network and it starts becoming a problem it says we're going to be behind because we're a little slow in our system.*
>
> *South Africa*, Worker 7

Workers experienced the pressure of maintaining their pace of work and the scope of surveillance extended beyond the confines of the shop floor. Cameras installed in trucks diligently tracks drivers' movements, including whether they wore their seat belts. The pervasive nature of this surveillance eroded workers' sense of privacy, leaving them uneasy and disconcerted about being subjected to the watchful gaze of technology. One worker aptly conveyed this sentiment, stating

> *The truck has cameras that watches, if you put on your seat belt….They see you every movement, every movement ….You don't have privacy. You're even scared to cough.*
>
> *South Africa*, Worker 7

In Italy and France, the data collected and monitored does not appear to be yet used for worker evaluations, contrasting with the clear implementation of this practice especially in South Africa and India. The handheld device enables to record individual productivity in terms of the number of products picked per hour. Specifically, in the *Indian Logistics Private 1*, workers' picking rates are tracked on an hourly basis. Managers closely monitor whether employees meet pre-determined minimum standards, and exceptional performers are identified for monthly recognition and rewards. Conversely, workers who fall short of these thresholds are directed towards retraining. Workers are also tracked in the process flow, from the receiving in the central warehouse to the last-mile delivery to the retail customer, and in cases of errors, digital technologies are employed to identify workers responsible for errors. This allows managers to take corrective action, prioritizing cycle counts and bin audits, and mandating workers for retraining when needed. A senior member of the *Indian Logistics Private 1* technology team reflecting on the limits to technological solutions commented that:

> *We have to balance between technology and people issues. Knowing what is the right mix is the key challenge. Not all technology solutions might work all the time.*
>
> *Indian Logistics Private 1,* Technologist

In *the Indian Logistics Public 2*, workers were monitored in the warehouse to minimize leakages. As a result, the entire supply chain was digitally traced with clear handovers between different actors - source depot (i.e. Food Corporation of India), the transport vendor, the depot manager and the Fair Price Shop (FPS) licensee. For instance, the depot manager can only enter the centrally allocated quantity to the FPS owner. As one depot manager said, "What we do is to *fill in the blanks*. Everything is already decided by the head office". Apart from this monitoring, no additional initiatives are in place at the warehouse to improve worker productivity.

In South Africa, delivery drivers are subject to monitoring by an administrative clerk responsible for ensuring that deliveries adhere to specific timeframes. By 11 a.m., drivers are expected to achieve 50 per cent of their delivery targets for the day; if this threshold is not met, the clerk intervenes to find out the reason. However, challenges arise due to power cuts in South Africa, making the app inoperable and preventing updates due to malfunctioning cell phone towers. In such instances, the clerk intervenes to address the issue. Nonetheless, both drivers and clerks face consequences if performance targets are unmet, and they are threatened that they would be terminated. Workers also revealed that they were not compensated for overtime if deliveries extended past 5 p.m., beyond the promised delivery timeframe. A further challenge expressed by drivers in South Africa pertained to incidents of hijacking and crime, despite the presence of GPS and security tracking systems in trucks. While medical expenses were covered by the company, drivers were not otherwise compensated for the emotional toll of such traumatic events.

The availability of surplus labour reduces the motivation for investing in expensive digital technologies for in-depth performance monitoring in South Africa and India. Additionally, in South Africa, the substantial cost of software and applications from European or American companies, combined with unreliable internet connectivity and power disruptions, poses obstacles to the reliance on these digital tools, and workers are often penalised for technological glitches (see box 4 for further details).

Box 4. Penalisation of workers due to technological glitches

In South Africa, workers encountered connectivity issues that led to errors not attributable to their actions, yet they were penalized for these mistakes:

… sometimes [there is] a mistake and it's not because of us. You can find yourself picking up a pallet then the network is gone. You told yourself that you did configure the pallet to take to the cage after that they come in and say there's a pallet that is in the cage that has not been picked".

South Africa, Worker 8.

Despite the presence of backup generators in the warehouse, network was unreliable, particularly during heavy rainstorms. As a result, workers frequently faced reprimands for technological glitches. Instances emerged where pickers were unfairly held accountable for mistakes originating from computer errors, rather than human errors. A worker highlighted that:

"if the computer says take 15, I take a 15. If I made the mistake of taking 22 or 25 then there is a problem."

The worker emphasized that if they were provided incorrect information manually, they wouldn't be blamed, they faced consequences for acting on inaccurate machine-generated data. The worker suggested that,

"they should receive different treatment in such situations, rather than being punished for a machine's error."

South Africa, Worker 7

Similarly, a reach driver shared an experience where the scanner did not work, which resulted in mis-picked orders and the blame was unfairly placed on the pickers. The driver expressed his feelings of insecurity due to the technology problems as they were penalized by the Manager for the errors:

"(Scanner) is putting us under pressure. It's a technology. It's something that …you cannot rely on and you can't control. It can make mistakes that we didn't intend. This is my example. I take a scanner and I pick one pallet. It sent me to a bin… it says it needs 100 only to find out when you're finished picking that it only needs ten. You will find out after the scan of a security that they call, a checker, that they write you down as [he] sent this extra. [He] was stealing. They ask you why you picked 100 instead of ten but the scanner did that. And what happened to the scanner at that moment they didn't consider that…"

South Africa, Worker 8

Source: own elaboration

3.5.4 Social environment and interpersonal relations

The social environment appears to have improved in the companies analysed in Europe, whereas a contrasting trend is observed in South Africa. Broadly speaking, the adoption of technologies in Italy appears to have created a positive impact on the social environment in terms of collaboration, communication and even a healthy workplace competition among workers:

> *Team leaders and managers must constantly communicate with their teams, as their objective is engaging and motivating us to learn new things. The engagement can be maintained by assigning the workers with new roles, like the Top Performer or the Amnesty Floor Monitor. To this end, empathy and good communication are essential.*
>
> *Italian Logistics 1*, Warehouse Worker 4

However, it is noteworthy that in a comparable scenario, Cirillo et al. (2022) document a division among workers in the shopfloor. At *Italian Logistics 2*, interviewees agreed that the introduction of the dynamic DSM technology improved collaboration among colleagues, plausibly thanks to the increased task standardisation:

> *Collaboration between postmen and workers in charge of internal processes has improved, because now everyone knows his own colleagues' work. In this way, it is possible to help each other.*
>
> *Italian Logistics 2*, HR Manager

However, such an outcome was not observed in South Africa. In the large warehouse, the integration of digital technologies led to a decline in interpersonal relations and contributed to a more punitive style of management. According to a reach driver:

> *There's no communication. … that's why when you make a mistake, the Depot Manager will come to you and make noise instead of sitting you down because we don't know each other …. as there is no*

introduction to the employees ... you will just hear then he will come on floor, this is the person who picked pallets. [Accusing you] I've lost something like 150 000. Fire this person. He doesn't know you.

South Africa, worker 8

This attitude and style of management led to a distant relationship between the management and workers, leaving workers with a prevailing sensation of being subjected to monitoring and surveillance, and unjustly accused of mistakes without adequate explanation. The assistant driver in South Africa said that:

The complaints we are getting are from the pickers. It's the approach of the management. Some of the managers or controllers are the ones that they are having the problem with. Maybe the approach, how to talk to people and then that's the one that is a problem for them.

The assistant driver said instead of speaking with your superiors around work, "*you just speak to your device" (South Africa, Worker 7).* The small warehouse in South Africa also encountered similar challenges with work intensity and surveillance; however, the dynamic was nuanced by a blend of manual tasks or operations and more complex tasks, requiring coordination and collaborative efforts among workers. There was an undercurrent of resentment towards the management, indicating a change in their relationship.

The algorithmic management of picking and packing, as determined by the hourly productivity rate, also divided workers on the shopfloor. In South Africa, for example a packer described the implementation of a new system wherein items were brought to packing stations via conveyor belt system instead of being manually delivered to each packer. The conveyor belt was designed linearly, ensuring that all totes would sequentially pass through each of the 15 stations. This arrangement enabled the packer stationed at the first station to scan orders in a manner that would prove to be most efficient for their own workflow:

So, you found out that the worker who is packing in front, he can choose the order which he wants to pack. Because the only thing they do when the tote passes, you just scan it and then you ask, okay this is a multi, a 20 [item] multi and then you put it aside [for yourself].

South Africa, Worker 4

In instances where a packer received a large multi-order package containing several items destined for the same customer, they would consolidate multiple items within a single package, effectively reducing their packing time. Nonetheless, packers stationed toward the rear frequently found themselves handling single items, posing challenges for them to attain their target rate. As a packer stated:

And then you found out those people who [are] packing in the back, they are only getting single items. It means they can't make a rate. The only people who can make the rate are the ones packing in front.

South Africa, Worker 4

The implementation of the new system of conveyor belt for packing significantly impacted the workers' relations with each other, leading to disputes over the distribution of workloads. While there was an expectation of shared responsibilities, those stationed at the front would often undertake the majority of the tasks and leave nothing for their counterparts situated at the rear. This dynamic contributed to strained relationships among workers but also with the management. Instances of verbal reprimanding were observed from young managers, further exacerbating the tense atmosphere. In an effort to mitigate the effects of the new belt system, one of the supervisors began to manually assign totes to individual packers. One of the workers explained that:

When the belt is full, there is work that they are going to take off to put on the pallet. So that guy was taking that work from the pallet and giving it to those ones packing in the back. You see, so that everyone can make a rate and it was working for us.

South Africa, Worker 4

Nevertheless, the warehouse decided to terminate the employment of the Supervisor for blocking the passageway with stored goods, instead of appreciating the human intervention in solving the problem and improving the interpersonal relations in the shopfloor.

3.5.5 Stability of work and career advancement

Regarding the contractual stability and potential career advancements of workers, no major changes have been reported in the Italian case studies. However, the blurring of the organisational boundaries linked to the fragmentation of labour, holds the potential to affect employment relations, as explained earlier. This could manifest through increased use of subcontracting, outsourcing and crowdsourcing, including through digital labour platforms. Contrastingly, in the large warehouse in South Africa, the pressure exerted on pickers to expedite order processing led to fear and apprehension regarding potential displacement of permanent workers by labour broker employees into the workplace. The hiring of labour broker employees was aimed at addressing the surges in staffing requirements during peak times, and benchmarked against the productivity of the permanent in-house pickers:

> *There's pressure on those that are picking…because sometimes if normally you are getting the orders like for a week, you can say, I started preparing these things for a week there can't be a problem. But the problem comes when you pick up the volume today and the same day you have to pick it, and then you don't have enough people who can do the job at the same time. You have to then rely on your labour broker and the labour broker must bring enough staff*.
>
> *South Africa*, Worker 7

In the South African context, all shop stewards were permanent workforce, working on nine hours shift, and they mentioned the use of labour broker workers during peak demands. The permanent workers worked nine hours a day and they were classified by distinct skill categories, with general workers receiving a monthly wage of R6500 (around Euros 320) and a year-end bonus of R7200 (around Euros 350) (South Africa, Worker 9). Meanwhile, the picking controller earned a monthly remuneration of R11,500 (around Euros 560) (*South Africa*, Worker 10), which was higher than those of pickers and packers in the larger warehouse, who sometimes worked longer hours. Overtime emerged as a pertinent issue among workers in the small warehouse (*South Africa*, Workers 7 and 8). According to worker accounts, the company sought to avoid paying permanent staff overtime. It was in this context of cost-cutting that workers noted that there was increased reliance on labour brokers for weekend shifts, notably without overtime wages. Shop stewards argued that labour brokers were directly engaged to undercut the union-prescribed wage rates stipulated in the bargaining council agreement.

Nonetheless, the labour brokering model introduced an element of uncertainty to employment stability and working hours for workers (*South Africa*, Worker 1). In addition, the technology enabled workers to complete tasks more rapidly; and if they completed their assigned tasks within the time-slot of their shift, they feared that they might be released from work without providing any remuneration, as they have not completed the actual number of hours in that shift. Labour brokering was less prevalent in the small firm, although the union actively challenged its use and noted an increased effort by management towards hiring through labour brokers. The hiring of outsourced workers or through external agencies was also observed in both the *Indian Logistics Private 1 and Indian Logistics Public 2*, largely in an effort to cut costs, which has huge implications on workers security and stability.

3.6 Industrial relations

Overall there seems to have been a lack of awareness and low level of involvement of trade unions in the decisions concerning technological change. In the case studies in Italy and France trade unions appear to have had limited involvement in decisions concerning the implementation of new technologies, as was also observed by Cirillo et al. (2022). Unions abstain from intervening in technological innovation matters; this stance is acknowledged and corroborated by union representatives themselves, who assert their role in 'managing the outcomes' of automation. The adoption of these technologies was unequivocally a managerial decision; unions were never engaged in the process, even for safety or training considerations, and were informed only once preparations for technology integration were finalized.

Evidence from the Italian establishments is inconclusive with regard to the engagement and consultation of workers in negotiations concerning working conditions. The conditions under which interviews were conducted in Italian Logistics 1 do not allow a proper assessment of the situation. In Italian Logistics 2, the technology is being applied in a pilot phase, but the Site Manager took personal initiative to disseminate information, foster encouragement, and cultivate a collaborative atmosphere. Workers were also granted opportunities to offer suggestions, identify defects, and propose improvements either to their managers or directly to IT specialists responsible for the process. Across both Italian establishments, no significant changes have been reported in terms of professional practices among key industry partners, relations with providers and suppliers, or interactions with clients and pertinent stakeholders.

In France it was not possible to gather direct evidence on this issue but interviews with stakeholders showed a significant degree of controversy and concern around digital monitoring of workers, with the French National Commission on Informatics and Liberty (Commission Nationale de l'Informatique et des Libertés, CNIL) – an independent oversight authority on information technologies, playing a role in important controversies between employers and unions.

In South Africa, even where companies had recognised unions, they did not engage in consultations with unions about the adoption or changes in technologies. Furthermore, none of the worker interviews, including those with national sectoral union representatives, indicated that digital technology was a subject of bargaining or negotiation. Instead, all union officials recognized that the technology itself was not the issue; rather, it was the existing management-worker relationships that failed to establish a connection between training in new technologies and the upskilling of workers. In India, the digital technologies adopted in the private sector were top-down without any consultations with workers and unions.

4 Algorithmic management in the healthcare sector

4.1 Overview of the sector

Digital technologies are revolutionising healthcare. The use of data analytics, mobile applications, digital tools and integrated digital platforms are opening new frontiers in telemedicine, predictive diagnostics and medical assistance generating services for patients, healthcare professionals and healthcare managers. During the COVID-19 pandemic, digital technologies played a crucial role in enabling millions of people to continue their work and social lives while confined to their homes due to restrictive measures. These technologies were also instrumental in assisting governments and national health systems in effectively monitoring the spread of the virus. Tracking apps were widely adopted across the globe, while artificial intelligence tools were employed to forecast the hospitalisation rates and predict the trajectory of the pandemic.

There has been a significant rise in investments in digital health in the aftermath of COVID. The expected outcomes extend beyond addressing the challenges faced during the pandemic and aim to improve the quality, the accessibility, and the efficiency of healthcare systems. Digital health has the potential to enable national health systems to use resources more efficiently, to be more inclusive and deliver personalized healthcare treatments, especially for the elderly and long-term care patients.

The use of algorithmic management as part of digital health platforms is newer and some of the uses of algorithmic management in healthcare services include, but are not limited to:

- Creating efficiencies and improving the accuracy of diagnosis: Much of the use of the digital technologies and algorithms are for decision-making and thereby to improve the accuracy of diagnosis (Grote and Berens 2020), by preventing diagnostic errors and cognitive biases associated with health care practitioners, and managing inefficiencies at the provider-health service interface. Algorithmic decision-making at the institutional level is seen to reduce inefficiencies in workflow which result in wasted resources, inequities, and unnecessary costs (Grote and Berens 2020).
- Health care system planning: For healthcare system planning at a national, sub-national and institutional level, algorithmic management may help in effective allocation of resources (human and capital). Available evidence based on an ethnographic study on a healthcare network in the US tries to understand how healthcare organisations use algorithms to improve efficiency (cost saving) and effectiveness (quality) of care. They found that differences occurred in the use across national and practice/local levels. At the national level, they found that algorithms have the potential to be harmful to healthcare quality because they do not consider (and differentiate) contextual issues for example, local social and cultural dynamics. At the practice/local level, where individual healthcare practitioners are involved, the challenges of the one-size-fits-all approach can be better mitigated because practitioners are able to override hospital-based algorithms. They conclude that for the algorithms to be successfully used across contexts they need constant supervision and monitoring of how they are applied, especially in relation to diverse local and social and cultural contexts (Marabelli and Newell 2019).
- Coordinate work process: Healthcare sector management including coordination of work processes has largely been dominated by healthcare service provision at home, for example for palliative care, and for other dependent persons, and telemedicine. In the case of home-based care, the recruitment of healthcare workers is externalised and the coordination of work process is often mediated by intermediaries, including digital labour platforms and placement agencies (Blanchard 2022; Rodriguez et al. 2022); and the use of these platforms is expanding in both the global North and global South. Telemedicine as well is characterised by coordination of the work process between the healthcare provider and the patient, although generally the coordination of service provision and work process remains under the responsibility of the hospital. The growth of telemedicine has come hand in hand with an expansion in algorithmic management. The COVID-19 pandemic highlighted the gap between the demand and supply of healthcare services and pushed for a rapid expansion of labour demand in this sector. There is also literature on organisational changes in the healthcare sector that tends to deal with digitisation of processes or the use of algorithms for medical decision-making. For instance, Barrett et al. (2012) provide an example of work intensification in the context of a hospital pharmacy, which resulted both from the redefinition of workers' tasks and roles, and being instructed of the exact time and the pace to perform job tasks. Kellogg et al. (2020), report that in the U.S. hospitals use gamification as means of algorithmic control, and they show cases where algorithms are used to constrain and control real-time operations of pharmacy assistants.

Box 5. The healthcare sector in Italy, France, India and South Africa

Italy and France experienced severe tensions during the pandemic due to the continuous surge in patient flow in emergency departments and in need of intensive care. Both medical and paramedical staff reported high level of stress and overfatigue, leading to a massive resignation in the aftermath of the crisis, aggravating the already grim shortage of medical staff in Italy. In 2021, the French government presented the Health Innovation 2030 plan. The plan foresees an investment in technologies and digital infrastructure of 2 billion along three lines of investment: biomedical manufacturing, digital health and health emergency crisis response. About 650 million Euros was allocated for digital health with the aim of assisting medical staff and to bring innovation in several areas such as prevention, teleconsultations, surgical robotics and medical devices based on artificial intelligence. In Italy, a similar investment in digital health was announced. As part of the Italian Recovery and Resilience Plan (RRP), 2 billion Euros have been allocated to improve the health data infrastructure, to activate telemedicine services and to create a telemedicine platform to connect demand and supply of such services.

In South Africa understanding the potential for digital health technology, the Department of Health released its National Digital Health Strategy in 2019. The private sector has witnessed a more extensive adoption of digital health applications for both healthcare providers and patients, and this trend is gradually gaining traction in the public sector as well, especially when supported by non-governmental organizations (NGOs). An important development in South Africa is the Electronic Vaccination Data System (EVDS), designed for the rollout of the national COVID-19 vaccination campaign. It serves as a basis for a potential national electronic patient record system. Additionally, the Protection of Personal Information Act No. 4 of 2013 (POPIA), which took effect in 2018, further facilitates the transition to digital technologies by establishing the legal and regulatory framework for safeguarding patient data.

India experienced at least two significant waves of the COVID-19 crisis, resulting in extensive devastation, which was worsened by severe shortage of hospital beds and oxygen. Telemedicine played a pivotal role in enabling access to healthcare professionals in remote areas and households during lockdowns. The adoption of digital technologies has been growing in India's health care in recent years. The 2017 National Health Policy had already embraced the idea of a digital health ecosystem, and in 2021, the central government launched the National Digital Health Mission (NDMH, also called Ayushman Bharat Digital Mission). The mission is to improve availability, affordability, accessibility and to provide universal healthcare for all by constructing a digital health system to ensure easy access to healthcare services.

Source: own elaboration

4.2 Profiles of case studies

In Italy, four public hospitals were chosen for case study. *Italian Healthcare 1* is one of the largest hospitals in central Italy in terms of employment and number of hospital wards.[2] It is composed of two main sites. In 2022, it had a total capacity of over 1,000 beds and around 52,000 hospitalisations (with significant percentages of extra-regional hospitalisations), employing close to 5,000 workers under the Italian national healthcare system and 244 university doctors. The establishment is a public hospital unit, part of the national healthcare system (*Sistema Sanitario Nazionale*, hereafter SSN) and of ESTAR, a regional support body established in 2014 for the exercise of technical and administrative functions of health bodies in the Tuscany region. As explained in the methodology section, the other three public hospitals[3] analysed are drawn from the study by Cirillo et al. (2022).

Similarly, in France two public hospitals were chosen for case study. *French Healthcare 1* is a leading general hospital in France. It has a capacity of about 1,800 beds, more than half of which are in Surgery, Medicine, and Obstetrics. The hospital has an agreement with a local university for joint work in favour of health research. The establishment is an innovative and expanding one, and it is at the forefront of recent technological advancements experienced in French hospitals. *French Healthcare 2* is a leading university hospital in the

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2 The hospital is highly specialised in testing points and clinics, transplants (liver, kidney, pancreas, marrow) and robotic surgery. AOUP collaborates with other health establishments to promote medical research, improve the quality of patient care and advance innovative care treatment. Moreover, the hospital is integrated with the University of Pisa, as it also functions as a health research centre and it hosts medical students.

3 The first was a public hospital unit with autonomy at management and organisational level which has implemented a "telestroke" technology with remote monitoring of heart devices. The second case analysed by Cirillo et. al. (2022) was an entire regional public health authority which has implemented a technology that allows for transmission between emergency vehicles and the cardiology hospital units. The third case was a highly specialised hospital, research and teaching centre using a software "televisit" technology to store and share patient medical documents across departments, such as radiographs and test results.

country and one of two university hospitals in the region. In 2022 it had a total capacity of around 1,700 beds, with approximately 6,500 staff, including nearly 800 doctors. Being a university hospital, it ensures the triple mission of care, teaching, and research. The establishment actively collaborates with other health establishments to promote medical excellence, facilitate patient care, and propose new innovative care structures. The hospital has a partnership with a local university.

In India, a private and public hospital were chosen for case study in Bangalore. The private-sector hospital, *Indian Healthcare Private 1* is a leading hospital with a chain of 30 other hospitals and clinics spread across the country in multiple cities employing 15,000 employees. This hospital is a public listed company founded by a practising healthcare professional and the central corporate office monitors the performance of all the hospitals in the group as well as providing strategic direction.

The public hospital, *Indian Healthcare Public 2* is of national importance specialising in mental health and neurosciences. It is also an academic institution with postgraduate courses in neurosurgery, neurology and psychiatry specialisations. The establishment has three main departments[4] – neurosurgery, neurology and psychiatry. For this case study we focus on two departments – Centre for Addiction Medicine (CAM) which is a specialised clinic associated with the psychiatry department and addresses the issue of addiction among patients and a neurosurgery unit.

The case studies chosen in South Africa include a private hospital and an NGO providing primary and preventive health care services. The private hospital (*South African Healthcare Private 1*) is part of a global business. The private hospital is actively engaged in introducing digitisation to manage integrated care packages for specific health conditions designed around well accepted clinical pathways. The NGO linked to the public health services (*South African Healthcare Public 2*) is a well-established organisation that provides primary health care services across South Africa and several other African countries. The NGO is reliant on international donor funds and is therefore required to account for the deployment of its workforce and to demonstrate efficiencies in primary and preventative health care delivery.

4.3 Use of digital technologies

Progress in technology impacts the healthcare sector at different levels. It modifies the way health services are delivered, the outreach into communities, the interaction between patients and healthcare workers and the organisation of health systems. The complexity behind the digital transformation of health services reflects the extended ecosystem of different stakeholders and different interests that operate within the healthcare industry.

The adoption of new technologies, followed by new organisational and business models, may have large consequences for the future of healthcare delivery and health systems at different levels. The results and the outcomes of digitalisation of health services strictly depends on the quality of the process implemented, the level of involvement of all stakeholders and the attainment of the main health system goals, including universal coverage and efficiency. The digitalisation process should reflect such complexity and foresee an integrated development plan that involves all the final users of digital services, be it healthcare professionals, care workers or the general public; the producers and developers of digital health services; and local and national governments.

The principal technological solutions in healthcare include ehealth, mhealth, telehealth and telemedicine and they all describe the use of ICT and interactive technologies for the provision of remote care services. Often, those terms are easily confused and used interchangeably, even if they represent different use of technology in healthcare. See box 6 for definitions.

[4] A number of other departments exist, such as neurochemistry, neuropathology and neurophysiology. However, these three departments contribute to the bulk of healthcare services with the rest providing auxiliary services.

Box 6. Definition of key concepts: eHealth, mHealth, Telemedicine and Telehealth

The WHO defines eHealth as the 'cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research'. eHealth therefore includes a wide range of solutions including electronic health record systems, patient and laboratory administration systems, telemedicine and mhealth.

mHealth (mobile health) is defined by the WHO Global Observatory for eHealth as 'medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices'. Patients can store and monitor their health data, consult electronic medical records on their mobile devices, communicate directly with doctors and therapists through text messages or video visits, and use reminders and medical applications to follow appointments or pursue a healthy lifestyle.

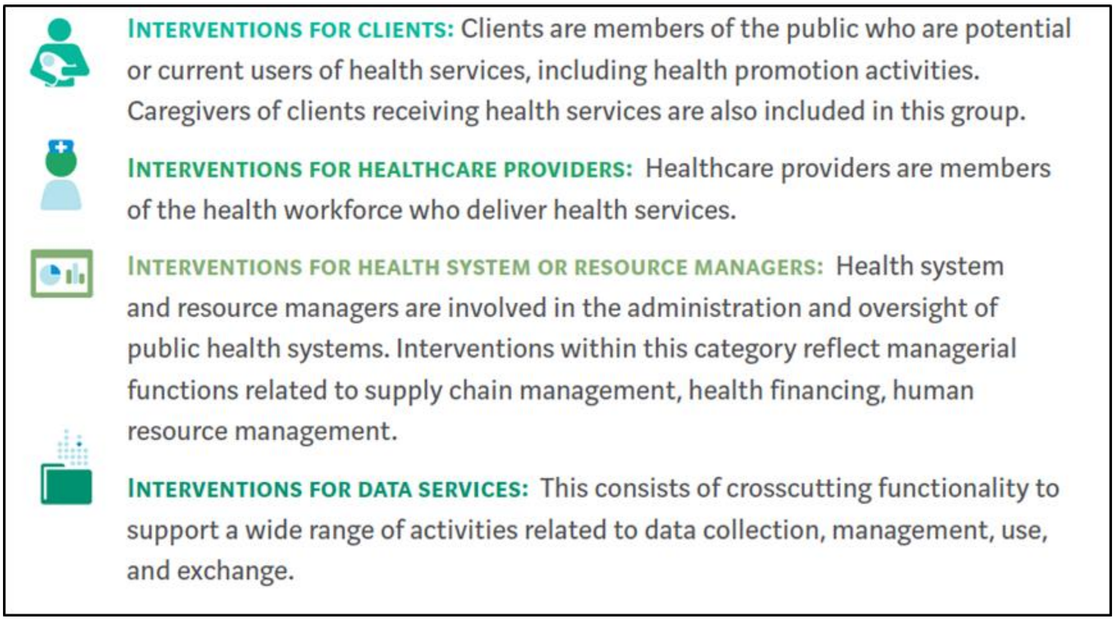
Telemedicine refers exclusively to the provision of remote clinical services to patients. It is defined as 'the delivery of health care services, where distance is a critical factor, by all health care professionals using information and communication technologies for the exchange of valid information for diagnosis, treatment and prevention of disease and injuries, research and evaluation, and for the continuing education of health care providers, all in the interests of advancing the health of individuals and their communities' (WHO, 2010).

Telehealth refers to both remote clinical and non-clinical services. It is associated with telemedicine but includes a wider application of technologies, such as distance medical training, consumer awareness, nursing call centres and other digital applications designed to support health services. The terms telehealth and telemedicine are often used interchangeably as there are no universal definitions of these concepts.

Source: Belmonte et al. (2021)

Digital and mobile technologies may also be categorised according to the purpose for which they are used in the health systems. The World Health Organization (WHO) distinguishes among four different categories of digital health services, based on the targeted primary users:

Figure 2. Digital health services



Source: World Health Organisation (2018)

Although these distinctions are useful for evaluation purposes, the technology adopted may actually cross over multiple categories, as many of the digital health services could require more than one functionality to be considered simultaneously. For example, interventions for data services are by default embedded and at the core of the correct functioning of many of the functionalities in all other categories.

The case studies examined in this chapter show the application of different technologies to improve access to health services at different levels of care, the organisation of patient flow, to predict peak periods in the emergency room, to provide telemedicine services - all of them fall under the realm of healthcare providers category. Moreover, these technologies also address inefficiencies in workflow, thereby mitigating wasted resources, disparities, and unnecessary costs. Just like the logistics sector, the types of digital technologies that are used for providing health care services in the case studies can be classified as specific-purpose digital technologies and general-purpose digital technology:

4.3.1 Specific-purpose digital technologies

Hospital Information System: The hospital information system (HIS) is one of the standardised software solutions used by the hospitals for its front desk and it manages and stores all the information related to the administrative, financial and clinical aspects of a hospital.[5] It serves as a digital architecture to facilitate efficient healthcare delivery, streamline operations, and enhance patient care. While the use of digital technologies in hospitals is not a novel concept, its application for clinical decision-making, workload management, and performance analytics is relatively new. However, the extent of utilization and implementation of these digital technologies varies across hospitals and healthcare organizations, and even within a hospital it might differ across departments as they adopt modules based on their specific requirements.

Indian Healthcare Private 1 has implemented HIS to manage the entire workflow, ranging from patient registration to discharge. They have incorporated four modules tailored to their specific requirements: the ambulatory module, which handles registration, appointment scheduling, and billing processes; the billing module; the module for managing appointments, discharge, and patient transfers; and the electronic health record (EHR) module. In addition, the hospital has procured third-party laboratory and radiology information systems (LIS/RIS) applications, which interface with the HIS application. The RIS has a picture archiving and communication system (PACS), which is seamlessly integrated with the HIS and the scans can be seen anywhere within the hospital chain. Previously, the hospital relied on an external vendor for software design, but the management observed a significant disparity between the design and their expectations. As a result, all the applications are developed internally by a dedicated software development team. Although hospital management software solutions are available in the US market, they were functionally inadequate to serve the needs of this particular hospital.

As mentioned earlier, France has observed a rise in the number of patients treated in the emergency department, which increased by 64 per cent during the period 2008-2019. By September 2019, over 250 emergency departments were on strike in France, including the two establishments analysed, and in 2022 an average of 200 adults/130 children were admitted per day in unchanged premises. To ensure timely healthcare services, *French Healthcare 1* has implemented an algorithmic technology, which effectively supports and optimizes logistics within the emergency department. This technology comprehensively tracks and monitors patients from admission to hospitalization or discharge. Additionally, the technology has the remarkable ability to forecast upcoming surges in the emergency department by integrating medical data collected and stored by the hospital with external factors such as weather, events, and traffic. By leveraging the power of artificial intelligence and deep Learning, the algorithm precisely predicts the probability of heightened pressure in the emergency rooms, providing accurate hour-by-hour forecasts several days in advance with more than 90 per cent accuracy.

Similarly, *French Healthcare 2* has introduced a technology to support the organisation of patient flow in the emergency department by using algorithms and artificial intelligence. The technology provides real-time global picture into the flow of patients and their care requirements, while assisting medical staff in resource and bed management. The tool allows them to detect and differentiate between urgent and non-urgent patients, speeding the triage phase when the patients arrive at the emergency. According to the Data Protection Officer, while the tool was able to accurately classify 80 per cent of patients during the first week of implementation, it remains only consultative, and the staff decides whether to utilise it or not.

Customised software and apps: To improve the workflow process, in *Indian Healthcare Private 1*, a mobile care application has been integrated into the in-patient EHR module which facilitates improved communication within the care team, which was one of the challenges identified by the design team. Further, the EHR module

[5] The HIS has several modules or components such as patient registration and scheduling, electronic medical records, clinical decision support, laboratory and radiology management, pharmacy management, billing and financial management, and administrative and operational management.

serves as a valuable tool for clinical diagnostics and is utilized by doctors during patient consultations. However, doctors have different approaches when it comes to note-taking, as some provide a comprehensive history, detailed symptoms, and diagnosis, while others focus solely on the diagnosis and treatment. To facilitate data analysis, the software engineers in the hospital developed a template-based form instead of allowing free text input in the EHR module. This standardized format enables ease of analysis and data interpretation.

Indian Healthcare Public 2 introduced a software in the specialist psychiatric clinic (Centre for Addiction Medicine (CAM)) that integrates three key features to address the challenges of patient waiting time, high attrition and conversational language. These include algorithm-based assignment of doctors to patients based on various criteria, such as language, the existing workload of the doctors and the nature of the visit (first visit versus follow-up); digitally maintaining patients' medical records to reduce dependency on paper-based medical records; and aiding in follow-up with patients for the pending visits. The neurosurgery department of the hospital uses the ehospital software designed and developed by the Ministry of Electronics and Information Technology of the Government of India. This software is used in many public hospitals across India for the core aspects of hospital management, such as registration, billing, IP admissions and discharge. Alongside the ehospital software, different departments and units use a few additional software to address their specific needs. An IT cell with dedicated staff was established to harmonise the multiple software systems in 2016 and to introduce new technology systems.

The Public/NGO healthcare sector in South Africa *(South African Healthcare Public 2*) has introduced a digital time and attendance register wherein workers “clocking” on and off is remotely managed and helps to plan for their workforce across multiple primary care and outreach settings. The log-in and log-off can be either completed using a biometric finger pad found at a clinic and office locations or by entering through a web-based link accessible through the organisations’ intranet. In addition, they have introduced Geographic Information System Applications (GIS-APPs) which measures the performance of outreach vaccination teams on the delivery of COVID-19 vaccination services in hard-to-reach communities living in remote rural areas of South Africa.

Predictive data analytics: Digitalisation of health data can play a crucial role in delivering effective and efficient digital health services, but at the same time it would be important to safeguard the privacy and confidentiality of patients through appropriate data governance. By employing a well-considered and responsible approach to utilising health data, it becomes possible to protect citizens and enhance the quality-of-care delivery and assistance. This, in turn, yields substantial benefits at both the individual and societal levels, while also preventing data breaches and unauthorised access by third parties. This is particularly relevant when data are employed for predictive purposes.

Indian Healthcare Private 1 has introduced predictive data analytics which encompasses three main domains: operations, finance, and clinical practice. The data analytics dashboard offers real-time data regarding the performance of approximately 3000 doctors within the hospital chain. The hospital uses a system which comprises of a number of software applications, and it provide insights about the data collected on different parameters in the hospital.

Italian Healthcare 1 implemented in 2019 value data technology with the goal of optimising the flow of information related to drug usage within the hospital and pharmaceutical expenditure. This technology utilizes data analytics to integrate regional spending systems with internal budgetary elements, ultimately facilitating improved management of innovative drugs.

French Healthcare 1 has implemented a technology capable of forecasting upcoming surges in the emergency department by integrating historical data on medical access and external information that may impact the patient flow trends, such a weather, events, and traffic, reaching an accuracy beyond 90 per cent.

Telemedicine and digital healthcare platforms: There is an increasing effort to provide quality post-patient care and to reduce the need for in-person appointments. The Italian cases analysed in Cirillo et al. (2022) have successfully implemented telemedicine practices. One of the case study they analysed has introduced various telemedicine tools, such as televisits and remote reporting systems. The remote reporting systems enable examinations to take place in one location while the results are analysed in a different setting. For instance, in cases of suspected cerebral strokes, the telestroke technology allows emergency doctors or nurses from any hospital within the province to connect with the hospital through televisits to seek guidance from the neurologists.

Similarly, in one of the hospitals in Italy, remote monitoring of heart devices has been **introduced in** which enables implanted patients to undergo remote check-ups. The resulting reports are uploaded onto a digital platform used by the hospital for document sharing, and then added to the electronic health (ehealth) records of the patients. This significantly reduces the need for in-person appointments, and currently, around 1,200 patients are being followed in the "virtual clinic." This hospital also uses a technology for remote monitoring of cardiovascular conditions and onboard defibrillation in advanced emergency vehicles. To use this device, a station has been installed comprising a desktop computer connected to the monitor/defibrillator.

South African Healthcare Private 1 has introduced a digital healthcare platform that organises a delivery of a standardised care package to patients. It provides a patient facing App which enables them to book pre- and post- surgery appointments, to communicate directly with healthcare professionals, review test results and to read about what to expect next. Once the patient is registered, they are allocated to a medical care coordinator who assists them on this journey both through digital interactions over the platform and with face-to-face meetings at the hospital during treatment. The platform also provides a healthcare provider facing App, which is used for communication with patients and to access the complete patient record of tests and care. The digital care platform facilitates all patient details, treatment, medication and pathology reports being loaded onto one platform.

4.3.2 General-purpose digital technologies

In the Neurosurgery department of the *Indian Healthcare Public 2*, a simple OneNote application in the tablet has been introduced to maintain records and notes of every patient, to monitor the patients' vitals and implementing the treatment plan once the surgery is performed. In addition, they use WhatsApp (instant messaging application) to communicate the health condition of the patients between the junior residents, senior residents and the consultants.

Although no evidence has emerged from the case studies in Italy and France about the use of instant messaging apps, there is empirical evidence on the increasing use of messaging applications in hospital in both the UK and Italy. De Benedictis et al. (2019) collected data through a survey administered to physicians and nurses in an Italian University Hospital and found that a growing number of healthcare professionals adopted WhatsApp in their daily work in order to share information with peers and patients. Similarly, Gould and Nilforooshan (2016) asked 40 junior doctors about their use of WhatsApp and found that “WhatsApp is performing an essential function, providing juniors whose teams are fragmented between theatres and wards with a hotline to senior opinion” and that “it improves the relationship between grades and breaks down the traditional hierarchies that can stunt effective communication within a team”. At the same time, there are concerns about the use of instant web messaging applications and data governance, particularly about the risk of leaking sensitive patient data and misuse of information, as well as the potential unsuitability of such digital tools to respond to complex cognitive tasks (Gould and Nilforooshan, 2016).

4.4 Business model and work organisation

The introduction of various digital technologies in hospitals under analysis across the four countries has affected work organization to a different extent. Overall, these technologies – and the resultant changes in work organization – have successfully demonstrated improved outcomes for patients, enhanced the coordination of work processes and workflows, improved overall efficiency and productivity, and in certain cases, even generated new employment opportunities for workers.

In India, the implementation of digital technologies in both the public and private hospital has required the setting up of a dedicated technology team within the organizations. This dedicated team has played a crucial role in ensuring the successful integration of digital technologies for various workflow processes. In South Africa, significant changes were brought into both the private and NGO case studies as a result of the introduction of a digital health platform. *South African Healthcare Private 1* has introduced an alternative business model which influences both the workflow as well as the working conditions of the hospital staff. Similarly, the NGO supporting public health service delivery (*South African Healthcare Public 2*) introduced digital tracking tools and reporting platforms to improve reporting to funders in a context where donor funding is extremely competitive, has also resulted in changes in work organisation. In general, in Italy and France the impact of digital technologies did not lead to significant changes in work organisation but improved and smoothened the administrative process reducing the overall time spent on non-medical tasks by nurses and doctors. In France, the introduction of technology to support the organisation of patient flow and optimise the logistic has been regarded as positive in both case studies analysed. However, many of the healthcare workers declared that the technology is ‘silent’ and its impact has not been tangible as their workflow has remained unchanged in terms of procedural steps to follow. In Italy the adoption of value data technology to streamline drug policies management helped reallocating roles and responsibilities and reducing the burden of administrative tasks to healthcare professionals.

4.4.1 Enhanced coordination of work processes and improved health service delivery

The process of digitalisation of health records has improved work coordination and health service delivery, and improved communication within the teams. The integration of the mobile care application within the EHR module of HIS in *Indian Healthcare Private 1* has significantly improved communication within the care team, especially where consultants from different specializations and nurses are involved (see Box 7 for more details). The app allows quick access to lab and radiology reports and has increased transparency, facilitating prompt interventions when needed. Furthermore, the app streamlines communication with patients' relatives, enabling doctors to provide briefings after reviewing patient data on their mobile phones. Notably, the app also offers a feature that allows periodic communication to be sent to the registered mobile numbers of patients' caregivers, ensuring continuous and transparent information sharing.

Similarly in *French Healthcare 2,* the adoption of predictive technology for bed management purposes improved work coordination and better communication between doctors from different wards, reducing the searching time for emergency physicians which normally would take about 2.5 hours a day to search for beds. Another source of efficiency in the workflow comes from knowing exactly what the next steps are. This allows for a better integration of different responsibilities and tasks among the medical staff and grant greater autonomy, reducing the cost of asymmetrical information.

In *French Healthcare 1*, the algorithm has enabled for real-time monitoring of each patient's progress within the emergency room while also providing valuable insights into the projected staffing requirements based on patient flow forecasts within the department. The system has the capability to propose an optimal schedule for the healthcare workforce, taking into account predictions of forthcoming pressure and considering the shift and personal constraints of the medical staff. The General Manager at *French Healthcare 1* reported that,

> *In the past, if one person was on leave, we would replace him/her immediately. Now, we can see if they are really needed or not. The tool also helps to re-evaluate the needs during a single day and potentially grant some recuperation to staff if it's going to be less busy.*
>
> *French Healthcare 1, General manager*

The improved workflow has expedited some administrative processes and improved general efficiency and the hospital administration has a better understanding of the material and human resources available at any given moment. It has also helped in reducing the waiting time for patients and improving the general time efficiency of the task performed. For instance, the use of AI and deep learning to predict the surge in emergency room in the public hospitals in France has affected work organisation in terms of a better allocation of medical and paramedical human resources. According to the general manager of *French Healthcare 1,* the automation of the resource planning is a saving time (one hour per week) for the head of the department. Furthermore, AI allows also for a better coordination between doctors in different wards as the tool helps in predicting hospitalisation.

Similarly, the digitalisation of patient's health records and the use of the simple algorithm to assign patients with doctors in one of the departments (Centre for Addiction Medicine) of *Indian Healthcare Public 2*, has reduced the waiting time and the delays in fetching their health files, which would often take few hours, having a positive impact for both patients as well as doctors. Further, it has reduced the clerical activities for medical staff and saved time that could be used for caring and attending patients. The process of patient assignment is monitored by a counsellor who exclusively manages it. In addition, the software also helps in patient follow ups to ensure that they are on course to de-addiction. The software lists patients who are due for follow-up or have missed consultations, and the counsellor calls them and reminds/counsels them to visit the clinic.

Digitalization has also the ability to enhance transparency throughout the healthcare service, ensuring that all involved parties have visibility into the patient's diagnosis and treatment journey. For instance, doctors input their observations digitally within the system and an algorithm ensures that the doctors follow the diagnostic. In cases where a junior resident is involved, the diagnosis and treatment plan are subsequently reviewed by a senior resident or consultant. The digital format simplifies the reviewing process for consultants, allowing them to access and assess the files digitally.

The implementation of data analytic technologies such as the dashboards has resulted in notable improvements in productivity and streamlined information flows within the hospitals in all the four countries. In all the case studies analysed, data analytics helped optimising the internal processes and supported the administration with more efficient procedures aimed at avoiding duplication, improving communications and automating manual tasks. Both medical and para-medical staff benefitted from the adoption of data analytics technology in terms of improved time management and quality of the care services provided.

At *Indian Healthcare Private 1*, the implementation of data analytics has significantly enhanced the evaluation of key performance indicators. These include the assessment of costs associated with various surgeries and procedures, revenue generation, and patient workload. With the help of a comprehensive dashboard, the corporate office can now monitor real-time data such as patient wait times, radiology report turnaround times, surgery costs, drug usage patterns, and revenue generated by individual doctors. Furthermore, the dashboard allows for a comparative analysis of expenses between different surgeons performing the same procedures, as well as tracking prescribed medications and dosages for patients. Additionally, data analysis has proven invaluable in establishing average consumable usage for different types of surgeries, enabling the identification of trends and cases that exhibit slightly higher consumption rates. Similarly, it has helped to increase the occupancy of the operation theatre. The data analytics has ensured significant productivity gains and enabled boardroom discussions to be more productive.

The data collected on the dashboard also provided valuable insights for assessing the costs per patient. Furthermore, as data on patient profiles and ward preferences are collected, it helps the marketing team to identify cases where patients choose not to undergo recommended surgeries due to increased costs or other reasons behind such decisions. This would help the management to identify potential measures that need to be implemented. However, it is worth noting that currently, doctors do not have direct access to their own data and are not aware about this data collection process, as the data analytics system is primarily utilized by senior management within the hospital.

In *South African Healthcare Private 1* the introduction of digital technologies has profoundly influenced and changed the process in which a standardised care package involving a surgical procedure was managed and monitored. The technology has created different levels of efficiency within the occupational role of surgeon; as a consequence of digital monitoring, surgeons are tiered by their efficiency to deliver good patient outcomes determined by a number of variables including length of hospital stay, reduction of infection, patient pain management. Surgeons who are the most efficient are paid a higher global fee per patient.

For surgical, high care and operation theatre nurses there have not been any major changes in roles with the introduction of digital health platform. However, they are indirectly affected as they are closely monitored by the management in the execution of their tasks and are continuously assessed of patient outcomes.

In both French case studies, the data analytic tools have led to changes in the data management practices of the hospital, in the management of medical and paramedical staff and improved the information exchange. By predicting the flow of patients and the number of hospitalisations the data analytics tools provide real-time information on the prediction of in-patients that can be used to decide how many staff is required (especially paramedical, but also medical) or the number of beds needed. By profiling patients and monitoring their care, the tool improves communication in the emergency room about the next steps to be taken and estimates waiting time.

In *Italian Healthcare 1,* the data analytic tool is used to streamline the flow of data related to the reassignment of credit notes deriving from negotiated agreements for innovative and non-innovative drugs or high-cost drugs used in multiple therapeutic areas. The data tool automatically calculates how much of the credit notes should be reassigned to the hospital and creates easily accessible dashboards which are used for economic analysis and to rationalise pharmaceutical spending. Moreover, by optimising drugs flow management and improving the efficiency of the documentation and physical flow of innovative drugs, the technology allows to calculate the effects of clinical trials and save costs for the national healthcare systems (SSN).

> *The introduction of the technology led to an improvement not only of the activities related to patients' care, but also of the tasks concerning the budget planning, which constitutes a big portion of the work I do. Through the dashboards developed by the Value Data technology, I can see how many patients participate to trials and the costs that the hospital saves by conducting these trials with innovative drugs.*
>
> *Italian Healthcare 1, Pharmacist 2*

However, there has also been significant resistance from users, including doctors and nurses, towards adopting certain digital technologies. For instance, healthcare workers and doctors in the Centre for Addiction Medicine unit in *Indian Healthcare Public 2* resisted the use of the technology as it was considered to increase their workload. The resident doctors were eventually convinced to use the software, while nurses still oppose the technology adoption, as they believe it is outside their job description to update data on digital systems, as it increases their workload.

Similarly, at *Indian Healthcare Private 1*, there was initial resistance to the adoption of template-based forms in the EHR modules due to concerns of increased workload for doctors and nurses. As a solution, the hospital employed four dedicated data entry operators whose role was to update the system based on the paper notes provided by the nurses. Additionally, some doctors showed reluctance in updating data on the system, as they felt it could potentially reduce their engagement with patients.

Box 7. Use of general-purpose digital technology for transparency and improving communications in clinical care

The adoption of general-purpose digital technology, such as Whatsapp (instant messaging applications) or Tablets, has notably enhanced transparent communications in clinical care, particularly in India. Within *Indian Healthcare Private 1* hospital, junior doctors who assumed patient care responsibilities often sought instructions from senior doctors through phone calls or messaging apps like WhatsApp, where important instructions and decisions were shared. According to evidence, the utilization of digital tools promotes transparent communications in clinical care and may also serve as a valuable learning resource for junior doctors. However, for tools not specifically designed to medical purposes there are concerns about messages being misunderstood, issues around privacy and ensuring quality control.

Similarly, the EHR module implemented at *Indian Healthcare Private 1* hospital serves as a valuable tool for clinical diagnostics, offering a template-based form that doctors utilize during patient consultations. Following a clinical examination, consultants document their observations within this module, which can be accessed by physicians easily through the software. To facilitate efficient data analysis and interpretation, the template-based form incorporates auto-suggestions for commonly used phrases based on patient history, assisting doctors in their documentation process. This feature enables doctors to populate their advice and medication recommendations based on the patient's medical history, streamlining the workflow. Furthermore, the EHR system plays a crucial role in supporting clinical decision support systems (DSS). The integration of basic drug interaction-related rules into the system enhances patient safety and provides valuable guidance to healthcare professionals during the decision-making process.

In the neurosurgery department in *Indian Healthcare Public 2*, a combination of applications is used, which helps in both work coordination as well as enhancing transparency. Every neurosurgery resident is required to purchase a tablet on which they use a commercial digital note-taking application to maintain records and notes, which is then used to communicate patient conditions and share scan images with the senior resident doctors or the consultants. It allows senior resident doctors to discuss patient care plans with the consultants and provide instructions to junior resident doctors through the chat group. This group enables quick communication and allows the consultants or senior doctors to monitor the actions or decisions made by the junior resident doctors around the clock.

Source: own elaboration

The digital technologies assist the management in having better control over the organisational performance in real time using the data, which was traditionally done at frequent intervals. It provides transparency into doctor's actions and decisions for improving the accuracy of diagnosis, however, their use extends beyond the improvement of health outcomes to the monitoring or surveillance of doctors. This could overtime lead to increased use of digital technologies and the need to follow specific protocols and procedures to ensure that the process is followed correctly.

4.4.2 Impact on jobs and skills

The impact on jobs resulting from the adoption of these technologies has varied significantly across countries and hospitals. Overall, a contrast appears between the case studies in the Italy and France, where the impact on jobs appears to have been limited so far, and in India and South Africa where the adoption of digital technologies has led to the creation of new jobs and/or occupations.

Indeed, while in Italy some data managers and technology specialists were recruited after the adoption of new technologies the overall impact was limited. In the hospitals in France, the need for new clerical workers was mentioned to particularly deal with bed logistics and enhance the use of hospital material resources. It is important to keep in mind that the hospitals in the European case studies are public hospitals, depending on public budgets. Despite a warning coming from a WHO (2022) report[6] on the gravity of the shortage of health care workers in the European region, both Italy and France have not undertaken any specific actions to increase

6 https://iris.who.int/handle/10665/362379

public healthcare spending. In the 2024 Finance act proposed in September 2023, France announced an increased in Social Security and Health public spending for a total of 600 million Euros[7]. However, this policy measure is expected to tackle several issues and not only the reinforcements of the healthcare personnel. While the proposed Italian budget law foresees further reduction of the healthcare spending/GDP ratio for the coming years, preannouncing, de facto, further cuts to the national health system[8].

In contrast, in India, the adoption of digital technologies has resulted in the recruitment of technical staff to support their implementation. For instance, at *Indian Healthcare Public 2* the software requires the assistance of three Data Entry Operators (DEOs). One DEO is responsible for updating demographic data, another for printing prescriptions, and a third for transferring medical records from paper format to the central database of the medical records department. While these DEOs may hold various job titles such as counsellors, clerical staff, or project assistants, their role is crucial in maintaining the smooth functioning of the information system, according to senior administrators.

Similarly, *Indian Healthcare Private 1* has an in-house software development team, with more than 100 software professionals and three dedicated teams to handle the integration of digital technologies in the hospitals. These teams include data analysts, software developers, and an EHR implementation team. As in the case of the public hospital, *Indian Healthcare Private 1* too has employed dedicated DEOs, especially in intensive care units (ICU), to support the nurses in updating data on services provided in the Health Information System. Additionally, there are approximately 40 professionals specialized in data analysis or analytics. It has also resulted in obsolescence of certain job roles such as those in the erstwhile Management Information System (MIS) unit who are no longer hired for these tasks.

The introduction of a digital health platform in *South African Healthcare Private 1* created the role of care co-ordinator. The portfolio of tasks inscribed within the role is new in terms of nursing care and the focus for these professional nurses is on managing relationships, communication, data collection and analysis and feedback on the digital healthcare platform. The integration of these technologies has also placed new demands for workers and contributed to some upskilling of workers. This phenomenon is observed mostly in India and South Africa, with more modest impacts in Italy and France. However, it is uncertain if it has led to expanded knowledge and opportunities for "learning by interaction" with technology providers and technology specialists.

In *South African Healthcare Private 1*, many of the medical doctors involved with the digital health platform have been required to learn on the job about digital technology and health outcomes. Doctors were not overly enthusiastic about the use of technologies and needed support from relationship managers. Care co-ordinators also needed to support doctors with the amount of data/information they required to in-put as well as to draw their own data from the system for their use.

While nurses showed concerns about potential job losses as technology takes over, they also expressed a sense of excitement for the new way of doing things and the opportunity for a different approach. For instance, the hospital is currently piloting an "at-home" care program, and managers reported that nurses are enthusiastic about the changes and the expanded scope of nursing care it represents. One of the major changes for nurses is to acquire digital literacy to use the digital technologies.

> *Mainly nurses are not computer literate So our training must first begin with computer. Basic computer literacy, how to use a mouse, how to open a browser, how to add more tabs, how to close the browser, how to switch off, how to reset. It's simple things, but before we can train on the electronic health record, we must first train them on computer because they have been using paper for so many years.*
>
> *South African Healthcare Private 1*, Manager

However, it is important to note that these innovations may primarily benefit registered nurses in higher categories, while enrolled nurses (who cannot progress to become registered nurses under South Africa's current nursing framework) may not have access to these trainings and using these technologies. This exclusion raises concerns about equity and access to new opportunities for professional growth. Furthermore, the shortage of skilled nurses is a critical issue, leading to the recruitment of highly qualified and experienced nurses from

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[7] https://www.economie.gouv.fr/budget-projet-loi-financement-securite-sociale-2024-plfss#:~:text=Elle%20pourrait%20concerner%206%2C7%20millions%20de%20personnes%20en%202024.&text=Les%20assur%C3%A9es%20de%20moins%20de%2026%20ans%20b%C3%A9n%C3%A9ficieront%20d'une,compens%C3%A9e%20par%20les%20organismes%20compl%C3%A9mentaires.

[8] https://www.rgs.mef.gov.it/_Documenti/VERSIONE-I/Attivit--i/Contabilit_e_finanza_pubblica/DEF/2023/DEF2023-Sez-II-AnalisiETendenzeDellaFinanzaPubblica.pdf (Table 3, p40).

countries like India. Additionally, the hospital often relies on re-employing retired nurses to fill some of these positions. Addressing the shortage of skilled nurses and ensuring equal opportunities for professional development across different nursing categories are some of the ongoing challenges.

In Italy, Cirillo et al. (2022) show that the introduction of the telemedicine resulted in a significant upskilling of the medical staff, particularly for nurses. The nurses in two of the hospitals analysed underwent a relevant training to learn how to read and use the data from the telemedicine systems and were required to perform more complex tasks, gaining greater autonomy from doctors. Such increased upskilling of nurses in medical knowledge, however, found some resistance and scepticism from doctors. Equally, professional and non-professional medical staff had to undergo a training on medical language to ensure effective communications when treating patients remotely. The increasing use of technology at all levels of medical assistance calls for a general upskilling of the health care workers, not limited to on-the-job-training but starting already during the university years. In the field of telemedicine, for all cadres of healthcare providers there is a need for curricula to address digital enablement and digital applications and how to conduct yourself in a digital world and use tools available to them. For example, surgeons are increasingly exposed to robotic surgery and there are AI radiology programmes that are reported to be more accurate than trained radiologists. Health care curricula across the spectrum will need to address this and prepare professionals for an increasingly digitised health workspace.

4.5 Job quality

Similarly to the findings on job quality in the logistics sector, for healthcare we also observe a significant contrast between the case studies in Italy and France and the India and South Africa s. In general, the evidence in this regard is quite mixed: in Italy and France the situation appears to be generally positive, and in India and South Africa the evidence is mixed, with particular concerns emerging in terms of worker monitoring and surveillance.

4.5.1 Work intensification

In the case studies in Italy and France, although the working hours did not change, according to medical staff, the evidence points towards some improvement in working time quality thanks to a better organised workload, lower pressure, particularly at the emergency departments, and less stress. None of the workers interviewed in the French case studies reported increased work intensity. On the contrary, some workers declared that the algorithms helped in reducing their work stress. According to the HR manager*:*

> *The tool facilitates the staff's work. It helps them in daily work and improves the quality of life by allowing them to work with more serenity. We aim to avoid irritation between a speciality department and the ER and avoid delays. Thanks to the anticipation, the tool is supposed to generate less misunderstanding, stress, and disorganisation… We can anticipate and make things run more smoothly.*
>
> *French Healthcare 2***,** HR manager

However, at *South African Healthcare Private 1* the technology has impacted on the working conditions of surgeons in two ways: first, on how they are remunerated, and second, on how they are monitored, which are inter-dependent. Surgeons have had a change from self-determined fees-for-service to a global fee benchmarked against a set of criteria that establish level of efficiency. For surgeons who were already in the efficient or super-efficient tier there was unlikely an increase in work intensity, but for those in the lower tiers, work intensity would have to increase for improvement in outcomes, cost efficiencies and hence their salaries. Similarly for the physiotherapists a global fee is provided, with the motive to reduce the therapy period and to ensure that the patient is treated and healed in the shortest duration as possible:

> *Now in the current system, in a fee for service system, the physio would treat that patient once a day and bill them once a day because they're not allowed to bill them more than once a day. So why would they treat them more than that? But in our system it's about, there is a global fee in place, and the more, the sooner you were able to get the person to their goal, the better. So the physio might come in and treat the person three times that day.*
>
> *South African Healthcare Private 1*, Worker

As a result, in this case, the physiotherapists' work intensity increases, as s/he has more interaction with the patient in a shorter period of time and the hospital system has greater autonomy in terms of being able to intensify their work to achieve results for the same fee. In other words, they are incentivised to have the patients achieve their goal in the fastest possible time. Currently healthcare providers (surgeons, physiotherapists, care co-ordinators) do not have a mechanism on the digital platform to complain or raise any concerns in relation to their working conditions. At present, inefficiencies, complications or conflicts are usually picked up by the care co-ordinator who attempts to address these with the individual, failing which it would be escalated to management. Confidential complaints can be raised through the hospital manager.

4.5.2 Worker autonomy

The evidence is limited across the case studies and countries regarding worker autonomy. In the case of Italy and France, whilst in some cases the technology increased the autonomy of specific categories (i.e. nurses) by supporting them in preliminary data analysis and diagnosis, in other cases the increased standardisation as a result of the need of inputting information according to specific framework has reduced the autonomy of healthcare workers. Moreover, the telestroke and heart monitoring devices technologies foresee a strict collaboration between emergency medical staff and specialised doctors (i.e. cardiologist, neurologist, etc.) that reduces the individual doctor degree of autonomy in favour of a team-oriented work. The development of the technologies did not have any major impacts on the personnel's autonomy in medical interventions, nor on the decision-making process, as these decisions are exclusively taken by humans. Nonetheless, some doctors pointed out the risk that the suggestions made by algorithms may create an acritical consensus among medical staff, given also to the specific order of intervention defined by the algorithm. In other words, the algorithms may induce the whole chain of personnel involved in the care to synchronise on the suggested outcome removing the debate among the medical team.

4.5.3 Data collection for performance evaluation

Like in logistics, it is important to note that a common element across all the technologies analysed in this chapter is that they all embed a strong potential for the collection of a wide range of data about workers (nurses, technicians, doctors, etc.). Although the technologies keep records of all activities occurred, there is some evidence of its use to evaluate workers' performance in *South African Public Healthcare 2* case study, wherein the performance of the Team leaders in the vaccination outreach teams are compared and the management tries to move around the underperforming team. In the *Indian Healthcare Private 1,* data is collected on the number of patients that each doctor consults, and it allows for tracking and comparing the performance of doctors as well as hospital across multiple financial and operational parameters through the dashboard. While the use of digital technologies has made the functioning of employees (doctors and nurses) transparent to the higher management, at the same time there is a possibility in the future to increase their control over them.

Similarly, in the *Indian Healthcare Public 2,* the customised software introduced in the psychiatric unit ensures that doctors follow certain protocols and fill mandatory information about the patient. The digital accessibility of all the patient diagnosis by doctors at all levels can easily be used for evaluation, if needed.

According to head of the emergency in *French Healthcare 1,* the system implemented can trace who is logged in to a patient and can find out how many patients a doctor has seen and how much time is spent per patient. However, he explained that this is not a useful measure because in the emergency room, seeing one patient does not mean you have worked less than someone who has seen 20. Ultimately, the doctor noted that as long as he is working, he will oppose the use of the tool to measure performance. For the technology specialist, the tool does not allow to say that one caregiver is more efficient than another but how the services are provided to the patients. It provides the management with some indicators to observe the occupancy rate of a ward, the average length of stay, monitor how the patients are handled.

Similarly, the patient management tool in the *French Healthcare 2* is not used to evaluate workers, however it is expected to inform general managers about the `correctness of decision´ and `the appropriateness of hospitalisation´ once the technology is 'stabilised'.

> *When we are sure that it works well, it could become a tool for evaluating doctors, to compare the machine's decision with that proposed by the doctor. And maybe later, it could also be used to decide what medical procedure to use. It will be a tool that will reinforce performance or allow us to understand why we have a different result. It could become a training and evaluation tool. However, we are not there yet.*
>
> *French Healthcare 2,* General manager

While this information is not being used to discipline the doctors or nurses, in the hospitals analysed in Italy and France as well as in India and South Africa, there is a potential for such use in the future.

4.5.4 Monitoring and surveillance

The technology adopted in *French Healthcare 1* can monitor the work performed by the workers logged-in and it can register the number of patients visited, the length of the visit as well as the idle time between visits**.** Although currently it is not used neither for surveillance nor for evaluation purposes, it has the potential to be used in the future for such purposes. In addition, the managers could retrieve data on the occupancy rate of a ward, the average length of stay and the number of hospitalisations in the wrong department, which can be used for improving efficiencies.

In South African Healthcare Private 1 data about the surgeons is constantly collected and analysed to assess and compare the costs of surgeons, to achieve cost efficiencies and optimal patient outcomes. In essence this means less autonomy over their working conditions and greater control by the private hospital over how they work.

In the *South African Healthcare Private 1*, the introduction of the digital health platform brought about changes in terms of management practices and teamwork co-ordination and communication. The integrated digital platform and its database facilitates the collection of a significant data set that presents a new opportunity for algorithmic management practice. For example, the care co-ordinator can see in real time the care provided to the patient including whether healthcare professionals in the ward are complying with standard care protocols such as pain medication and use of drips.

This introduces a new mechanism for surveillance where staff who are not even based in the same ward/unit can see the activities of other workers. However, the management interprets this as providing a creative opportunity for engagement around making improvements and that it is not about surveillance.

> *It's not a policing function. This is not to find fault and then lambast somebody. This is about seeing what is the baseline present to us, where are the areas that we can improve on? OK, let me discuss that with the unit manager and how can we, you and I resolve this issue because at the end of the day this is a collaboration. This is not punitive, this is a creative medium whereby we want it to be seen in a very positive light. So even where you need to improve, it's not to lambast somebody. It's about saying do they understand, for example, if they don't give the pain medication, what are the downstream effects?*
>
> *South African Healthcare Private 1*, Manager

Similarly, the introduction of dashboard in *Indian Healthcare Private 1* assists the management in having better control over the organisational performance in real time using the data, which was traditionally done at frequent intervals. It provides transparency into doctor's actions and decisions for improving the accuracy of diagnosis, however, their use extends beyond the improvement of health outcomes to the monitoring or surveillance of doctors. This could overtime lead to increased use of digital technologies and the need to follow specific protocols and procedures to ensure that the process is followed correctly.

The Human Resource Information System that has been developed in the public sector NGO in South Africa is also used to monitor the working time, work contracts, and to centrally coordinate staffing in health care facilities. The donor driven automation to support the public health care services is currently replacing time sheets into digital systems and biometrics have been introduced to clock-in and out of work in some physical spaces in *South African Healthcare Public 2*. The human resource information system however has greater potential for evaluation as it links worker's biographical data to performance data, and was developed and piloted to coordinate work processes. Currently, the data is stored on the server of the technology service provider in compliance with POPIA.[9] However, this system has not been implemented due to lack of funds. Staff were not consulted during the development process of the system, however once developed they consulted with various levels of management and trained them to use the platform.

4.6 Industrial relations

The consultations with workers in adopting digital technology and automation in the hospitals has been very limited across countries. A novelty in *Italian Healthcare 1* was the utilisation of a public-private partnership for the development and application of the digital technology. Nevertheless, we do not find any evidence of a proper consultation process in the case studies covered in France and in Italy, although it is important to note that the technologies analysed have not been perceived as controversial or problematic in any of these cases, and

[9] POPIA or Protection of Personal Information Act No.4 of 2013.

workers have not expressed a concern about them or the lack of consultation. While this can be explained by the initial stages of deployment, the limited use so far, the mostly positive impacts observed for the moment and the fact that existing regulations and institutions play a safeguarding role for the moment, it is surprising that the intrinsic potential for misuse in terms of, for example, worker surveillance has not been taken into account at all by trade unions so far and does not seem to raise any concerns for the time being.

In the case studies in India and South Africa, we find some evidence of worker consultation, which are largely formal in nature and without any practical implications. For example, the process of consultation that *South African Healthcare Private 1* had undertaken to implement the digital healthcare platform was management-driven and exclusively focused on buy-in from the senior medical staff involved, namely, surgeons. There were no consultations with trade unions or nursing councils, although this was acknowledged as a gap. Instead, during the development phase, the private hospital consulted extensively with the Health Professions Council of South Africa (HPCSA) which is the regulatory body for healthcare providers in South Africa. The hospital also had extensive consultations with the discipline specific professional body for the surgeons to negotiate the introduction of the new global fee structure.

In the hospitals analysed in India, the implementation of digital technologies has largely been a top-down approach with resistance from the staff. However, the management has managed to introduce it through persistent persuasion and iterative redesign of the software. Despite such a top-down approach, there has been some consultation with the more enthusiastic adopters among the user groups at the *Indian Healthcare Private 1*. In addition, the feedback from users, particularly doctors, is actively communicated to the design team. For instance, a doctor had provided valuable feedback regarding patient data fields, specifically distinguishing between oxygen saturation levels with and without external oxygen, which helps the design team to improve the software. Similarly, a nurse is part of the IT team and contributes significantly to the software's features. On the other hand, the introduction of software, particularly in the e-hospital at *Indian Healthcare Public 2*, has not been consultative at all. The software has been made mandatory for all hospitals across India, offering limited opportunities for consultation with potential user groups.

5 Discussion and conclusions

The emergence of algorithmic management and its implications for work, employment and our economies and societies as a whole is becoming a highly topical issue both in policy and academic circles. There is increasing concern that, while beneficial from certain points of view, the recent and complex phenomenon of algorithmic management of work can lead to potentially negative repercussions for workers that need to be anticipated and duly taken into account. In particular, the deterioration of working conditions that we already observe in many cases, the changes in the balance of power within the workplace and the practices of digital monitoring and surveillance of workers are reasons for concern. However, the phenomenon is far from being well-known and its consequences need to be further analysed.

This report contributes to the ongoing debate by developing the earlier work on the concept of algorithmic management (Baiocco et. al. 2022) and by presenting original qualitative evidence on algorithmic management. We show, through the case studies conducted in Italy, France, India and South Africa, that algorithmic management is already a reality, and indeed a growing one, in all these countries. We also show that this reality is far from homogeneous: similar technologies may exert very different effects.

A common element to all of these tools is that they are implemented and driven by the objective to maximise profit, increase productivity, improve the business model and foster efficiency gains. Another common element in the technologies we have analysed is that all of them are either being used already, or embed a strong potential to be used, for the purpose of worker monitoring and surveillance, and as there is a power imbalance, there is a potential for individual's privacy and autonomy to be sacrificed in pursuit of corporate profit and control, which is defined as behavioural surplus by Zuboff (2019).

From a conceptual point of view, it is important to note that the use of algorithms for work management functions need not be explicit or even intentional in order to have direct consequences in terms of work organisation, working conditions and industrial relations. In many cases, the technologies we have analysed have implications on working conditions even if they are not directly intended to be used for work coordination. We observe in this report that, for example, the use of business, health, customer or logistics management software may, in practice, lead to the automation of certain decisions that have implications for workers, as it collects and processes information about their work. In practice, these business management software tools can therefore be considered, albeit indirectly, as algorithmic work management platforms. We also show that general-purpose digital technologies such as instant messaging apps can have significant impacts on job quality or worker surveillance, just like sophisticated, ad-hoc algorithmic tools. This implies that the focus cannot be strictly confined to the use of algorithmic tools used for the coordination of work, and instead needs to be broadened to include the use of a wide range of digital tools with implications for the organisation of work within the workplace, including in terms of monitoring and surveillance of workers. The evidence we show in this report reflects two significant contrasts.

First, there is a contrast between the responses we obtained from the workers interviewed in the case studies, who often see no changes in working conditions and no effects in terms of monitoring and surveillance, and the strong potential that these technologies embed in this regard, and in fact are observed in other countries. This may be partly linked to the methodological constraints described in the methodology section, particularly the difficulties to interview a sufficient number of workers and worker representatives, and also the fact that interviewees sometimes did not have the chance to reply anonymously, which may have prevented full disclosure of concerns and particularly negative repercussions. Also, this may be linked to the fact that the very design and implementation modalities of these technologies is opaque, not allowing workers to fully understand the consequences of their implementation. A precautionary approach is therefore warranted in order to seriously consider the possibility that these tools are used for these purposes, even if we do not have evidence yet that they are at the moment.

Second, there is a striking contrast between the impact of these technologies in Italy and France on one side, and in India and South Africa on the other. The case studies conducted in Italy and France show a generally milder impact of the introduction of these tools, with benefits in terms of work coordination and improvements in the business models without pervasive negative consequences in terms of job quality, and also without visible negative implications from the point of view of monitoring and surveillance of workers. In the case studies conducted in India and South Africa the situation is different. With similar technologies and similar types of work, we see productivity and efficiency gains as well as improvements in business models in the hospitals, which have also led to improved outcomes for both customers and patients due to enhanced coordination of work processes and workflows. The impact on working conditions is quite mixed depending on the specific task and technology that has been introduced. However, there is some evidence of the performance being closely monitored and there is a potential to use these monitoring tools, including with disciplinary consequences in the future, if certain regulations are not put in place.

The issue of differential impacts on women were explored as far as possible in the case studies. Many of the healthcare workers such as nurses are predominantly women in India and South Africa, and the case studies are less conclusive regarding the impacts of digitalisation on these workers. Digital technologies can change the role of nurses, and they could become coordinators or supervisors of patient care, or it might lead to work intensification as more tasks are added to their existing roles.

These differences between Italy and France and India and South Africa imply that the impact of algorithmic management in regular workplaces appears to be at least partly mediated by the institutional and the regulatory framework in place. The degree of unionisation and the share of public employment also seem to play an important role in mitigating negative consequences. Indeed, in Italy and France, regulation and trade unions still play a key role in preserving labour standards. In India and South Africa, the negative impacts on job quality and digital monitoring are becoming a reality, and an increasing concern given the lack of appropriate safeguards and controls.

However, the situation in Italy and France require further analysis and leaves no room for complacency. Even in the cases analysed in this report, within a context characterised by a robust body of labour law, more developed social dialogue and strong regulatory enforcement mechanisms, algorithmic management shows already potentially negative repercussions for workers. While overall the situation does not appear to be critical yet, the conditions are created for a deterioration of working conditions and job quality, and the technologies already in place allow for the same forms of worker monitoring and surveillance that we are beginning to observe in some of the case studies in the India and South Africa.

As far as industrial relations and public employment are concerned, the contrast in findings is particularly apparent in healthcare. While in Italy and France the findings are overall positive in a context of mostly public, highly unionised establishments, in the case studies in India and South Africa, there is a significant change in business models with an increasing focus on profit and productivity, also with negative implications for health staff's job quality. The voice of trade unions and different cadres of health workers are excluded from the design and decision-making about digitalisation in the workplace, which needs to be remedied.

However, it is important to acknowledge that technology by itself is not an issue and they by themselves cannot shape their own outcomes. Bailey (2022) argues that the technological outcomes are not hardwired and can be shaped by human choice and agency. This would involve taking decisions on what kind of technology needs to be developed, the design, implementation and use of this technology to ensure that the outcomes are beneficial to all. In this context, the role of policy makers is of utmost importance.

What can policymakers do to address these consequences?

Algorithmic management creates important regulatory loopholes in Europe and beyond that need to be addressed. In Europe, the EU's regulatory framework is already being challenged by the implementation of these technologies. At EU level there have already been policy initiatives aiming at addressing some of these issues. The proposal for a Directive on the working conditions of platform workers addresses algorithmic management, but only as far as digital labour platforms are concerned while, as we show in this report, algorithmic management practices are extending fast into regular workplaces. The Commission proposal for an AI Act also looks into the implication of the introduction of AI in the workplace and classifies as high risk some of the related uses. However the nature and wide scope of the phenomenon as well as its pervasiveness may well require further regulatory steps specifically targeting algorithmic management in the workplace in order to ensure that Europe's regulatory framework remains fit for the digital age, looking at issues such as the reinforcement and actual enforcement of data protection requirements for the workplace currently emanating from GDPR; the regulation of employers' responsibilities in preventing AI risks; the definition of limits to digital monitoring and surveillance to define appropriate safeguards to preserve job quality and address the potentially problematic appropriation of workers´ skills and knowledge, data, etc. It may also be necessary to improve the explainability and transparency of algorithmic management tools: AI systems are very opaque, sometimes even for the people that design or use them. If they are used for monitoring or decision-making or any other purpose at work, it can be technically extremely difficult to understand or perhaps even notice their mechanisms and effects, which makes it very difficult to challenge them.

This applies not only for workers, but also for their representatives and even for the authorities who have to implement labour regulation. In terms of social dialogue and industrial relations, it is essential to ensure that trade unions develop the appropriate technical, institutional and operational capacity to deal with these challenges, ensuring that workers and their representatives get the necessary skills to confront the current algorithmic management practices and the potential expansion of the managerial use of AI at work which, in the light of very recent technological developments in the field of AI through the improvement of, for example, large language models, is most likely to generalise in the future, making even more important a strong role for social dialogue to shape the process.

In any case it is clear that in order to support future policy discussions on algorithmic management and inform policy decisions and social dialogue, further research will be essential to deliver robust evidence on the evolving nature of algorithmic management, its growth and its increasingly visible consequences. In this regard, the recent AMPWork survey conducted by Joint Research Centre (JRC) offers an avenue for further development that could lead to additional quantitative evidence on the nature and prevalence of algorithmic management in Europe and beyond. However, quantitative data as such will not be sufficient to fully grasp this phenomenon and understand its actual repercussions on the ground. The qualitative methodology we have followed in this report, based on case studies analysing in-depth specific establishment offers a highly valuable complementary approach. While there are limits to the amount of high quality, impartial information that can be obtained with these methods, this methodology appears to remain a key available method to gather direct evidence on the impact of algorithmic management in the workplace. It is essential to collaborate and engage with the industry to get a better understanding of what is happening in reality. Further efforts in this direction are therefore worth pursuing, expanding the coverage of countries and sectors, in order to complement existing and future efforts to quantify the phenomenon such as AMPWork.

It is also essential to continue analysing this phenomenon from a global perspective. Regulatory action in the European Union (EU) should take into account the potentially negative spillovers in developing countries: issues of worker exploitation in many of the countries in the Global South can be exacerbated if tighter regulatory requirements are introduced in developed countries and it can lead to changes in global value chains, for example through outsourcing towards developing countries under precarious working conditions, or further use of digital surveillance. Therefore, further comparative analysis of the situation in the Global North and South is particularly important in view of the differences in terms of implications for working conditions and job quality that we observe in this report.

Furthermore, more research in this area should look at the broader implications of this phenomenon for industrial policy, labour law and innovation, taking into account also the energy transition and the interaction between the green and digital transitions in the workplace. It will be essential to continue exploring the implications of algorithmic management for the EU and global regulatory frameworks, labour standards, labour law and employment policies in general.

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Annex 1: Outreach and fieldwork

Logistics

France – Logistics: Outreach activities involved accessing logistics companies of all sizes across France, including multinationals and start-ups. From the beginning of the project, French logistics companies were particularly reluctant to participate in the study. The main reasons for companies declining participation as a case study at the establishment-level included concerns on the legislative process of the EU, time constraints, lack of interest, and unavailability due to lack of resources. In total, around 50 different companies using algorithmic management tools were contacted to participate as a case study at the establishment-level. Consequently, the methodology of the research study for the French logistics was modified to overcome the concerns raised by companies and to collect sufficient data whilst maintaining the overarching scope of the research project. In other words, the field work in the French logistics sector did not consist of two in-depth case studies at the establishment-level, but instead, 25 stakeholders from diverse backgrounds in logistics were interviewed across 14 different organisations or enterprises. This enabled to gain a better understanding of the impacts of algorithmic management tools in the workplace. Stakeholders included French start-ups and large logistics companies, but also industry associations, academia, and public regulatory bodies. All interviews, desk research, fieldwork, data collection and reporting were carried out between December 2022 and March 2023.

Italian Logistics 1: The case study focuses on the robotic technology employed in a large company's new greenfield site covering the logistic process in Italy. The research team had a first preliminary meeting with the EU Public Affairs Manager of the establishment in the first half of June 2022, and after several meetings the participation was confirmed by the Public Policy Manager and Operations PR Manager for Italy in the first half of September 2022. The research team finally carried out the field visit to the site and conducted the interviews in January 2023 following a pre-established questionnaire sent in advance. The Public Policy Manager of the company was present throughout the field visit and the interviews.

Italian Logistics 2: The case study focuses on the employment of the dynamic Driven Sorting Mail technology, a pilot initiative introduced to support workers in the last-mile delivery operations and provide them with real time information in an accessible way. The research team carried out the field visit to a distribution centre in February 2023 and most of the interviews were carried out in-person with the presence of only the research team and the interviewees followed a pre-established questionnaire sent in advance. Only one interview was not conducted face-to-face, with it conducted via MS Teams.

Indian Logistics Private 1: Gaining access to the firm posed several challenges. Being a private organization, the company was as hesitant to participate in a project funded by the International Labour Organization (ILO) due to concerns about it being perceived as an audit of their labour practices. Nonetheless, insights were gained into its operations through two day-long visits to a central warehouse and two half-day visits to local warehouses. During the visits, we observed the work of warehouse managers, supervisors, and workers. However, it should be noted that some participants, particularly those in management roles, chose not to answer all the questions. Additionally, access to staff was limited, and we were not granted access to interview the blue-collar workers.

Indian Logistics Public 2: Visits were conducted at three warehouses. However, similar to the previous case, the company expressed concerns, particularly due to the prevalent issues of leakages and corruption in the retail and backend supply chain, including procurement, transport, storage, beneficiary identification, and retail distribution, which are frequently highlighted in the media. A notice posted at their warehouses strictly prohibits unauthorized entry. During the visits, discussions were held with warehouse managers, data entry operators, and farmers who had come to sell their produce. All interviews were conducted in the local language at their respective workplaces. To augment the interviews, we also engaged in participant observation at two warehouses in India Logistics Private 1 and three warehouses in India Logistics Public 2.

South Africa – Logistics: As part of the outreach activities, a number of attempts were made to gain access to firms in the logistics sector, including liaising with NEDLAC who had endorsed the project and closely works with the tripartite stakeholders, including employers. However, despite numerous efforts, it was difficult to gain interest or access companies. Instead, the study relied on using existing contacts to access different stakeholders who were located within the logistics sector. A total of 17 interviews were conducted with four main stakeholders to get different perspectives: managers, technology specialists, trade union representatives, and workers. These interviews were conducted with logistics sub-sectors reliant on digital technologies; as well as shop floor level workers at various levels from three different firms, in different sub-sectors. All the interviews were carried out in person with the presence of only the research team and the interviewees were sent a pre-established questionnaire in advance so that they were informed about the purpose of the interview and also its content.

Healthcare

French Healthcare 1: The research team contacted the CEO of the technology provider for the algorithmic management tool used at the establishment to manage patients' inflows in June 2022, and the first preliminary meeting was held in October 2022. At that meeting, the company agreed to participate in the project alongside staff members of the establishment. Interviews were carried out between November and December 2022, and were conducted online via MS Teams with a pre-established questionnaire sent in advance.

French Healthcare 2: The research team had a first preliminary meeting with the establishment in June 2022, during which the establishment confirmed its participation. Interviews were conducted between August and October 2022 via MS Teams with a pre-established questionnaire sent in advance.

Italian Healthcare 1: The research team had a first preliminary meeting with the doctor in charge of the deployment of the new technology in November 2022, who immediately confirmed their participation in the study. Interviews were carried out via MS Teams between December 2022 and January 2023 with the presence of the research team and the interviewees following a pre-established questionnaire sent in advance. The selection of the second case study in the Italian healthcare sector, after the completion of the first one, has been quite challenging. Most of the contacted establishments (more than 20) did not answer or reply about their participation. The research team finally decided to compare the findings coming from the first case study with those of the report "Case studies of automation in services" (Cirillo et. al., 2022)[10].

Indian Healthcare Private 1: The connection with the chairperson of the company facilitated the access to this organization. However, we encountered certain challenges specific to the nature of the healthcare profession during the course of the study. Healthcare professionals had demanding schedules and were often occupied with emergencies, leaving us with limited time for interviews. Some interviews had to be conducted while doctors were moving between wards to attend to patients. At the establishment, access to interview participants was primarily controlled by the management, resulting in a limited diversity of perspectives. The data collection process involved both participant observation and semi-structured interviews. All interviews were conducted in the participants' workplaces with their prior informed consent. To protect the anonymity of the participants, their names were anonymized. In addition to the semi-structured interviews, we also conducted participant observation, which complemented the insights gained from the interviews.

Indian Healthcare Public 2: Access was gained through a pre-existing institutional collaboration with the institution. The data collection process involved both participant observation and semi-structured interviews. All interviews were conducted in the participants' workplaces with their prior informed consent. To protect the anonymity of the participants, their names were anonymized. In addition to the semi-structured interviews, we also conducted participant observation, which complemented the insights gained from the interviews.

South African Healthcare Private 1: The permission for participation was provided by senior management and was followed by an application to an internal research committee in the private company. During the initial interview with the senior management, they recommended key individuals to speak with. Once permission for the research had been granted, the research coordinator from the internal research committee approached

[10] The report "Case studies of automation in services" includes three cases of Italian healthcare establishments, i.e., Santa Maria Nuova Hospital, Riuniti Torrette Hospital and IC Humanitas. The interviews conducted at these hospitals have been carried out both in person and online between October 2021 and February 2022 by the research team in charge of the report drafting. A follow-up meeting took place among the researchers in charge of drafting the present report and two of the researchers who drafted the "Case studies of automation in services" report, i.e., Prof. Marialuisa Divella (University of Bari) and Prof. Eleonora Costantini (University of Modena and Reggio Emilia) took place in April 2022 to further discuss the main findings.

potential respondents about participating in the research and set up interview times. Qualitative data was collected through key informant interviews (KIIs) using an in-depth, semi-structured interview protocol. These were conducted in English and over online platforms either MS Teams or WhatsApp. All interviews were conducted with informed consent and permission for audio-recording. The data was collected between November 2022 and April 2023.

South African Healthcare Public 2: The permission for participation was provided by senior management and in the initial interviews the management facilitated access to middle management and workers. Key informants were in the first instance purposively selected by researchers. Thereafter the research team used snowballing method to identify the respondents for the case study. Qualitative data was collected through key informant interviews (KIIs) using an in-depth, semi-structured interview protocol. These were conducted in English and largely over online platforms either MS Teams or WhatsApp. Four interviews were conducted in person during site visits. All interviews were conducted with informed consent and permission for audio-recording. Two site visits were made in the province of Gauteng: one to the head office and one to a clinic. The data was collected between November 2022 and April 2023.

Annex 2. Distribution of interviews in case studies

Table 1. Distribution of interviews for the logistics sector in France

Organisation/ Company	Interviewee	Interview Date
Multinational shipping & receiving and supply chain management company	HR and Social Relations directors	01/12/2022
Software and consulting firm	Account and Project Manager	01/12/2022
Independent logistics and supply chain association	9 different technology experts and project leaders	02/12/2022
Software company	Co-founders and Partners	09/02/2023
Law firm	Lawyer, Professor and Tech expert	09/03/2023
Policy practitioner	Project officer	10/03/2023
Non-profit AI organisation	'AI Security' group leader	13/03/2023
Digital services company	CEO	13/03/2023
Software company	Director and Tech expert	16/03/2023
Multinational container transportation and shipping company	Data Scientist	17/03/2023
Higher education	Computer Science and AI ethics Professor	17/03/2023
Software company	Co-founder	24/03/2023
Public institution	Technology and AI experts	27/03/2023

Table 2. Distribution of interviews at Italian Logistics 1

Interviewee	Main Task	Interview Date
General Manager 1	General Manager	26/01/2023
General Manager 2	Senior Operations Manager	26/01/2023
HR Manager	Senior HR Manager	26/01/2023

Employee Relations Manager	Employee Relations Manager in Italy in charge of collective agreements negotiation, union relations, and disciplinary process management	26/01/2023
EU Director Robotics	Director of Mechatronics and Robotics Department in Europe	26/01/2023
Public Policy Manager	Public Policy Senior Manager for Operations in Italy	27/01/2023
Warehouse Worker 1	Team lead - Stow	26/01/2023
Warehouse Worker 2	Team lead - Wall	26/01/2023
Warehouse Worker 3	Team lead – Stow Inbound	27/01/2023
Warehouse Worker 4	Trainer in the Learning & Development Unit in charge of the training of Amnesty Floor Monitors	27/01/2023

Table 3. Distribution of interviews at Italian Logistics 2

Interviewee	Main Task	Interview Date
Site Manager	Site Manager	08/02/2023
HR Manager	HR Manager	08/02/2023
IT Specialist 1	Production Specialist	08/02/2023
IT Specialist 2	Engineering and Security Specialist	08/02/2023
IT Specialist 3	Engineering and Operations Specialist	27/02/2023
Postman 1	Mail delivery tasks	08/02/2023
Postman 2	Mail delivery tasks	08/02/2023
Worker in charge of internal processes	Sortation tasks	08/02/2023
Workers' Representative	Employee and workers' representative of the company	08/02/2023

Table 4. Distribution of interviews in the logistics sector, South Africa

Interviewee	Sector	Date of interview
Dispatch supervisor (Permanent worker)	E-commerce	09/10/ 2022 15/10/ 2022
Inventory clerk - CT (Labour broker employee)	E-commerce	11 Dec 2022
Inventory clerk/ stock controller (Permanent worker)	E-commerce	09/10/2022
Packer - CT (Labour broker employee)	E-commerce	28/10/2022 29/10/ 2022
Warehouse clerk (Labour broker employee)	E-commerce	09//2022
Regional union representative	E-commerce	09/10/2022
Checker	Food distribution	19/10/2022 10/12/2022
Technology specialist: Project manager/IT systems	Road freight and logistics	11/11/2022
Technology specialist: Systems architect	Export horticulture	15/11/2022
Logistics supervisor/Manager	Road freight and logistics	07/11/2022
National union representative	Road freight and logistics	19/01/2023
Logistics consultant	Property management (warehousing)	06/02/023
CEO of small logistics company	Road freight and logistics	07/02/2023
Assistant driver and shop steward	Road freight and logistics	10/02/ 2023
Reach truck driver and shop steward	Road freight and logistics	10 Feb 2023
Dispatch general worker and shop steward	Road freight and logistics	10/02/2023
Picking controller, operator and shop steward	Road freight and logistics	10/02/2023

Table 5. Distribution of interviews in the logistics sector, India

Interviewee	Sector	Interview Date
Analytics and Software team	Logistics- Indian Logistics Private 1	29/03/2022
Analytics and Software team	Logistics- Indian Logistics Private 1	29/03/2022
Head, Distribution centre	Logistics- Indian Logistics Private 1	25/03/2022
Head, Distribution centre	Logistics- Indian Logistics Private 1	14/05/2022
5K store head	Logistics- Indian Logistics Private 1	20/05/2022
5K store head	Logistics- Indian Logistics Private 1	03/10/2022
Entrepreneur	Logistics-others	16/02/2023
Head, Analytics	Logistics-others	13/03/2023
CEO	Logistics-others	17/03/2023
Assistant Prof	Logistics-others	14/03/2023
District Manager	Logistics- Indian Logistics Public 2	13/01/2023
Office Manager, MSP	Logistics- Indian Logistics Public 2	24/01/2023
Office Manager, PDS	Logistics- Indian Logistics Public 2	24/01/2023
General Manager	Logistics- Indian Logistics Public 2	18/01/2023
District Manager, Ramanagara	Logistics- Indian Logistics Public 2	30/01/2023
Depot Manager, Ramanagara	Logistics- Indian Logistics Public 2	30/01/2023
Depot Manager, Channapatna	Logistics- Indian Logistics Public 2	30/01/2023
Data Entry Operator, MDM	Logistics- Indian Logistics Public 2	18/01/2023
Depot Manager, Kaderenahalli	Logistics- Indian Logistics Public 2	29/09/2022

Table 6. Distribution of interviews at French Healthcare 1

Interviewee	Main Task	Interview Date
General Manager	Emergency physician and head of department	07/11/2022
HR Manager	Head of HR	07/11/2022
Technology Specialist	Director of performance and IT	09/11/2022
Technology Specialist	Technology provider	10/11/2022
Key worker affected by the technology	Bed manager	14/11/2022
Key worker affected by the technology	Bed manager	16/11/2022
Key worker affected by the technology	Physician	07/12/2022

Table 7. Distribution of interviews at French Healthcare 2

Interviewee	Main Task	Interview Date
Technology Specialist	Emergency physician, project manager, university researcher	04/08/2022
General Manager	Emergency physician, head of the emergency unit and EMS	13/09/2022
Key worker affected by the technology	Emergency physician and teacher/researcher	15/09/2022
Key worker affected by the technology	Emergency physician and head of EMS	22/09/2022
Key worker affected by the technology	Emergency Nurse	22/09/2022
Technology Specialist	Data protection officer (DPO) and emergency physician	29/09/2022
HR Manager	Director of Innovation	14/10/2022

Table 8. Distribution of interviews at Italian Healthcare 1

Interviewee	Main Task	Interview Date

Hospital Pharmacy Director	Hospital Pharmacy Director and Value Data technology promoter	19/12/2022
Oncology department Director	Oncology department Director	19/12/2022
Pharmacist 1	Clinical oncology galenic Pharmacist	19/12/2022
Haematology department Director	Haematology department Director and University Professor	20/12/2022
Pharmacist 2	Hospital Pharmacist	11/01/2023
Pharmacist 3	Clinical trial Pharmacist	20/12/2022
Director General	Director General	11/01/2023
Economy and Finance department Director	Economy and Finance department Director	12/01/2023
Administration Officer	Administration Officer	12/01/2023
Clinical Trial Centre Director	Clinical Trial Centre Director	12/01/2023
IT Specialist 1	IT and Communication Specialist	20/12/2022
IT Specialist 2	IT Specialist	19/12/2022

Table 9. Distribution of interviews in the healthcare sector, South Africa

Interviewees	Main Task	Interview Date
Technology manager	ICT senior manager	20/12/2022
Business specialist	Cost analysis	12/12/2022
Clinical specialist	Digital care co-ordination	30/11/2022
Technology/data specialists 1	Health/clinical informatics	29/11/2022
Technology/data specialists 2	Digital health applications	29/11/2022
Technology/data specialists 3	Clinical informatics	29/11/2022
Technology/data specialists 4	Project manager	01/03/2023
Human resources 1	Manager	02/11/2022
Human resources 2	Manager	02/11/2022

Human resources 3	Manager	17/11/2022
Senior manager 1	Clinical product development	28/11/2022
Senior manager 2	Business development	29/11/2022
Senior manager 3	Programme development	23/01/2023
Supervisors & middle management 1	Nurse supervisor	12/12/2022
Supervisors & middle management 2	Nurse supervisor	17/02/2023
Supervisors & middle management 3	Service manager	27/01/2023
Supervisors & middle management 4	Team leader	07/03/2023
Supervisors & middle management 5	Team leader	30/03/2023
Supervisors & middle management 6	Monitoring & evaluation	17/03/2023
Workers affected by technology 1	Nurse	31/03/2023
Workers affected by technology 2	Administrator	17/01/2023
Workers affected by technology 3	Administrator	17/01/2023
Workers affected by technology 4	Data capturer	15/03/2023
Workers affected by technology 5	Data capturer	15/03/2023
Workers affected by technology 6	Community outreach	07/03/2023

Table 10. Distribution of interviews in the healthcare sector, India

Interviewee	Sector	Interview Date
Entrepreneur	Healthcare	23/02/2022
Senior Resident	Healthcare	10/03/2022
Director, Training institute	Healthcare	09/03/2022
Hospital Management	Healthcare	18/03/2022
Chief Radiologist and CEO	Healthcare	31/03/2022

Dermatologist	Healthcare	22/04/2022
Vice President, Analytics	Healthcare	21/04/2022
Vice President, Software Development	Healthcare	26/04/2022
EHR Implementation	Healthcare	26/04/2022
EHR Design	Healthcare	26/07/2022
Chairperson, IT Cell	Healthcare	26/04/2022
Neurosurgeon	Healthcare	06/08/2022
Resident surgeon	Healthcare	06/08/2022
Resident surgeon	Healthcare	06/08/2022
Technology advisor	Healthcare	03/01/2023
Technology developer	Healthcare	03/01/2023
Associate Professor	Healthcare	01/11/2022
HMIS Design/Occupational Therapist	Healthcare-public hospital	22/03/2022
Datacentre Officer	Healthcare-public hospital	28/11/2022
Ex-chairperson, IT Cell, HOD, Dept of Biostatistics	Healthcare-public hospital	30/11/2022
Deputy Chair, IT Cell, Radiologist, Deputy Medical Superintendent	Healthcare-public hospital	02/12/2022
Medical Records Officer	Healthcare-public hospital	08/12/2022
Junior Resident	Healthcare-public hospital	05/01/2023
Junior Resident	Healthcare-public hospital	05/01/2023

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