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TEMPORARY TEAMS LEARNING AND PERFORMANCE: THE CASE OF 3D PRINTING TECHNOLOGY IN ORTHOPAEDIC SURGERY

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Table of Contents

Overview of the dissertation

1. Introduction

The twenty-first century has witnessed a transformation from work organised in stable teams to temporary teams. Temporary teams are short-lived organizational units assembled on demand to perform complex tasks. It is important to note that may be impossible to reassemble the members again once the task is accomplished (Valentine, 2018). As teams are assembled on demand, participants come from different organizational units with a different area of expertise, may engage in various teams at the same time, and move to another team once their contribution to the tasks is no longer needed (Bakker, 2010; Bertolotti et al., 2015; Hinds & Mortensen, 2005; Mortensen & Haas, 2018). The fundamental challenge in temporary teams originates from temporary participation in the teams. First, as participants join the team for a short period of time, there is not enough time to build trust, share understanding, and have effective teamwork interactions. Consequently, team outputs and practices built on teamwork interactions become vulnerable. Secondly, as team participants move on and off the teams, teams' boundaries become blurred over time. It leads to uncertainty among team participants and leaders about who is/is not identified as a team member causing collective disagreement within the team (Edmondson, 2012; Massaro et al., 2020; Mortensen & Haas, 2018).

One of the places this happens frequently is in the hospital setting. Organising and developing a temporary interdisciplinary team of healthcare professionals are now becoming necessary in healthcare organisations. Moreover, healthcare professionals do not simply rely on their knowledge, rather, they use different types of health technologies to improve the quality of the caregiving process (Tucker et al., 2007). In a setting where patient outcomes depend on effective interdisciplinary teamwork and the use of new technologies, there is a need to better understand temporary teams' dynamics.

This dissertation aims to contribute to the scholarly debate on how temporary teams share knowledge and perform while the use of technology enhances the complexity of the tasks. To do so, I gathered data from Rizzoli Orthopaedic Institute in Italy. In this setting, teams of engineers, physiatrists, and surgeons work synergically to provide customised implants with the support of 3D printing technology. I have gathered the data from three main sources: interviews and observations, surveys, and the archival database of the institute. The data have been analysed using qualitative and quantitative methods through two broad research questions: In healthcare temporary teams that work with 3D printing technology:

Research question 1: How and under what conditions does knowledge sharing occur?

Research question 2: How does boundary-blurring impact temporary teams' performance?

2. Research setting

This study has been conducted in a setting where the use of temporary teams is frequent, particularly for the numerous introductions of novel technology. Rizzoli Orthopaedic Institute is a highly specialised public hospital with state-of-the-art research facilities in the field of Orthopaedic and traumatology acting under the arrangements of the Italian national healthcare system. It is recognised as a Scientific Institute for Hospitalisation and Care (also called IRCCS, the Italian acronym). The primary mission of the institute is the strong integration between healthcare activities and scientific research. The latter is carried out by nine laboratories of standard translational research and six industrial research laboratories, all operating at the institute, where about 250 people are employed including doctors, biologists, engineers, and other professionals. Within these research activities, the application of modern technologies for the design of customised or large-scale customisation devices is now becoming increasingly performed; most of this is conducted under the coordination of the Laboratory of Movement Analysis and Functional Evaluation of Prosthesis (www.ior.it). Surgical planning teams are highly hierarchical, each team having a single Head/Supervisor with high competence and long experience in Orthopaedic surgery. The treatment process starts when a patient is visited by one of the surgeons of the team and, the clinical indication is surgery. The head decides about the team participants and the techniques to treat the case. If standard solutions and devices are deemed inappropriate, a possible personalised treatment is exploited. According to the specific case requirements, a number of additional participants from internal and external units may then join the team.

2.1. The use of 3D printing technology

3D printing technology has started to make significant changes in the healthcare sector. It is rapidly changing clinicians' perspectives on how health care services can be delivered more efficiently. The fundamental idea of 3D printing technology is to create a part by adding material layer by layer, each layer on top of the previous layer (KhorramNiaki & Nonino, 2018), which makes providing any internally complex object possible, such as customised and personalised prosthetics and implants (Ventola, 2014). Therefore, the ability of the technology to personalise the delivery of health services and the flexibility of design are the real differentiation (Culmone et al., 2019). On the other hand, 3D printing presents the extreme potential to improve the research environment, knowledge, and abilities of the new generation of clinicians as well as the relationship between clinicians and patients and a precise understanding of disease and patient-specific needs for implants and surgery; more importantly, it optimises the cost of surgery based on personalisation and customisation (Diment et al., 2017).

3. Research Outputs

The dissertation consists of three main research outputs. The first is a conceptual chapter that reviews the literature on temporary teams as well as the pertinent bibliometric analysis. Research on temporary teams has been conducted for decades, but the literature is scattered and the lack of a clear picture of research on temporary teams is evident. Through bibliometric analysis, core authors, core literature, and the themes emerging from temporary teams' literature are identified. Moreover, current research hot spots and future research directions are presented through synthesising the literature. Finally, this chapter highlights the strong connection between the literature of temporary teams and project teams.

The second output is a qualitative study that specifically focuses on the challenge of temporary relationships among team participants. Team knowledge sharing is a closed-loop process, heavily built on the interaction among individuals. Long-term and stable relationships are hampered in temporary teams; this negatively impacts knowledge sharing practices. On top of this, there is always a reason to organise temporary teams which is the complexity of the tasks. Complexity in the setting is the use of 3D printing technology to provide a customised and personalised treatment. Therefore, I explore how and under what conditions knowledge sharing occurs in temporary teams which use 3D printing technology to support surgical interventions. The study focuses on the planning phase of orthopaedic surgeries in which senior surgeons organise a temporary team to provide highly personalised patient treatment using 3D printing technology. Results of this study show that the hierarchical structure of the teams facilitates knowledge sharing at the team level.

The third output of this dissertation is an empirical paper that focuses on members' movement on and off the teams and continuous change in membership status. It highlights the gap on team boundaries in temporary teams' literature. Participants' movements on and off the teams raise broad questions on the boundaries of the teams not only for the employing and managing organisations but also for the teams themselves. However, extant research does not fully address the membership status and movements within and between teams, either conceptually or empirically. Using a quantitative study, I explore how the drivers of temporary teams' boundary-blurring impact team performance at different levels of task complexity. On the one hand, the paper focuses on surgical teams who use 3D printing technology to provide customised implants for orthopaedic surgery and developed hypotheses on the direct effect of boundary-blurring on team performance. On the other hand, moderating effect of complexity on team performance was investigated.

4. Structure of the Dissertation

This dissertation is comprised of five chapters. The first provides an overview of the dissertation. The second chapter illustrates the bibliometric analysis and review of previous literature from 2010 to 2021. The third chapter consists of the qualitative study that explores the knowledge sharing process at the team level. The fourth chapter consists of the second empirical paper that investigates the impact of blurred boundaries on temporary teams' performance. Finally, conclusion and directions for future studies have been provided in chapter five.

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On the transform of teams from stable to temporary: bibliometric analysis, synthesising the literature and future directions

For several decades there has been interest in understanding the new forms of the teams and their dynamics. There is now a new form of teams called temporary teams, and the most significant feature of these teams are the time period team participant perform their tasks together. Temporary teams represent a growing response to the need for fast solution to complex tasks. The attention to so called "temporary teams" has resulted in a body of research that has become largely scattered and fragmented. Hence, this study offers bibliometric analysis to identify patterns, theme, and clusters on the research of temporary teams. Moreover, we review and position the articles within identified themes from bibliometric analysis. As an important contribution, the systematic approaches to synthesizing earlier research enables us to identify important areas that the field has been dealing with as well as potential areas for future research.
Keywords: Temporary teams, bibliometric, future research

1. Introduction

There is now a new form of the team that is making a big difference among organisations in the past and contemporary organisations (Lv & Feng, 2020). Temporary teams are increasingly viewed as a common way to get work done which includes interdependent and connected participants (Valentine, 2018). From this perspective, any change in membership status, lifespan of the teams, or team leaders introduces a pattern of formal and informal communications, relationships, and performance among new participants within the teams (Park et al., 2020).

Over time, teams literature has indicated several challenges by examining different contexts, such as project-based teams, R&D teams, healthcare teams, software development teams, and virtual teams. However, there is a consensus that the essential factor in organising and leading temporary teams is complexity of the task, and the project that teams are expected to accomplish. As tasks become more complex, the adoption of temporary teams increases sharply in real workplaces. The increasing adoption of these temporary teams provides a fairly rich ground on which to expand our knowledge of the new forms of doing tasks in organisations. Hence, the notion of temporary teams is not a new phenomenon, and research on temporal aspects of the teams has found its right position in team literature. There already exist some studies reviewing the literature on temporary nature of teams such as narrative or integrative reviews (Lv & Feng, 2020; Bakker, 2010). However, prior reviews focus on the core studies and core authors rather than having comprehensive view on recent studies. Yet, the state of knowledge is scattered, and has not advanced in a cohesive way that involve recent researches. Our study focusses on the temporary nature of the teams, aiming to reveal the most important topics and debates in temporary teams literature, and the way future research can advance this field of study. This paper takes a broader view on recent state of the art publications in Web of Science database by combining bibliometric analysis and summarizing the literature. Alternatively, our main research question is: how has research on temporary teams been advanced in recent years? What do we know about temporary teams in the field of management? The importance of our review lies in the fact that temporary forms of the team is the way of working in contemporary organisations. Therefore, a deep understanding of temporary teams' functions and characteristics can provide insightful guidance to manage and work with the teams in a more productive way.

2. Concept of temporary teams

The transformation from stable to temporary teams has made team literature vibrant during past decades, and has generated a new stream of research for management scholars. Today's teams are temporary, short-lived organisational systems that assemble on demand to accomplish very complex tasks, and which are disbanded once the tasks have been fulfilled (Valentine, 2018). In other words, temporary teams are concerned with performing the ongoing tasks, faced with time pressure, and are not configured for future interactions or long-term efficiency in the team process (Saunders & Ahuja, 2006). In the same vein, project management literature takes a bottom-up view of teams, by looking at the project-based organisation of work, while following by the people (in the form of project teams) performing the projects. The project-oriented organisation is conceptualised as an innovative organisation, which uses projects as temporary, task-focussed organisations to define and develop new products, services, and business models (Gemünden et al., 2017). This perspective helps to theorise projects as temporary organisations regularly relying on team structures with a temporary nature that tends to focus more on the tasks (Sydow & Braun, 2018).

The use of temporary teams helps managers to isolate the changes to smaller parts of an organisation, define tasks, and allocate additional resources on a small scale (Jacobsson & Hällgren, 2016). Given the complexity of the tasks temporary teams deal with, many of them are necessarily fluid, with employees moving easily from one team to another team (Dibble & Gibson, 2018; Summers et al., 2012). Members may experience multiple memberships, as they can be engaged in several teams at the same time and individuals may vary in terms of geographical location or organisational units (Mortensen & Haas, 2018). However, what attracts attention in the case of temporary teams is the fact that participants may meet each other for the first time and start collaboration to perform the tasks within a finite timeframe without any shared experience (Valentine, 2018). All these aspects invite more academic insights in management studies to deal with temporary teams.

Of interest in the present study are 'temporary teams'; we highlighted their unique characteristics by making comparisons between temporary and stable teams in terms of inputs, process, and output (Table 1). In turn, we believe that 'temporariness' in the teams is more relevant to the problem-solving process rather than team design process. With regard to the setting, teams are embedded, and address the problem to be solved; they set a target point and establish the time to achieve the target (Seers & Woodruff, 1997).

--Insert Table 1 about here--

3. Search methodology and inclusion criteria

For the first step of searching, we focussed on temporary teams as the main unit of analysis to better structure our study and understand the main topics of the subject. The main factor for inclusion in our database was whether the paper investigated a phenomenon in the context of temporary teams. Our objective was to summarise what has been studied in the context of temporary teams, how the knowledge about temporary teams emerges (by studying variables), and what the directions for future research are. Our search method started with the identification of relevant research published on this topic from 30th December, 2009, to 1st November, 2021. An extensive search based on the titles, abstract, and keywords of the published articles in the Web of Science was performed by submitting several keywords (available in the Appendix). Having listed search results, we performed a manual check of the title and abstracts of the papers to remove irrelevant articles. At the end of our search, 226 relevant papers were included in our database.

Further exploration of the papers was implemented by bibliometric analysis using RStudio followed by coding in NVivo. Moreover, we examined PRISMA, 2020 guidelines for abstract checklists (Page et al., 2021) to review abstracts of the included studies. Further, we collected the data on research questions, methods, context and variables studied in the papers. The first level codes included Research Questions (to investigate what has been studied with regard to temporary teams), methodology (in terms of qualitative and quantitative research methods), team context, and the main variables (to identify how the knowledge related to temporary teams has been emerged), and future directions (to understand the main domains to be studied further).

Our search methodology was not limited to the key words, rather a snowball approach was followed while reviewing papers. Therefore, there was a back-and-forth procedure to provide a deep overview through each paper and to identify the progress of temporary teams in management research.

4. Descriptive details of extant publications

As mentioned, the articles we considered for review were published between 2010 and 2021, Figure 1 shows number of articles published per year within the period. However, the number of articles reached double digits soon after 2010, and maintained the same trend except for the years 2012 and 2015. Moreover, the number of articles reached the maximum in 2018 with 33 publications. The trend also spanned a wide range of journals; as Table 2 shows, the greatest number of articles were published in the *International Journal of Project Management*, followed by *Project Management Journal* and *International Journal of Managing Projects in Business*. The presence of project management journals among the top three emphasises the importance of temporary teams in project-based organisation. Figure 2 illustrates the growth of the publications in the first three journals that have the highest number of articles on temporary teams. As the figure depicts, the *International Journal of Project Management* maintains this increasing trend by 2021, whereas *International Journal of Managing Projects in Business* remains at the lowest level. With regard to the universities ranked by research output, we found that research on temporary teams comes from ten major universities located in different geographical areas. Figure 3 shows that the highest number of publications is attributable to the corresponding authors affiliated in European universities such as the University of Agder, BI Norwegian Business School, and Tilburg University.

--Insert Figure 1 about here--

--Insert Table 2 about here--

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As citations are a measure of influence in the literature, we ordered the most globally cited papers in our database. Table 3 shows the most cited papers between 2010 and 2021. As the journals publishing most cited papers are related to the subject of project teams, it can be concluded that studies in the area of temporary teams have a strong connection with literature on project teams. This is because of the increasing complexity of projects that motivates the formation of temporary teams. This idea is reinforced by the word cloud derived from the papers (Figure 4), indicating that a major part of the word count belongs to 'temporary' followed by 'organisations', 'projects', and 'teams'.

--Insert Figure 4 about here—

Moreover, a co-citation map provides a tool for filtering the most important publications in a field. Therefore, a network visualisation was mapped using RStudio. Regarding the co-citation network in Figure 5, two articles depicted by nodes are connected (shown by links) when they cooccur in any research article. According to our initial analysis of the co-citation network analysis, three main interrelated clusters emerged: Cluster 1(red cluster), Cluster 2 (blue cluster), and Cluster 3 (green cluster). The co-cited papers in these clusters tend to share some common themes in terms of subject similarity.

--Insert Figure 5 about here--

--Insert Table 3 about here--

To identify common themes within the clusters, we studied all the articles in them. Cluster 1 is the largest, and includes nineteen papers contributing to the literature on project-based work. The main theme for this cluster is the emergence and evolution of temporary teams organised around projects, and the antecedents for the organisation of project-based work, considering temporal aspects. The body of literature contributes to the project-based organisations that organise their work based on the project structure. However, a major proportion of the studies investigated the challenge of the temporary nature of the teams, and the interplay between time constraints and project organisation. Moreover, the studies conceptualised projects as temporary entities that bring organisational units together temporarily, and then investigated the relationship between the project team and the parent organisation. Therefore, we summarise this research stream in a theme that mainly looks at the 'inputs and antecedents' of temporary teams.

Cluster 2 is the smallest cluster, and includes fourteen research works; yet, it shows significant linkages to the articles in cluster 1 and cluster 3. Although, the second cluster is strongly attached to the project teams' literature, discontinuous constellations and content is more highlighted in comparison to Cluster 1. In fact, the difference between project teams and stable teams is reiterated by highlighting the difference between the project-based organisation and the standard organisation of the work. Having studied the second cluster (blue), we realised that the cluster mainly concentrates on the success of projects and factors that impact the project teams' effectiveness, success, and creativity with a close eye on the project teams. Therefore, we can labeled the main theme of the papers 'expectations and outputs' in temporary teams.

Studies positioned within the third cluster focus on the linkage between task and team, and map the interplay between project tasks and project teams. The research stream is more concentrated on the process within the teams such as learning, innovation, trust formation, and collaboration. In some studies, the authors pay special attention to the context of collaboration to model the interactions between project members. Therefore, the label 'process and dynamics' will fit with the content of the third cluster.

5. Review of research on temporary teams

Having reviewed our research aims and the questions originating from our database, we categorised temporary teams' literature in terms of the three main themes identified in the previous section.

5.1. Inputs and antecedents

Given the inputs and antecedents in our review, we organised this section in terms of the pre-existing factors before the formation of the teams, such as prior work experience, prior ties among team members, and the intellectual capital that had been investigated at the individual levels. Buvik and Rolfsen (2015) investigated the impact of prior ties on trust development during teamwork through a qualitative methodology. They devoted special attention to the nature of ties, indicating that positive ties facilitate development of trust. In the same way, Prikladnicki et al., (2017) examined the prior experience of working together among the team members, based on the degree of complexity of the projects. Buengeler et al. (2020) investigated the degree of intactness across project teams and the way it impacts project success. They discovered an inverted U-shaped relationship between degree of intactness and project success, indicating that maximum success corresponds with a minimum degree of intactness. Nisula and Kianto (2016) examined the antecedents of innovative behaviours shown by individuals in the team setting. They supported the idea that innovative behaviour depended on the personal characteristics such as individual creativity and task orientation, rather that team and environmental factors. Massaro et al. (2019) referred to the resource-based view theory to investigate the impact of intellectual capital on performance of temporary teams. Their results show that intellectual capital influenced the performance once it was mediated by the team level mechanisms, such as the decision-making procedure and leaders' experience. Chan et al. (2020) studied the impact of multiple membership on individual and team learning. Although they found a positive impact on individual learning dependent on the high and low need for cognition, the negative impact on team external learning was supported in their study. Similarly, Bertolotti et al. (2015) considered the subject of the impact of multiple team membership on the performance of the teams by focussing on the use of instant messaging during knowledge work. Their findings revealed inverted U-shaped relationships in the way that the use of instant messaging positively influenced team performance when multiple team membership was low, and negatively affected team performance when multiple membership was high. Tarandach and Jazaieri (2020) indicated the most challenging part of temporary teams, which is temporary relationships. They investigated the ways to exploit a swift sense of community through short-lived and temporary interaction. However, they underlined the importance of dyadic and momentary interactions in the formation of a swift sense of community. Chae et al. (2015)

explored the dependency of factors enabling individuals' creativity on the characteristics of teams. They made a comparison between temporary and stable teams in terms of the tasks each team needed to accomplish. Their results showed that the complexity of the tasks was highly related to individual creativity in stable teams rather than in permanent teams. However, they emphasized the importance of task complexity and team characteristics to achieve team goals. Fernandes et al. (2021) examined the impact of IT support on the execution of processes in temporary teams. They highlighted ambiguous nature of IT use in multi-level work procedures. Benedittis (2019) studied the transaction process between temporary teams for enabling and prohibiting the transaction process. Moreover, they investigated the combination of factors identified during their study. Winch (2014) paid special attention to the role of the owners and operators of the project as a permanent organisation who are the main source of financial support and human resource for projects.

5.1.1: Input and antecedent related variables

The current stream of literature on the inputs and antecedents presents input in the form of independent variables in situations where their impact will be fundamental. Perceived task orientation and safety (Nisula & Kianto, 2016), prior ties and experience (Buvik & Rolfsen, 2015; Ebers & Maurer, 2016; Lindner & Wald, 2011; Valentine et al., 2019), skills (He et al., 2019), intellectual capital (Massaro et al., 2020), multiple membership (Bertolotti et al., 2015; Chan et al., 2020; Spanuth & Wald, 2017), and role stress (Savelsbergh et al., 2012) were studied as the main inputs and antecedents in the literature.

5.2. process and dynamics

Our review of the literature involved process as a concept that embodied team dynamics after the formation of the teams. The idea investigates the ongoing process within the teams as a part of team procedures. Process in teams mainly refers to the formation of trust, collaboration, coordination, leadership, and engagement, within the team without any consideration of the results and outcomes of the team's efforts.

5.2.1. Trust

An extensive body of literature has investigated swift trust in temporary teams. These studies propose that the temporary nature of the teams prohibits meaningful relationships and trust among team members who perform successfully. However, the studies strenuously investigate swift trust in temporary systems, and concur that the most important barrier in this stream of literature is conceptualising trust in the setting. One reason is that development of trust is highly dependent on normative actions in the temporary systems. Trust is one of the widely studied subjects in organisation studies, and team literature has extensively explored it. Once again, the temporary nature of teams highlights the importance of trust and the way trust is built within teams.

Crisp and Jarvenpaa (2013), argue the essential normatives of swift trust guiding team performance. They built their theory on early beliefs about trusting, and support it by designing experiments on virtual teams. Their results clarified that early trust enabled team members to engage in normative actions. McLaren and Loosemore (2019) present a qualitative approach to investigate trust formation in international disaster teams. Relying on the swift trust theory, they examine the assumptions and represent the importance of acting with respect, openness, humility, and respect with regard to local cultural traditions.

Müller et al. (2016), performed a deductive study to argue temporary organisations governance and ethical issues originate from the governance and the way ethical issues were influenced by corporate governance. The study revealed that temporary organisations' governance strongly affected ethical issues when the corporate governance is absent. Rather, corporate governance was associated with one third of the ethical issues originated from the temporary organisations' governance.

5.2.2. Knowledge and learning

Faraj et al. (2011) studied online communities and the way these communities engage in knowledge collaboration. They identified five tensions associated with five different resources that dynamically affect knowledge collaboration in online communities. The five tensions include passion, time, socially ambiguous identities, social disembodiment of ideas, and temporary convergence. Bakker et al. (2013) studied the perceived timeframe of teams that work on creative projects and its effects on project dynamics. Through an experimental study they found that timeframe moderates the negative effect of team conflict on team cohesion. These results were consistent with the temporary nature of creative projects that shape different timeframes among project participants. Hällgren (2010) theoretically conceptualised groupthink in mountain climbing teams using retrospective analysis of survivors' accounts. Their case study indicated symptoms of groupthink that made the situation problematic and resulted in the death of several people. Parent and Maclntosh (2013) focussed on the organising team of Winter Olympic Games of 2016, and qualitatively examined the way in which the organisational culture was built. Their results revealed that organisational structure, culture, and socialisation interacted together relying on the time. Müller et al. (2013) investigated some ethical issues raised in temporary organisations, and explored them in the particular context of governance and trust.

Vashdi et al. (2013) investigated temporary teams' learning. They conceptualised learning as a team property, and proposed a model that indicates that the short lifespan of the teams does not impede team learning. As long as helping behaviours occur in the teams, teams are able to learn and achieve their desired performance. The importance of learning behaviours and their relationship with team outcome was discussed in the study by Braun et al. (2013). They studied citizenship behaviours in temporary organisations, and realised that these substantially improved the overall success of the temporary organisations. They also found evidence indicating improvement in the quality of relationships beyond the termination of the projects. Bakker et al. (2011) investigates knowledge transfer in project teams. They take an inter-organisational viewpoint to knowledge transfer, in which multiple organisations work jointly to produce complex goods or services in a limited amount of time, and multiple knowledge flows occur simultaneously. In the same vein, Pauget and Wald (2013) focussed on the project team members' network to investigate how they exchange information and knowledge as well as coordination. Their qualitative in-depth analysis showed that for the majority of project members, their network position and roles corresponded to those prescribed by the formal project organisation.

Valentine (2018) qualitatively explored the conditions in which team members of hospitals' emergency departments engaged in extra-role behaviours. She focussed on the existence of justice in the distribution of work, and the members were more willing to engage in extra-role behaviours and were coordinated as a team. Fisher et al. (2018) conducted an inductive study to explore the way temporary teams receive support while working on a complex project. They introduced the idea of deep help as the core finding of their study; this means the intensive and continuous support of the teams (Fisher et al., 2018). Kohonen-Aho and Tiilikainen (2017), conducted a qualitative study to investigate the way temporary teams of students engage in informal interactions, and the way informal interactions were related to shared context. They realised transgression helped teams to construct a shared context. However, transgression was highly dependent on the interpretation of the team members of interaction, and this can positively or negatively impact team performance.

Schulze and Hogel (2006) investigated the stream of knowledge creation in the new product development teams. They focussed on the product success as the outcome expected from the project team, and explored the impact of knowledge creation on the outcome. However, their conclusion suggests that knowledge creation in different phases is differently associated with the final product success. Shepherd et al. (2019), performed a conjoined analysis of R&D teams, and investigated individuals' knowledge sharing within the team. However, they introduced R&D teams as their context, and their level of analysis was at the individual level.

Chan et al. (2020) investigated team and individual learning, while the project teams involved participants from inside and outside of the organisation. They concluded that participants' multiple membership positively affected individual learning. Chae et al. (2015), made a comparison between temporary and permanent teams to explore the relationship between individual creativity and the type of teams. They considered the complexity of the tasks, and examined individuals' creativity in temporary project teams against permanent R&D teams. Their results confirmed the strong relationship between the team type and task complexity, showing that more complexity and deadline pressure required more knowledge sharing and creativity. Sergeeva and Roehrich (2018) implemented a broader approach on temporary organisation. They approached literature of learning organisation through abductive multiple case studies, to identify the key characteristics of learning and its impact on temporary teams. The importance of boundary spanners in collective learning processes and formation of the personal networks were revealed as factors promoting learning.

Ojansivu et al. (2021) investigated the interplay between temporary and permanent units to see the way that teams used the boundary objects to overcome knowledge boundaries. They introduced three main boundary objects that teams used to obtain knowledge based on their aims to manage situations.

5.2.3. Coordination

Pilbeam (2013) highlighted the importance of coordination in temporary teams while they are being formed across different organisations. The study identified a four-stage model of coordination in the context, given the stages dependence on temporal and social embeddedness. Fernandes at al. (2021) qualitatively studied intra-organisational coordination in the temporary organisation of the Olympic games organising committee. They realised that coordination on operational mechanisms is built on a combination of formal and informal mechanisms. Valentine and Edmondson (2015) performed a mixed method analysis to understand the way meso-level structures result in effective coordination in emergency departments of hospitals. They realised that team scaffolds were the core to achieving optimal team structure and roles, which enabled reliable interactions in temporary and short-lived teams. In an ethnographic study, Marrewijk et al. (2016) studied project teams negotiations on roles and responsibilities. They attempted to understand how project teams members negotiate their roles, responsibilities, and hierarchical relations in the collaboration between members from large scale and geographically distributed teams. They concluded by proprosing three types of practices by individuals to facilitate negotiation among members.

5.2.4. Leadership

Leadership literature has proved the important role of organisational context for leadership, and has encouraged the publication of more studies on the match between leadership styles and organisational context. Tyssen et al. (2013) investigated the effects of transactional and transformational leadership by considering temporary organisations' characteristics. They concluded that transformational leadership is more effective than transactional leadership in temporary organisations, although the impacts became stronger by increasing the complexity of the project. In the same vein, Palanski and Yammarino (2011) investigated the impact of leaders' behavioural integrity on followers' job performance in temporary work teams. They found that leader behavioural integrity was not directly related to followers' job performance, but was related indirectly via trust and the follower's satisfaction with their leaders.

Klein et al. (2006), qualitatively examined leadership in medical teams of trauma resuscitation units in the hospital setting. They realised that the leadership system in the teams being studied was highly hierarchical, but also flexible. Similarly, Zhuo et al. (2016) explored the impact of a directive and empowering leadership style on the performance of temporary teams using agent-based modelling. Their results show that directive leadership is not a proper style of leadership in temporary organisations, but performs rather better in stable organisations. Unger-Avriam et al. (2013) focussed on the importance of leadership behaviours and management style in project teams, and quantitatively explored the goal attainment activities, feedback, and recognition for project teams' performances. Their findings showed that the leadership behaviours positively influenced effectiveness in the teams, rather than efficiency.

Tabassi et al. (2019) explored the relationship between conflict management style and team performance. They studied multicultural project teams, and found that avoiding conflict management can yield a positive impact on team performance. Savelsberg et al. (2012) empirically investigated shared stress at the team level and its impact on the collective performance of the project teams. They focussed on the role of stress in the teams, and found it to have a negative impact on the team performance, as it inhibited team learning.

5.2.5. Process and dynamic related variables

In addition to the themes related to process and dynamics, a major proportion of the research papers in our database have been enriched by exploring new moderators. Moderators have been conceptualised in the form of work load share and complexity (Vashdi et al., 2013), knowledge exchange (Haynie, 2012), feedback behaviour and activities (Bertolotti et al., 2015; Massaro et al., 2020; Unger-Aviram et al., 2013), and trust development (Ebers & Maurer, 2016); these were the frequent factors that authors were interested in exploring.

5.3. Expectations and outputs

Another stream of literature included with the academic works that comprised the studies focussed on the outputs of the teams and organisations. Tabassi et al. (2019) investigated the impact of the conflict management style on team performance. Their results revealed that avoiding style of conflict management can positively impact team performance. Wegmann (2020) studied the factors influencing performance of disaster response teams using the grounded theory approach. They realised that the process and methodology of performing the tasks in terms of leadership and management was the determinant factor influencing performance. Similarly, He at al. (2019) empirically investigated key influential factors on team performance by focussing on individuals employed by exhibitors in trade shows. They realised that servant leadership and swift trust have a strong positive impact on team performance. Focussing on knowledge-intensive consulting projects, Hanisch and Wald (2014) investigated the effects of complexity on the success of temporary organisations. They showed that structural complexity negatively impacts temporary organisations' success, while task complexity has no significant effect (Bjorvatn & Wald, 2019; Hanisch & Wald, 2014).

Buengeler et al. (2020), explored project teams' fluidity and its impact on team success. They investigated the relationship by focussing on the transition from one project to another, and tracking the degree of intactness in project management teams. They showed that a lower level of intactness is associated with the the increased success of projects, and when projects are more innovative.

5.3.1. Expectation and output related variables

Another important observation inferred from our review is that many studies have focussed on outputs from different levels of analysis. Although, the main team emergent output was team performance, researchers approached team performance from different viewpoints considering the multilevel nature of team performance (individual, team, and organisational level). Individuals' innovative behaviour (Vashdi et al., 2013), quality of work, and project success (Braun et al., 2013; Schulze & Hoegl, 2006), knowledge development (Valentine et al., 2019), individual creativity (Chae et al., 2015), effective coordination (Tabassi et al., 2019), team learning (Chan et al., 2020), commitment (Spanuth & Wald, 2017), and effectiveness (Lindner & Wald, 2011) were the main themes that emerged in the research papers.

6. Future directions

A major proportion of the publications studied in this paper encourage further research to deeply investigate the main challenges related to temporary teams. The challenges arise when skilled individuals who may never have worked together before join together as a team to perform complex, interdependent, and time-limited tasks (Klein et al., 2006). As temporary teams play an important role in project teams' literature, the majority of the studies in this area have paid special attention to the multilevel nature of projects. On the one hand, projects became temporary in order to be fulfilled a series of multi-level tasks, but on the other hand, different teams gathered around projects at different stages of the projects' lives. Therefore, the importance of leadership and management style at different stages of the project needs to be expanded upon. Second, the satisfaction of prior collaboration and its impact on project success should be investigated in a multi-stage approach through the project's lifetime. For example, project success may vary in the planning phase in comparison to the operation phase. Success in both stages is highly dependent on the act of translating the plan to the operation, as well as the degree of knowledge creation from one stage to the other. Here a potential research question is to some extent knowledge creation modes of one project are of relevance for later projects? Or can further research address the antecedents that lead to the occurrence of knowledge creation modes? In the same vein, the interplay between leadership style, commitment, and project characteristics can be further investigated considering different levels of project complexity.

In addition, the importance of prior collaboration and its impact on team process and outcome has been encouraged continuously in different contexts taking into account network, team, and organisational approaches. However, while project and social network literature devotes special attention to the prior collaboration at individual levels, less attention has been paid to the prior collaboration as a team emergent factor. This highlights the importance of team overlap at the different levels of work progress. One potential research can form to investigate the impact of team overlap on the final performance of the teams. In other words, to some extent team overlap between two phase of the project contributes to the success of the project.

Having focussed on more psychological perspectives in teams, investigating the impact of group and role stress, wellbeing, and trust on temporary teams' processes have been suggested for future work. Moreover, identifying the factors motivating desired interactions and competency, learning, helping behaviours, and shared understanding have been encouraged in the context of temporary teams. Moreover, there is a great opportunity to investigate how temporary teams access knowledge resources and how they retrieve knowledge at the team level. Does access to knowledge resources occur as the result of individual efforts or team environment, especially in the context of virtual teams and teams that are working through digital platforms?

As for collaboration, there is a gap in the literature on how creativity and innovative ideas evolve within temporary teams in response to the complexity of the tasks, and how any change in solutions generates additional connections and trajectories to other contexts. Another research question would be to investigate the dynamics of new ideas generation along with the flow of people within the teams.

Moreover, the impact of the organisational/departmental/team culture on team process has been proposed in team literature. It is important as culture is a factor that leads individual and team practices while doing tasks. Moreover, culture helps to identify organisational justice which in turn impacts individuals' performance enhancing behaviours.

Empirical work on project networks seems less developed in project teams literature. As network-analytical studies in project management are still significantly less prevalent than in related management disciplines, there are several calls for further empirical work on project networks. There are also research interests from project governance viewpoints. They suggest investigating trust and ethics when projects are governed simultaneously from a corporate centre and in settings in which projects are governed by temporary multi-organisational teams. Potential research questions can be proposed by investigating the related implications for governance in these settings or settings with both features.

As for investigating team level attributes, team task, team structure, teamwork process, workplace, and organisational context provides opportunities for future research to extend the characteristics of any of these factors and their interplay, in order to contribute further insights. In line with these streams of literature, we build the concept of this dissertation on the temporary nature of the teams focusing on the team participants interactions. Relationships in the teams are temporary, this hampers trust and social interaction within the teams challenging knowledge sharing practices among participants. Secondly, less attention has been paid to the movement of the participants in and off the teams that highlights the issue of the boundaries in temporary teams. This arises because of the fact that the teams assemble on demand and disband after the tasks are fulfilled, and there are not necessarily any prior or follow-up interactions. Therefore, it is important to investigate how temporary relationships contribute to the knowledge sharing environment in the teams and how blurred boundaries of the temporary teams impact performance which will be addressed in the third and fourth chapter.

Tables

Table 1: Differences between stable and temporary teams

	Characteristics	Temporary Teams	Stable Teams
Input	Boundary	Blurred boundaries as the result of membership change and the concept of membership turns to participation (Mortensen & Haas, 2018)	Stable boundaries (Mortensen & Haas, 2018); membership is typically stable, full time and well defined (Cohen & Bailey, 1997)
	Time	Strict and pre-defined deadlines, increasing deadline pressure (Chae, Youngwook, et al., 2015)	There is less deadline pressure
Process	relationships	Temporary, one-time meeting	Relationships are long term during the employment period in organizations (Edmondson & Reynolds., 2016)
	Team learning	Team learning is hampered as a result of temporary relationships (Vashdi et al., 2013)	Promotion in team learning is expected (Vashdi et al., 2013)
	Task	-No two projects are alike, Tasks are unique, non-repetitive and complex (Cohen & Bailey, 1997)	Tasks are standard, pre-defined and less complex (Edmondson, 2003; Sydow & Braun, 2018; Wageman et al., 2012)
Output	Performance	There is deadline pressure to find a solution to meet the standards (Cohen & Bailey, 1997)	There is less deadline pressure to meet the standards (Cohen & Bailey, 1997)

Table 2: Top publication outlets and their respective number of articles on temporary teams

Name of the journals	Year of publication												
	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	Total
INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	0	1	0	6	3	1	5	2	7	3	2	5	35
PROJECT MANAGEMENT JOURNAL	0	1	0	2	2	0	3	3	2	1	2	1	17
INTERNATIONAL JOURNAL OF MANAGING PROJECTS IN BUSINESS	0	0	0	0	0	0	4	0	0	4	1	1	10
ORGANIZATION STUDIES	0	0	0	0	0	0	5	0	1	1	0	0	7
SCANDINAVIAN JOURNAL OF MANAGEMENT	0	0	0	0	1	0	2	2	0	0	0	1	6
CASE STUDIES IN KNOWLEDGE MANAGEMENT RESEARCH	0	4	0	0	0	0	0	0	0	0	0	0	4
EUROPEAN MANAGEMENT REVIEW	0	0	0	0	0	0	1	0	0	2	0	1	4
HUMAN RELATIONS	0	0	0	0	0	0	1	2	0	1	0	0	4
INTERNATIONAL JOURNAL OF HUMAN RESOURCE MANAGEMENT	0	0	1	1	0	0	0	0	1	0	1	0	4
PROJECT-BASED ORGANIZING AND STRATEGIC MANAGEMENT	0	4	0	0	0	0	0	0	0	0	0	0	4
TEAM PERFORMANCE MANAGEMENT	0	0	0	0	0	1	1	0	2	0	0	0	4
BRITISH JOURNAL OF MANAGEMENT	0	1	0	1	0	0	0	1	0	0	0	0	3
ELECTRONIC COMMERCE RESEARCH AND APPLICATIONS	0	0	0	0	0	0	0	0	0	0	3	0	3
INDUSTRIAL MARKETING MANAGEMENT	0	0	0	0	0	0	0	0	1	2	0	0	3
INDUSTRY AND INNOVATION	0	0	0	0	0	0	0	0	1	0	2	0	3
INTERNATIONAL JOURNAL OF MANPOWER	0	0	0	0	0	1	1	1	0	0	0	0	3
JOURNAL OF BUSINESS RESEARCH	0	0	0	0	0	0	1	0	0	0	1	1	3
LEADERSHIP \& ORGANIZATION DEVELOPMENT JOURNAL	0	0	0	0	0	0	0	0	2	0	0	1	3
ORGANIZATION SCIENCE	0	1	1	0	0	1	0	0	0	0	0	0	3

Table 3: the most cited papers between 2010 and 2021

Paper	Total Citations	Total Citation per year
FARAJ S, 2011, ORGANIZATION SCIENCE	445	40.455
BAKKER RM, 2010, INTERNATIONAL JOURNAL OF MANAG REVIEW	306	25.5
WINCH GM, 2014, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	110	13.75
BUVIK MP, 2015, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	91	13
BAKKER RM, 2011, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	89	8.091
PAUGET B, 2013, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	75	8.333
TYSSEN AK, 2014, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	73	9.125
VALENTINE MA, 2015, ORGANIZATION SCIENCE	72	10.286
GREGORY RW, 2013, MIS QUARTERLY	70	7.778
MARREWIJK A, 2016, ORGANIZATION STUDIES	70	11.667
PALANSKI ME, 2011, THE LEADERSHIP QUARTERLY	63	5.727
BAKKER RM, 2013, BRITISH JOURNAL OF MANAGEMENT	61	6.778
GEMUNDEN HG, 2018, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	60	15
MUELLER R, 2013, PROJECT MANAGEMENT JOURNAL	59	6.556
BJORVATN T, 2018, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	55	13.75
SYDOW J, 2018, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	53	13.25
HANISCH B, 2014, SCANDINAVIAN JOURNAL OF MANAGEMENT	52	6.5
BRAUN T, 2013, INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT	48	5.333

Figures

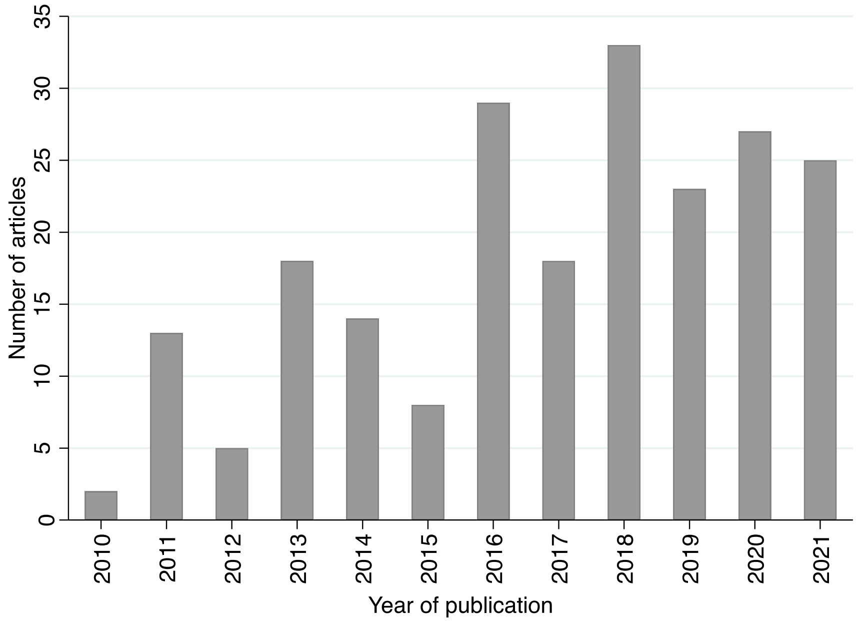

Figure 1: Number of articles published per year, from 2010 to 2021.

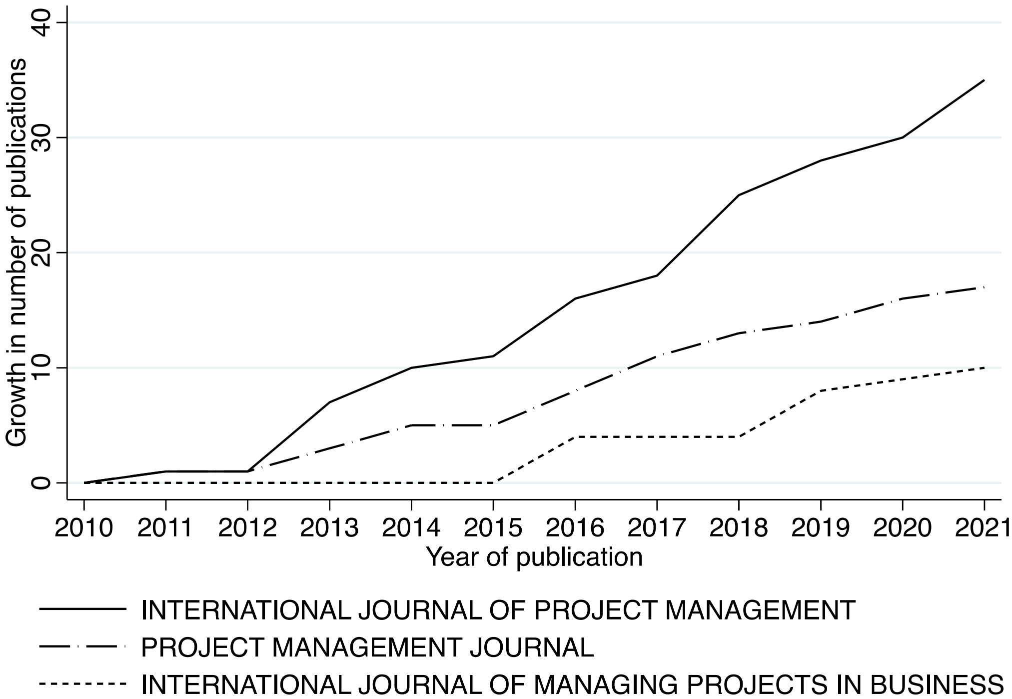

Figure 2: Growth of the articles in top three journals, from 2010 to 2021.

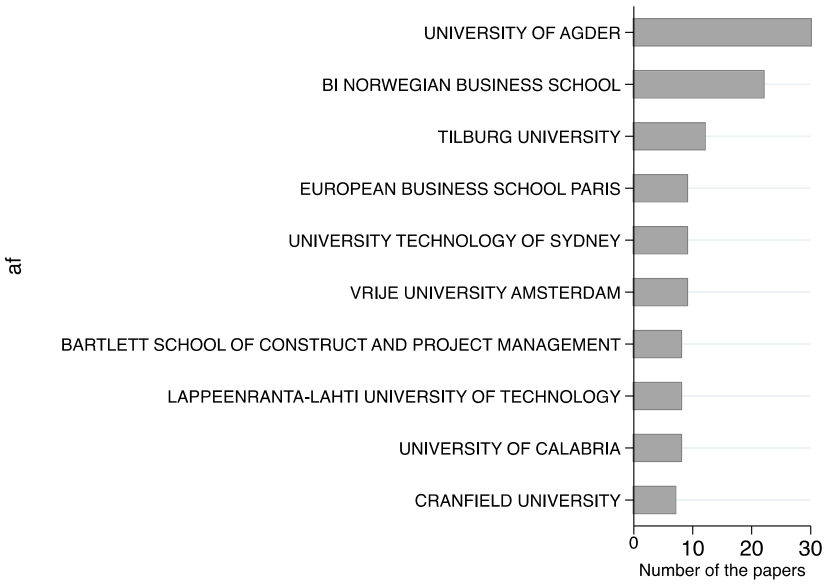

Figure 3: top 10 universities in terms of research on temporary teams based on correspondent authors' affiliation

Figure 4: Word cloud in the title of the articles

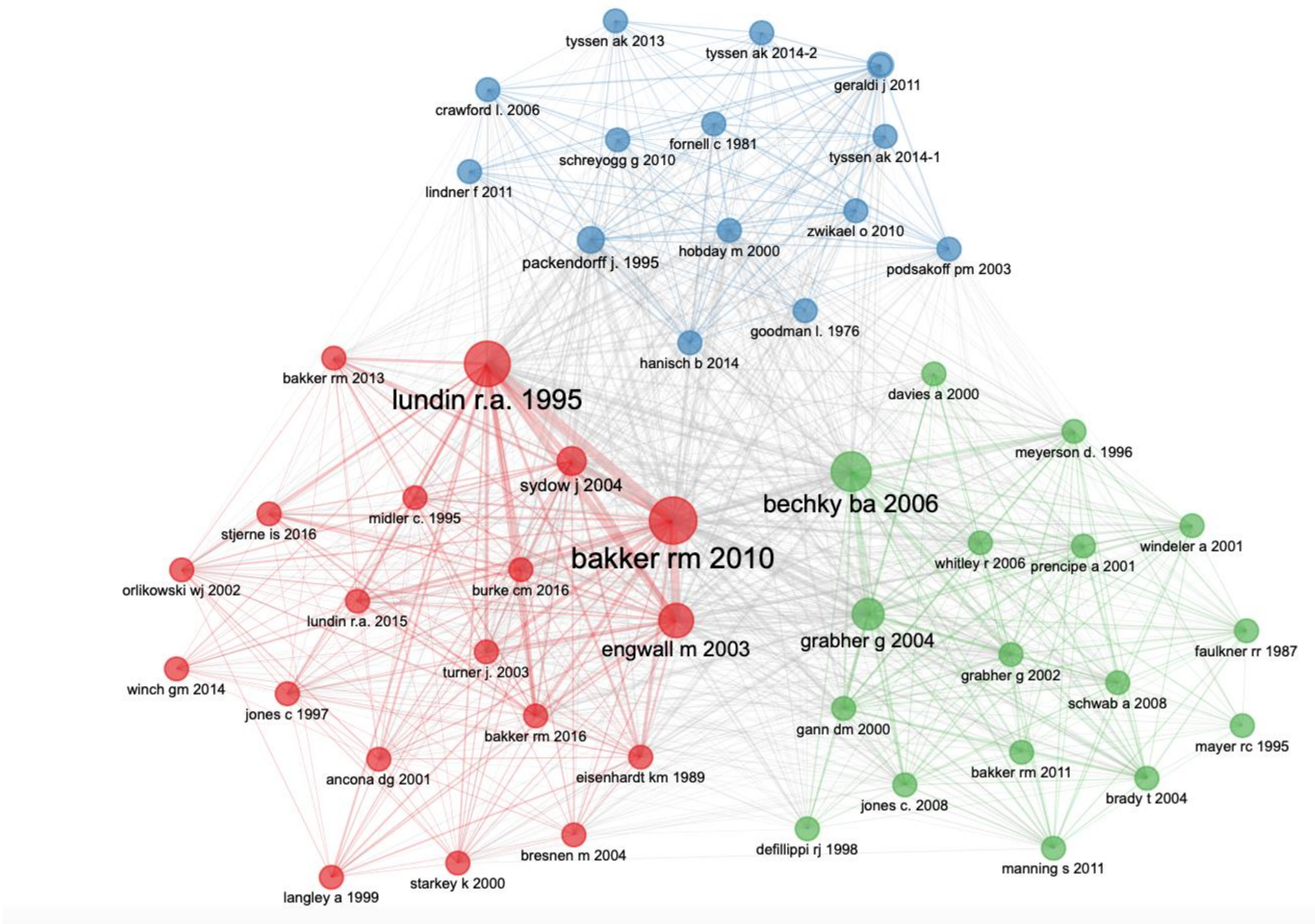

Figure 5: Network visualization map of research study clusters

Appendix:

1. Search methodology:

First, we chose the keyword “temporary” AND “team” as the main keyword for search, in the categories “Management OR Business” within the document types “Article” and “English” language. The results included 136 research papers. Further, we performed a manual check to see if the concept of the papers was built on the team basis. We removed papers investigating “temporary employment”, “temporary contract”, “temporary workers”, “temporary absence”, “temporary accommodation”, and “temporary impact”. Hence, we put 106 relevant papers in our database. Secondly, we searched key words temporary” AND “group”. 194 papers appeared; however, we did manual check to remove the repeated articles from the previous database. After removing irrelevant topics, we added 24 articles to our database. Third, we checked the keywords “temporary” AND “virtual*” the results showed 24 articles, but after removing the irrelevant article we got 3 relevant articles. Fourth, keywords “temporary” AND “project*” were searched the results showed 384 papers, having done the manual check we put 49 papers in our database. Fifth, we checked for the keyword “temporary” AND “organis*”and 10 irrelevant papers appeared. the results of search for “temporary” AND “organiz*” showed 638 papers, however manual check resulted in 44 relevant papers in our documents.

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Hierarchy within temporary teams? Exploring how knowledge sharing occurs on the use 3D printing technology

Abstract

This study explores knowledge sharing activities in temporary teams that use 3D printing technology to support surgical interventions. We focus on the planning phase of orthopaedic surgeries in which senior surgeons organise a temporary team to create personalised treatment using 3D printing technology. The data is collected by means of observations and group interviews with 25 surgeons in one of the most relevant research hospitals focused on orthopaedic surgery in the Italian national health service. Based on our qualitative study, we find that when the technology provides a basis for the surgical planning, knowledge sharing opportunities exist on two-way relationships among team participants, which we label as dyadic relationships. Moreover, the hierarchical structure of the temporary teams facilitates the formation of dyads and the emergence of knowledge sharing opportunities. This study is novel in highlighting the challenge of temporary relationships and the ways temporary health care teams deal with knowledge sharing challenges due to the continuous changes in team composition. The study provides evidence of how knowledge sharing opportunities are built on temporary relationships within teams as well as on the way complexity of 3D printing technology impacts knowledge sharing practises in orthopaedic teams.

Keywords: Temporary team, knowledge sharing opportunities, healthcare, 3D printing technology

1. Introduction

Today's organisations are embedded in a complex environment that includes many unexpected events which make continuous changes in work procedures necessary (Edmondson, 2012). In response to this changing environment, organisations arrange temporary teams around projects or tasks, and the teams disband once the projects or tasks are performed. While organisations isolate the changes to smaller parts of the organisation, define tasks and allocate additional resources on a small scale (Jacobsson & Hällgren, 2016), the temporary nature of relationships among team members can jeopardise work processes and knowledge sharing within teams. As relationships are temporary, team participants do not have enough time to build trust, interact and share relevant knowledge in order to fulfil complex tasks (Edmondson, 2012). Therefore, lack of stable relationships within the teams hampers knowledge sharing practices (Carmeli et al., 2009; Nguyen et al., 2021).

The challenge of temporary relationships is more pronounced due to the use of new technologies that temporarily adds more participants to the teams. Although new participants provide new sources of knowledge and information (Nahapiet & Ghoshal, 1998), they increase the fluidity of teams (Mortensen & Haas, 2018) and temporary relationships. In environments where the team creates an innovative personalised solution, team participants must exchange and recombine complex knowledge into the work practices. The creative outcome depends on social process, relational strength and appropriate interactions that result in knowledge sharing (Rouse, 2020; Tzabbar & Vestal, 2015). In turn, tension occurs when technology adds more complexity to the tasks inviting more team participants, yet demands more creative work and knowledge exchange among participants.

Prior studies on team knowledge sharing highlighted that knowledge sharing does not happen automatically in the teams; rather, team characteristics and processes influence team participants' knowledge exchange practices (Haas et al., 2015; Hansen, 1999). In the same line, team diversity and more agreeableness in communication style of the teams lead to willingness for knowledge sharing among the team participants (Thomas-Hunt et al., 2003; Vries et al., 2006). The studies address that longer life span of the team can result in effective knowledge sharing among team participants (Bakker et al., 2006; Sawng et al., 2006). Yet, less attention has been paid to the process of knowledge sharing through temporary relationships that are embedded in temporary teams.

Our study explores knowledge sharing opportunities within healthcare temporary teams. Healthcare organisations increasingly organise temporary teams to achieve desired outcomes (Lemieux-Charles & McGuire, 2006). The complexity of health problems, the pressure of deadlines and the unpredictability of events amplified the use of temporary teams as an integrated part of health caregiving practices (Heinemann & Zeiss, 2002). In addition, caregivers do not simply rely on their knowledge but use new technologies to improve the quality of the caregiving process. Studies focusing on healthcare settings addressed that the use of new technologies reshapes work relations in complex and unexpected ways (Barley, 1986; Beane & Orlikowski, 2015; Kellogg, 2021; Sergeeva et al., 2020) because new members are invited to contribute the team tasks, provide the relevant knowledge, and use their skills to better handle the technologies (Nembhard & Edmondson, 2006). We focus on teams of orthopaedic surgeons who aim to provide customised treatment using 3D printing technology. Our main research question is: How knowledge sharing occurs in the context of temporary teams while membership is fluid and relationships are temporary?

This work offers two main contributions to the extant literature on knowledge sharing in temporary teams. The first contribution lies in our clarification of how knowledge sharing opportunities emerge in the context of temporary teams that have an extra level of complexity due to the technology use. Knowledge sharing is an important process that predicts team learning and performance (Vashdi et al., 2013). Therefore, knowing the process through which knowledge is exchanged can have implications for predicting team success and outcomes. Moreover, understanding the way in which the main actors bring prior experience into play is important to creating a learning environment within the teams. Secondly, this study contributes to the literature on hierarchy by highlighting the functional role of hierarchy in facilitating knowledge sharing practices. Knowing the role and potential benefits of hierarchy helps to establish a team structure through which knowledge sharing can be effective.

In addition, given the fact that 3D printing technology offers an enabling occasion for creative work, it requires effective interactions among team participants. We unpack how creative work evolves in orthopaedic teams when 3D printing technology mediates teamwork. This brings insights into theorising the usefulness and drawbacks of the technology at the team level and how powerful the technology can be in stimulating creative work.

2. Theoretical background

2.1. Temporary teams with fluid members

As the nature of work becomes more complex, many organisations tend to use temporary teams to ensure effective functioning in changing environments. Temporary teams are short-lived organisational units that assemble on demand to accomplish very complex tasks, and the teams are disbanded once their tasks have been fulfilled (Valentine, 2018). Typically, participants in temporary teams came together from various organisational units and larger workforce (S.-H. Kim et al., 2021). Moreover, temporary teams tend to focus on the ongoing tasks, face with time pressure, and are not configured for future interactions or long-term efficiency in the team process (Saunders & Ahuja, 2006; Sydow & Braun, 2018). Given the complexity of the tasks temporary teams deal with, many of them are necessarily fluid, with employees moving quickly from one team to another team (Dibble & Gibson, 2018; Mortensen & Haas, 2018; Summers et al., 2012).

Although the use of temporary teams helps managers to isolate the changes to smaller parts of an organisation, define tasks, and allocate additional resources on a small scale (Jacobsson & Hällgren, 2016), it also involves considerable fluidity of team participants. The composition of teams varies over time as the team shifts from one task to another task or even from one week to another week (Valentine & Edmondson, 2015). While members of stable teams have the opportunity to interact and work together for a long period of time, temporary teams do not have the luxury of stable relationships due to the fluid membership. Yet, participants have to engage in multidisciplinary knowledge, share their skills, connect and socialise, and optimise knowledge sharing activities to perform complex tasks successfully.

Given the specialised nature of teams where complex projects must be done through intense knowledge work in a short period of time, interdependency of the tasks requires interactions among team participants to facilitate knowledge sharing activities (J. W. Kim, 2020; Thommes & Uitdewilligen, 2019). Yet, the fluidity of temporary teams does not allow participants to have enough time to build trust, interact and communicate appropriately about the tasks (Edmondson, 2012). Consequently, knowledge sharing activities become a vulnerable factor and team participants are not able to translate knowledge into teamwork practices (Thommes & Uitdewilligen, 2019).

2. 2. Knowledge sharing and teams

Knowledge sharing is defined as the process intended "either to create new knowledge by differently combining existing knowledge or to become better at exploiting existing knowledge" (Christensen, 2007: 37). Effective knowledge sharing occurs when team participants are adequately motivated, engaged, and interact during the entire process of teamwork (Natalicchio et al., 2017). Although the literature on organising knowledge within the teams has made substantial progress over the past decades, progress in understanding how knowledge sharing occurs over temporary and short-term relationships has been more fragmented. Prior research emphasised the importance of team interactions in knowledge exchange procedures since team interactions can facilitate or inhibit the flow of knowledge within and between organizational units (Allen & Cohen, 1969; Tortoriello et al., 2012).

Knowledge sharing is important for the success of teamwork for several reasons; it creates access to diverse sets of knowledge, expands the scope of available knowledge, and facilitates creative and innovative work (Carnabuci & Operti, 2013; Hargadon & Sutton, 1997). Furthermore, team outcome is a function of the relationships through which task related knowledge is exchanged (Casciaro et al., 2021). In particular, knowledge sharing appears an important factor in team context, since it improves creative work on within team relationships (Ritala et al., 2015).

As Knowledge sharing is a type of social-exchange behaviour, it usually occurs in teams and work group context (Wu & Lee, 2017), but it is rarely known how group/team type impacts knowledge sharing. In temporary teams that team participants change over time, the knowledge sharing process is ambiguous as it depends on closed-loop interactions stable and long-term relationships that are violated in temporary teams (Huckman & Staats, 2011; S.-H. Kim et al., 2021). A related stream of literature documented that changes in team composition result in establishing new ties in the teams, which impact knowledge sharing practices. However, the body of literature agrees that interactions with new team participants can provide opportunities to create the knowledge that supports exploration of new ideas.

March (1991) showed that the team creativity is improved once new members join the team. In the same line, knowledge exploration and arguments on new ideas are increased due to the new members engagements (Gruenfeld et al., 2000). Hence, sharing the relevant knowledge improves the innovative capabilities of the teams (Huizingh, 2011). On the other hand, the fact that team participants have relevant knowledge does not guarantee their success in using it. Knowledge sharing depends on individuals' characteristics and accountability (S. Wang et al., 2014). Based on Wang et al., (2014) individuals' consciousness, neuroticism, and openness to experience played an inevitable role in knowledge sharing practices. Furthermore, prior experience, social skills and emotions related to the team participants are important in knowledge sharing process since the exchange of knowledge happens through team participants interactions (Z. Wang et al., 2014).

As knowledge is embedded in the individuals, the process of knowledge sharing is nevertheless troublesome. Challenges related to the process originate from social and knowledge dilemmas such as stickiness of knowledge, no common identity, no relation between the individuals (receiver and sender of knowledge), no willingness to share knowledge, and no knowledge of knowledge (Borgatti & Cross, 2003; Cabrera & Cabrera, 2002; Christensen, 2007). Focusing on the individuals who participate in teamwork, the nature of knowledge, motivation to share, opportunities to share, and the culture of the work environment have constant impacts on the knowledge sharing process. Moreover, there are two main factors that motivates knowledge sharing among participants: trust and status of the participants within the organizational units and groups, where the former is more influential on individuals' social actions (Ghoshal & Bartlett, 1994).

The absence of relations among team participants hampers knowledge sharing practices; this situation becomes critical when the team environment is competitive (Andrews & Delahaye, 2000). Another barrier for knowledge exchange is the power and status of the participants in the teams. Prior research showed that power and status influence the flow of knowledge through team interactions (Goetz & Wald, 2021; Iacovou et al., 2009; Morrison, 2011; O'Reilly, 1978). Team participants with higher status tend to exchange knowledge with peers of the same status than participants of lower status. Similarly, participants with lower power and status are willing to direct knowledge to those participants with higher status (Ipe, 2003). There is also empirical evidence indicating that team participants are more interested in the knowledge which travels upward to the higher levels of status (Schulz, 2001). Therefore, the lack of trust leads to an environment where team participants are reluctant to initiate knowledge exchanges with others, however, the higher status and power of team participants can mediate the process.

The recent knowledge sharing literature has emphasised the importance of interactive technologies and their mediating effects on knowledge sharing (Paroutis & Saleh, 2009). However, the use of technology is not limited to interactive technologies; rather technologies enabling new interdependencies within and between organisational units with actors who have been considered outside the work boundaries. In the following section, we discuss the interplay between the new types of technologies called "emerging technologies" and actors embedded in organisational units.

2.3. Emerging technologies

The introduction of new technologies as an element of social context, reshapes the organisation of work (Barley, 1986; Orlikowski & Barley, 2001). It first disturbs the existing patterns of work and then re-formulates work procedures (Barley, 1986). Recently, the use of emerging technologies such as artificial intelligence, digital platforms, robotics, social media, blockchain and 3D printing is continuously reshaping human action and interaction at the different levels of organisations (Bailey et al., 2022; Massaro, 2021; Sergeeva et al., 2020; Spanò et al., 2021). The technologies are called "emerging" since they are still changing and adopting, yet there is no stable pattern for their utilisation (Bailey et al., 2022). It is important to highlight that organisations adopt the emerging technologies to gain a competitive advantage, but, in turn, new behaviours and new routines are developed in the implementation of the technologies (Edmondson et al., 2001).

In the context of temporary teams, the use of emerging technologies allows experts to reduce experience-based skills and imply the need for new skills and the reconfiguration of work (Sergeeva et al., 2020). One of the places where this frequently occurs is healthcare teams. Healthcare professionals do not simply rely on their knowledge; they increasingly adopt new technologies to increase the quality of caregiving practices. The technologies open up new opportunities to provide personalised treatments and improve medical care services (Massaro, 2021). Although the adoption of the technologies has made healthcare organisations more mature (Shaygan & Daim, 2021), concerns about the challenges imposed by emerging technologies on the team based structure of healthcare is increasing.

Barely (1986) was among the first to investigate the interplay between new technology and new work structure in the healthcare sector. His study focused on the interaction between CT scanners and radiology departments and treated technology as an occasion for structuring the work. By studying patterns of interactions and roles, he opened the argument to treat technology adoption as a social action than an element to change the organisational structure. Edmondson (2001) studied the implementation of a new cardiac surgery technology in four hospitals to investigate how new organisational routines were developed and what a successful implementation means for an organisation. In the same line, Edmondson et al. (2003) differentiated tacit and codified knowledge and explored their impact on performance improvement in hospitals. To do so, they focused on minimally invasive cardiac surgery and demonstrated that performance improvement varied among hospitals when the performance relied on tacit knowledge. In contrast, performance improvement through codified knowledge was evident among later adopters of the technology.

More recently, the introduction of new pharmaceutical-dispensing robots changed on the work procedures of three categories of pharmacists, technicians and assistants in hospital settings (Barrett et al., 2012). The technology reconfigured the relationships and interactions among three types of occupations. In showing the role of robotic telepresence in healthcare units, a field study in post-surgical intensive care units revealed the potential impact of telepresence in the coordination of distributed knowledge work. The coordination of work was remotely controlled by several telehealth technologies and transformed hospital rounds by enabling new coordination modalities (Beane & Orlikowski, 2015).

Concerns about the transformation of work practices were raised by the evolution of da Vinci robot as an endoscopic surgical system. The impact of robotic surgery on surgical team's coordination gained a lot of attention. As a matter of fact, through the use of da Vinci robot in operation theatres, the supervisory role of the main surgeon is highly reduced; moreover, the main surgeon loses the sense of touch with the patient, and the responsibility for checking patient safety goes to anaesthesiologists (Sergeeva et al., 2020). Moreover, robotic surgery motivates shadow learning among less-skilled surgeons and trainees who do not have enough opportunity to practice with the da Vinci (Beane, 2019). Recent studies on the use of da Vinci robot showed improvement in surgical teams' performance through knowledge sharing practises (Tonellato et al., 2019).

Multiple applications of emerging technologies highlight the promising role of the technologies on team success by enabling innovation and collaboration. With the potential for such changes in relations and scope, new questions about the interplay between emerging technologies and work groups were arisen (Bailey et al., 2022).

Therefore, by focusing on the temporary nature of relationships within the teams, we aim to understand knowledge sharing opportunities that occur when 3D printing technology is the main tool to perform the tasks.

3. Methods

Given the exploratory nature of our research question, we conducted a qualitative field study to explore temporary teams' dynamics. Hence, the single case study methodology was well suited to our goal. The method allows a deeper exploration of team interactions and knowledge sharing within this specific type of teams, while team participants do not have enough space and time to build stable relationships.

We were interested in retaining real-life characteristics of the context such as individual behaviour, team process, and membership change (Yin, 1994) which frequently occur in temporary teams. Moreover, context is an important component in our study that cannot be neglected. Thus, healthcare context was selected as the setting where temporary teams are organised continuously and need to plan and make the decision on complex tasks. In addition, the single case study approach constitutes the context in which real-life phenomena embedded.

Here the case was defined as the planning phase of orthopaedic surgery, where the orthopaedic surgeons decide to provide a personalised treatment for the patients using emerging technologies. Therefore, they include engineers into the teams to exploit full potential of the technology. In our case, the technology that enables the team to provide customised treatment is 3D printing technology. The technology is important since it enables orthopaedic surgeons to personalise the treatment for a unique patient, on the other hand it brings complexity to the work of teams by adding more participants with a different speciality.

3.1. The case of 3D printing technology in Orthopaedic surgery

The fundamental idea of 3D printing technology is to create a part by adding material layer by layer, each layer on top of the previous layer (Ventola, 2014), which is a quicker and cheaper mechanism to design and create highly personalised products to meet patient needs. The technology started to play an inevitable role in producing custom-made implants and improving personalised treatments, proving its full potential in orthopaedic surgery.

The reason that leads us to consider 3D printing technology as a complex technology derives from the paradoxical concept of the technology in orthopaedic surgery. First, it demands more innovative work as the outcome of the technology should be a customised implant characterised by every patient. This ability is more evident in Figure 1, which shows the vertebral column. Spinal tumour extension is depicted with the circle in pic A, meaning that the single vertebra has been destroyed and should be removed to protect the whole vertebral column. After removing the damaged vertebra, the empty space should be filled by an object similar in design to the vertebra. Pic B shows the simulated object made by 3D printing technology to replace the damaged vertebra (affected by the growing tumour). The object should find the best fit with the whole vertebral column and the best connection to the vertebral column from the top and bottom (labels 1 and 2 indicate the linking points). A superior view of the open surgery in pic C depicts the position of the implant within the vertebral column. Pic D implies MRI illustration of the final reconstruction of the vertebral body. As the procedure reveals, there should be a lot of creative work and knowledge application in the surgical planning phase, which differs from one body part to another. These innovative and knowledge works among team participants are particularly salient in orthopaedic teams.

Secondly, starting from pic A, in Figure 1, moving to pic B and pic C, and then reaching pic D, the surgeons confront several limitations which cannot be solved with their knowledge. The skills and knowledge of computer designers, bioengineers and external partners are required to produce the implant in pic B. Surgeons go to the operating rooms due to their collaborative work with engineers at the planning phase. The procedure heavily relies on image acquisition, segmentation, file optimisation and material selection; beyond all these procedures, shared understanding and consultation among surgical teams and engineers are clearly required. This is a complex procedure that requires a considerable number of back-and-forth practices, innovative work and knowledge sharing to create personalised implants. Apart from all the complexities brought to the work of surgeons, the technology enables orthopaedic surgeons to rapidly create customised implants at low cost (Ballard et al., 2020). Therefore, the entire process presents an ideal context to explore knowledge sharing at the team level.

--Insert Figure 1 about here--

3.2. Research setting

Our study was performed at Rizzoli hospital in Bologna, a highly specialised research hospital in the field of orthopaedics and traumatology in the Italian national health system. A distinctive feature of this hospital is the close integration between research activities and patient treatment services, which are carried out by nine translational research laboratories and six industrial research laboratories that overall employ about 250 people, including doctors, biologists, engineers and other professionals. Every year, it counts more than 150,000 admissions and carries out more than 20,000 hospitalisations, most of which are of the surgical type.

A team of engineers, physiatrists and surgeons synergistically works on various types of movements in the Laboratory of Movement Analysis. The laboratory uses state-of-the-art instruments to make objective measurements of human movement, such as stereophotogrammetry or inertial sensors, and the internal and external forces generated during movement through force and pressure platforms and surface electromyographic systems as well as 3D printing technology.

The surgical teams consist of three levels of hierarchy: 1) the head of the unit (HU), that is, the person who makes the final decision and is primarily responsible for patient health, who is a highly specialised orthopaedic surgeon and decides upon the use of 3D printing, prostheses, prostheses compatibility and the external participants who produce the final implant; 2) the team leader (TL), who holds the middle level of hierarchy and contributes to the decision-making procedures and is responsible for supporting activities; and 3) the team members (TM), who are in close contact with the patients, conducting daily checks and follow-up controls, and are only partially involved in the decision-making process.

However, each caregiving practice starts with an orthopaedic problem stated by a patient. The patient is hospitalised in one of the clinics based on the anatomical area of the problem. After a problem has been presented within the team, the HU recognises the potential utilisation of 3D printing technology for the specific clinical case by assessing its potential benefits for the patient. Then the HU starts forming the team by inviting colleagues specialised in the field, bioengineers (from the Laboratory of Movement Analysis) who are experts in the application of 3D printing, internal labs and other required divisions within the hospital, such as biology and radiology. In addition, people from companies and manufacturers (external participants) join the teams to ensure the supply and quality of the material, the manufacturing process and the creation of the final implant. The process of patient hospitalisation, organising the team, and utilisation of 3D printing is illustrated in Figure 2. Rizzoli hospital was among the first organisations to realise the potential of 3D printing technology to provide customised treatments for rare diseases in the Italian National Health Service. In our setting, the anatomical area of the clinical cases treated with the support of 3D printing technology involved knee, pelvis and hip, ankle, elbow, spine and thorax. However, the majority belonged to Pelvis and hip surgery (Table 1; Appendix). In terms of pathologies, the application of 3D printing is highly beneficial in cases in which the patient suffers from tumours and bone loss (Table 2; Appendix). 3D printing technology supports surgeons in finding the best position for osseointegration and the best fit between the bones and the implants.

--Inset Figure 2 about here--

3.3. Data Source

Our fieldwork started in June 2019 by contacting the laboratory of movement analysis and moved forward after receiving official permission to enter the field and start data collection over a period of 22 months.

The sources of data included group interviews, focused observations, and individual semi-structural interviews. During this period, six group interviews with 25 overall participants were conducted, followed by observation of team meetings (of the same teams) at the end of each interview session. Each group interview included one HU (Orthopaedic surgeon), one TL (Orthopaedic surgeon) and a bioengineer, although in some cases, team members participated in the meetings. Decisions on the participants were based on the real workflow in the hospitals, and the authors involved in data collection did not make any choices about team meeting participants. Details related to the participants and composition of the group interviews have been provided in Table 1.

There were two fundamental reasons for using group interviews as the main tool to gather data. First, our respondents were surgeons who are extremely engaged with their responsibilities. Due to their busy lives, they are always occupied and unavailable to participate in the interviews. Therefore, group interviews were an excellent mechanism to bring us closer to more respondents within a shorter timeframe (Frey & Fontana, 1991). Second, as this study focuses on medical teams, we arranged the interviews so that clinicians from the same teams could come together and be kept at the same level of hierarchy. Therefore, we simulated the real teamwork environment and captured actual interactions, behaviours and team dynamics.

Our semi-structural interview protocol was designed after preliminary-individual interviews with director of the laboratory of movement analysis. The questions were categorised into three parts: the first part included general questions about decisions on choosing 3D printing as an underlying technology for surgical planning such as: who makes the decision on the use of 3D printing technology? The second part included questions on organising team meetings, interactions during team meetings, follow-up/informal interactions and the types of the interactions (offline/online) such as: How often do you organise team meetings? The third part included questions on problem solving process, challenges through problem solving, and if there is any opportunity for knowledge sharing. For instance: What is your first reaction when you confront a problem? Although it is not clear how many team meetings are organised to decide about the cases, rather the follow-up meetings depend on the results concluded during the first meeting. Therefore, we scheduled our group interviews almost one hour before the team meetings to have the opportunity to observe team meetings after group interviews.

After each group interview, the teams discussed the clinical cases at hand and the treatment plans. We were thus able to capture the actual patterns of communication occurring within the teams. Our aim to perform observations right after group interviews was two-fold; first, we were able to access the same teams that had been interviewed, and second, we were able to observe and find support for the identified concepts during the interviews. A set of specialists and three levels of hierarchy (HU, TL and TM), together with bioengineers (engineers laboratory of movement analysis) and one of the authors, were present during group interviews and the author aimed to capture all the interactions among team participants and recognise if the interactions implied a meaningful contribution to the study.

As data collection and analysis were parallel procedures, we started coding the data after the first group interview, and preliminary themes emerged from the data.

--Insert Table 1 about here--

3.4. Data analysis

In analysing our qualitative data, we adopted the guidelines provided by Strauss and Corbin (1998), where data collection, coding and analysis are intertwined. Therefore, we were able to move back and forth around the subject as it was a flexible approach that gave us a good understanding of the concepts and their relationships. However, the data collection and analysis parts were integrated, thereby providing the opportunity to handle better the message delivered by row data (Corbin & Strauss, 2014). As we continuously moved back and forth between our field notes and interview transcripts, new ideas came up from the data and we were able to validate them through observations. For instance, since we started to code the first interviews, we recognized that more informal interactions occur and more follow-up meetings scheduled for complex and severe cases. Therefore, in subsequent interviews, we asked our informants to comment on the severity of the cases they discussed, and we kept track of follow up/informal interactions.

Step 1: Qualitative data: In the early stage of analysis, we integrated qualitative data from group and individual interviews (interview transcripts) and our field notes from observations. After multiple readings of the data, the data imported in NVivo (NVivo 12) and data coding was started. Following Strauss and Corbin (1998), in open coding phase, we identified themes and concepts in our data and grouped them to categories. We were interested in identifying opportunities and behaviours associated with knowledge sharing within the teams. In particular, we were looking for behaviours such as seeking feedback, sharing information, asking for help, talking about errors and experimenting (Edmondson, 1999) which bring the knowledge to the surface and make participants to reflect. Therefore, we performed line-by-line analysis of our data to generate categories, keeping the following questions in mind: What does this relationship suggest? Does this relationship result in knowledge sharing at the team level? How is it related to 3D printing technology? Why did it occur?

Once the text opened up and some concepts was labelled, we realised that certain concepts could be categorized under one unique and higher concept (axial coding). Categorisation of the concepts was gradually started based on the reasons which cause the behaviours/opportunities and labelled according to the logic behind each (first-order codes). Then we selected the core categories relating major categories to it (selective coding). Grouping concepts into categories is beneficial because it enables us to reduce the number of concepts. Figure 3, summarises these steps in the columns first and second order codes.

Now that we had two levels of the codes, we looked for the relationships among first- and second-level codes to answer the following questions: Where is the source of these relationships? How do they emerge? In other words, we were looking at the stream of interactions among team participants to explore the origin of the relationships, meaning, the starting point of the interactions as well as the end point and when the topic of interactions changed. The results of this categorisation revealed the source and opportunity for knowledge sharing in the data. Figure 3, summarises these steps in the column called theme.

Step 2: Supporting data integration: In a preliminary stage of coding, we realised that the interactions varied from one team to another team as the problems with the patients changed. Based on the complexity of the clinical cases, some teams concluded to move further steps, some of them organised follow-up team meetings and informal meetings. Therefore, we asked team leaders to comment on the severity of the cases they have treated with the support of 3D printing technology. Precisely, we asked TLs to code each case and rate the severity of the case by asking: How do you rate the severity of this case from 1= the least severe to 10=the most severe. The aim was to investigate how follow-up interactions correlated with the types of problems.

--Insert Figure 3 about here--

4. Findings

By including contextual hierarchies in our group interviews during the surgical planning phase, we investigated temporary relationships that result in knowledge sharing; then we investigated the source and potential of the relationships for creating knowledge sharing opportunities. All the experts on the team complement each other by sharing directions for an innovative solution. The results of our study suggest that the links established by two individuals within the teams are particularly relevant to the creation of knowledge sharing opportunities. The dyadic relationships that temporarily link two participants at the team level show the capacity to surface the knowledge stored in participants' minds. As information travels through dyadic relationships, all the participants within the team are able to capture and learn the knowledge from the dyads. Although the relationships are temporary and the uniqueness of the organisational culture in the healthcare context does not allow top-level surgeons to speak up and share their questions and doubts (Edmondson, 2003), there is an underlying process of dyadic interactions that facilitates knowledge sharing. Hence, the teams do not follow question and answer interactions; rather, they share their knowledge through complementation and reflection. The dyads embedded in the temporary teams carried out the most important part of the surgical planning phase. Two types of dyads were revealed in our observations, each composed of two types of ties: Head of the Unit (HU)-Bioengineer dyads, including Head of the Unit (HU)-Bioengineer ties and Bioengineer-Head of the Unit (HU) ties; and Head of the Unit (HU)–Team Leader (TL) dyads, including Head of the Unit (HU)-Team Leader (TL) ties and Team Leader (TL)-Head of the Unit (HU) ties. We realised that the potential of the dyads to enable knowledge sharing activities depends on the hierarchical order of the participants who start the ties. In addition, since the aim is to plan innovative and customised surgery, all the interactions were under the theme of 3D printing technology and its functionality.

Moreover, we observed the importance of the hierarchical structure of the teams to create knowledge sharing environment. Data from group interviews and observations confirmed that when the use of 3D printing technology intervenes in team interactions, the hierarchical structure of the teams plays a more active role in facilitating dyads formation. Newcomers (in our case including engineers and 3D printing technology experts) bring different perspectives and ideas, to the team that can challenge the existing standard routines of the teams. Thus, the hierarchical structure of the teams supports team participants in understanding when to value, pay attention and contribute to the knowledge sharing practices. We observed that the HUs helped to form dyads among team participants by keeping the functionality of 3D printing as the background scenario. TLs served the surgeons with information related to the patient's status (if they were asked) and attempted to regain their position as active members. Interestingly, the HU kept its leading role at the top level during the team interactions, and all the dyads moved on a unique path to serve the HU as the main actor. The key points in the dyadic relationships pattern were the fact that even if the HU was not a part of the dyads, the two parts of the dyads looked for feedback from the HU.

In other words, HUs play a central role in starting a meaningful pattern of knowledge sharing by giving direction and an overview of the desired outcome of the clinical cases. Building on this, we focused on the interactions between HUs, TLs and bioengineers to detail the relationships and interactions.

4.1. Dyad between Head of the Unit (HU) and Team Leader (TL)

The dyad includes HU-TL and TL-HU ties formed during team interactions. Focusing on dyads between HU and TL, the tie can be started by the HU (HU-TL) or TL (TL-HU) with different aims. Through these interactions TLs have a chance to update the HUs about the requested information by presenting medical data and lab results. However, the HUs represented an information-seeking approach while TLs maintained a supporting approach in providing information for HUs. In turn, HUs paid considerable attention to each item of data presented by the TLs, meaning that they processed all the data to make the decision.

In addition, the structure of the teams seemed flat with no evidence of hierarchy or organisational status during patient-oriented dyadic interactions. Continuous and relevant participation from the surgeons concentrated on a specific topic emerged from the beginning and steadily moved forward. Interestingly, no directions were provided by the participants, rather sharing and reflection approach was followed by the participants (mainly TLs), and all the surgeons had a chance to approach the topic of discussion serving the HU with information.

4.2. Head of the unit (HU)-Bioengineer ties

The HU initiated the tie by representing the case concerning the information that surfaced from the HU-TL dyad, followed by the criteria he/she expected from the 3D printing technology. The expectations were presented in terms of the initial idea or plan of the surgery through a direction-giving approach. We realised that the plan presented was almost manageable from the bioengineers' viewpoint, meaning that the HU had enough knowledge and a clear understanding of the technology originating from his/her prior experience.

> Surgeon 1: 3D printing is clear and straightforward; I already know what I can do with the technology for any particular case.

However, direction-giving is not only a representation of the initial ideal treatment for the patient but also the creation of the idea building on the limitations with which the HU was confronted. The HU faces three types of constraints which form the direction-giving approach indicated by the HU. The first constraint is the cost related to the 3D printing technology.

> Surgeon 2: It is complex and needs very tight efforts from the engineers. And the steps from the 3D printing are not yet well standardised, it makes the cost and time complications in producing phase.
>
> Surgeon 3: As a surgeon, I have a limited budget, and I have to think of the rest of the patients in future.

The second limitation comes from the time consideration. Most of the cases are required to be promptly and quickly treated to prevent the situation from getting worse. The situation is more problematic in very severe cases of tumours and bone loss. If they do not react quickly enough, they risk the life of the patient as well as the efforts the team has made.

Surgeon 4: In terms of deformity, we use this technology to plan and study. The patient can still survive with the deformity, so time is not the main problem here, but the sooner the better.

Surgeon 5: You know the tumour is growing so fast. Sometimes, this could be a big problem because while we are planning and discussing the construction of the device or implant, the tumour grows on the other hand, and the solution which is efficient today is not good for tomorrow. Sometimes the patient receives chemotherapy before the surgery; therefore, we have time to plan. But if you have increasing growth of the tumour, you are obliged to perform very fast.

The third limitation originates from the capability of the external partners. We found that the HU-Bioengineer ties are not limited to their internal collaborations but also to external units and how to deal with the companies to obtain a perfect outcome. Although the bioengineers were more specialised in using the 3D printing technology, the surgeons played more active roles in communicating with the manufacturing companies, which again highlights the importance of hierarchy.

Surgeon 6: They know nothing about prostheses but have the full technology … the only things they do are sell and produce and the certification and administration.

There is a discussion between us and companies. Companies say this is the standard prosthesis from the shelf but I can do something more special for you, and you have to pay more than normal. In fact, this is very difficult to do for your budget and for everything.

The best thing for us as surgeons is to have a joint venture with one company that is not interested in getting money from the health sector, like NIKE, FERRARI and LAMBORGINI. One that is interested in sharing the technology with others.

Having considered the limitations, the HU created the initial plan and represented the directions to fulfil it. In this phase, non-verbal interactions from the HU became more evident to clearly highlight what exactly was expected from 3D printing technology. As the HUs elucidated the main plan for the bioengineers, they started moving around, pointing to the specific parts of their bodies and making specific shapes using their fingers to better explain the process of fusion. However, these movements never occurred in the interactions among HUs and TLs. The reason for this is the fact that clinicians are trained to understand the vocabulary of surgeons in team meetings with no need for clarification, but this is not true for bioengineers. Another interpretation could be that although surgeons (HUs in our study) indicate a willingness to accept bioengineers' technological preferences, they do not expect bioengineers to have knowledge of anatomy, pathology and symptoms of the disease.

4.3. Bioengineer-Head of the Unit (HU) ties

The ties initiated from the bioengineers' side indicated a feedback-seeking approach. However, the ties were not immediately formed after receiving the directions; rather, the bioengineers took pauses to think and process the information and present the solution based on the resources they had at hand that were a) compatible with all the directions and b) manageable with the functions of 3D printing technology.

> Surgeon 7: The tailor-made prosthesis forces you to think more about the case.
> 3D printing is all about planning. If you plan well, I believe the 3D printing is much easier, more straightforward, you are going to revise the final outcome through the position of data, after that you see the model that you use to make the final object.

4.4: Bioengineer-Team Leader (TL) ties

In our setting, very few Bioengineers-TL ties were formed; however, among the few observed ties, bioengineers were the ones who began the formation of the ties. The ties were different in some features. First, the tie was formed following the formation of the HU-Bioengineer ties. In addition, bioengineers started the tie by information-seeking behaviours to make sense of the situation. The tie was disentangled by the immediate formation of the Bioengineer-HU ties. Second, the team leader had the information-giving role. However, the information generated by team leaders was not technology related rather patient related, which made the bioengineers pause and think for a short time to reflect on the HU.

We referred to our data on the severity of the case treated by the teams to investigate the relationship between the severity of the cases and formation of the Bioengineers-TL ties. Based on our data (Table 3 in Appendix), Bioengineer-TL ties formed in more severe cases. In other words, more severe cases call for more collaborations. However, the probability of more follow up and informal interactions steadily increased in line with the increasing trend of severity. This suggests that the ties are more sensitive to the complexity of the cases considering the severity and the knowledge required to plan the surgery since the teams are supposed to plan a customised surgery in a short period of time.

As the cases became more severe, the complexity of the case increased, therefore, teams established more relationships with bioengineers. The relationships did not appear within team meetings but were rather informal interactions between team leaders and bioengineers. This concept was also supported by the data from group interviews:

> Surgeon 8: I just have a phone call and say: ok we have a complicated case and I want to discuss about this patient, please come and let's have a one hour or two hours to look at this. In fact, for me, formal meetings are important, it is important but I cannot say it helps the most.
>
> Surgeon 9: I would say informal conversations, phone calls and exchanging emails helps me to resolve the problem but not formal conversations. I would say the very friendly conversations make us to exchange the information.

In our setting, the fear of failure is higher in more severe cases; thus, the HU allows the formation of more ties beyond team meetings. When the HU confronts severe cases, he/she leaves the floor to the others, and the bioengineers have greater courage to speak up and bring team leaders on board. The impact of prior collaborations was also slightly observed. Based on the field observations and the data from interviews, the ties between bioengineers and team leaders were stronger if they had worked on cases using 3D printing since the ties appeared continuously and seemed to be continuous for the follow-up practices. Figure 4 outlines the formation of ties and approaches within the teams.

--Insert Figure 4 about here---

5. Discussion

The results of our study demonstrate the following. First, dyadic relationships can facilitate knowledge sharing when a team is temporary and fluid. The reason is that as dyads are stablished for one time and a specific objective, participants feel safe to share their knowledge to achieve a short-term purpose. In this line, hierarchy assists participants in defining and outlining the way team is approaching to a solution. This becomes more evident when the team is engaged in a complex task demanding innovative work and procedures. Based on our field study, as knowledge flow happens through dyads, dyadic relationships can reduce the negative impact of temporary relationships on the knowledge sharing process. The participants who engage in the dyadic relationships acquire knowledge domains from their colleagues. The importance of the dyadic relationships lies in the fact that information is shared at the team level creating synergy in the knowledge sharing activities.

Although the teams are composed of top professionals, the top level of the hierarchy (in our case, the HU) plays the leading role in facilitating dyadic relationships and ties. This also aligns with the extensive research in team literature which indicates that the hierarchical structure of teams is both beneficial and detrimental to team success. The top level of hierarchy facilitates the formation, integration and analysis of the information by putting team participants in dyadic relationships.

5.1: Theoretical implications

Our first implication is related to the literature on temporary teams by examining the challenge of temporary relationships caused by the participants' fluidity and their role on knowledge sharing. The results suggest that dyads are important in knowledge sharing activities. The management literature has approached dyads from several viewpoints, such as leader-follower, member-member and co-worker-co-worker relationships, and much of what has been learned is relevant not only to person perception, attraction, similarity, personality, values, liking and respect but is also relevant to the organisations. Recently, the potential of dyads and their impact on joint task performance have been highlighted by several scholars (Casciaro et al., 2021; Liden et al., 2016). However, our study suggests the contribution of the dyads in the context of temporary teams. There are several reasons to believe that dyads play an important role in knowledge sharing. First, each participant directly contributes to the sharing process and information flow. Secondly, the boundaries around the dyads are strict and closed, making the knowledge sharing process focused and relevant. Moreover, participants will feel less uncertainty and fear of judgment through dyadic relationships(McGrath, 2015; Moreland, 2010; Rouse, 2020). Dyads are formed and dissolved based on a particular purpose, and there is less need for strong trust, commitment and socialisation which are the main challenges to the knowledge sharing in temporary relationships. Therefore, the unique role of dyadic relationships in compensating the absence of long-term and stable relationships highlights the importance of theorising their impact on knowledge sharing activities.

Second, dyads are formed for the purpose of knowledge sharing. One question that emerged from our data was to some extend the dyads continue knowledge sharing? The quality and frequency of the dyads are relevant to the complexity of tasks the team deals with. The more task complexity, the more informal and beyond meeting dyads are established. Since these types of dyads are established for a specific aim indicated at the meetings and follow a clear process; they open a new source of knowledge to the creative work of their teams. Informal dyads can continue for a longer period of time, explore divergent solutions and manage paradoxes. Therefore, we advance the findings of our study by arguing that the interplay between meeting dyads and informal dyads is the key to resolving the complexity of tasks. The combination of within-team dyads and informal dyads generates an ecosystem for knowledge sharing and creative solutions to the problem. Moreover, sensitivity to the type of dyads and their relation to the complexity of tasks adds value to the literature on intimate co-creation (Rouse, 2020) by focusing on different types of dyadic relationships in the context of temporary teams.

By addressing these issues, this study also contributes to the literature on hierarchy which attempted to clarify the impact of hierarchy on information sharing in knowledge diverse teams (Gray et al., 2022; Matusik et al., 2021; Widmann & Mulder, 2018). Although literature on hierarchy addresses that teams' hierarchical structures can be beneficial for team functioning compared to flatter structures (Anderson & Brown, 2010; Bunderson et al., 2016), what is missing here is the link between hierarchy and participants' knowledge sharing activities. This study adds theoretical insights to the debate on the beneficial impact of hierarchy on knowledge sharing practices taken by team participants. In the context of temporary teams where time pressure is relevant, hierarchy reduces conflict and provides social materials to promote knowledge sharing. Thus, it helps to emerge and share unique knowledge that is incorporated into the team decision.

Eventually, considering fast-changing environment, ranging from technology, economy, and socio-political context, disaster and pandemics; healthcare systems face with constant challenges. There is a need for healthcare organisations to have a proper strategy, not only to benefit public, rather to offer high quality care in the changing environment by boosting their internal practices. It seems the concept of antifragile strategy (Cobianchi et al., 2020) in developing knowledge management strategies can provide advantages for healthcare organisations. Given that dyadic relationships are the key components of knowledge sharing process, healthcare organisations will be able to secure their knowledge sharing activities by improving the quality of dyads.

5.2. Practical implications

This study has implications for the health care context in which temporary teams are central in everyday practices. Considering the dyadic dynamics in healthcare teams, highly professional teams who aim to personalise caregiving practices provide an excellent space for knowledge sharing while engaging with innovative technologies.

As the study by Zhao et al. (2021) suggests, the application of 3D printing technology in practice needs to be "stage specific". Conducting this research within a specific context of orthopaedic surgery, opens a black box of 3D printing applications for healthcare policymakers. By focusing on the directions followed by the surgical teams and the formation of relationships to exploit 3D printing technology, new insights, ideas and initiatives will arise to support caregiving practices. Moreover, as the use of technology becomes more complex, effective relationships to work through the technology is needed. In some cases, caregiving practices may require high-level informal dyads among different participants. Based on this finding, health care managers will be able to facilitate the formation of dyads by integrating more resources and supporting programs in addition to formal team meetings.

Given the importance of hierarchy within the teams, healthcare managers might want to put more effort into the top levels of hierarchy in hospital settings to exploit the positive impact of hierarchy. This can motivate managers to complement traditional tools by paying more attention to hierarchy within the surgical teams.

6. Limitations and future directions

Our choice to study health care teams as a complex and diverse context presented some limitations. Data collection in health care organisations is a challenging process that requires extended periods of time to track real practices in healthcare. Although we made a lot of efforts to enrich our database, we failed to include more ethnographic data in our study. One reason for this limitation could be the extremely dynamic and complex nature of hospitals. Although group interviews helped to meet more respondents, there are strict regulations involved in gaining access to the site; once this is achieved, the most important barrier is the difficulty of arranging meetings with surgeons who have a busy working life. Secondly, we have yet to expand the number of organisations under study. It will have more implications if the study includes multiple organisations under the same or different policies. Thirdly, our data collection process started simultaneously with the pandemic related to COVID-19 while Italy experienced a strict lockdown. Therefore, organising group interviews, and following the interactions and work practices in the hospital setting was a big challenge. Although, we attempted to improve the quality of the study by expanding the timeline of the project; pandemic was present at the background of every action during data collection.

As another future work, we suggest the adoption of quantitative approaches to measure knowledge sharing behaviours in the presence of 3D printing technology. We also suggest more studies on temporary teams' knowledge sharing process in which the underlying technology promotes a flat team structure to investigate if the same concepts emerge.

7. Conclusion

Participants in the stable teams have the opportunity of prior shared experience which is missing in temporary teams. Yet participants in temporary teams must synergically socialise and share knowledge to successfully fulfil complex tasks (Massaro et al., 2020). Moreover, the use of new technologies temporarily adds more participants and increases fluidity of the temporary teams.

As a result of the increase in temporary relationships, participants can not build trust and have a shared understanding of team tasks (Edmondson, 2012). Therefore, knowledge sharing process becomes a vulnerable factor since it depends on constant and long-term relationships. Building on this, we studied temporary relationships in the context of orthopaedic teams, since the relationships play an inevitable role in creating a sharing environment within teams that need to do creative work. The orthopaedic teams use 3D printing technology to provide customised treatment.

Results of our qualitative study show that dyadic relationships play an inevitable role in facilitating knowledge sharing within the teams, while informal dyads established beyond team meetings are the key to resolving the complexity. Furthermore, the role of hierarchy in leading the dyads and facilitating knowledge sharing is an important factor that should be considered.

Tables

Table 1: Source of the data and use of the data in analysis

Data source	Type of data	Participants	Data use in the analysis
Group interviews followed by observations on team interactions (6 focused groups)	Voice record of the conversations, field notes from meeting attendance, number of participants and their role, their position in the meeting, and their movements. Visual documentation, materials and artifacts used during the meetings. Field notes on the type of interaction, visual materials supporting the conversations considering the roles in the teams.	Group 1: 6 participants (team leaders, team members, bio engineers) Group 2: 4 participants (head of the unit, team leaders and bio engineer) Group 3: 3 participants (team leader, bioengineers) Group 4: 3 participants (Head of the unit, team leader and bio engineer) Group 5: 4 participants (Head of the unit, team leader and bio engineer) Group 6: 5 participants (head of the unit, Director of the unit, team leaders)	Group interviews: • To validate and confirm the concepts identified during observations and semi-structural interviews. • To understand the difference between behaviours and interactions Observations: • To identify the main actors and roles in the team. • To create a map of real practices during surgical planning, facing the problem, material choice, and meeting deadlines. • To become familiar with the subject of the conversations in each single stage • To become familiar with the process of exchanging ideas and source of behaviours.
Individual Interviews (17 preliminary and semi-structural)	*Preliminary interviews (5)*: *V*oice record of all the conversations, field notes from meeting attendance, record of social interaction, and use of artifacts, pictures and virtual bodies in their offices. to investigate the history, nature of teams, type of printers, number of printers available in the setting, number of staff members and general work processes. *Semi-structured interviews (12):* with 12 members of staff who actively work and research in orthopaedic surgery	• CEO of the hospital, Director of the Trauma clinic I, Site manager of the Oral and Maxillofacial Surgery of the external unit, and mechanical engineers. • Director of the Movement Analysis Laboratory. • Biomedical Engineers (2 people)	• To become familiar with the context and provide a basis of work procedures in orthopaedic surgery. • To improve our understanding of the starting point of the clinical problems, team dynamics and team-related decisions • To identify the main learning behaviours before and after utilization of 3D printing technology

	and have experience with the application of 3D printing to discuss their insights, attitudes and experiences during projects in which they have been involved. *Informal interviews:* informal but 3D printing related conversations ranging from brief exchanges to longer talks during work breaks, and everyday conversations.	• Research consultant • Associate Professor in Physical Medicine. • Orthopaedic Surgeon (7 people) • Head of the Oral and Maxillofacial Surgery department • One of the authors had a workstation in the hospital, during one year field study. Therefore, she had opportunity to spend time with the managers, designers, engineers, and support staff.	

Figures

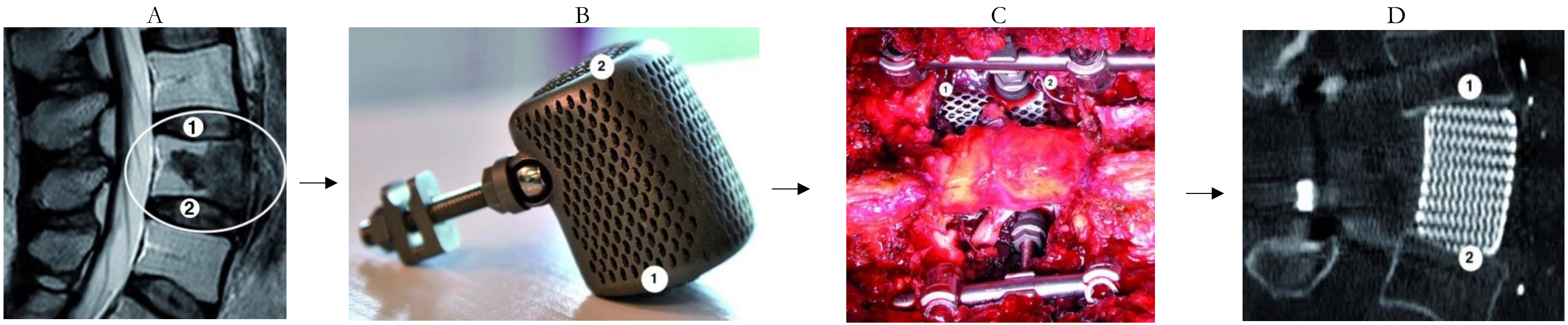
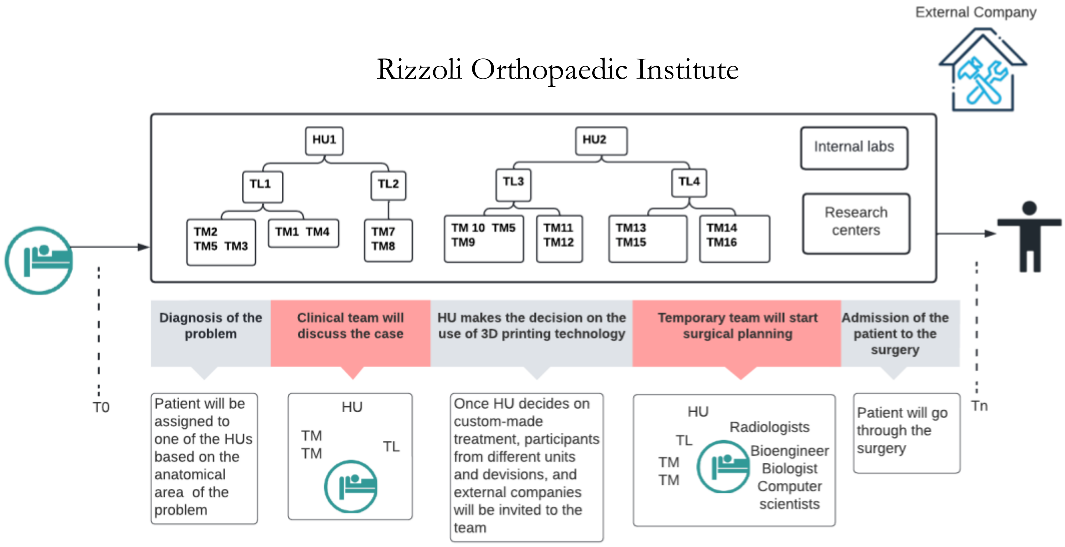


Figure 1: Prosthesis produced in titanium cage is reconstructed to be replaced with the infected vertebra. A: Tumour extension in vertebra, B: Lateral view of the prosthesis in titanum, C: reconstruction of the anterior column during the surgery, D: Coronal CT-scan showing final reconstruction of the anterior column (Girolami et al., 2018).



HU: Head of the Unit
TL: Team Leader
TM: Team Member

Figure 2. Team formation and care giving process in the setting

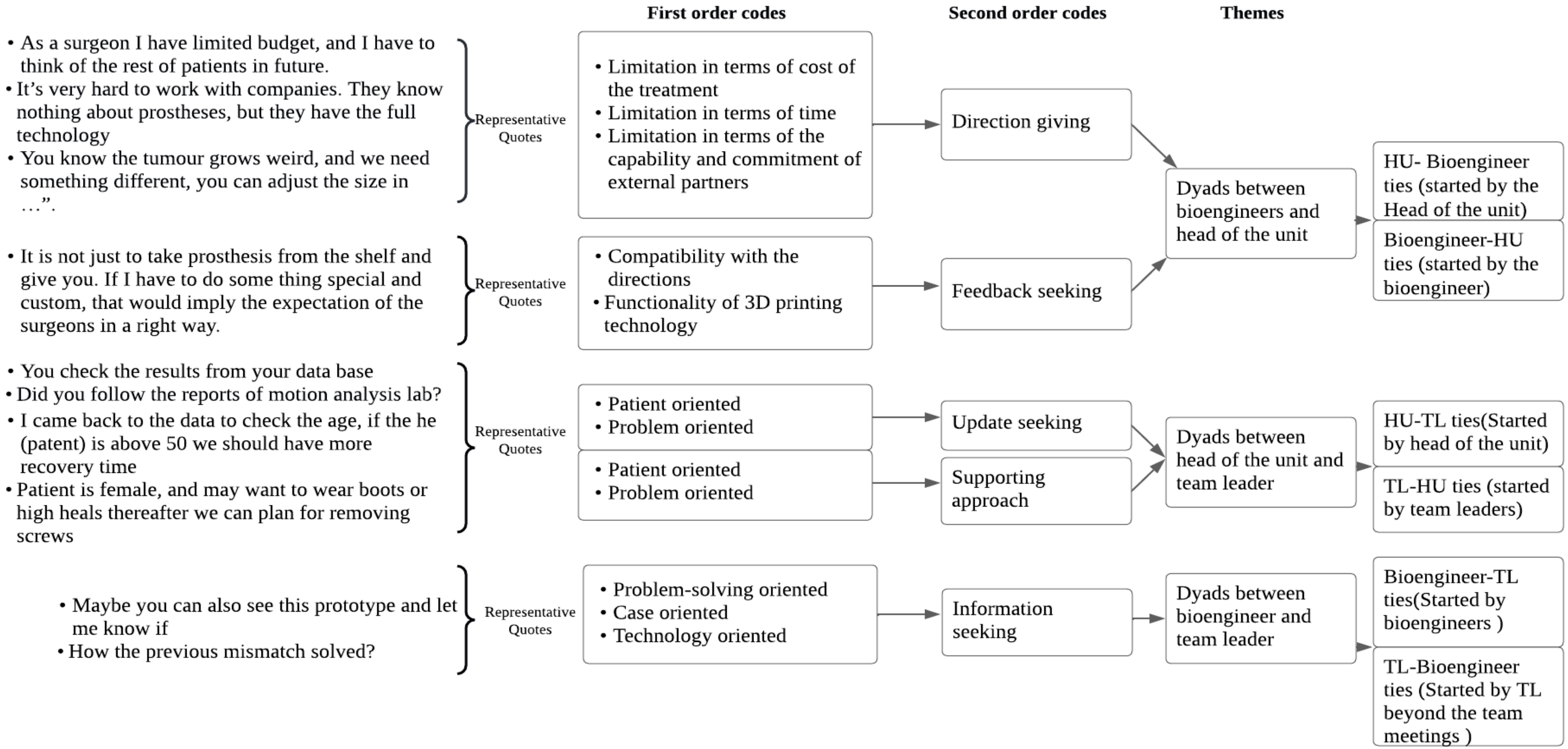
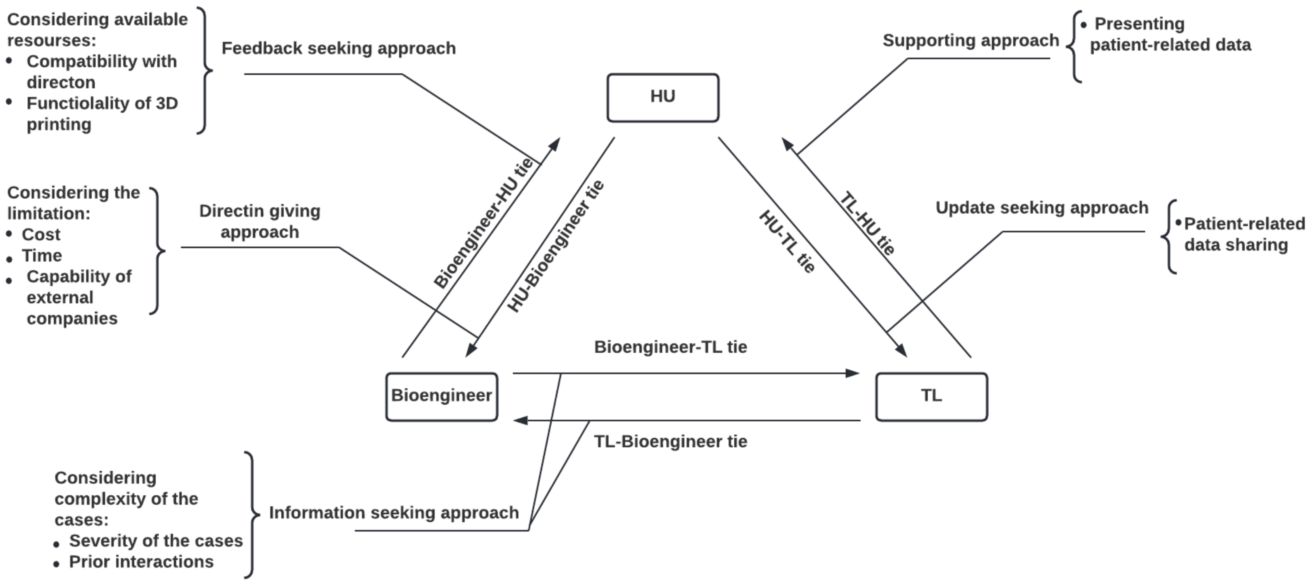


Figure 3: Qualitative Coding Scheme



HU: Head of the Unit
TL: Team Leader
TM: Team Member

Figure 4: Formation of the dyads and ties

Appendix

Table 1. Frequency table of Anatomical Area of the cases treated with the support of 3D printing

Anatomical Area	Frequency	Percent
Knee	27	25.23
Pelvis and hip	31	28.97
Ankle	10	9.35
Foot	7	6.54
Elbow	3	2.80
Tibia	4	3.74
Spine	24	22.43
Thorax	1	0.93
Total	107	100

Table 2: Frequency table of Pathological Area of the cases treated with the support of 3D printing

Pathological area	Frequency	Percent
Arthritis	26	24.30
Tumour/bone loss	50	46.73
Big trauma/infection	4	3.74
Osteonecrosis	8	7.48
Talocalcaneal coalition	3	2.80
Calcaneonavicular coalition	4	3.74
Deformity/instability	5	4.67
Infection after loosening prosthesis	3	2.80
Infection/infection after loosening prosthesis	3	2.80
prosthesis loosening	1	0.93
Total	107	100.00

Table 3: Number of cases treated in team with collaboration of bioengineers and mean severity of the cases

Team (clinic)	Mean severity	Number of the reported cases
Team Z	8.4	33
Team S	7	7
Team D	8.9	37
Team F	7.2	5
Team G	8.5	22

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Boundary blurring and temporary teams' performance: The case of 3D printing technology in surgical teams

Abstract:

We build on boundary blurring research to explore the relationship between temporary teams' characteristics and their performance. We focus on the three main drivers of boundary blurring, namely fluidity, overlap and dispersion (Mortensen & Haas, 2018), and we develop hypotheses on their direct effect on temporary teams' performance. Furthermore, we explore to what extent their effect is moderated by different levels of task complexity. We use data on 107 surgery teams using 3D printing technology in a highly specialised research hospital in Italy. Our analysis shows that team overlap has a negative impact on team performance and the impact is stronger when the task complexity is high. Conversely, team dispersion positively impacts team performance, and the positive impact is reinforced in more complex cases.
Keywords: temporary teams, boundary blurring, 3D printing

1. Introduction

To date, research on teams has attracted considerable attention in management studies, as many organisations have turned to team-based-procedures to overcome the complexity of tasks and projects (Chae, Seo, et al., 2015). However, as research has progressed, scholars have started questioning the ability to clearly delineate between members and non-members, challenging the traditional view that sees teams as static and bounded (Mortensen & Haas, 2018). In fact, many of today's teams do not involve co-located, full-time members (Wageman et al. 2012), but exist for a short period of time, being disbanded once the tasks have been fulfilled (Lv & Feng, 2020). In these so-called "temporary teams", participants come from different departmental units and institutes, frequently move from one team to another, and often engage several teams at the same time (Mortensen & Haas, 2018).

A growing body of research has investigated the characteristics of temporary teams, taking into consideration social processes, collaborations, leadership style, and performance (A. Edmondson et al., 2001; Hällgren, 2010; Klein et al., 2006; Massaro et al., 2019; Valentine, 2018; Valentine & Edmondson, 2015). However, extant research does not fully address, neither conceptually nor empirically, the membership status and movements within and between teams. Individuals' movements on and off the teams raise broad questions not only for the employing and management organisation but also for the teams themselves (Schüßler, 2017).

In this paper we explore how the three main drivers of temporary teams' boundary blurring, namely fluidity, overlap and dispersion, impact team performance at different level of task complexity. We conduct a field study in a hospital specialised in orthopaedic surgery, and focus on surgical teams who use 3D printing technology to provide customised implants for orthopaedic surgery.

This research offers two main contributions. First, to the best of our knowledge, it's the first study to assess the effect of teams' boundary blurring emergent states on temporary teams' performance. Thus, it adds to the recent research stream studying new forms of teams and their boundaries (Massaro et al., 2019; Mortensen & Haas, 2018; Valentine & Edmondson, 2015). In addition, it enriches our understanding of their functioning at different levels of task complexity. Project complexity has been proven as the main reason to organise temporary teams (Mortensen & Haas, 2018). Understanding the interaction between work complexity and boundary blurring and its impact on performance, contributes to advance our understanding of the mechanisms driving temporary team performances.

Second, it sheds lights on the interaction between the use of 3D printing technology and teams in healthcare. As technology and teams do not exist in isolation during healthcare delivery practices, teams need to facilitate their work using enabling technologies (Thielst, 2007). Therefore, research on this interplay can be beneficial to increase the quality of patient care procedures, providing practical insights for professionals operating in hospital settings.

2. Theoretical background

2.1. Temporary teams

Temporary teams are organised for managing a specific or set of issues (Agha et al., 2*021*). There is also some evidence that suggests temporary teams as a solution for managing complexity of tasks (Lv & Feng, 2020; Mortensen & Haas, 2018). When a team needs to accomplish a work that has not been done before, boundary crossing behaviours occur as the team is looking for more support and recourse (Edmondson, 2012; Mortensen & Haas, 2018). Moreover, due to the temporary nature of the teams, there is always a lack of social exchange among individuals preventing successful team performance (Agha et al., 2021; Valentine, 2018).

Research on temporary teams has widely focused on the means to overcome the challenges. As time and deadlines are the unique features of temporary teams, attention to deadlines has been explored from different perspectives (Seers & Woodruff, 1997). On the one hand, the existence of deadlines and time pressure makes teams start working with new participants. Consequently, the lack of trust and familiarity among team participants result in conflict (Edmondson, 2012; Seers & Woodruff, 1997). On the positive side, it can increase their attention to task based activities, creativity and innovative thinking (Amabile et al., 2002; VanEerde, 2000). To overcome the challenges related to the temporal aspects of temporary teams, psychological safety has been recognised as a key factor for facilitating knowledge sharing and creativity (Kessel et al., 2012), since a high level of psychological safety reduces the negative effects of temporariness (Nembhard & Edmondson, 2006). Secondly, management style and leadership have been identified as the factors to manage uncertainty of work procedures (Almost et al., 2016). While the existing body of research pays extensive attention to the process and output of the teams based on team composition theories, rather less attention has been paid to the inputs. Absent from the literature is a cohesive study of the boundaries based on individuals' movements. We believe that boundary blurring theory can explain members' movements from one team to another team by paying attention to the membership status of the participants.

2.2. Boundary blurring

Mortensen and Haas (2018), suggest rethinking teams from bounded units to dynamic hubs with blurred boundary composed of participants rather than members. Boundary blurring refers to the "lack of clarity about who is or is not a member of the team". This lack of clear boundary increases as the result of overlap, fluidity, and dispersion (Mortensen & Haas, 2018: 343) in the teams.

Team overlap: team overlap also known as multiple membership refers to the extent to which "individuals who work in a team are simultaneously working in other teams" (Mortensen & Haas, 2018: 344). As organisations increasingly organise teams around tasks, overlap appears as a relevant factor in multi team settings (O'Leary et al., 2011). Despite the fact that overlap has become prominent in today's organisations, there is no agreement on the impact of multiple membership on team performance. Bertolotti et al. (2015) investigated the relationship between multiple membership and team performance, and concluded a curved linear relationship with regard to the moderating effect of technology use. They indicated an inverted U-shaped relationship between multiple team membership and team performance with the optimum performance corresponding to multiple membership in nine teams at the same time. On the other hand, Crawford et al. (2019) stated a negative relationship between multiple membership and team performance. The negative effect becomes more problematical as the task complexity was increased. Even though studies on multiple memberships offer a puzzling picture of its impact on team performance, they all agree that the key reason for increasing overlap in today's teams is the complexity of the projects and tasks (Gann & Salter, 2000)

Team fluidity: is the extent to which participants join a team based on demand, fulfil their tasks and leave the team once their knowledge is no longer needed (Mortensen & Haas, 2018). Prior research supports the thought that fluidity promotes team performance since it provides a new source of knowledge. This becomes beneficial in teams dealing with complex and creative tasks (Bedwell et al., 2012). New participants play an inevitable role in generating ideas and improving the work process (Choi & Thompson, 2005). Similar results have been confirmed by La Hera and Rodriguez (1999). Both studies compared open teams who encourage member movements across tasks and closed teams who do not experience diversity in terms of their members.

Team dispersion: refers to the extent to which members come from "different functional areas, divisions, or business units within an organisation, or to different organisations" (Mortensen & Haas, 2018: 345). To achieve a successful performance, face-to-face interactions during teamwork are always encouraged. Studies on distributed teams indicate different viewpoints to interpret the distribution. Haas (2006) considered dispersion among team members based on their categorical distinction as local and cosmopolitan members . Hind and Bailey (2003) have gone a step further and categorised geographical distance in the workplace. Cummings (2011) suggested investigating dispersion as physical distance at the country level across time zones. However, the existence of dispersion in today's teams has prompted scholars to explore the circumstances where dispersion can be beneficial for team outcomes. The results suggest investigating dispersion considering the clear definition of distance in terms of time zone, location or categorical distance as well as its interaction with moderators related to participants.

Each of the above-mentioned drivers has become common in recent years because of their beneficial impacts for team outcomes. They offer teams more flexibility and efficiency, yet each can also lead to uncertainty when engaging with the complexity of the tasks (Mortensen & Haas, 2018)

2.3. Task complexity

Temporary teams have proven their ability to effectively deal with unique and complex tasks (Bakker, 2010). The task itself calls for more complexity in terms of collaboration and interdependence. The reason lies in the fact that the necessary skills and knowledge are stored in the minds of people who are distributed among different units and organisations (Wageman et al., 2012). Existing literature revealed that organising temporary teams is an appropriate mechanism to manage the complexity of tasks (Hanisch & Wald, 2014), as they are more action oriented rather than decision making (Lundin & Söderholm, 1995).

The impact of task complexity on team performance has been agreed in previous studies (B.Clark & Fujimoto, 1992; Elsner, 2004; Morel & Ramanujam, 1999). Yet, the meaning of task complexity needs to be unpacked based on the context being studied. Task complexity includes uncertainty and uniqueness that plays an inevitable role on temporary teams' success (Hanisch & Wald, 2014). Xiao et al. (1996) identified four elements of task complexity in emergency departments of hospitals: multiple and concurrent tasks, uncertainty, continuous change of the work plans, and extensive workload. They concluded that the four elements caused challenges and conflicts for team functions. Wegge and Carla (2008) confirmed that complex tasks are better accomplished in diverse teams compared to homogenous teams. Chae et al. (2015) suggested knowledge sharing behaviours as a supporting mechanism to cope with complex tasks. Since the task complexity is growing and it becomes an intrinsic factor of work, the need for understanding task complexity seems more important (Vashdi et al., 2013). Since teams' characteristics and complex tasks interact in several ways to create a successful performance (Espinosa et al., 2007), this study sheds light on the interaction between teams' boundaries and task complexity.

2.4. Hypothesis development

2.4.1. Team overlap and team performance

As today's modern organisations tend to team based structures dealing with several projects at the same time, participants are involved in multiple teams (Bertolotti et al., 2015). Such a situation requires participants to manage all the projects properly as projects may require various practices. The overlap caused by multiple participation often influences team performance depending on the environment, context and deadline pressure (O'leary et al., 2011). Building on the knowledge acquisition approach, as participants simultaneously exchange tasks from one team to another, they interact and communicate with different participants and acquire knowledge from different sources (Carley, 1986). However, it can be less beneficial as involvement increases and team participants are not able to devote enough time to multiple teams at the same time (Mortensen & Haas, 2018). Moreover, higher task complexity demands higher coordination, exchange of knowledge and information processing (Jones & Deckro, 1993) which are violated in a high degree of overlap. Complexity of the tasks invites more knowledge, creativity and information processing for the main actors (Argote et al., 1995; Wood, 1986). Therefore, as team participants are involved in several complex cases, more actions, intense communications and knowledge processing are required (Chae et al., 2015). Therefore, in our case:

H1: In temporary teams, team overlap negatively influences team performance.

H1a: The negative impact of team overlap on team performance is stronger when the team deals with more complex cases.

2.4.2. Team fluidity and team performance

In fluid teams, as team participants change over time, new participants join to fulfil specific short-term needs and leave the team once their contribution is no longer needed (A. Edmondson, 2012; Valentine & Edmondson, 2015). Thus, participants of fluid teams experience lack of familiarity within the teams. Knowing that team familiarity has positively linked to the team outcome (Gruenfeld et al., 1996), fluid teams face a dilemma here. Although fluidity of the teams opens up new opportunities for knowledge sharing, it does not necessarily result in successful team performance (Avgerinos et al., 2020). In fact, the relevance of fluidity to team performance occurs through the tasks (Dokko et al., 2009). In the same line, task complexity gives directions to the pattern of collaboration and is known as a predictor of performance (Chae, Seo, et al., 2015). As the tasks become more complex, the knowledge acquisition process is initiated in the teams, and participants who seek knowledge to achieve successful performance (Lankton et al., 2012) search for new participants as new source of knowledge. Thus, new participants who have related knowledge will contribute to complex tasks by sharing their knowledge. As a result, this study predicts:

H2: In temporary teams, team fluidity negatively impacts team performance.

H2a: The negative impact of team fluidity on team performance is less strong when the team deals with more complex cases.

2.4.3. Team dispersion and performance

Face-to-face interactions are always preferred in teamwork, since team interactions are not only dependent on verbal interactions, but also visual interactions among all team participants (Sergeeva et al., 2020). However, geographical distance may not be the cause of problems (Espinosa et al., 2003), since use of communication technologies has facilitated interaction in concurrent organisations (Malhotra et al., 2007). Rather, it can be beneficial since opens the source of new knowledge to the teams by adding skilled participants. Crossing boundaries in distributed teams helps participants access to specialised expertise that can make them better-informed and provide more creative solutions to complex problems (Malhotra et al., 2007). Moreover, as geographical distance is not at country level and different time zones, interactions among the participants in corridors and break times provide a comprehensive overview of the problem, technology at hand and directions for the solution, and team participants can share knowledge effectively (Kiesler & Cummings, 2002; Orlikowski & Barley, 2001). Therefore:

H3: In temporary teams, team dispersion positively affects team performance.

H3a: The positive impact of team dispersion on team performance is stronger when the team deals with more complex cases.

The model in Figure 1 summarises the hypotheses presented above.

--Insert Figure 1 about here--

3. Setting

We conducted our study in a setting where the use of temporary teams is frequent, particularly for the numerous introductions of novel technology. The Rizzoli Orthopaedic

Institute is a highly specialised Italian public hospital with state-of-the-art research facilities in the field of orthopaedics and traumatology (www.ior.it). Surgical planning teams are highly hierarchical, each team having a single Head, with high competence and long experience in orthopaedic surgery, and responsible or all final decisions of the team. The treatment process starts when a patient (in this study also called 'clinical case') is visited by one of the surgeons of the team and the clinical indication is surgery. The head decides on the team participants and the techniques to treat the case. If standard solutions and devices are deemed as inappropriate for the case, a possible personalised treatment is exploited. According to the specific case requirements, a number of additional participants from internal and external units may then join the team.

3.1. Complexity of 3D printing technology in the hospital setting

Printing body parts was always a dream in health-care until recent technological developments have made it real (Aimar et al., 2019). As 3D printing is moving ahead, it opens an avenue in orthopaedics to design innovative medical devices personalised to each individual case. Customisation can address the patient-specific anatomy of bones and joints to be operated, complex bone fractures, deformities of limbs and spine, and large bone loss for revision surgery, infections and bone tumours. The customisation also implies a careful pre-surgical planning, prototyping of devices and relevant jigs, and final manufacturing (Vaish & Vaish, 2018), the latter however always performed by specialised external companies.

However, complexity mainly originates from the long printing workflow, which starts with medical imaging acquisition and image processing, i.e. conversion from a DICOM file to STL format, editing of the 3D bone models, design of the implant and preoperative planning , and finally the 3D printing (Vaish & Vaish, 2018). A team of engineers, physiatrists and surgeons should work synergistically, sharing their knowledge and skills to obtain a final implant best matching the anatomy and condition of each single case (Jordan, 2019). Therefore, the first indicator of complexity is brought to the work of surgical teams by adding more participants from different educational backgrounds and area of expertise. Secondly, production of custom-made tools and implants is expensive, and its use is limited to the a few hospitals. However, the cost usually includes cost of materials, cost of software used and cost of qualified personnel (Frizziero et al., 2021) which brings complexity to the surgical planning process. Therefore, we consider the use of 3D printing technology as a baseline for case complexity for two abovementioned reasons. Moreover, If the printing workflow is broken down into small and well defined components, careful analysability of the tasks is evident (Ahuja & Carley, 1999; Wei, 2012), and it becomes easier to figure out diversity among team participants. Secondly, cost of the use is embodies the cost of team participants as well as materials representing complexity of each case.

Therefore, as tasks may be interpreted differently by different professionals according to their understanding of the tasks (Chae, Seo, et al., 2015), the use of 3D printing technology provides a consistent criteria of complexity for the team.

3.2. Data, participants and procedures

Our data were collected from two sources in our setting: a paper-based survey, and archival data stored in the database of the hospital from 2020 to 2021. Data collection started with several field visits to identify the current procedures of the surgical teams and survey design. The survey was sent out to the heads asking for information related to clinical cases treated by 3D printing technology in their clinic. The heads distributed the questionnaires to the team leaders involved in the treatment process. The team leaders answered the questions considering each single case, meaning that each questionnaire was correspondent to one single case. We distributed questionnaires among six heads and they filled the questions including the codes related to 107 clinical cases (questions were about timeline of the treatment, and rated team performance related to each single case). There were some ongoing treatment processes at the time of data collection and respondents needed to conclude the cases to provide final responses and rate the performance. Eventually, our sample comprised 107 clinical teams and corresponding cases, including 324 team participants at the end of 2021. Figure 1 in the Appendix illustrates the starting time of team formation and planning time period for each individual team.

Having finalised the information related to each case and teams from the survey data, we started collecting additional data from the hospital database (SIR2020) by searching the codes of the cases. Therefore, we gathered data on team participants and the timeline of the treatment process, recovery time, and the cost of the treatments. The final database was supplemented using public curriculum vitae to complete the demographic information related to team participants. While our analysis mostly relied on the survey, archival data and participants' curriculum vitae, we conducted follow-up interviews with the director of the laboratory of movement analysis and bioengineers working in the laboratory to do some sensemaking of the observed patterns and results.

3.3. Measurement

Dependent variable

The dependent variable is operationalized using temporary team performance. Team leaders were asked to rate the performance of the team on scale ranging between 1 (the least successful) and 10 (the most successful). As the variable distribution is highly skewed (98% of the responses are above 7, Mean= 8.3, St. Dev= 0.84), we created a variable encompassing four categories: Poor [0; Mean - St. Dev], Low [Mean - St. Dev; Mean], Medium [Mean; Mean + St. Dev] and High [Mean + St. Dev, 10].

Independent variables

Team overlap: we operationalised team overlap based on the average number of cases managed by the team participants simultaneously. The time period (months) for the treatment of each case is our baseline for measuring overlap. The number of cases each participant is involved in has been calculated at the end of each month over the treatment period. Then the average number of cases each participant was involved in during the time period was calculated as the measure of overlap for a single participant. Consider Figure 2 in the Appendix, while team A is working on Case 1, participants may be involved in teams other than team A working on cases other than Case 1. Therefore, in a treatment process for Case 1 from April to June, participant "a" may be involved in 2 cases in April, 1 case in May, and 3 cases in June. Therefore, participant a's overlap is $\frac{2+1+3}{3months} = 2$. Thus, team A's overlap is the average overlap among all participants of team A.

Team fluidity*:* surgical teams in our setting have a core-periphery nature meaning that there are participants who do not change from one team to another team (core) while other participants join the team or replace other participants (periphery). Therefore, movements and member exchange occur in the periphery of the teams that makes teams fluid. As the core parts remain similar from one team to another, the fluid part is changing over time and can be conceptualised as dis-similarity among the teams. For measuring team fluidity, we use the Jaccard distance that is increasingly used to measure dissimilarity between a set of nodes in network analysis (Pietilänen & Diot, 2012). The original formula of Jaccard Distance is $d_j(A, B) = 1 - J(A, B) = \frac{|A \cap B|}{|A \cup B|}$ suggested by Kosub (Kosub, 2019).

Taking all the cases in chronological order, the fluidity of a team is calculated in comparison to any single previous case and summed up at the end. The following example shows the operationalisation approach:

- In January 2016, Team A is treating Case 1: {participant a, participant g, participant c}
- In March 2016, Team B is treating Case 2: {participant a, participant b, participant e}
- In July 2016, Team C is treating Case 3: {participant a, participant g}

Fluidity between Team C and B = 1- ($\frac{|(\text{participant a, participant g}) \cap (\text{participant a, participant b, participant e})|}{|(\text{participant a, participant g}) \cup (\text{participant a, participant b, participant e})|}$

= 1- (1/4) = 0.75

Fluidity between Team C and A = 1- ($\frac{|(\text{participant a, participant g}) \cap (\text{participant a, participant g, participant c})|}{|(\text{participant a, participant g}) \cup (\text{participant a, participant g, participant c})|}$

= 1-(2/3) = 0.3

Fluidity of team C = 0.75 + 0.3= 1.05

Team dispersion: was operationalised based on average geographical distance of participants' offices. The location of their offices was rated based on the scale proposed by Cummings (2012): 1 = same room, 2 = different room on the same corridor, 3 = different corridor, 4 = different floor, 5 = different building, 6 = different city. Participant' office was rated compared to the offices of their pairs in the team. The average distance was calculated by adding up the distance for each participant by number of pairs within the team.

Moderating variable

Task complexity: many concerns about 3D printing technology originate from the higher cost of technology to provide customised implants in comparison to the standard implants. Standard manufacturing methods are less expensive for large-scale production while the cost of 3D printing technology is becoming reasonable for small production runs (Ventola, 2014). Therefore, the more complicated cases demand more financial resources, while more accurate design causes a reduction in the cost and rework. Therefore, we considered cost of the technology use (in our case 3D printing technology) as a measure of task complexity.

Control variables

Age diversity in the surgical team: surgical teams are hierarchical composed of senior and junior medical doctors, bio-engineers, mechanical engineers, biologists, radiologists. Considering the context influence in healthcare, the main surgeon's age would be associated with the rank and status as well as tenure. Therefore, to measure the age diversity within surgical teams, we conceptualised the variable as disparity. Therefore, age diversity is measured via a coefficient of variation ($CV = \sqrt{[\sum(D_i - D_{mean})/n]} / D_{mean}$), as suggested by Harrison and Klein (2007).

Planning time duration: surgical planning using 3D printing technology is a complex process relying on computer imaging in addition to making the diagnosis and assisting the elected surgical tools. Moreover, pre-operative planning includes counselling the patients and education of the surgical team in order to predefine the surgical steps (Fadero & Shah, 2014; Pugliese et al., 2018). Therefore, we recorded the time spent on the procedures before surgery (day), as it can indicate the complexity of each surgery.

Recovery time after surgery: reduction in time to full recovery after surgery is a fundamental advantage of surgical planning. However, surgeons do not have full control on the home recovery time, but patients will probably stay in the hospital to closely monitor health information after surgery (Talamini et al., 2004). We recorded recovery time duration in hospital (in days) after each surgery as it is associated with the complexity of the surgery process.

Patient's age: care givers usually report on the patient's age when describing a health problem. This is because of the fact that medical treatments and advice given to each patient are based on pre-defined age categories in healthcare (Maguire et al., 2000). Therefore, we keep control on patient's age as an indicator of the complexity of each case.

4. Results

Before testing the hypotheses, a preliminary analysis was conducted. Table 1 presents descriptive statistics and correlation for dependent, independent and moderating variables. It is important to note that team performance is negatively correlated with team fluidity and overlap, whereas it is positively correlated with team dispersion. Given that our dependent variable was rated from 1 to 10, it is mostly distributed above 7 (98 percent of the data). We clustered the dependent variable in four categories as intervals. Team performance will be at the Lowest level if the rate is in the interval (0, Mean - St. Dev), Low: (Mean - St. Dev, Mean), High: (Mean, Mean + St. Dev) and Highest: (Mean + St. Dev, 10). Therefore, our dependent variable was normally distributed. Secondly, the logarithm of the moderator has been calculated to use in regression models. We also mean centred all independent variables and moderator before hypotheses testing.

--Insert Table (1) here--

Considering team performance as an ordinal variable, we used an ordered logit model to test our hypothesis. However, in robustness check section we applied tobit regression models and simple linear regression. Table 2 represents the results of the ordered logit models to test our hypotheses. In Model (1), control variables were entered, and team age diversity showed a significant relationship with team performance with a negative impact on team performance ($b = -10.38, p<0.01$). In Model (2), we tested the impact of three independent variables on team performance. Thus, the negative impact of team overlap ($b = - 0.260, p<0.01$), and negative impact of team fluidity ($b = - 0.162, p<0.01$) on team performance are statistically significant. Moreover, the positive impact of team dispersion (b = $1.508, p<0.01$) on team performance is statistically significant. This means that H1, H2 and H3 are supported by the data. In Model (3), task complexity has been added to explore the main effect of task complexity on team performance, which does not indicate a significant impact on team performance. Model (4) examines the interaction between team overlap and task complexity ($b = -1.037, p<0.1$) which supports the negative impact of interaction on team performance (H1a supported). Moreover, R^2 increased from 0.3436 in Model (2) to 0.3702 in Model (4) and the change in R^2 was statistically significant

($\Delta R^2 = 0.02; F = 6.33, p<0.01$). Figure 2 shows predicted values estimated after running model (4), when task complexity is at minimum (Low) and maximum (High) level, and other variables at mean with 90% confidence intervals. It indicates that the negative impact of team overlap is stronger when task complexity is high (H1a supported). In Model (5), we entered a moderating variable (Task complexity) to test its interaction with team fluidity. However, results confirm a positive interaction effect, but the impact is not statistically significant. In addition, R^2 increased from 0.3436 in Model (2) to 0.3634 in Model (5) and the change in R^2 was statistically significant ($\Delta R^2 = 0.01; F = 6.15, p<0.01$). Therefore, hypothesis H2a is not supported. In support of H3a, we tested the interaction between task complexity and team dispersion in Model (6), and the positive impact is statistically significant ($b = 5.329, p<0.05$). The change in R^2 from 0.3436 in Model (2) to 0.3815 in Model (6) was statistically significant ($\Delta R2 = 0.03; F = 6.65, p<0.01$). Figure 3 illustrates the stronger positive impact of team dispersion on team performance while task complexity is higher. The predicted values estimated after running model (6), when task complexity is at minimum (Low) and maximum (High) level, and other variables at mean with 90% confidence intervals.

--Insert Figure (2) here—

--Insert Figure (3) here--

Further, we entered all interaction effects in a full specified model to test for any simultaneous interaction effect. Even though we failed to support H2a in Model (5), but the interaction effect was supported in model (7).

--Insert Table (2) here—

4.1. Robustness checks and further analyses

To assess the robustness of our results, we submitted our data to a series of robustness checks. First, because 98 percent of our dependent variable was rated above 7 and observed only within a certain range of values, we run Tobit regression with the lowest level of 7 to test all main effects and interaction effects. Results (Table 1: Appendix) showed the same statistically significant impact of variables on team performance. Secondly, we run simple linear regression model to test the robustness of our findings and we achieved robust results (Table 2: Appendix). Moreover, simple slope plots of simple linear regression illustrated robustness of interaction effects in

Hypotheses H1a and H3a (Figure 3 and Figure 4: Appendix). Third, to control the extent to which the moderator may affect the three independent variables at the same time, we run a full specified model (Model 7, Table 2), and all interactions were statistically significant accordance to our hypotheses.

5. Discussion

The purpose of this study is to understand whether and how drivers of boundary blurring impacts team performance while teams are temporary, existing for a short period of time. Prior research suggested team context (Zellmer-Bruhn & Gibson, 2006) and team tasks (A. C. Edmondson et al., 2007) as the factors that substantially impact the way teams operate. These are important factors since team outcome and performance are influenced by the factors in organisational context (Bresman & Zellmer-Bruhn, 2013). As temporary teams are increasingly organised in healthcare sectors, this study was conducted in hospital setting. Therefore, our paper started with the premise that team performance is highly affected by the context, hence, we considered operationalising the variables in the specific context of study. Further, as complexity of the tasks is the main reason to form temporary teams, we kept a close eye on the complexity of the tasks. Our investigation of interaction between boundary blurring and task complexity suggests that complexity has multiple functions when it interacts with boundary blurring drivers. Our analysis suggests that increasing dispersion and complexity positively impact team performance. Further, team overlap negatively impacts team performance, and the impact is more negative when the complexity increases.

5.1. Theoretical implication

Ambiguity in the boundaries has been investigated for years in the team literature, although the lack of cohesive studies on the main drivers of boundary blurring is evident. In response to the call by Mortenson and Haas (2018), the present study explores the interaction between boundary blurring drivers with complexity by arguing that boundary blurring and task complexity cannot be explored individually in temporary teams.

Considering hypothesis 1 and 1a, our results indicated the negative impact of team overlap on team performance. Contributing to the multiple team membership literature, our results are in-line with the fact that team overlap opens up a new source of knowledge for a team, but the nature and complexity of the tasks pose serious challenges to their performance. Concurrently working on multiple overlapping teams is detrimental for team performance since the team members must devote an extensive amount of time, knowledge and energy to all the projects at the same time.

In terms of Hypothesis 2, we argue that fluid teams, by nature, face uncertain dynamics and environment. Although fluidity enables teams with knowledgeable, empowered participants, the underlying work process is disrupted (Huckman & Staats, 2011). Our results contribute to the study by Huckman and Staats (2011), whose data confirms that the negative impact of team fluidity is dominant in temporary teams. However, increasing complexity of tasks can have the potential to reduce the negative effect, because it encourages extensive knowledge sharing environment. Moreover, prior research contributed to the team fluidity concept by operationalising the variable using team familiarity and prior experience. We operationalised the variable considering participants' movements, based on the Jaccard distance index which is fitted with the concept of fluidity. On one hand, the Jaccard distance is a measure of dissimilarity in network analysis, and it can provide more insights for integrating the social network literature with team literature. On the other hand, the measure is very sensitive to small sample size.

In relation to hypotheses 3 and 3a, our results are consistent with prior research on geographically distributed teams. We showed the advantage of team dispersion in temporary teams which is moderated by higher task complexity. Since the main reason to cross the geographical boundary is to achieve better outcomes, a positive impact was expected. It is important to mention that the distribution of the teams in this study is at site level rather than spatial or time zone level that facilitates the advantage of team dispersion.

In addition to expanding previous studies, these results highlight the importance of knowledge intensive work in multidimensional framework while using 3D printing technology. This contributes to the study by Hourd and Williams (2014). When tasks are complex and multidimensional, knowledge integration and intensive work is encouraged. Therefore, team dispersion appears beneficial to team performance rather than detrimental.

Finally, our study brings more precision to the debate on boundary blurring by relying on movements in temporary teams. Furthermore, the paper adds to the theoretical discussion on task complexity in the team context by conceptualising task complexity as technology use.

5.2. Managerial contribution

Fndings of this paper are highly relevant for managers in healthcare organisations. In this context, teams experience a high level of overlap allowing care givers to engage in several teams at the same time. Considering the fact that all clinical cases and tasks in healthcare are complex by nature, our results suggest that healthcare managers should reconsider assigning individuals to more than one team at the same time.

Health practitioners, nowadays, do not simply rely on their own knowledge, rather they use different types of technologies to improve the quality of care giving practices. Such an approach can positively influence healthcare services, yet the complexity of tasks is re-pronounced in the use of new technologies, as participants with different areas of expertise join the teams.

Clarifying the interaction between boundary blurring and technology use can provide more insights into work design in the healthcare setting.

Although we conducted our study in the healthcare sector, our results can provide implications for project managers and team-based settings. As project teams are fluid, and move from one project to another project, their boundaries can change over time. Furthermore, each project can have different levels of complexity in a unique way, demanding different practices and resources. Therefore, our results provide a potential guidance for structuring work around projects.

5.3. Limitations and future directions

Along with the study's implications, it also has several limitations. our study was conducted in one organisation. We suggest developing relevant studies in multiple organisations considering more organisational level variables to investigate if the interaction between team boundary blurring and organisational factors can impact team performance.

Second limitation is the peculiar dimension of performance that we study in this paper; performance in health care is multidimensional and multilevel making performance measurement as a challenging procedure. In this paper, we measured performance using a subjective measure, however, we suggest objective measures of performance for further studies. Moreover, we failed to fully support H2a because of small sample size. We suggest further analysis to test the measure using a large sample size.

Tables

Table 1: Descriptive statistics and pairwise correlations

Variables	Mean	St.dev	Min	Max	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) Team performance	8.31	0.84	4	10	1.000								
(2) Age diversity in surgical team	0.30	0.05	0.16	0.41	-0.144	1.000							
(3) Planning time duration in surgical team (day)	119.43	70.17	60	420	0.051	0.095	1.000						
(4) Recovery time of the patient (day)	11.55	12.96	2	84	-0.241*	-0.255*	-0.219*	1.000					
(5) Patient's age	44.97	18.50	11	88	0.083	0.015	0.114	0.215*	1.000				
(6) Team overlap	3.75	3.85	1	13.75	-0.229*	0.512*	0.319*	-0.354*	0.224*	1.000			
(7) Team fluidity	7.07	5.13	0	18.23	-0.309*	0.225*	-0.020	0.056	0.205*	0.284*	1.000		
(8) Team dispersion	3.34	0.47	2	4.5	0.265*	0.079	-0.254*	0.073	0.144	-0.066	-0.045	1.000	
(9) Task complexity (log)	9.07	0.23	8.72	9.60	0.042	-0.229*	-0.373*	0.605*	0.208*	-0.471*	0.079	0.223*	1.000

*** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table 2: Regression models

Variables	Model (1)	Model (2)	Model (3)	Model (4)	Model (5)	Model (6)	Model (7)
Age diversity in surgical team	-10.379** (3.682)	-4.910 (4.238)	-5.202 (4.263)	-6.422 (4.354)	-3.416 (4.435)	-10.111* (4.909)	-8.768 (5.056)
Planning time duration in surgical team (day)	-0.00016 (0.002)	0.005*** (0.003)	0.006* (0.003)	0.007** (0.003)	0.006* (0.003)	0.006* (0.003)	0.006*** (0.003)
Recovery time of the Patient (day)	-0.027 (0.017)	-0.048** (0.018)	-0.058** (0.021)	-0.063*** (0.021)	-0.059*** (0.021)	0.058** (0.023)	-0.063*** (0.023)
Patient's age	0.017 (0.010)	0.035** (0.013)	0.032** (0.013)	0.030** (0.013)	0.036*** (0.013)	0.034** (0.013)	0.038*** (0.014)
Team overlap		-0.235*** (0.076)	-0.207*** (0.081)	-0.394*** (0.140)	-0.175** (0.084)	-0.185** (0.083)	-0.343* (0.143)
Team fluidity		-0.150*** (0.047)	-0.157*** (0.047)	-0.150*** (0.048)	-0.183*** (0.051)	-0.134*** (0.050)	-0.163*** (0.053)
Team dispersion		1.785*** (0.518)	1.719*** (0.523)	1.721*** (0.524)	1.796*** (0.527)	1.857*** (0.540)	1.648*** (3.46)
Task complexity			1.314 (1.278)	-0.401 (1.616)	1.991 (1.376)	0.643 (1.340)	-0.265 (1.687)
Team overlap X task complexity				-1.007* (0.609)			-1.088** (0.636)
Team Fluidity X task complexity					0.336 (0.237)		0.443* (0.249)
Team dispersion X task complexity						5.434** (2.482)	5.160** (2.485)
Log likelihood	-109.506	-90.184	-89.381	-87.986	-88.467	-86.958	-84.426
χ^2	10.14**	48.78***	50.39***	53.18***	52.22***	55.24***	60.30***
df	4	7	8	9	9	9	11
R-squared	0.0866	0.3436	0.3546	0.3702	0.3634	0.3815	0.4071
ΔR^2		0.25	0.01	0.01	0.01	0.01	0.02
N	107	107	107	107	107	107	107

Notes: * p<.10, ** p<.05, *** p<.01. Regression results are based on ordered logit model by clustering dependent variable in four categories, two categories lower than mean and two categories higher than mean including: Lowest, Low, High, Highest. Standard errors in parentheses. *R*-squared and ΔR^2 were computed in a separate analysis using ordinary least squares regression.

Figures

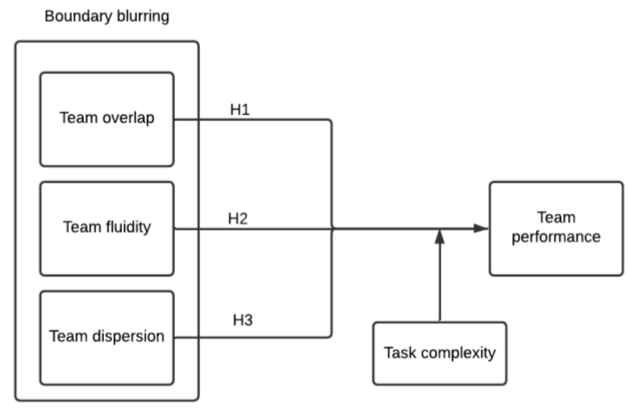


Figure 1: Hypothesized relationships

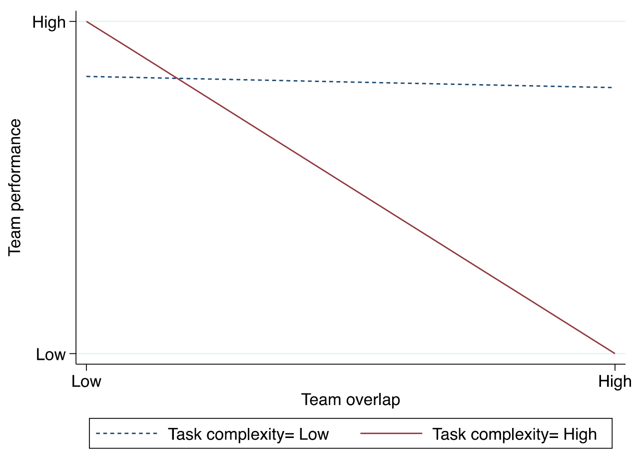


Figure 2: Interaction plot of team overlap with task complexity. Predictive effect of team overlap on different values from low to high, on team performance on the lowest value of task complexity (Low) and highest value of task complexity (High) with 90% CIs.

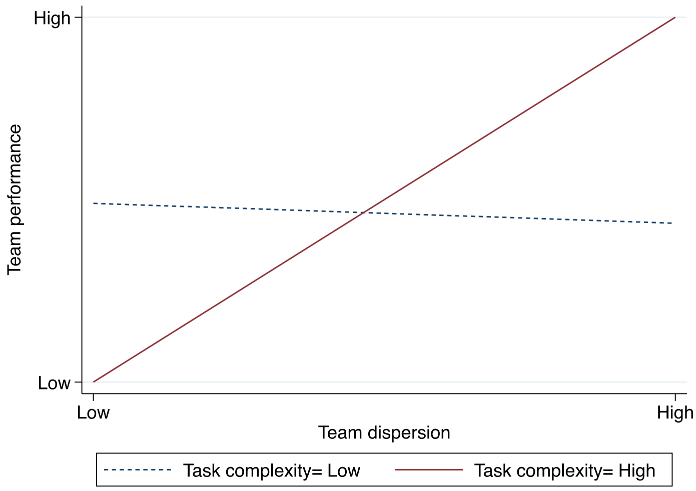
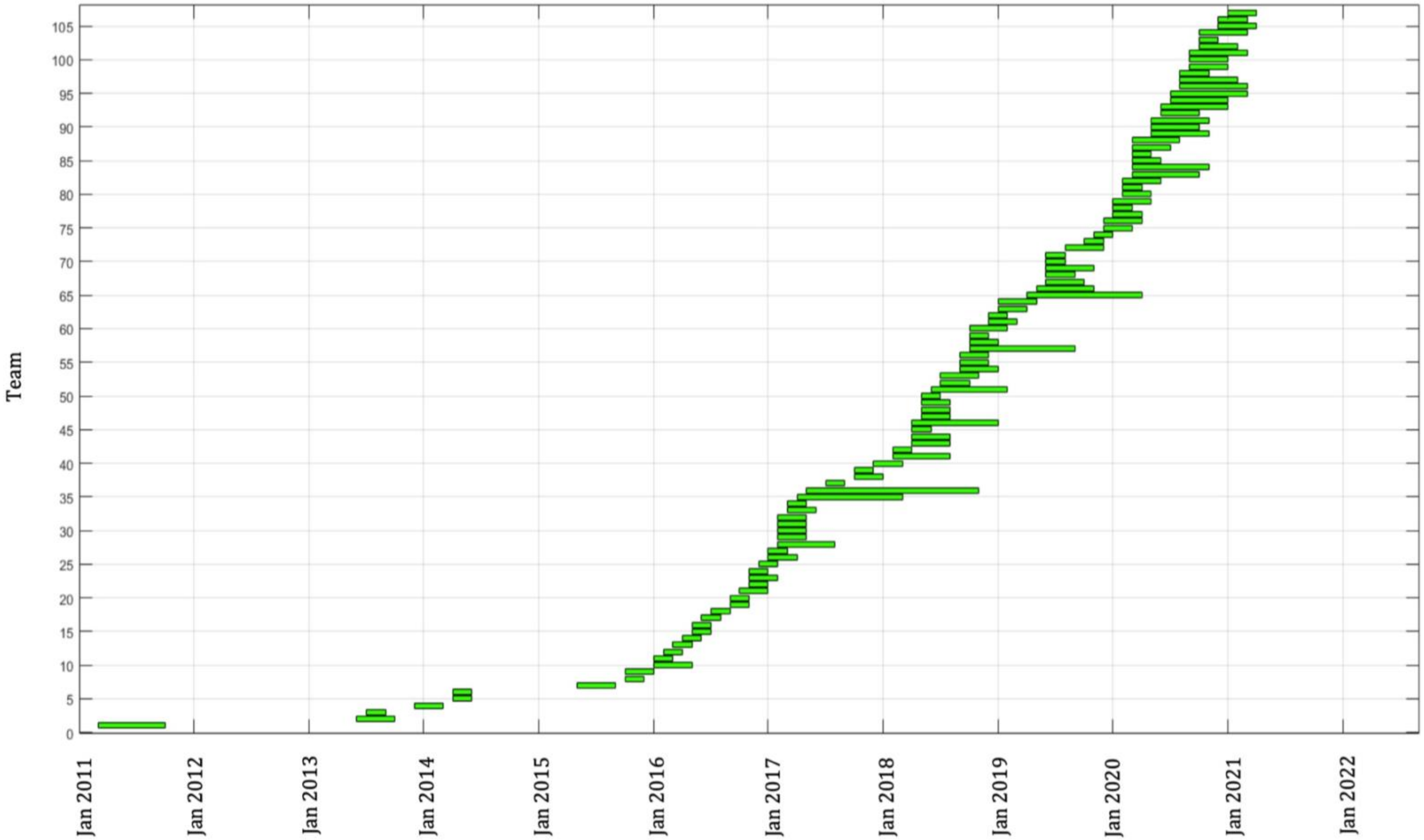


Figure 3: Interaction plot of team dispersion with complexity. Predictive effect of team dispersion on different values from low to high, on team performance on the lowest value of task complexity (Low) and highest value of task complexity (High) with 90% Cls.

Appendix:



Time duration from the starting point to the end point of surgical planning

Figure 1: Team formation and time duration planning for each case

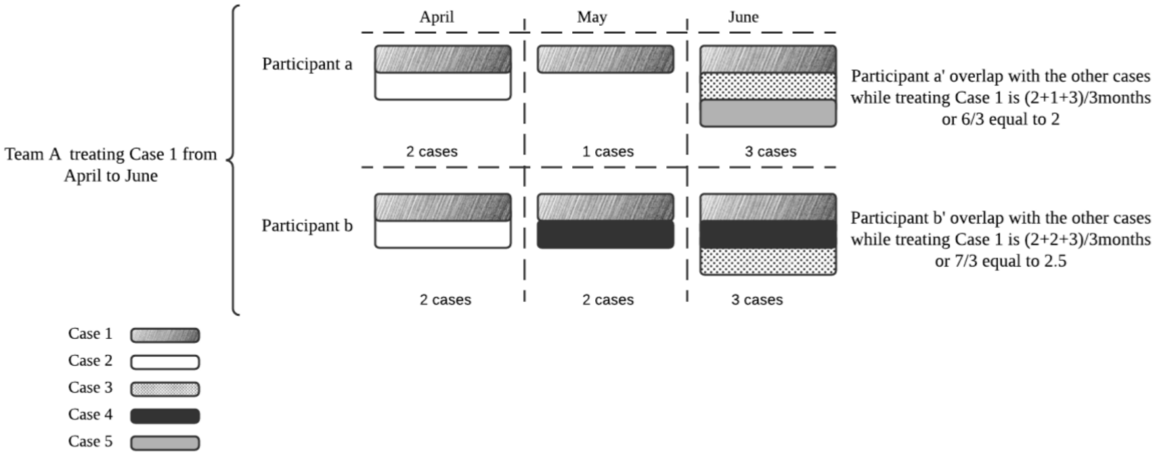


Figure 2: operationalizing team overlap on monthly basis

Table 1: Tobit Regression

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Age diversity in	-3.142**	-0.718	-0.796	-1.151	-0.329	-2.253	-1.938
surgical team	(1.305)	(1.274)	(1.267)	(1.270)	(1.308)	(1.386)	(1.404)
Planning time duration	0.003	0.001*	0.0019**	0.002**	0.001*	0.001*	-0.018***
in surgical team (day)	(0.001)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	(0.0009)	()
Recovery time of	-0.009	-0.014**	-0.017***	-0.018***	-0.017***	-0.017***	0.001**
the patient (day)	(0.006)	(0.005)	(0.006)	(0.006)	(0.006)	(0.006)	(2.00)
Patient's age	0.006	0.010***	0.009**	0.008**	0.010***	0.009**	0.010***
	(0.006)	(0.003)	(0.003)	(0.003)	(0.010)	(0.003)	(2.75)
Team overlap		-0.068***	-0.058**	-0.113***	-0.049**	-0.051**	-0.096**
		(0.021)	(0.022)	(0.040)	(0.023)	(0.022)	(-2.43)
Team fluidity		-0.039***	-0.041***	-0.038***	-0.047***	-0.032**	-0.036***
		(0.012)	(0.012)	(0.012)	(0.013)	(0.013)	(-2.69)
Team dispersion		0.439***	0.416***	0.402***	0.432***	0.455***	0.456***
		(0.136)	(0.136)	(0.135)	(0.136)	(0.134)	(3.44)
Task complexity			0.454	-0.066	0.621	0.265	-0.0545
			(0.380)	(0.490)	(0.399)	(0.379)	(-0.11)
Team overlap X				-0.299*			-0.309*
task complexity				(0.181)			(-1.72)
Team fluidity X					0.0913		0.111
task complexity					(0.070)		(1.61)
Team dispersion X						1.632**	1.502**
task complexity						(0.707)	(2.17)
log likelihood	-121.361	-104.379	-103.671	-102.33	-102.826	-101.037	
χ^2	8.39*	42.35***	43.77***	46.45***	45.46***	49.04***	
df	4	7	8	9	9	9	

Note: * p<.10, ** p<.05, *** p<.01. Standard errors have been reported in parentheses.

Table 2: Linear regression

Variables	(1)	(2)	(3)	(4)	(5)	(6)
Age diversity in	-3.389**	-0.748	-0.822	-1.242	-0.750	-3.043**
surgical teams	(1.410)	(1.428)	(1.429)	(1.437)	(1.494)	(1.520)
Planning time duration	-0.0002	0.0013	0.001	0.001	0.001	0.001
in surgical team (day)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(1.42)
Recovery time of	-0.022***	-0.027***	-0.030***	-0.031***	-0.030***	-0.028***
the patient (day)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)	(0.006)
Patient's age	0.007*	0.0113***	0.0102**	0.009**	0.0103**	0.010**
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)
Team overlap		-0.080***	-0.069***	-0.133***	-0.068**	-0.0568**
		(0.023)	(0.025)	(0.045)	(0.027)	(0.024)
Team fluidity		-0.033**	-0.0363**	-0.0332**	-0.037**	-0.022
		(0.014)	(0.014)	(0.014)	(0.015)	(0.014)
Team dispersion		0.457***	0.434***	0.416***	0.436***	0.489***
		(0.152)	(0.135)	(0.152)	(0.155)	(0.147)
Task complexity			0.472	-0.133	0.497	0.179
			(0.429)	(0.556)	(0.454)	(0.419)
Team overlap X				-0.348*		
task complexity				(0.206)		
Team fluidity X					0.0139	
task complexity					(0.079)	
Team dispersion X						2.503***
task complexity						(0.761)
F statistics	3.71***	7.66***	6.86***	6.53***	6.04***	7.91***
R squared	0.12	0.35	0.35	0.37	0.35	0.42

Note: * p<.10, ** p<.05, *** p<.01. Standard errors have been reported in parentheses.

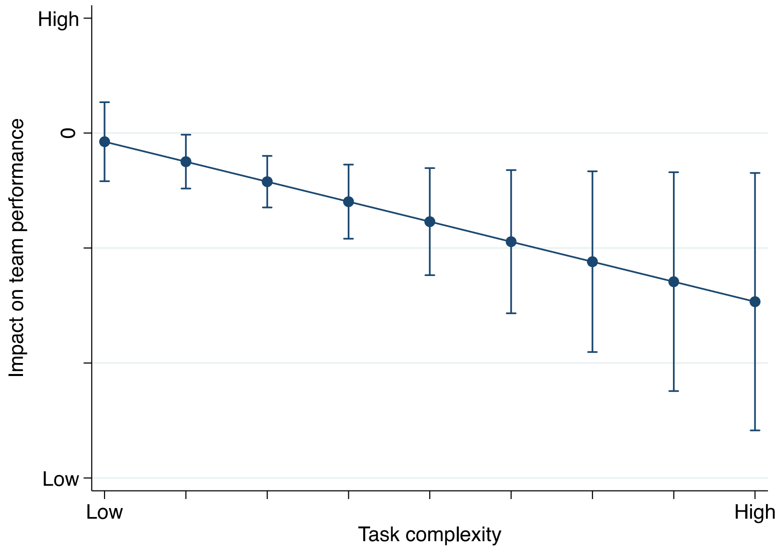


Figure 3: Simple slops indicating average effect of team overlap on team performance on different values of task complexity (with 90% Cls) from the lowest value to highest value. The interaction is negative and significant when task complexity starts increasing.

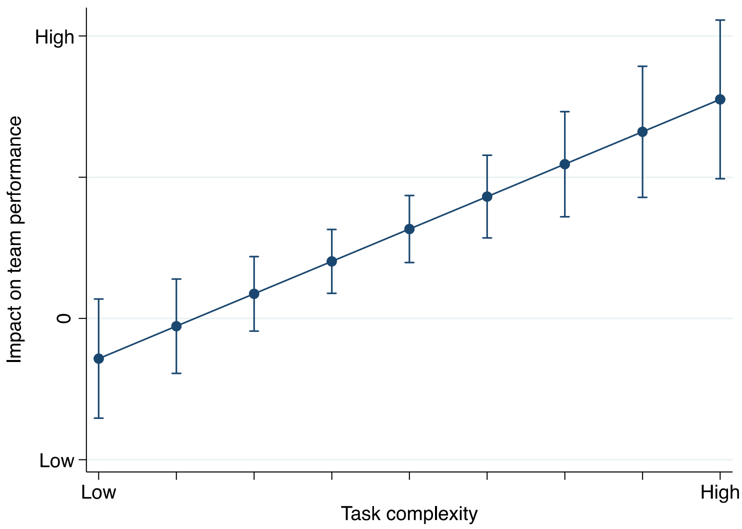


Figure 4: Simple slop plot indicating average effect of team dispersion on team performance on different values of task complexity (with 90% Cls) from the lowest value to highest value. The interaction is positive and significant when task complexity starts increasing.

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Conclusion

This dissertation aims at shedding light on the literature on temporary teams by exploring team interactions and boundaries. Building on the fact that the increasing complexity of tasks and projects is the main reason for organising temporary teams, we investigated team interactions and performance from the lens of task complexity. Thus, we explored temporary teams' literature to identify research gaps. The review of the literature revealed that temporary relationships are the characteristics of temporary teams that hamper knowledge sharing and learning within the teams. Secondly, participants' movements in and off the teams cause blurred boundaries as another characteristic of temporary teams that need to be explored.

We conducted this research in the context of healthcare organisations since the use of temporary teams in healthcare and hospital setting is prevalent. In particular, we focused on orthopaedic teams that provide personalised treatment for patients. Furthermore, the concept of task complexity was built on the use of 3D printing technology since the technology is frequently used in orthopaedic surgery to customise treatments. Qualitative and quantitative data were collected using interviews, observations, questionnaires and archival data at Rizzoli Orthopaedic Institute, Bologna, Italy.

This study provides the following research outputs. The first is a conceptual study that explores temporary teams' literature using bibliometric analysis and systematic literature review to highlight research gaps. The second paper qualitatively studies temporary relationships within the teams by collecting data using group interviews and observations. The results highlighted the role of short-term dyadic relationships as a ground to share and transfer knowledge at the team level. Moreover, hierarchical structure of the teams facilitates knowledge sharing by supporting dyadic relationships within and beyond the team meetings. The third paper investigates impact of blurred boundaries on temporary teams' performance. The idea of boundary blurring has been characterised as fluidity, overlap and dispersion in temporary teams' literature, yet literature provides a puzzling impact of boundary blurring on team performance. Using quantitative data collected through questionnaires and archival data, we concluded that boundary blurring in terms of fluidity, overlap and dispersion differently impacts team performance at high and low levels of task complexity.

While developing this dissertation, we confronted several limitations that provide opportunities for further research. First, our data were collected focusing on a single setting during a short period of time. Future research should observe temporary teams for extended time in multiple settings and make comparisons based on the various timelines and settings. Having multiple settings, we suggest considering more variables at the organisational level, such as organizational size, decision-making strategies, team formation strategies and organisational financial resources. Secondly, 3D printing technology has been adopted in orthopaedic surgery, yet it is not widely used as a standard way of surgical planning. Therefore, the lack of information related to clinical cases is a barrier. We suggest long term studies to capture the economical impact on the technology and to enrich the data. As another future study, we suggest considering more control variables related to team diversity in regression models.

This study was done during the COVID-19 pandemic while Italy experienced a strict lockdown. Hospitals postponed non-emergency surgeries related to orthopaedic problems and went through elective procedures for high-risk patients to reduce staffing and encourage stay at home orders. Moreover, conducting in-person group interviews and observations were core in this study, and we strongly avoided online platforms to increase accuracy of the collected data. Yet, the consequences of the lockdown as a background scenario during the data collection process were inevitable.