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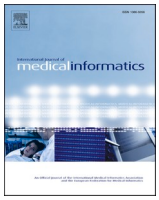

Review article

The role of telehealth startups in healthcare service delivery: A systematic review

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ABSTRACT

Objectives: The role of startups has been growing in healthcare delivery, particularly in telehealth and telemedicine. Yet, little has been published about their role in evolving digital healthcare ecosystem. This study aimed to review the literature on telehealth startups to understand their roles, challenges, business models, and directions for sustainable innovation and commercialization.

Methods: Ten databases were screened: PubMed, Scopus, Web of Science, IEEE Xplore, ACM digital library, EBSCOhost, Embase, Medline, Cochrane review, and PsycINFO. The articles were shortlisted based on predetermined screening criteria, and qualitative synthesis was performed. The quality of included studies was assessed using the Mixed Methods Appraisal Tool. Cohen's K was calculated to ensure the reliability of the authors scoring on the quality appraisal test and qualitative synthesis.

Results: 26 articles were included in the review. Findings are clubbed under five themes: remote and on-demand healthcare; healthcare data management; digital therapeutics; high-tech driven personalized care; and information integration and exchange. Technical infrastructure, regulation, and revenue generation were identified as major challenges for telehealth start-ups. Osterwalder business canvas was the predominantly used model. Value perspectives were recognized for a sustainable telehealth innovation and its commercialization.

Conclusion: Telehealth startups are evolving to meet digital healthcare needs and playing a significant role in teleconsultations, telemonitoring, and electronic health record solutions. Recently, their focus has shifted towards smartphone-enabled AI-driven personalized care, including digital therapeutics and wearable device innovation. They have significant technical and operational challenges in innovation and commercialization to optimize their role. The review also provides researchers with a new understanding of telehealth startups' sustainable innovation and commercialization through the systematic direction of value proposition, creation, and capture.

1. Introduction

Recent advancement in information technology (IT) has significantly changed the way healthcare is traditionally delivered [1,2]. The use of IT for delivering care is broadly known as telehealth. Evidence suggests that telehealth can be used for disease prevention, tracking and monitoring of diseases, and delivering clinical care to patients [3].

The role of large IT companies in healthcare has been significant, and it is well-recorded. IBM has been developing medical software to create comprehensive patient data records since 1960 [4]. Microsoft built AI-powered virtual assistants, chatbots, and cloud data-sharing tools; Google uses AI to help with cancer diagnosis and predict disease outcomes [5]. However, smaller IT companies have also been making a significant contribution to the field for decades. Such companies are typically called telehealth startups [6]. Most of the innovations in telehealth emerge from them [7].

While identifying a gap in the service space, these health startups typically initiate businesses to fulfil such gaps. However, for several reasons, telehealth startups operate in a more uncertain and vulnerable space compared to large IT companies. They often attempt to sustain themselves through external funding, such as crowdfunding, venture capital, and angel investment. Once a startup is able to scale up and

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sustain its growth, it becomes a conventional tech company [8]. A good example of such a startup is *Babylon Health*. It was initiated as a health venture in 2013 and received several rounds of funding between 2016 and 2019 from governmental and non-gov funding agencies, including Hoxton Ventures, Kinnevik AB, Public Investment Fund of Saudi Arabia. At present, *Babylon Health* is a well-established digital healthcare enterprise in the healthcare service space [9].

The contribution of telehealth startups can be seen in various areas, including aged home care, chronic disease management, women's healthcare, diagnostics, digital therapeutics, data integration, and analysis. Another important area where startups have recently been active is the use of artificial intelligence in healthcare. For example, *PAIGE AI* and *PathAI* are telehealth startups that help speed up patient diagnosis using artificial intelligence. *Ava Science* is a fem-tech startup that focuses on fertility tracking devices.

The global telehealth market is proliferating and is envisioned to reach $390.7 billion by 2024 from $187.6 billion in 2019, with a compound annual growth rate (CAGR) of 15.8 %. Reportedly, telehealth startups generated over $17 billion in 2020 [10]. As online healthcare services expand, more health startups are making their way into the digital healthcare market. The COVID-19 pandemic has shown a notable expansion of the use of e-care, paving the way for telehealth startups to offer their services [11].

Telehealth startups are emerging rapidly with numerous innovations, and their contributions are becoming more significant in the evolving digital healthcare system [12,13]. Apart from the trade media information mentioned above, scholarly literature remains scant on telehealth startups in healthcare service delivery. The existing studies discussed the telehealth business models, their components, and key aspects but did not highlight the aspects of startups [14,15]. Startups' business models are different from the existing businesses [16]. No evidence has been synthesized on their contribution, challenges, and direction for innovation commercialization.

This systematic review will attempt to understand the role of telehealth startups in healthcare services by investigating the following questions: What are the emerging dimensions of telehealth startups in healthcare services? What are the predominant healthcare services provided by telehealth startups? The review also talks about telehealth startups' challenges in healthcare services and a framework for telehealth startups' sustainable innovation and commercialization in evolving digital health ecosystems. These findings extend the understanding of telehealth startups', their sustainable innovation, and commercialization through the systematic direction of value proposition, creation, and capture. The study has practical implications regarding sustainable telehealth innovation, entrepreneurship, and policymaking.

2. Methodology

2.1. Study design

The systematic review was conducted using Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines [17]. This review is listed in the International Prospective Register of Systematic Reviews (PROSPERO) - registration number: CRD42021254771. This review focuses primarily on the role of telehealth startups; however, the review does not intend to evaluate the outcome of the startups' services due to a lack of relevant studies.

2.2. Search strategy

Scopus, PubMed, Web of Science, Institute of Electrical and Electronics Engineers Xplore (IEEE Xplore), ACM digital library, EBSCOhost, Embase, Medline, Cochrane review databases, and PsycINFO were searched until October 2022. Medical Subjects Headings (MeSH) terms such as telehealth, telemedicine, mhealth, and ehealth and key terms in business domains such as startup, venture, born global, and competitive advantage were used. The search string was prepared with the librarian's assistance. An example of the detailed search string for retrieving the studies in the Scopus database were presented in Table 1.

2.3. Inclusion and exclusion criteria

The studies were screened using the following inclusion and exclusion criteria.

The included studies: (1) presented information on telehealth ventures in healthcare services, (2) depicted the product or services of the telehealth startups, (3) mentioned startups' challenges in service delivery, (4) discussed telehealth business model, (5) highlighted telehealth entrepreneurial innovations in healthcare service delivery, (6) talked about commercialization of telehealth startups innovation, (6) were peer-reviewed articles, and (7) were available in English.

The articles were excluded, which have: (1) startup information or product but not related to healthcare services, (2) in-depth technical information without references to the role, (3) lack of focus or reference to startups, (4) unavailability of the full-text article, and (5) non-empirical research (including book chapters, commentaries, letter to the editor, perspective, short communication, and review papers).

2.4. Study selection and screening process

Rayyan [18], a web-based systematic review tool, was used to screen the potential articles collaboratively. Initially, Rayyan scanned all the entries to remove the duplicate studies, and then articles were filtered based on the title and abstract screening. Full-text eligibility was assessed to finalize the studies for our systematic review. The discrepancies were resolved through discussions among the team members to reach a consensus.

2.5. Quality assessments

The quality of the included articles was assessed using Mixed Methods Appraisal Tool (MMAT, 2018 version). The evaluation was conducted using the responses ('Yes', 'No', and 'Can't tell') of different methodological quality criteria [19]. The final score for each article was calculated by the number of yes in the total number of quality criteria. The score indicated the quality as low (<50 %), average (50–75 %), and high (>75 %). Two authors independently screened the included articles and gave their remarks. Further, Cohen's k statistic was performed to ensure agreement among the authors for quality appraisal [20].

2.6. Data extraction and analysis

The data were extracted in a spreadsheet containing detailed information about the startups' demographics, contributions, delivery channels, target clients, challenges, and business models. IC (primary author) assessed the entire text, while SE and VI checked the extracted datasheet. Results were discussed in the team meetings.

A narrative synthesis was performed from the selected articles. The

Table 1
The search string for searching articles in Scopus.

Database	Search strings
Scopus	(TITLE-ABS-KEY ((telehealth OR telemedicine OR mhealth OR digital AND health OR "mobile health" OR ehealth OR "health IT" OR "health tech" OR "med tech" OR "electronic health" OR "e-health service" OR "electronic health record" OR "medical informatics" OR teleconsultation OR "online health" OR "virtual health")) AND TITLE-ABS-KEY ((startup* OR firm OR platform OR business OR venture OR app OR enterprise OR entrepreneurship OR "born global")) AND TITLE-ABS-KEY ((" business model innovation" OR "sustainable business" OR competition OR advantage OR "competitive advantage")))

key findings were identified through an inductive approach to realize the data comprehensively. Cohen's k statistic was also calculated to check the intercoder reliability among the authors. Startups' dimensions were distinguished, delineated the contribution of telehealth startups in healthcare services, and highlighted their challenges. The business models and concepts utilized in the included studies were also discussed.

3. Results

The initial search yielded a total of 3548 records. Eighty-six full texts were screened for the eligibility assessment. Finally, 26 papers were considered for quality assessment before being included in the review. The MMAT result showed scores between 60 and 100. Cohen's K value was 0.68, reflecting substantial agreement and ensuring the reliability of the scoring. Ten articles received a full score of 100, eight studies got 90, three studies received 80, four studies got 70, and only one scored 60. None of them scored < 50 to be denoted as low quality. Hence all the articles were eligible and included in this systematic review. The PRISMA flowchart describes the detailed screening process in Fig. 1.

3.1. Study Characteristics

The categories of selected study types were journal articles (n = 23) and conference proceedings (n = 3). The selected publications were between 2011 and 2022. The included papers were from various countries, especially Germany (n = 3) and Sweden (n = 3). Most articles were either case studies (n = 14) or semi-structured interviews (n = 8). The studies predominantly used qualitative analysis approaches (n = 25). Table 2 shows the fundamental characteristics of the included papers.

3.2. Emerged themes

Literature showed a wide range of services provided by telehealth startups, which target a niche market to deliver their offerings. We have

Table 2
Characteristics of the included studies.

Characteristics	Number of studies
Type of publication	Journal articles: 23, Conference proceeding: 3
Country	Germany: 4, Sweden: 3, USA: 2, Canada: 2, Australia: 2, Switzerland: 2, Netherlands: 2, UK: 1, Italy: 1, Iran: 1, India: 1, Ireland: 1, Norway: 1, Romania: 1, Mexico: 1, Canada: 1
Year of publication	2011: 1, 2016: 3, 2017: 1, 2019: 1, 2020: 7, 2021: 7, 2022: 6
Study type	Case study: 14, Secondary data: 4, Interview: 8
Analysis	Qualitative: 25, Quantitative: 1

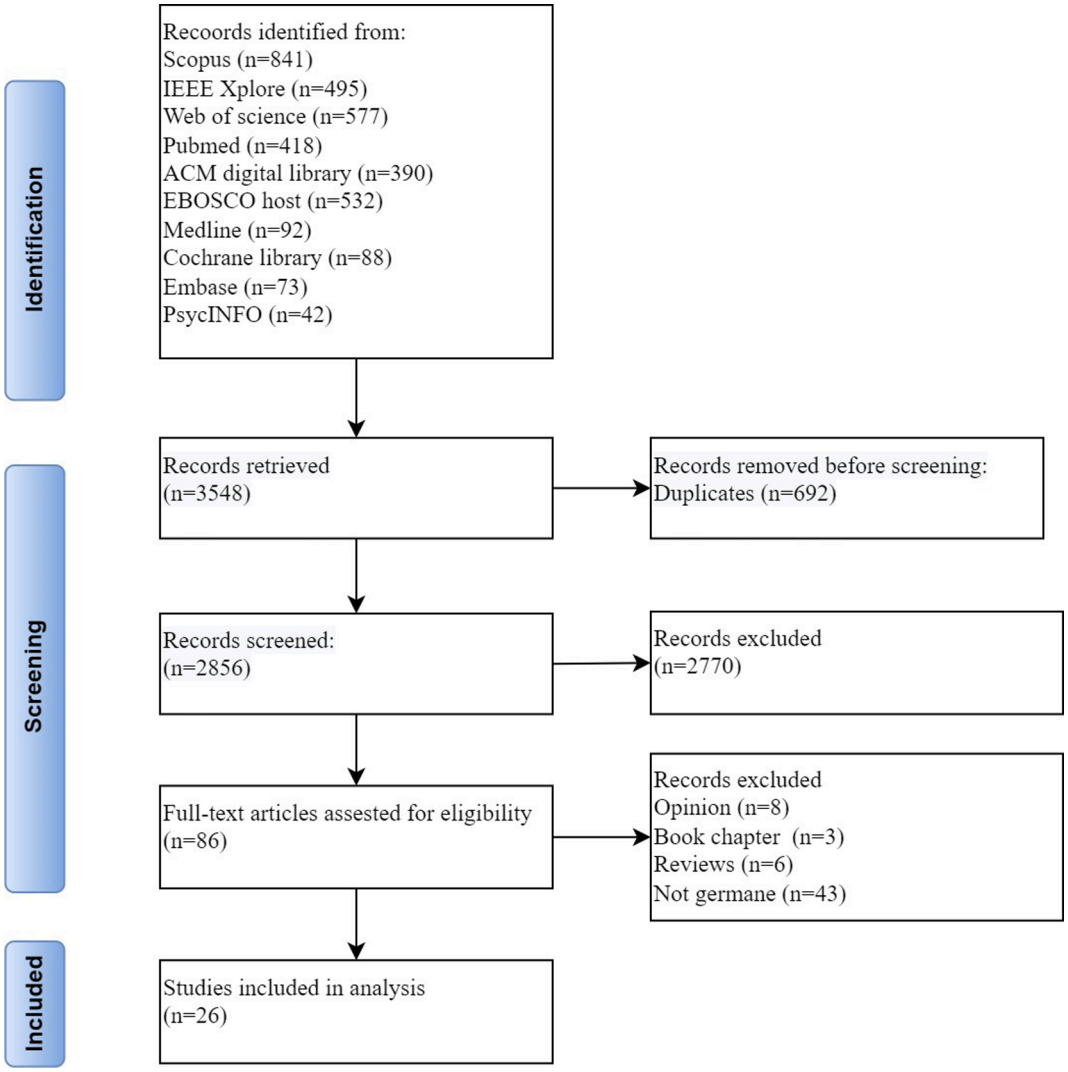

Fig. 1. PRISMA flowchart of the study selection process.

collated emerged themes (n = 5), service genres, and niche markets from the findings in Table 3. Cohen's K value was 0.76, which ensures the reliability of the qualitative data analysis.

3.2.1. Remote and on-demand healthcare

The literature showed that remote monitoring is an emerging area of telehealth startups. One article depicted the usage of ITs to monitor patients' medical conditions remotely, especially with the help of highly experienced clinicians such as *Airstrip technologies*, a remote monitoring telehealth startup [21]. Five articles stated that online consultation was the predominant focus of startups' remote healthcare services that enabled patients to connect with a general physician, specialized doctors, or other clinicians over the internet for healthcare advice, diagnosis, and treatment [7,22–25]. Two articles represented *Teladoc,* an international and virtual healthcare startup that offered primary healthcare services, including telemedicine, medical opinions, and medical devices [21,26]. Current literature reflected that the main focus of telehealth startups in this area was not only on the services or products but also on establishing a health service platform ecosystem for virtual care [21,27,28].

3.2.2. Healthcare data management

The need for accessing, storing, retrieving, and analysis of electronic healthcare data has become an integral part of virtual care delivery. Seven studies described electronic medical records as a digital version of various healthcare data such as diagnosis, medications, lab results, radiology images, and patients' medical history [7,8,21,29–32]. Four studies delineated some telehealth startups, such as *O care cloud* and *My referrals*, that provide cloud-based electronic health record services to bridge accessibility and interoperability gaps [7,8,22,31]. Three studies shared the emergence of enormous healthcare data due to digitization and digitalization, which unlocked the potential of big data analysis to unravel hidden treasures for better healthcare service and outcomes [27,33,34]. Two studies reported *23andMe*, a tech-driven telehealth startup that provides direct-to-consumer DNA testing facilities [21,32].

Table 3
Emerged themes, service genres of telehealth startups, and their niche market.

Themes	Service genres	Telehealth Startups	Niche market*
Remote and on-demand healthcare	Online consultation	Teladoc, eVisit	Online health consumers (No age bracket)
	Remote monitoring	Airstrip technologies	Older adults, chronic patients
Healthcare data management	Electronic medical records	O'care clouds, My referrals	Service providers and online health consumers
	Big data analysis	23andMe	Genetic testing consumers (especially young age adults, 18–35 years) and health service providers
Digital therapeutics	Evidence-based software	WellStart Health	Mental and behavioral health consumers
	Mobile wearables	MyoTel	Chronic neck and shoulder pain patients
High-tech driven personalized care	AR/VR for clinicians' support	Applied VR	Service providers (i.e., clinicians, practitioners, nursing staff)
	AI for personalized care	Docandu, RO-smart Aging	Online health consumers (No age bracket)
Information integration and exchange	Health information searching	ZocDoc	Online health consumers (No age bracket)
	Online consumer interaction	PatientsLikeMe, HealthForMe	Online health consumers (young and middle-aged adults, 18–55 years)

* It is represented based on the information given in the selected studies. An actual niche market for these service genres, including mentioned startups, might differ based on their business model, especially because some startups function inter-domain.

3.2.3. Digital therapeutics

Evidence-based therapeutics operated with high-end software facilities and wearables to diagnose, manage, prevent, or treat health disorders. Two articles discussed evidence-based healthcare software, a digital therapeutic solution that assisted in treating diseases by positively changing patients' behaviors and closely tracking outcomes [33,35]. One article shared a case of such a solution, *WellStart Health*, a digital therapeutic startup for chronic disease reversal [7]. Besides, one study described mobile wearable devices as another digital therapeutic solution with several real-time sensors to monitor health conditions. The study shared the case of *MyoTel*, a wearable myofeedback-based device (a form of feedback the patients receive from electronically recorded information about their physiological processes) for telerehabilitation services [36].

3.2.4. High-tech driven personalized care

Emerging technologies pushed healthcare services and brought many high-tech telehealth startup solutions. Four articles shared the predominant technologies in the health service space, such as augmented reality (AR), virtual reality (VR), artificial intelligence (AI), and so on [7,21,26]. The study discussed the case of *Applied VR*, a high-tech health startup in pain management solutions using VR [21]. Another two studies shared the telehealth startup's usage of AI and data learning algorithms in healthcare data to deliver more personalized and exclusive healthcare services [34,37]. One article delineated a high-tech startup *Docandu* that implemented AI to enrich the doctor-patient relationship and enable personalized healthcare. [26].

3.2.5. Information integration and exchange

Four articles shared that telehealth startups also empowered information exchange via consumer interactions and prior feedback. It was found that two telehealth startups provide options to search online health information such as provider's details, delivery process, and clinician's service review [7,8]. One article described *Zocdoc*, a telehealth startup that delivered online dental healthcare bookings and provided a platform to explore information on a wide range of healthcare services [21]. Two articles showed that telehealth startups brought consumer interaction opportunities with prior and ongoing consumers. It was noticed that online communication among healthcare consumers enabled sharing, discussing, and receiving health service information, including support from peers [38,39]. One article illustrated a telehealth startup, *PatientsLikeMe*, which offered patient-to-patient interaction options to deal with similar health complications [32].

3.3. Startups offerings

Included articles mentioned telehealth startups in various areas of healthcare services (see Table 4). They were further categorized into two types based on the tech front: tech-enabled and tech-driven. Tech-enabled startups use existing technologies to solve operational issues or improve customer experience, whereas tech-driven startups bring technological innovations and build advanced technology products. Tech-enabled telehealth startups use IT for software or tool-based application development to strengthen healthcare service delivery. In contrast, tech-driven telehealth startups utilize emerging ITs to invent high-tech solutions for healthcare.

It was identified that most telehealth startups were tech-enabled to deliver healthcare services. Nine articles stated Software as a Service (SaaS) startup in telehealth is a predominantly developed electronic health record (EHR) solution. Three studies reported the role of

Table 4
Details of included studies on telehealth startups services and challenges in healthcare services.

Studies (MMAT)	Startups	Emerged themes	Services	Tech type	Challenges	Model/concept
Aweisi 2022 (90 %)	100 Startups	Remote and on-demand healthcare, high-tech driven personalized care, Information integration and exchange, Healthcare data management, digital therapeutics.	Remote clinical services such as consultations, diagnosis, treatment, monitoring, data storage, and clinician assistance	Tech-enabled, Tech-driven	Quality and cost	X
Chaudhuri et al., 2021 (100 %)	iKure, Neurosynaptic	Remote and on-demand healthcare	Online consultation, low-cost medicine delivery, diagnostics	Tech-enabled	Resource scarcity, financial, leadership issues, scalability, institutional and regulatory environment weakness	Value creation, delivery, and capture
Emilsson et al., 2020 (70 %)	7 Startups (Name not revealed)	Remote and on-demand healthcare	Primary care and collaboration with big players for sustainable services	Tech-enabled	X	Resource-Based View (Strategic resources to attain a sustainable competitive advantage)
Florescu & Florescu, 2020 (90 %)	RO-Smart Aging	Remote and on-demand healthcare, high-tech driven personalized care	Home care for older adults	Tech-driven	X	Value, Interface, Service, Organizing model, Revenue (Value proposition, delivery, and capture)
Furstenau et al., 2021 (90 %)	Ambulanzpartner.de (APST)	Remote and on-demand healthcare, digital therapeutics	Amyotrophic lateral sclerosis supports, monitoring, consultation	Tech-enabled	X	Osterwalder business model (Key partners, Key activities, Key resources, Proposed value, Customer relationships, Channels, Customer segments, Cost structure, and Revenue stream), value creation
Gehde et al., 2022 (70 %)	237 startups	Remote and on-demand healthcare, high-tech driven personalized care, Information integration and exchange, Healthcare data management, digital therapeutics.	Consultation, diagnosis, treatment, monitoring, data storage, and clinician assistance	Tech-enabled, Tech-driven	X	Osterwalder business model canvas, Value creation, proposition, delivery, and capture
Geiger, 2020 (100 %)	23andMe	Healthcare data management	Direct-to-consumer DNA tests and online health record	Tech-enabled	X	X
Gleiss and Lewandowski 2022 (90 %)	36 (Names not revealed)	Remote and on-demand healthcare, High-tech driven personalized care, Information integration and exchange, Healthcare data management.	Online consultation, diagnostics, monitoring, data storage	Tech-enabled	Financial, legal, technological, organizational	Value creation and value proposition
Hammond et al., 2021 (100 %)	Dynami care health	Digital therapeutics	Consultation and monitoring on contingency management for substance uses disorder	Tech-enabled	Implementation	X
Hermes et al., 2020 (100 %)	9 Startups (Zava, Teladoc, eVisit, Docandu, Applied VR, 23andMe, Airstrip technologies, ZocDoc, PatientsLikeMe)	Remote and on-demand healthcare, high-tech driven personalized care, Information integration and exchange, Healthcare data management	Remote clinical services such as consultations, diagnosis, treatment, monitoring, data storage, and clinician assistance	Tech-enabled, Tech-driven	X	e3(Economic – Energy – Environment) value approach (Actors, Market segments, Value objects, Value ports, Value interface, and Value exchange)
Iakovleva et al., 2021 (80 %)	11 Startups (Names not revealed)	Remote and on-demand healthcare, Healthcare data management, Information integration and exchange, digital therapeutics	Web-based services for chronic care, aged care, mental health, online health record, and health information provider	Tech-enabled	X	Responsible Innovation (stakeholders' strategy to enhance and share the responsive nature for innovative outcomes while dealing with challenges)
Kelley et al., 2020 (100 %)	6 Startups (Names not revealed)	Remote and on-demand healthcare	Remote care and monitoring for cardiology, geriatrics, dermatology, and mental health	Tech-enabled	X	X

(*continued on next page*)

Table 4 (*continued*)

Studies (MMAT)	Startups	Emerged themes	Services	Tech type	Challenges	Model/concept
Kho et al., 2020 (100 %)	7 Startups (iDoc24, DermatologistOnCall, Firstcheck, Skinvision, Helfie, DirectDerm, ShyMD)	Remote and on-demand healthcare	Direct-to-consumer teledermatology services	Tech-enabled	X	Ash Maurya's Lean Canvas (Key metrics, Unique value propositions, Unfair advantages, Channels, Customer segments, Cost structure, and Revenue stream)
Kijl et al., 2011 (70 %)	MyoTel	Digital therapeutics	Myofeedback based teletreatment	Tech-driven	IT investment, Operation cost	Service, Technology, Organization, Finance (Value creation for providers and consumers)
Lai et al., 2021 (100 %)	11 Startups (Names not revealed)	Remote and on-demand healthcare	Online consultation for chronic disease and mental health	Tech-enabled	Policy	X
Morgenstern-Kaplan et al., 2022 (90 %)	Sofia	Remote and on-demand healthcare	Online consultation	Tech-enabled	X	X
Muhos et al., 2019 (70 %)	5 Startups (Names not revealed)	Remote and on-demand healthcare	Chronic skincare, Diabetic care, and services to the disabled person.	Tech-enabled	X	Focus, growth management, development and delivery, network management
Sax 2021*(80 %)	X (No details reported)	Information integration and exchange	Health information search, fitness	Tech-enabled	Data privacy	X
Singh et al., 2021 (90 %)	Aiisma, Qure.ai, TruFactor	Healthcare data management, high-tech driven personalized care	Data-driven disease prediction and management	Tech-driven	X	X
Sprenger, 2016(80 %)	PatientsLikeMe	Healthcare data management, Information integration, and exchange	Data sharing between patients, Mental health	Tech-enabled	Value creation, delivery, and capture	Problem identification and motivation, objectives of a solution, design and development, demonstration, evaluation, and communication
Sprenger and Mettler, 2016 (100 %)	Flatiron Health, 23andME	Healthcare data management	Cancer research and treatment discovery, Genetic testing	Tech-enabled, Tech-driven	Limited experience	Osterwalder Business Canvas
Truong and McLachlan 2022 (90 %)	Oliva Health, Modern Health, Unmind, Lyra Health, Ginger	Remote and on-demand healthcare	Mental healthcare consultation, monitoring, therapy	Tech-enabled	Data privacy and sharing, Lack of trust	X
Vannieuwenborg et al., 2017(100 %)	O'Care Clouds	Healthcare data management	Electronic health record	Tech-enabled	Complexity of value network, Technology, Finance, willingness to pay, Privacy, Legal issues	Osterwalder Business Canvas
Velayati et al., 2022*(90 %)	X (No details reported)	Remote and on-demand healthcare, Healthcare data management	Online consultation, electronic health record	Tech-enabled	Legal, Financial	Value creation, key resources, key activities, key partners, licenses and permissions, product pricing, product revenue, product marketing, supporting services
Visconti, 2020* (60 %)	X (No details reported)	Remote and on-demand	Online consultation	Tech-enabled	Scalability, Capital	value creation and evaluation
Wass and Vimarlund, 2016 (100 %)	My referrals	Healthcare data management	Electronic health records to be tracked by providers and consumers	Tech-enabled	Technology, Data security, Revenue, Policy	Service, Technology, Organization,Finance

* Three studies did not mention startups' names or how any startup was considered in their research but represented essential aspects and challenges of telehealth startups.

telehealth startups in EHR, contributing to healthcare services through software-based IT solution development for better data sharing and tracking between provider and consumer [7,21,30].

Only a few articles represented tech-driven telehealth startups along with tech-enabled startups. One article depicted a telehealth startup that offers a wearable device, *MyoTel*, which provides myofeedback-based EMG devices for telerehabilitation services. The study reported this startup's involvement in capturing SaaS dimensions associated with telediagnosis [36]. Besides, two articles discussed high-tech startups such as *Applied VR* for clinicians' assistance [21] and *RO-smart Aging* for geriatric services [26].

Nevertheless, one article delineated two startups that fall in both tech-enabled and tech-driven categories. They started as tech-enabled startups to deliver healthcare services but gradually developed high-tech solutions [32].

A similar direction of the delivery channel was identified for the offerings of both tech-driven and tech-enabled telehealth startups. Most articles reported that telehealth startups (*MyoTel*, *PatientsLikeMe*, and *My referrals*) used the internet and smartphone to deliver healthcare services [8,29,36].

3.4. Challenges

Telehealth startups face many challenges, from ideation to scale-up stages. These startups primarily see the hurdles in sensitive data management and the hardship of clinical validation.

Fourteen studies illustrated the challenges faced by telehealth startups (see Table 4) [8,15,22,27,29,31,32,34–36,38,40–42]. Most of them shared that telehealth ventures met with difficulties in technology, data security, revenue, data interoperability, and policy [8,22]. One study discussed IT investment and operational cost as the most significant challenges [36]. Two studies reported that design patterns and limited experience were the factors that impeded an IT startup's value creation [29,32]. One article further shared that scalability and capital were critical challenges for telehealth startups [42]. Another study highlighted the challenges in the telehealth-based software solution market: the value network's complexity, technological skill, insufficient finance, and willingness to pay [31].

3.5. Startups innovation and commercialization

The analysis identified essential components of telehealth startups' business models, including their innovation objectives and value goals. Eighteen studies mentioned telehealth startups' innovations. The innovation was discussed as technological innovation [7,8,21,27,28,30,33,34,36,41,43] and service innovation [7,15,25,27,33,38,44]. Technological innovation predominantly focuses on product development using emerging technologies. Service innovation aims to bring innovative delivery methods or processes to be new or improved service products. Additionally, emerging information from prediction and analytics leads the service and technological innovation process [33,37,40].

The Osterwalder business canvas was a predominantly used model (Table 4). Four studies employed the nine elements of the business canvas to enquire about the value creation of telehealth startups [31,33,44]. Value creation aspects were also used extensively to investigate the telehealth startup services' effectiveness, innovation, market fit, and revenue generation (please see Appendix 1 for a detailed description). Additionally, most articles discussed one of the three value aspects: value proposition (why consumers choose a product or service), creation (turning resources into perceived value), and capture (willingness to pay for the final product and service) [15,26,33,34,36,40,44].

Two studies only reported the importance of telehealth startups' sustainable innovation [7,23], as most of them perish [45,46] due to numerous challenges in the digital health ecosystem (Table 4). The analysis of the reviewed articles showed that telehealth startups' contributions remain limited due to the lack of sustainable innovation in effective products (or services) or unable to fit that offering in the target market [21,23].

4. Discussion

The analysis showed that most telehealth startups in healthcare were involved in remote patient monitoring and on-demand health services. The involvement of telehealth startups in medical health records is expanding [36,48]. However, they face various data privacy and security-related issues while ensuring safety and consumer trust. It may be assumed that telehealth startups have a strong potential to innovate using digital healthcare data even if they comply with data protection regulations. There is also growing evidence of big data analytics startups that exploit the sectoral requirement and bring disruptive solutions [13,32,33,47]. Telehealth startups extensively develop solutions using artificial intelligence, machine learning, deep learning, and AR-VR. The current studies highlight that emerging technologies are the growth engines for telehealth startups [49].

Software for evidence-based healthcare and wearables solutions were mentioned as potential areas for telehealth startups with a CAGR of 13 %. Limited insight was found into the contribution of telehealth startups in these areas. However, many wearable telehealth innovations are globally accepted by healthcare consumers [50,51]. Existing scholarly literature shows a significant rise in digital therapeutics in the digital innovation space. Telehealth startups are engaging with big hospitals to create clinical pipelines of digital therapeutics [52,53].

In the digital healthcare ecosystem, tech-driven and tech-enabled startups have diffident kinds of offerings to serve consumers. Tech-enabled telehealth startups offer online information exchange opportunities for healthcare providers and consumers. Provider interaction platforms are a secure portal for various communications among healthcare professionals, including clinicians and paramedical staff. Similarly, a consumer interaction platform enables one healthcare seeker to interact with another having similar health issues. Information exchange and interaction assist in e-learning, healthcare guidance, resource identification, and many other benefits for different stakeholders of telehealth startups, especially patients and clinicians [39]. It opens the opportunity for innovation in a multi-sided market for more inclusive services.

Identified telehealth startups utilized the internet and smartphone technology along with emerging high-tech for their innovation. *HealthForMe*, a startup, has used low-cost mobile technology to enable ease-of-use teleconsultation at remote locations for the underprivileged community [39]. *PatientsLikeMe* and *My referrals* have facilitated all the services through their smartphone-friendly solutions. Therefore, it is worth noting that the internet and smartphone integration with high-tech significantly impacts the healthcare service innovation developed by telehealth startups.

Due to several challenges, telehealth startups struggle to meet conventional healthcare costs, which impacts their sustainable innovation and commercialization. An analysis showed that myo-feedback teletreatment was more expensive than traditional treatment because of the IT investment and operational cost. Labor cost savings could not compensate for the additional IT costs [36]. Despite the product or process innovation, it may be assumed that telehealth startups face barriers in revenue generation due to service or product cost confrontation in value capture. From the consumers' perspective, the literature also pointed to additional hardships every startup faces, such as ease of use, trust, data privacy, and so on [54].

Some directions were found in business models to address such challenges, but telehealth startups' innovations and commercialization directions were limited [7,23]. Therefore, considering innovation and its commercialization perspective, a conceptual framework is proposed from the underlying relationships analyzed from the articles (Fig. 2). The framework can aid the key stakeholders for telehealth startups' sustainable innovation and commercialization in evolving digital health ecosystem.

Our analysis identified that the value perspective could be significant in innovation and commercialization in the digital healthcare ecosystem. Consequently, our proposed framework can support key stakeholders for telehealth startups' sustainable innovation and commercialization in evolving digital health ecosystem through three threads- value proposition, value creation or transfer, and value capture.

This work strictly followed the PRISMA 2020 guidelines for conducting the systematic review. The study is also registered in The International Prospective Register of Systematic Reviews [Reg. No. CRD42021254771], ensuring the work process's robustness. The included articles' quality was confirmed using the Mixed Methods Appraisal Tool. To downplay the possibility of bias and information overlooking in qualitative analysis, one author (IC) extracted the data from existing literature, and other authors (SE, VI) verified them. Additionally, Cohen's K value ensured the reliability of the synthesis. However, this study has some methodological limitations. The review only considered the papers that were written in English. There could be some significant publications in other languages. Though the review is interdisciplinary and exhaustive coverage of ten different bibliographic databases, grey literature was not covered. Trade magazines can be a good source of insights on the telehealth space.

The study has practical implications regarding telehealth innovation, entrepreneurship, and policymaking. The data protection and interoperability aspect of the intended innovation should be considered before

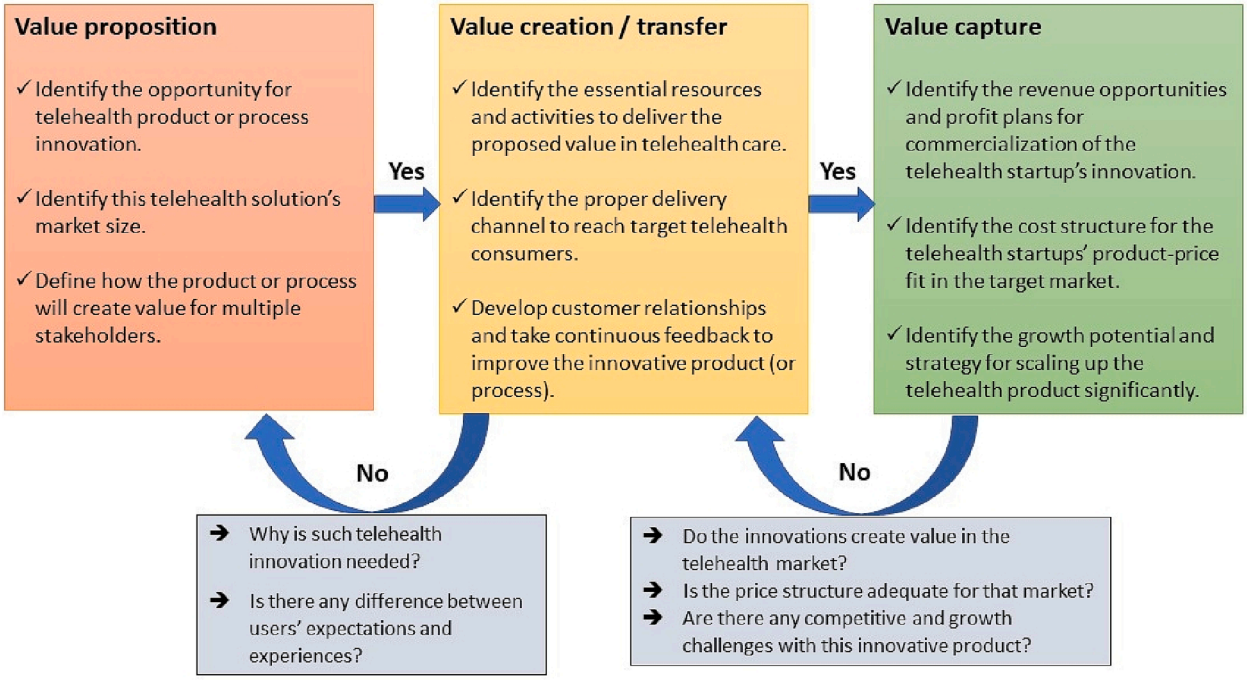

Fig. 2. Framework of telehealth startups' sustainable innovation and commercialization.

commercialization. High-tech innovation of telehealth startups should be ease-of-use and cost-effective for the target digital health market. Instead of generalized solutions, entrepreneurs should identify the opportunity in specialized care for a specific group, for instance, pediatric, female health, and aged care services, as there could be open markets for innovation, especially in digital therapeutics and wearable devices. The proposed framework should direct the telehealth innovators for their innovation potential and commercialization aspects. Besides, investors and incubators of telehealth startups should identify innovation potential for investments and provide support for better outcomes. Policymakers should encourage telehealth startups as they fill accessibility, affordability, quality, and equity gaps through innovations and offer aid to innovators to ramp up successful commercialization in evolving digital health ecosystem.

5. Conclusion

Existing telehealth startups have set up a significant position in the digital healthcare ecosystem. Besides online consultation and electronic records, telehealth startups are expanding on specialized services such as teleorthopedic, teledermatology, and telemental health services, including digital therapeutics, wearable devices for health monitoring, and AI-driven personalized care. Smartphones are the most effective communication channel for providing services. Albeit telehealth startups are emerging, but technological, financial, and legal challenges hinder their innovation and commercialization in the digital healthcare space. Value proposition, creation, and capture give some systematic direction to telehealth startups' sustainable innovation and commercialization. Further, high-quality research is indispensable to exploring the sustainable innovation of telehealth startups and their value aspect in the digital healthcare marketplace.

Appendix A

Summary table.
What was already known on this topic.

- Telehealth startups in filling healthcare gaps.
- Telehealth startups are booming, and potential market opportunities.

What this study added to our knowledge.

- This review identified the emerging dimensions of telehealth startups.
- The predominant services of telehealth startups and their challenges in digital healthcare.
- Telehealth startups' sustainable innovation and commercialization can be accomplished through the systematic direction of value proposition, creation, and capture.

CRediT authorship contribution statement

Imon Chakraborty: Conceptualization, Data curation, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Sisira Edirippulige:** Conceptualization, Supervision, Validation, Writing – review & editing. **P. Vigneswara Ilavarasan:** Supervision, Conceptualization, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Model	General description	Studies	Context in the study
Resource-Based View (RBV)	It is a framework utilized to examine an organization's strategic resources to attain a sustainable competitive advantage.	Emilsson et al., 2020	Used RBV in the context of innovation in telehealth venture firms. The study conceptualized resource as an appropriate element for innovation.
Value, Interface, Service, Organizing model, Revenue (VISOR)	VISOR comprises a value proposition for target consumers, an Interface, Service platforms to enable delivery, an Organizing model for process and relationships, and a Revenue model for cost calculation of all the partners.	Florescu and Florescu, 2020	Utilized the components of VISOR to explore the business model of a tech-driven telehealth startup.
Service, Technology, Organization, Finance (STOF)	STOF is a business model composed of four main concepts- Service domain, Technology domain, Organization domain, and Finance domain; these domains are interlinked and together create value for providers and consumers.	Kijl et al., 2011	To explore one tech-driven telehealth startup's business model for value creation and examine it under three dynamics- market, technology, and regulations.
		Wass and Vimarlund, 2016	Discussed the STOF model with a case study of a telehealth startup and highlighted the societal value addition to providers' and consumers' values.
Osterwalder Business Canvas	Osterwalder's business canvas is a business model composed of nine elements- Key partners, Key activities, Key resources, Proposed value, Customer relationships, Channels, Customer segments, Cost structure, and Revenue stream.	Sprenger and Mettler, 2016	Investigated tech-enabled and tech-driven telehealth startups' business models and demonstrated value creation, delivery, and capture perspectives.
		Vannieuwenborg et al., 2017	To identify the values of telehealth startups and platforms. Evaluated the go-to-market strategy of those values and discussed them.
		Furstenau et al., 2021	To demonstrate a tech-enabled telehealth startup case study.
e3(Economic – Energy – Environment) value approach	e3 value consists of a few concepts- Actors, Market segments, Value objects, Value ports, Value interface, and Value exchange.	Hermes et al., 2020	Explored nine telehealth startups and their digitization aspects in the healthcare industry using the e3 value approach.
Ash Maurya's Lean Canvas	A business model consists of nine elements- Problem, Solutions, Key metrics, Unique value propositions, Unfair advantages, Channels, Customer segments, Cost structure, and Revenue stream.	Kho et al., 2020	To explore the building blocks of digital health startups in the mobile tele-dermatology space.
Responsible Innovation	It can be conceptualized as the stakeholders' strategy to enhance and share the responsive nature for innovative outcomes while dealing with challenges.	Iakovleva et al., 2021	Investigated user empowerment in the telehealth startups' innovation process and explained the responsible innovation under four dimensions- Anticipation, Reflection, Inclusivity, and Responsiveness.
Focus, growth management, development and delivery, network management	Configuration perspective of business growth, stages of growth or lifecycle are conceptualized as focus, growth management, development, and networking management.	Muhos et al., 2019	Identified nine priority areas to investigate the configuration perspective of telehealth startups' growth.
Design science research approach	A scientific approach contains six phases: problem identification and motivation, objectives of a solution, design and development, demonstration, evaluation, and communication.	Sprenger., 2016	Utilized the approach to explore the telehealth startups' business model patterns for healthcare services.

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