Article

A Socio-Analytical Approach to the Integration of Drones into Health Care Systems

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Abstract: The integration of drones into health care as a supplement to existing logistics methods may generate a need for cooperation and involvement across multiple resource areas. It is currently not well understood whether such integrations would merely represent a technical implementation or if they would cause more significant changes to laboratory services. By choosing socio-technical theory as the theoretical lens, this paper intends to harvest knowledge from the literature on various organizational concepts and examine possible synergies between such theories to determine optimal strategies for introducing the use of drones in a health care context. Our particular interest is to examine whether the insights generated from the multi-level perspective (MLP) may have the potential to create dynamic spin-offs related to the organizational transitions associated with the implementation of drones in health services. We built our study on a scoping literature review of topics associated with the MLP and socio-technical studies from differing arenas, supplemented with studies harvested on a broader basis. The scoping review is based on 25 articles that were selected for analysis. As a way of organizing the literature, the niche, regime, and landscape levels of the MLP are translated to the corresponding health care-related terms, i.e., clinic, institution, and health care system. Furthermore, subcategories emerged inductively during the process of analysis. The MLP provides essential knowledge regarding the context for innovation and how the interaction between the different levels can accelerate the diffusion of innovations. Several authors have put both ethical topics and public acceptance into a socio-technological perspective. Although a socio-technical approach is not needed to operate drones, it may help in the long run to invest in a culture that is open to innovation and change.

Keywords: drones; socio-technical theory; scoping review; multi-level perspective; health care

1. Introduction

As health care costs surge and the need for resources seems to exceed any realistic prospect of supplying them, new technological solutions are being pursued to save costs and reduce the need for specialized resources [1–5]. Among the strategies for reducing the cost curve that several health care systems are considering is improved transport and logistics using drones for multiple purposes.

There are multiple reports on drones in health care, ranging from search and rescue following natural disasters, drug and vaccine delivery in rural districts, the provision of care technology in emergency situations and the transportation of blood samples and organs have been studied [6–15]. Transport of biological samples across laboratories and institutions and of blood samples from remote locations to central laboratories has gained special interest [6,16,17] and promises faster and improved laboratory services by providing service to rural districts and enabling savings.

Drones may be a complete substitute for ground transport in areas where roads are non-existent for large parts of the year. Alternatively, drones may also be relevant as supplements to existing logistics methods, where they can be integrated into existing ground transport systems as an extension to provide last-mile or on-demand services to

meet time-critical demands [18–21]. Such integrations may generate a need for cooperation and involvement across multiple resource areas, i.e., across medical, logistical, and transport workforces. How such processes should best be developed and implemented has not yet been studied extensively.

Another interesting topic is whether drones can be implemented in ways that have a broad impact on service and organization models. Creating support for the more substantial transformation of multiple services far beyond logistics offers a space to create sustainable service concepts and ideas with a broad perspective. There is increasing interest in how such extended integrations of drones in health care will interact with the social context of the human ecosystem of stakeholders and executing workforces [22,23].

Whether the implementation of drone transport will transform the laboratory services and logistics operations and health services [24], or if it is merely a technical implementation [25], is currently an unanswered question. However, implementing drones to create sustainability transitions in an extended perspective is a fascinating prospect that may require facilitating interactions between the realms of policy, economics, markets, culture, technology, and possibly public opinion.

Multiple theoretical models have been suggested for approaching such challenges, illustrating the multidimensional nature of sustainability transitions combined with the different aspects of structural change. Transitions for sustainability are goal-oriented with a specific purpose, and combinations of many "sustainable" solutions do not always offer obvious user benefits, as sustainability is a collective benefit. Challenges can present themselves during the process of both cultural and structural change: the existing, unsustainable systems may be fixed in place by various lock-in mechanisms related to the existing infrastructure, current competencies, and benefits for stakeholders, employees, and users, thus creating a dependence trajectory that makes it difficult to replace existing systems. Along with this broader definition of the problem comes a need for broader analytical perspectives [26].

Multiple models have been proposed as approaches to replacing and reconfiguring technological systems. For example, Hekkert et al. [27] described a technological innovation system approach from a multidimensional perspective but did not address structural change. The disruptive innovation approach of Christensen et al. [28] and the technological discontinuity model of Anderson and Tushman [29] are also helpful approaches but are mainly focused on the technology and market dimensions.

In contrast, Geels [30,31] and Geels and Schot [32] processed and refined the multi-level perspective (MLP) framework to explain how changes take place in socio-technical systems. As a follow-up related to drones, Haula et al. [33] suggested that "Interpreting drones through the lens of socio-technical theory, drones cannot be a standalone technological infrastructure but require an ecosystem to function optimally; humans to develop and manage them; regulations to protect the drones as well as people's freedoms from infringement; and perform the necessary responsibilities they were built for". This is an interesting hypothesis, although not further justified in their study. In addition, some of the previous statements on these topics may need modifications, for example, because future drones will mainly be autonomous, operated by remote systems with little need for personal attendance.

In our current context, we assume that drones are first implemented at the level of operational units (clinical units performing medical services, laboratory analysis, transport logistics) before generating innovations in a broader perspective at the institutional and health care system levels. The extent to which such use cases will require comprehensive organizational processes for implementation has not been extensively explored or understood. However, in designing the managerial policies related to drone implementations, it may be useful to profit from and build upon the experience of transformative policies in other areas of technology and innovation because drone solutions will combine several technological knowledge areas, such as software and hardware engineering, artificial intelligence, machine learning, internet of things (IoT) and logistical competence [34–36].

Based on a system design approach, we use the MLP [37] because it goes beyond studies of single technologies to focus on the various groups of stakeholders and their strategies, resources, beliefs, and interactions. We apply the MLP's micro (also called niche), meso (regime), and macro (landscape) perspectives and translate them into the health care context, where they parallel the levels of the clinic, hospital institutions, and health care systems in general (Figure 1).
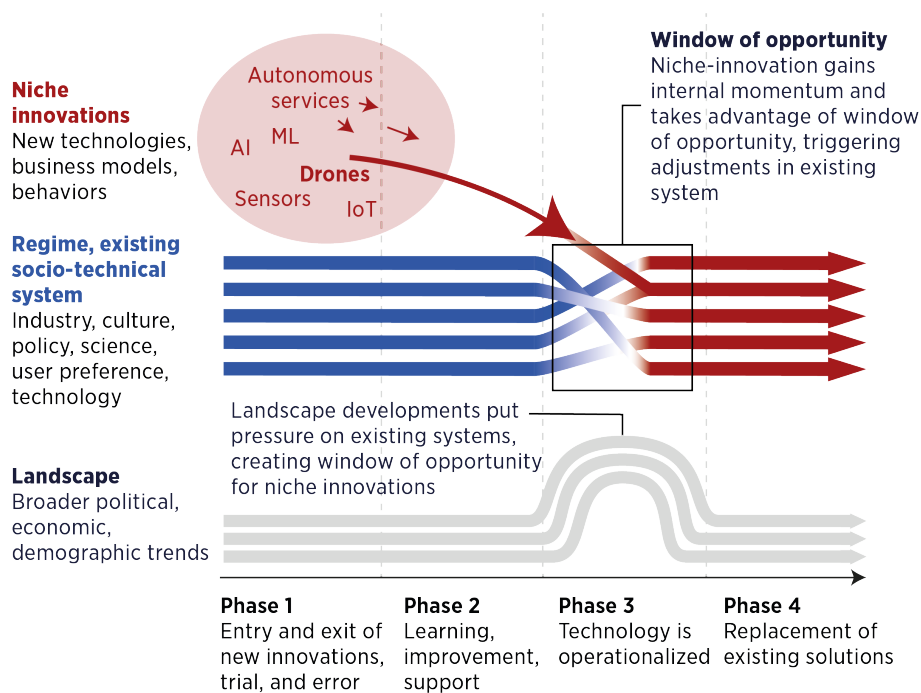

Figure 1. The multi-level perspective on system innovations (adapted from Geels [38]).

In this study, we examine whether the principles of the MLP regarding system innovations as merging transitions from one socio-technical system to another may offer a framework that can be helpful for understanding system innovations related to drones in health care [33,39–42]. By combining the three MLP, i.e., dimensions speed of change, size of change, and period of change [43] and the four MLP phases [42,43], i.e., introduction of technology within the existing environment, exploration of functionalities and user preferences, putting change into practice in daily operations, and gradual replacement of existing solutions, we examine the current knowledge regarding the implementation of drones in health care [42]. As we assume drones to be implemented in a "bottom-up" process, we use the levels in the MLP to sort out the various stages of the implementation of drones in health care systems.

Emerging technologies are usually influenced by the existing institutional solutions (in our context, hospitals), which operate in a stable configuration until a new technology emerges and creates an interplay of multiple technologies [37]. Compliance with legacy systems, as well as ethical standards and standards of clinical and laboratory processes, are crucial in such processes [44].

We believe that drones may be used efficiently for a multitude of purposes in health services, and we intend to harvest knowledge from the literature on various organizational concepts and examine possible synergies between such theories. We built our study on a scoping literature review of topics associated with the MLP and socio-technical studies from differing arenas, supplemented with studies collected on a broader basis. Our particular interest is to examine the potential to create dynamic spin-offs related to the organizational transitions associated with the implementation of drones in health services. The study is based on the following research question:

What knowledge of socio-technical theories may support an extended focus associated with implementing drones into health care systems?

The article proceeds as follows: in the next section, we introduce our scoping review method. In Section 3, we present the results and identify the categories of our research focus. Next, we use the clinic (niche), institution (regime), and health care system (landscape) levels to organize the literature, using a procedure related to the MLP inspired by Prayag and Ozanne [45]. In Section 4, we discuss our findings. Finally, in Section 5, we offer our conclusions.

2. Materials and Methods

Scoping reviews can be used to provide an overview of a given topic [46]. Furthermore, in comparison, for example, with systematic reviews, the review question can have a broader "scope" which is in accordance with the research aim of this study. This scoping review follows the approach set out by Arksey and O'Malley [47]. The framework consists of five stages: (1) identifying research questions and search terms, (2) identifying relevant studies, (3) selecting studies, (4) charting and analyzing data, and (5) collecting, summarizing, and reporting results.

2.1. Research Question and Search Terms

Based on the question "What knowledge of socio-technical theories may support an extended focus associated with implementing drones into health care systems?" we created three search concepts: "Drones, UAV, UAS", "Health care, Health Systems, System Integration", and "Transportation, Logistics, Innovation".

These terms were included in the search strategy because they define the context. Furthermore, "system integration" was included to cover integration from technical, organizational, and social perspectives. The search strategy aimed to identify the relevant literature concerning:

- The integration of drones into existing systems;
- Potential drivers of and barriers to the integration of drones;
- Prerequisites for the integration of drones.

2.2. Identifying the Relevant Literature

The literature search was conducted in March 2021 using the PubMed and Scopus databases and then supplemented with an additional snowball strategy to retrieve other relevant articles. Three strings were created with the operator OR and a combined search with the operator AND for the structured search. The list below displays the search strategy:

1. Drones OR Unmanned Aerial Vehicles OR Unmanned Aerial System;
2. Healthcare OR Health Systems OR Systems Integration;
3. Transportation OR Logistics OR Innovations;
4. 1 AND 2 AND 3.

2.3. Exclusion Criteria for Literature

Based on our primary interest in the use of drones to support laboratory services with a potential to extend such solutions in a broad perspective, articles that described the use of drones to capture images or video footage, their use in humanitarian response, or that focused on algorithms, physical drone parts, energy consumption, or carbon emissions were excluded.

2.4. Analysis and Charting of the Data

The technical process of analyzing the textual content was conducted using coding [48]. The content analysis software Atlas.ti (Version 9.1.3) was used as a tool to organize the data digitally. A first coding scheme was jointly developed by the authors and gradually adapted to the different categories. An inductive process allowed the codes to emerge

naturally from the data [49]. Mayring [50] described this category development process as qualitative content analysis, in which categories emerge over incremental revisions and reductions of the categories while working through the text.

3. Results

The search of PubMed with the first, second, and third strings yielded 2101, 1,493,810, and 3,624,067 results, respectively. The combined concept search yielded 51 results from the years 2014 to 2021. After applying the exclusion criteria, a final sample of 29 articles was derived.

The search in Scopus with the three strings yielded 68,376, 504,787, and 1,418,049 results. The combined query yielded 67 search results from the years 2012 to 2021. After applying the exclusion criteria, a final sample of 49 articles was derived.

During the full-text review of the database results, 19 additional articles were identified for inclusion using a snowball strategy.

A total of 97 articles were included for full-text review. First, we scanned the text to identify articles that included the keywords "innovation", "socio", "culture", "leadership", and/or "integration". This approach resulted in a sample of 30 articles.

Second, the three MLP levels were chosen to organize the articles. The two authors categorized the papers blinded to each other and finalized the results by consensus when initial disagreement occurred (five papers). The remaining 25 articles are the subject of this results section.

Figure 2 below provides a detailed outline of the document inclusion process from the scoping review.

The earliest article was from 2016, but 16 of the articles were published between 2019 and 2021 (64%).

Table 1 below presents the author keywords from the review sample. The analysis of the 92 keywords shows that 22% of the articles used "drone", "drones", "UAV", "UAS", "drone integration", "drone communication" or "drone design". In addition, 16% used terms referring to technology, 10% to health care, and 8% to logistics and transportation. The remaining 43% of keywords used were only used once. No specific keyword regarding socio-technical systems was identified.

Table 1. Keyword analysis.

Count	Percent	Keyword
20	22%	Drones (including UAV, UAS, integration, communication, design)
16	17%	Technology (including AI, IoT, Machine Learning, Blockchain, 5G, automation, innovation, and disruption)
9	10%	Healthcare (including laboratory, microbiology, health systems, and services)
7	8%	Logistics (including transport, delivery, and supply chains)
40	43%	40 unique keywords: open science; biobanking; iTRANS; bystander CPR RPAS; Canada; prehospital care; throughput; cell phone data; intelligent transportation systems (ITS) platform; learning health care system; community engagement; mobile microbiology; consolidation; policy; Danish public healthcare; remote medicine; surveillance; disasters; battlefield medicine; emergencies; massive open online education; emerging infectious diseases; medium access control; EMS dispatcher; noncommunicable diseases; energy efficiency; out-of-hospital cardiac arrest public access defibrillation AED; epilepsy; portable instruments; ethical framework; public access defibrillation; global health precision medicine; health applications; sudden cardiac arrest; telemedicine; automatic external defibrillation; United States; value-sensitive design (VSD); user experience; values hierarchy
92	100%	

Starting with the three MLP levels, ten subcategories emerged from the analysis. Table 2 displays a list of the articles included in this study, together with the corresponding MLP levels and subcategories.
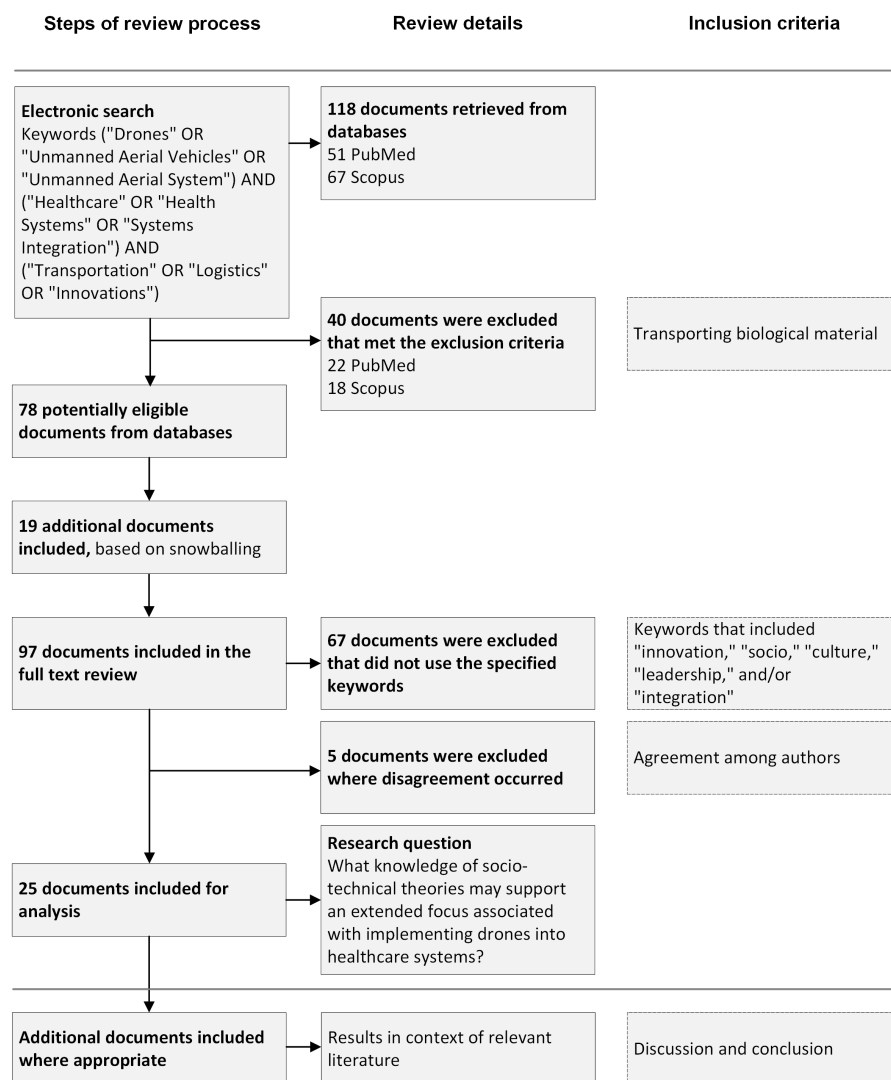
Steps of review process　　　**Review details**　　　**Inclusion criteria**

Electronic search
Keywords ("Drones" OR "Unmanned Aerial Vehicles" OR "Unmanned Aerial System") AND ("Healthcare" OR "Health Systems" OR "Systems Integration") AND ("Transportation" OR "Logistics" OR "Innovations")

118 documents retrieved from databases
51 PubMed
67 Scopus

40 documents were excluded that met the exclusion criteria
22 PubMed
18 Scopus

Transporting biological material

78 potentially eligible documents from databases

19 additional documents included, based on snowballing

97 documents included in the full text review

67 documents were excluded that did not use the specified keywords

Keywords that included "innovation," "socio," "culture," "leadership," and/or "integration"

5 documents were excluded where disagreement occurred

Agreement among authors

Research question
What knowledge of socio-technical theories may support an extended focus associated with implementing drones into healthcare systems?

25 documents included for analysis

Additional documents included where appropriate

Results in context of relevant literature

Discussion and conclusion

Figure 2. Document inclusion and exclusion process.

Table 2. Included articles.

Dimension	Category	Author
Clinic	Digitalization	Ferreras [51]; Gruson [24]; Vandenberg et al. [52]
	Integration of different technologies and services	Eichleay et al. [25]; Mishra et al. [53]; Ferreras [51]; Khisa et al. [54]; Syed et al. [55]
	Public Acceptance	Mion [56]; Zegre-Hemsey et al. [57]; Poljak et al. [58] Van de Voorde et al. [59]; Shawn et al. [60]
	Regulation/Legislation	Balasingam [61]; Braun et al. [62]; Nentwich et al. [63]
Institution	Integration challenges	Vandenberg et al. [52]; Flahault et al. [64]
	Facilitating innovation processes	Bhavnani et al. [65]; Mishra et al. [53]; Cawthorne et al. [66]; Mion [56]; Johannessen et al. [44]
	Collaboration	Ferreras [51]; Braun et al. [62]; Hiebert et al. [19]; Mion [56]; Truog et al. [67]

Table 2. *Cont.*

Dimension	Category	Author
Health care	Adoption	Mion [56]; Hiebert et al. [19]; Johannessen et al. [44]
	Diffusion/Acceleration	Flahault et al. [64]; Mateen et al. [68]; Mion [56]
	Change and transitions in relation to ethics	Faramondi et al. [69]; Cawthorne et al. [66]; Eichleay et al. [25]; Carrillo-Larco et al. [70]; Mishra et al. [53]; Greaves et al. [71]

3.1. Additional Documents

During our analysis of the documents and development of the discussion, we supplemented our literature review with further publications where appropriate, following a deductive identification of relevant articles. We included five additional recently published review articles [72–76], one essay [77], two online sources [78,79], and five research articles [80–84].

In addition, we identified eight MLP articles of relevance and included them in our discussion [26,30,40,85–89].

Even though the main arguments supporting the use of drones are their promise in terms of cost reductions, their ability to avoid ground traffic congestion, and their ability to maintain services in areas with poor transportation infrastructure and in hard-to-reach areas, only the review article by Hiebert et al. [19], among the articles identified in the scoping review, discussed these topics. We therefore specifically searched for papers dealing with costs and rural services to see if studies discussing perspectives related to our study subject were available and included four more articles [18,90–92] in addition to the study by Hiebert et al.

3.2. Descriptions of Findings

The descriptions of our literature findings are categorized according to whether they are concerned with the clinical, institutional, or health care system levels.

The Clinical Level (Niche)

The important topics discussed in these articles include digitalization as a driver of technological developments in general, the integration of drones related to their acceptance in public space and the role of regulation and legislation as enablers of future drone services.

3.3. Digitalization

Ferreras [51] discussed whether disruptive innovations involving robot vehicles supported by telecommunications or computers may be conducive to more efficient transportation and logistics solutions. From his perspective, drones represent an additional and new element in developing autonomous or semiautonomous vehicles, and there is substantial potential in their independence from heavy ground traffic and congestion.

Gruson [24] and Vandenberg et al. [52] discussed the digitalization and automation of laboratories. They provided an interesting perspective on the impact of technologies on laboratories. Gruson pointed out that integrating big data and real-time management, automation, blockchain, the internet of things (IoT), and the enhancement of the user experience are critical drivers for achieving "smart digital laboratories". Similar factors may also be relevant to perspectives related to drone solutions. As with Gruson, Vandenberg et al. supported the conclusion that new IT platforms that support integrated datasets across primary and secondary care and measures of outcomes and costs across patient pathways are needed.

3.4. Integration of Different Technologies and Services

Eichleay et al. [25] focused on the implementation of drones in either parallel or integrated setups into existing structures and systems. They pointed out the dilemma that

integration into existing structures may take too much time, whereas devising parallel technological systems may fracture health systems and cause informational and operational silos that may result in future inefficiencies. Furthermore, they also concluded that more information on what processes must be changed and how they impact workflows and health outcomes may contribute to the evaluation of sustainability and the actual cost of implementation.

Mishra et al. [53] considered various perspectives on integration synergies between 5G cellular systems and UAV technology. Their survey hypothesized that 5G technologies would enable seamless integration and UAV communication over mobile networks. Furthermore, B5G (so-called "6G") innovations may further enhance the performance and applicability for seamless integration of UAVs into mobile networks.

Ferreras suggested that the full potential of UAVs may be achieved with a combination of several technologies that need to be developed. For example, receiving constant location data provided by autonomous vehicles or autonomous drones in combination with powerful 3D computer visualizations could be used to build future computer interfaces for optimized transportation. In this transition, computer systems would move away from being human control-oriented toward being automated, and self-deciding systems [51].

The integration of UAVs with IoT networks was described as a new direction for research and industry by Khisa et al. [54]. IoT enables things to be connected anywhere, anytime, using any network, thus enabling almost any service. One of the most promising technologies for handling security-related issues in communication is the integration of blockchain with UAV-based IoT. Several studies have been carried out regarding the integration of machine learning mechanisms with IoT and UAV.

The versatility of drones and the potential to support different efficient solutions for smart transport applications were highlighted in the survey by Syed et al. [55]. For example, machine learning (ML) techniques, blockchain, or watermarking may alleviate security concerns regarding drones.

3.5. Public Acceptance

Mion [56] raised an essential question about public acceptance, pointing out that the general acceptance of new technological instruments is usually higher in the health care sector than in other domains, e.g., the application of drones in emergency situations such as the delivery of automated external defibrillators. The fact that drones may save minutes, which can save a life in critical clinical situations (Zegre-Hemsey et al. [57]), is observed as having high value for society and individuals, thus facilitating acceptance.

Based on case studies in Papua New Guinea, Asia, and Africa, a review by Poljak et al. [58] found that drones were generally well accepted. However, they concluded that more research may be needed to understand public acceptance in highly populated environments and high-density traffic airspaces. For example, Zegre-Hemsey et al. [57] suggested that as innovations in drone technology are entering emergency cardiac care [7,93], it may be necessary to explore ways to integrate drones into these environments.

The effect of the combination of purposes and actors involved on public acceptance was also discussed by Van de Voorde et al. [59]. Their article discussed how when police forces use drones for surveillance, regulations for safe and responsible handling of the drones and of the data they provide should not fall outside standard regulations. Relating this example to the transport of biological material, drones in this health care setting may have a higher chance of being accepted. However, at the same time, the proper and secure handling of patient-related data must be guaranteed.

The impact of increasingly demanding patients who expect the same level of innovation, service, and quality from health service providers that they see in other service sectors, such as online shopping, travel, and media, was discussed by Shawn et al. [60]. Consumers profit from being able to choose how their care offering is provided and can pick between different delivery models, including home health, concierge care, and online self-help. These new channels offer consumers qualities they look for from other service providers,

such as convenience, thoughtfulness, timeliness, value, and price transparency [94]. Such qualities may contribute to the acceptance of drone services.

Public acceptance and social benefit may act as enablers for policymaking regarding drones [59]. It may, therefore, be essential to understand public acceptance when new environments are being explored.

3.6. Regulation/Legislation

Several authors have discussed the challenge of national legislation. Balasingam [61] argued that the lack of timely legislation often forces organizations to apply for exemptions, hampering the progress of technological innovation. According to Braun et al. [62], the pace of drone design innovation generated by new applications places considerable demands on governmental and local regulatory agencies, which are not always able to keep up with the pace of innovation [95].

Such regulatory lags due to slow adaptation to new technological options were also discussed by Nentwich et al. [63]. The consequences related to new technologies and rapid developments such as drones are that barriers to innovation are created, i.e., autonomous drones could not previously be licensed under existing regulations. As a remedy for this discrepancy in regulatory speed, Balasingam suggested that the stakeholders involved in the medical and drone industries, insurance companies, legislative authorities, and government bodies should work together and develop prompt legislative solutions to integrate drones seamlessly into our communities [61].

It is interesting that although they were published only a few years ago, the findings of several of these papers have fortunately become outdated because proper regulations are being put in place in both the US and the EU [78,79].

The Institutional Level (Regime)

Integrating existing services and collaborations between various stakeholders at the institutional level may be essential to analyze and understand how long-term improvements and value creation should be achieved.

3.7. Integration Challenges

A perspective discussed by Vandenberg et al. [52] is how the introduction of laboratory automation and the linkage of information systems for big(ger) data management, including artificial intelligence (AI), may also strengthen drone implementations. However, they pointed out that the initial optimism associated with these developments has entered a more reality-based phase of reflection on the significant challenges, complexities, and health care benefits posed by these innovations.

Parallels between the integration of different technology systems in general and the implementation of drones were pictured by Flahault et al. [64]. They described the impact of a future health system that connects personal, provider, and population-level health information. This would provide feedback loops on many levels, thus creating computer-supported mechanisms for learning and improving the quality of the overall health system. They describe drones as an exciting example of possible interactions and cooperation between technological sectors both within and outside the health system.

In their scenario, most of the building blocks for learning health care systems exist but are insufficiently connected because of many weak links:

- Integration requires unprecedented levels of interoperability * and standardization;
- Implementation faces many technical and organizational challenges and raises unsolved ethical, legal, and societal issues;
- Impact on health outcomes is difficult to measure and has been poorly addressed so far.

* Interoperability is concerned with the ability of different systems, devices, applications, or products to connect and communicate in a coordinated way without any effort

from the end-user. Functions related to interoperability include data access, data transmission, and cross-organizational collaboration, regardless of developer or origin [54].

3.8. Facilitating Innovation Processes

Facilitating innovation processes may require leaders who know how to combine internal innovations with the capture of new ideas from outside their organizational boundaries. For example, Bhavnani et al. [65] argued that open-access and big data analytics are often developed outside of conventional medical and clinical arenas. To access this knowledge, fundamental changes to clinical teams' internal structures and composition may be necessary. For example, successful research teams should perhaps include clinicians and team members with expertise in big data analytics, bioinformatics, technology, engineering, health care administration, business and entrepreneurship, and health care policy. A cross-cultural, cross-competence process must, therefore, be developed.

Arenas for innovation may give the drone industry and others the potential to learn from each other, as a survey by Mishra et al. [53] suggested from a drone industry perspective. Their survey concluded that manufacturers in the drone industry are not exploring emerging technologies such as IoT, AI, and AR/VR sufficiently. Consequently, they do not fully appreciate which use cases would be interesting to roll out. Mishra et al. hypothesized that the skills needed for the drone industry will include sufficient domain training for equipment providers and technical users because it is necessary to extract users' specifications and requirements to maximize the benefits of the various use cases and generate drone applications.

The extent to which users are enabled to present their needs, specifications, and requirements in early innovation phases is another issue. Cawthorne et al. [66] proposed an ethically based design of drone prototypes to examine the public acceptance of health-related drones. Mion emphasized that organizations that intend to use drones for transport must be open to change and prepared to modify their operations [56].

Johannessen et al. [44] concluded that it would require extensive research to understand how best to engage clinical and laboratory leaders and managers in actively facilitating long-term improvement processes to optimize drone transport solutions. They highlighted the relevance of well-known specialized methods that focus on looking for waste in production processes to improve workflows and create more value with less effort: the LEAN method (originating from the Toyota car manufacturing system) and Six Sigma (originating from Motorola). Although the experience of implementing such organizational processes varies from successful improvements to processes to cases in which implementing LEAN in clinical cultures has sparked challenges that are more demanding than would have been the case with the implementation of the typical methods used in the industry, the generic concepts from the domain of industrial improvement techniques should be considered [96–104].

3.9. Collaborations

The recognition that successful integrations of technology generally require collaboration between professions that need to work together may also apply to drones, as suggested by several researchers [19,51,62,67]. They all recommended that authorities, leaders, and community representatives should be involved in this perspective and pointed out the importance of engaging a broad range of users to promote the development of health-related drone applications.

A review by Hiebert et al. [19] discussed how a range of health and digital proficiencies may support sustainable integration into health care services. Community engagement should include a broad spectrum of activities throughout the design, testing, development, integration, and evaluation stages of new technology program development. This was also supported by a report from a drone project transporting blood and pathology samples between two hospitals in Switzerland [56]; in addition to the public acceptance, regulatory

framework, and risk management dimensions, it was concluded that involving the top managerial level is of crucial significance.

The Health Care System Level (Landscape)

On the overall health care level, important topics may include the adoption of technology, the broad diffusion and coordination of innovations, and acknowledgment of the characteristics of change and transition processes in such complex sectors that are subject to regulations, ethical standards, and responsibilities that are far beyond the traditional industrial perspectives.

3.10. Adoption

Regarding health care's implementation of technology in general, Mion [56] suggested that effective implication of new technologies requires careful consideration of whether the solutions improve patients' overall quality of care. They considered both the policy and operational frameworks to be highly significant for adopting new technologies and avoiding obstruction. Furthermore, public acceptance and other sociocultural factors may affect the adoption of most technological innovations.

In their review paper, Hiebert et al. [19] suggested that there may be significant negative implications for the development of health care drone applications if they are driven only by those engaged in computer and software engineering, computer science, and aviation without significant input from health care researchers or professionals. They suggested that representation from the various technical disciplines should be orchestrated in close alliances with nursing, public health, medicine, paramedicine, aviation, kinesiology, and pathology.

A perspective that conceptualizes the interplay within the technology-organizational-environment framework (TOE framework) was depicted by Tornatzky et al. [105]. They described the innovation process as either "developing" or "using", indicating that the innovation generation and adoption processes differ considerably. In some cultures, there may be an ambition to extend new technologies to a broader innovative culture. In contrast, other cultures appear to implement new technologies mainly by fitting them to existing solutions. Therefore, the TOE framework may offer factors affecting the adoption of technologies to improve health care logistics processes when applied in a health care logistics setting. The TOE dimension related to drone implementation was discussed in the context of a logistic drone model by Johannessen et al. [44].

3.11. Diffusion/Acceleration

The MLP argues that a wider diffusion of niche innovations may only be achieved when linked to the ongoing regime and landscape processes [88]. This was the focus of a paper by Flahault et al. [64] regarding precision medicine. They discussed how better targeting of public health interventions, even on a global scale, through innovation and technology should be targeted to maximize the effectiveness and relevance of multiple topics such as the use of remote sensing data to fight vector-borne diseases; the use of large databases of genomic sequences of foodborne pathogens to identify origins of outbreaks; the use of social networks and internet search engines to track communicable diseases; the use of cell phone data in humanitarian actions; and the use of drones to deliver health care services in remote and excluded areas. Moreover, they illustrated how technological solutions may often be spin-offs of inventions initiated from specific targets, showing the value of the expansion from the niche to the landscape level.

A paper by Mateen et al. [68] suggested that education and appropriate training of personnel, instructions to ensure proper maintenance, monitoring in-flight performance, and awareness campaigns are critical factors to consider ensuring that the full potential of drone delivery systems is reached.

This is also in line with an article by Mion [56] that described vital factors from the experience of integrating drones in Switzerland. They focused on the value of integrating

such new technologies with organizations' business models, making it the ordinary way of working in the future. However, the impact of drones in the Swiss case had only a limited impact on organizational routines.

Several studies mentioned above may not have considered that future drone solutions will be unmanned autonomous vehicles. This indeed implicates the complex integration of different technology systems, but whether extensive personnel training is needed may be less obvious. The extent to which personnel resources are needed in future extensive drone traffic remains to be studied, and this may influence whether drones as a service will represent a transportation solution that must be delivered as a complete service where the provider operates all parts.

3.12. Change and Transitions in Relation to Ethics

We have hypothesized that a socio-technical approach may be helpful in the process of implementation of technology, as it highlights the importance of using technological transformation as an opportunity to improve processes by combining organizational and technological needs.

Multiple learning points from technological implementations have been described by Faramondi et al. [69] in their discussion of the interplay between different cultures and professional competencies. They argued that the digital transformation of companies is only deemed innovative and useful for creating novel business opportunities and improving efficiency if the company also improves its financial and innovative performance in general, thus illustrating the value of extended implementations of specific solutions.

In laboratory services, methodological concepts, such as sample collection decision support systems, innovations for automated robotic phlebotomy, novel sampling technologies such as fully traceable automated blood tube dispensers, and algorithms that detect sample collection errors, have been proposed to enhance patients' quality of care and the efficiency of the health care system. Whether such solutions result in an improvement of the quality of specimens and minimization of harm is still to be documented [71,80–82].

Although one of the key strategies of the MLP is to stimulate learning processes, it does not explain how to facilitate these processes. Faramondi et al. [69] and Cawthorne et al. [66] proposed different frameworks. Faramondi suggested using a "value proposition canvas" (VPC), a concept initially developed by Osterwalder et al. [106], as a part of a business model canvas. VPC is conceptualized as a framework to ensure that there is a fit between a product and its customers. The VPC is used to highlight the beneficiaries (usually multiple) of a new product/service and the gains and pains provided by the new product/service to each beneficiary or others in general concerning alternative products (if any). By adopting this canvas model, the authors intended to assess the value of a proposed system to multiple beneficiaries, distinguishing between the economic, environmental, and social aspects of the system and their respective implications. Faramondi et al. provided two illustrative examples in the form of a scenario with and without drones where the drone scenario was analyzed using the VPC and summarized in a SWOT analysis.

Cawthorne et al. [66] suggested using an ethical framework for the emerging domain of drones in health care. They assumed that, ideally, drones will be beneficial (in terms of costs, health, jobs, and environmental sustainability), do no harm (in terms of safety and security, privacy, and jobs), enhance human autonomy (trust), be just (fairly distribute benefits and risks), and be easily understandable (explicable). Based on their framework, they proposed that drones conducting transports of biological material should be identifiable in parallel to ambulances and emergency services; for example, they could be marked with a red cross, indicating that they belong to the health services.

The suggestions by Faramondi et al. and Cawthorne et al. to look beyond technology are interesting because both authors propose approaches to learn from stakeholders. The approach by Faramondi et al. presents two well-known tools that can be used to map dimensions and learn from different stakeholders. The design suggested by Cawthorne et al. may be used to build a prototype that can be used to learn about the public acceptance of

health-related drones. However, neither suggestion is based on a starting point of a deeper understanding of user and institutional needs.

A potential gap in the understanding of how drones can be integrated into the health system and how long-term sustainability should be achieved was discussed by Eichleay et al. [25]. They suggested five general steps of value in this respect: drones will need to operate within regulations, stakeholders must embrace the drone concept, financial resources need to be available, human resources must be in place, and operational procedures must be developed to work effectively within existing structures.

These steps, although based on interviews in Kenya—and thus possibly reflecting perspectives different from those of systems elsewhere—seem obvious for any system, although their argument that starting conversations about potential UAV integration and interoperability of systems in early phases is key to efficient system design and may have varying degrees of relevance in the drone context.

The topic of ethics has also been discussed by Carillo-Larco et al. [70]. They asked whether the innovative and constantly evolving nature of drone use may spark ethical challenges and suggested that ethics committees need to be aware of what permissions or regulations there are to operate drones in each area to ensure that all requirements are met. This was also discussed by Cawthorne et al. [66] in their reference to Van den Hoven et al. [107] that "technical innovation can entail moral progress ... (because) it enlarges the opportunity set by changing the world in such a way that we can live by all our values". However, "new options also bring new side-effects and risks", which must be managed.

Mishra et al. [53] also raised social concerns. The operation of UAVs must be adequately regulated to protect the privacy of business organizations and individuals. The existing regulations to protect privacy may not be sufficient due to the rapid evolution of UAV technology and its increasing capabilities; therefore, there is a need to formulate further legislation to protect privacy.

Drones for Remote and Rural Services and Cost Perspectives

Among the rich literature on the cost of drone services and the use of drones for remote and last-mile delivery services, the review paper by Hiebert et al. [19] identified 20 articles that discuss the ability of drones to improve the response time of emergency services due to their ability to fly above roadways, water, and forested areas and 12 reports that discuss how drones may be used to improve access to health services in difficult-to-reach areas. These studies described four overarching topics: health applications; the benefits and costs of drones; the factors influencing use and performance in sociocultural contexts; and community engagement and sociocultural contexts as key factors in tailoring new use of drone technologies to health systems. These studies noted the importance of working with diverse stakeholders (e.g., medical and drone industries, insurance companies, pharmacies, retail outlets, entrepreneurs, legislative authorities, and other policymakers) to successfully integrate drones into health systems and pointed out that there is limited literature on how drone applications may influence patient groups and communities, raising the question of for whom drone applications in health care are being developed.

In a recent review, Nyababa et al. [91] summarized several studies of the sociotechnical debate on the drone delivery of medical supplies in Africa. They concluded that in the African context, the implementation of medical drones will revolutionize health care delivery systems, particularly for rural communities that are hard to reach during health emergencies due to poor road infrastructure, thus improving access to health care. Interestingly, they pointed out that the adoption of drones in the medical sector in Africa may be an example of what is known as "leapfrogging", that is, when developing countries skip the gradual process of technological evolution and adoption seen in developed countries and leapfrog over these gradual steps to the rapid adoption of novel devices and systems. However, they noted that the initial cost of implementation of medical drones is usually high, thus implying that the adoption of medical drones in Africa is likely to be a long-term process, as it will take a considerable time for the benefits of drone implementation to

make up for the implementation costs, depending on the size of the population that will be served.

Müller et al. [18] did not study health services but discussed the MLP in relation to the mutual interdependence of transport systems during their development and the significance of the interaction of the transport systems' evolution with the socio-economic landscape. They concluded that the landscape comprises deep structural trends such as economic development and social paradigms, where several trends put pressure on the regime, slowly or spontaneously, resulting in the need for the dominant technology regime to adapt to the pressure. This techno-economic pressure is related to disruptive innovations, implying new paradigms that change labor skill profiles, demand patterns, the competitive base for companies' products, and production methods. They concluded that the landscape may generate remarkable pressure to modify the regime's innovation pathway, resulting in the inclusion of techno-economic pressures in the industry regime's incremental innovation pathway.

Zailani et al. [92] compared the costs of drones versus ambulances for transporting blood products to treat maternal obstetric hemorrhages in situations with challenging terrain and traffic flow. Their economic evaluation concluded that although drone transportation of blood products costs more compared to ambulance transport, the significantly reduced travel time offsets the cost. From an economic viewpoint, they concluded that drones are a more cost-effective and viable mode of blood product transportation, particularly during emergencies. The findings of this study add to the body of knowledge pertaining to the cost-effectiveness of drones as a vehicle for health care service delivery where delivery time is of crucial importance.

The review paper by Ling et al. [90] discussed the use of aerial drones for various purposes, such as blood delivery, medical device delivery (automated external defibrillators), and medication delivery, and concluded that aerial drones promise improved health care delivery by providing faster response times, reduced transportation costs, and improved access to medical products/services in remote and/or underserved environments. These are all factors that may be conducive to public acceptance of drones.

4. Discussion

The development of drones in health care will migrate from technological and medical environments into institutional applications for various purposes and may thus have an impact on the entire health care sector. The broad perspective of applications is illustrated by the span ranging from drone delivery of medications [74], emergency transports of blood products in maternal health care [76], and not least the extensive use of drone services to combat the COVID pandemic [75,84]. The scientific articles in our study indicate that it is necessary to build a cross-cultural approach and establish a discourse across several stakeholders to develop a sustainable future health care system. Based on our analysis of the literature, we believe that drone implementations may benefit from considering various organizational and societal topics. Although the extent of the implementation and the value created may differ across various health care systems, geographic localizations, and organizational environments, and the methods for successful implementation may differ from one context to another, we propose that some basic topics should be studied and properly understood regarding the added value that may be achieved if drones are appropriately integrated in an extended perspective.

There seems to be a solid consensus in the literature on the importance of public acceptance. Several researchers have focused on the value of communication between stakeholders across and within systems and have looked at this issue from a socio-technologic perspective, arguing that a holistic understanding of how the adoption of various drone applications may impact a community is necessary. This is a significant concept for the MLP method, which is aimed at building a universal understanding of and implementation approach to disruptive technologies.

Hiebert et al. [19] found the following arguments in favor of community engagement: community understanding and buy-in, ensuring relevance, and increasing sustainability through local control. Furthermore, information about community needs can guide policymakers and decision-makers to properly integrate drones. Agency, understood as the ability of actors to intervene in and change system innovations, is another important concept in understanding the MLP framework [40].

The large diversity of opinions in the public perception of drones is illustrated by the distance between a report by Truog et al. [67] from Malawi, which described how community leaders were afraid that autonomous drones could be perceived as something unnatural and possessed, and our own research at Oslo University Hospital, where we have found that the use of drones in health care is seen positively across professional groups, ages, and locations [83].

Because community perceptions are heavily influenced by culture and prior experience, the response to the use of drones in each local system will reflect the local beliefs, practices, and attitudes of that area. Such responses should not be considered generalizable within or across countries. Governments, drone companies, and implementing partners should assess community perceptions of drones when proposing activities in new areas where attitudes and preferences are poorly understood.

The consideration of ethical questions is essential in this context and has been addressed by several authors. A review by Wang et al. [73] concerning the use of drones for humanitarian services identified several critical areas of concern, with minimizing the risks of harm and protecting privacy appearing to be the most critical points. However, they concluded that ethical conflicts may emerge in the shift from humanitarian drone programs to commercially available drone delivery services. Furthermore, such transitions may reshape issues related to data management and security, control, and responsibility.

4.1. Future Actions: From the Clinical to Institutional Level—The Proof of Concept?

Clinics are one of the most crucial loci for technological innovation. Clinicians and others with innovative mindsets try continuously to solve problems by experimenting, combining, and testing new approaches and tools. In parallel to this, we assume that the process of drone solutions begins with someone launching the idea as a way of transporting biological material. Drones promise a substantial opportunity to interact with other environments, both within and outside the health system [64]. An active innovation policy may enhance such developments, where new knowledge is explored and exploited in a positive feedback loop.

How Does the MLP Concept Apply to This Process?

As we assume drones to be implemented in a "bottom-up" process, we find the three MLP dimensions speed of change, size of the change and the four MLP phases of implementation MLP interesting to guide the process. The MLP argues that landscape pressures create "windows of opportunity" for niche technologies to emerge. However, the starting point of pressure may often come from below, from the niche of "clinical" environments that create innovations in daily practice originating from dynamics in ordinary activities and challenges, such as producing, promoting, adopting, and aligning technologies; cultivating novelties within existing regimes; enlisting users and making them available for integration into practices [89]. Nevertheless, the MLP theory may also be used to understand such processes as the creation of pressures and windows of opportunity at the landscape level.

According to the MLP, innovations are strongly influenced by existing regimes and landscapes. New technologies fit into existing regimes. However, over time, new functionalities, forms, and design options are explored. The co-evolution of form and function may lead to a wider diffusion, adaptation, and new socio-technical regime [30]. However, this process may take time and depend on previous experience with integrating technological knowledge [86]. The MLP suggests that experimental projects help work toward long-term change, fostering learning processes and institutional change. Furthermore,

while policymakers can facilitate learning and network building, niche actors may decide the process [87].

An essential element in the MLP is that technologies are introduced into social and economic systems and thus embedded in an "extended universe" where understanding the effects of innovations and changes in systems is necessary. The challenge for innovation not only rests on economic potential but also on the societal changes induced by innovative activity and environmental and social sustainability consequences. Along with this broad framing of the problem comes a need for open-minded analytical perspectives [26].

The institutional level refers to the existing system, which is a guarantor for stability with established structures, rules, and groups of actors. Such systems develop over time, which can make them resistant to change. The MLP refers to such resistance as lock-in mechanisms related to needed changes to established work processes or to the replacement of technical tools or approaches and suggests that technological innovations may divide the audience into enthusiasts and skeptics, early adopters and the fearful, and the curious and the indifferent [56]. However, from a socio-technical perspective, the challenge may lie not in people supporting or opposing the new technology but in a lack of concordance between the requirements of the technologies and the practices that people perform and have developed over time [89].

MPL stresses that the success of an innovation depends substantially on how it becomes integrated into existing systems and technologies and on the extent to which it is approved and fits within regulatory frameworks. Proper integrations developed by deep involvement enforce acceptance by users and society at large [77]. Furthermore, public acceptance and the social benefit of innovations can enable health policies.

Innovations are created through the interactions between technological, social, economic, cultural, and political aspects [77], and technological innovations may be unpredictable for many reasons. Therefore, if and to what extent drones impact structures in laboratories, whether drones in combination with other technologies have the power to transform the health care system, or to what extent in-depth organizational processes are needed to implement drones, is currently unknown and only understood in hypothetical terms.

The aforementioned interactions should also include evaluation of the acceptance of drone integration because assuming such acceptance by default may lead to a later rejection, which in the long run may impact the broader integration process and invalidate all the previous regulatory work done to ensure smooth integration [84].

The requirements created by innovations at the clinical level may spark responses at the regime level, i.e., adaptations or regulations are needed to support further developments. On the one hand, prompt up-front regulation could enhance innovations and actively drive new developments. On the other hand, a holistic perspective at the regime or landscape level may need supplementary or broader information than the specific clinical level to ensure proper interests for an extended perspective. The institution may need to engage interdisciplinary teams crucial for giving feedback on consequences beyond the initial perspective. From such a perspective, the MLP theorizes that the integration of drones and drone-related applications can be strengthened with a process across different users and levels in the system [19].

Based on the MLP principles, leaders become essential in providing arenas for collaboration, both from within and outside health systems [64,65]. Creating and maintaining linkages and networks between clinics, institutions, and health systems may be conducive to a wider diffusion of drones.

In their review of logistics research, Rejeb et al. [72] discussed how IoT in the context of logistics requires the organization to continuously adapt, engage with, and implement new technologies to enhance the performance of logistic systems. With respect to drones, they recommended that managers inspect the technical features to enable them to identify use cases that may integrate economic, social, and environmental considerations into their strategic decision-making processes.

4.2. The Health Care System Level

Health care systems at the overarching level include broader societal processes, such as political, economic, and demographic trends.

The MLP landscape topic assumes that policy forms an integral part of an innovation, either because of directly triggered changes or because policy changes may be a prerequisite for the innovation. The MLP theory assumes that continuous interaction and communication between the MLP levels are crucial to creating the forces that allow the various transitions not to end until changes in the social and technical elements are embedded in the complete system, i.e., at the user level, the production level, and the institutional and system levels. Therefore, it is helpful to understand the potential policy effects at the earliest stage to take the necessary precautions with respect to unforeseen political consequences or to prepare an argument for any policy changes that should occur. In addition, this may help identify specific issues that influence how stakeholders should be addressed to keep their expectations as realistic as possible. Furthermore, understanding the degree to which organizations need to change is essential for developing a realistic concept and ideas of the potentials and limitations of a given domain. Finally, this is an essential platform for identifying where uncertainties remain and which issues need more attention.

The MLP theory points out that policymakers have an essential role in recognizing relevant niche innovations at the earliest possible occasion to identify lock-ins and help remove them. Creating an environment for trust may contribute an additional nutrient for the diffusion of innovation. Finally, by defining common goals and timely expectations, all stakeholders may work for a shared vision for a future system.

Limitations

Our scoping review has several limitations. First, some relevant papers may not have been identified on account of a search concept that may have been too narrow. However, the search results generated in literature studies that use a structured search approach are often limited.

Furthermore, choosing socio-technical theory as our theoretical lens determined our preferences for conducting our search. We conducted searches of the academic literature in the PubMed and Scopus databases. PubMed was chosen as a medical database, Scopus, because of its broad coverage in diverse fields and its quality [72]. Google Scholar was used to snowball relevant articles, which may be a further limitation. Google Scholar's search logic is based on full-text searches and thus generates a high volume of search results. Our search strategy was based on a structured search, which may have needed to be adapted for use with Google Scholar.

Furthermore, articles that were published after we conducted the literature search in March 2021 were not included. It is also possible that more extensive results could have been obtained from the gray literature, but we chose to restrict our search to peer-reviewed scholarly journal articles.

Additionally, the analysis of the literature revealed categories that may have yielded significantly more studies. For example, a search for "public acceptance" may have generated additional relevant studies for inclusion in this review—however, this scoping review intended to provide a more general overview. Thus, although its conclusions cannot be generalized, this review may spark a discussion about the socio-technical considerations for integrating drones.

Our objective in this study was to look for the value of taking a socio-technical approach. However, our search strategy did not identify any studies that used the keyword "socio-technical". This may be because socio-technical thinking is not very widespread. The MLP can be used to address this research gap.

5. Conclusions

This paper is based on our research question regarding how knowledge of socio-technical theory may support an extended focus on implementing drones into health care systems.

Based on a scoping review and supplementing literature, we found evidence in the literature that building a cross-cultural approach and establishing a discourse across several stakeholders is of importance to developing a sustainable future health system. Furthermore, from a socio-technological perspective, ethical considerations and public acceptance are topics highly relevant to the implementation of drones.

Several authors have addressed ethical topics. In the transition from humanitarian drone projects to commercially available service offerings, ethical issues may be seen concerning data management and security, control, and responsibility.

In addition, the topic of public acceptance has been raised by several authors. Community engagement is helpful for buy-in and ensuring the relevance of the innovation. Because acceptance is deeply influenced by culture and prior experience, the acceptance of drones should be evaluated.

Furthermore, addressing community engagement can ensure an agency in terms of the ability of actors to intervene in system change. Experimental projects can cultivate learning processes and institutional change. Policymakers can facilitate learning and network building. An active innovation policy can prompt up-front regulation, enhance innovations, and actively drive new developments.

Systemic knowledge about privacy is needed to obtain a social consensus on the capabilities of drones, thereby also guiding policymakers and decision-makers. Niche actors may decide on the process.

A holistic perspective and the regime or landscape level may need supplementary or broader information than the specific clinical level to ensure that the proper interests are considered in an extended perspective. The institution may need to engage interdisciplinary teams, which are crucial for giving feedback about consequences beyond the initial perspective.

In this process of transition, leaders are essential for creating and maintaining linkages and networks between clinics, institutions, and health systems. The MLP shows that continuous interaction and communication between the multiple levels create forces that secure the various transitions until changes in the social and technical elements are embedded in the complete system. Furthermore, the MLP is helpful for understanding potential policy effects at the earliest stage to take the necessary precautions against unforeseen political consequences and prepare arguments regarding the policy changes that should occur.

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