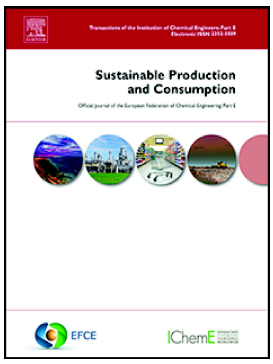

Telemedicine for innovation and sustainability: Social life cycle assessment (S-LCA) from the healthcare system perspective

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Telemedicine for Innovation and Sustainability: Social Life Cycle Assessment (S-LCA) from the Healthcare System Perspective

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Abstract

Telemedicine has rapidly transitioned from a peripheral innovation to a structural component of contemporary healthcare systems, particularly in the wake of the coronavirus disease 2019 pandemic. Although its environmental and clinical benefits have been extensively documented, its social sustainability impacts remain significantly underexplored, especially for internal stakeholders, including clinicians, administrative staff, caregivers, and the surrounding community. This study responds to this gap by applying the new ISO 14075:2024 standard for Social Life Cycle Assessment (S-LCA) to a real-world telemedicine program implemented at ASST Bergamo Est, one of the most advanced public healthcare organizations in Lombardy, Italy.

We operationalized ISO 14075 using a performance-based Social Life Cycle Performance Assessment (S-LCPA), integrating organizational records, staff interviews, user data, regional statistics, and peer-reviewed telemedicine evidence-derived qualitative, semiquantitative, and quantitative indicators. Six social impact categories, including access to care, quality of life and well-being, working conditions, community development, privacy and data security, and ethics and responsible innovation, were evaluated across four stakeholder groups: patients and caregivers, healthcare professionals, the healthcare organization, and the local community.

To structure the assessment, we developed five-level Performance Reference Points (PRPs) consistent with ISO 14075 and the Subcategory Assessment Method. Results revealed high institutional maturity in organizational governance, data protection, and the structural integration of telemedicine across multiple specialties (PRPs 3–4). However, several domains, including digital inclusion (PRP 2), community-level co-benefits (PRP 2), and patient-reported outcome measures (PROMs) (e.g., comfort, therapeutic adherence, and satisfaction [PRP 1]), remained underdeveloped. These asymmetries reflect broader patterns in the telemedicine sustainability literature, where governance infrastructures advance faster than the systematic measurement of social outcomes.

The findings demonstrate that ISO 14075 can be operationalized in a complex healthcare service and provide a replicable model for organizational S-LCA in digital health. This study concludes with methodological recommendations, including the significance of telemedicine-specific PROMs, routine digital inclusion metrics, and integration of S-LCA within regional planning and quality-improvement frameworks. As telemedicine becomes embedded in hybrid models of care, social sustainability assessment is crucial for supporting more equitable, ethical, and socially resilient digital transformation.

Keywords

Social Life Cycle Assessment, ISO 14075, digital inclusion; patient-reported outcome measures; organizational maturity; healthcare governance

1. Introduction

Healthcare systems worldwide are experiencing structural pressures stemming from three converging dynamics: demographic aging, the growing prevalence of chronic conditions, and the need to align health service delivery with environmental and social sustainability principles. Population aging is accelerating globally, with the number of individuals aged ≥60 years anticipated to substantially increase by 2050, whereas noncommunicable diseases continue to account for the largest share of global mortality and morbidity (World Health Organization, 2025a; World Health Organization, 2025b; GBD 2021 Forecasting Collaborators, 2024). Simultaneously, healthcare systems are

increasingly required to reduce their environmental footprint and contribute to climate-resilient, low-carbon, and socially inclusive care models (Health Care Without Harm and Arup, 2019; World Health Organization, 2023; Hussain et al., 2024; Messmann et al., 2024).

These demographic, epidemiological, and sustainability-related pressures expose the limitations of conventional hospital-centered care models. Conventional service delivery frequently relies on repeated physical access to healthcare facilities, potentially increasing travel burdens for patients and caregivers, reinforcing geographical inequalities, and placing added pressure on clinical infrastructure and staff. In this setting, healthcare systems are progressively moving toward distributed, digitally supported, and hybrid models of care that can maintain service quality and improve accessibility, efficiency, and resilience.

Telemedicine has become a relevant enabler of this transformation. It is widely recognized as the remote delivery of healthcare services through digital communication technologies, including real-time clinical encounters, remote monitoring, professional consultation, and remote support to patients or caregivers (Haleem et al., 2021; Barbosa et al., 2021; Lindenfeld et al., 2023; Shende and Wagh, 2024). Although telemedicine had been explored for several decades, its adoption considerably accelerated during and after the coronavirus disease 2019 (COVID-19) pandemic, when remote care became a crucial service continuity and healthcare resilience component (VanderWerf et al., 2022; Ezeamii et al., 2024).

In this study, four telemedicine modalities are considered relevant to the case of ASST Bergamo Est: televisits, teleconsultations, telemonitoring, and teleassistance. These modalities reflect established classifications in the telemedicine literature and are particularly vital for chronic disease management, follow-up care, primary care, and specialist support across geographically dispersed territories (Barbosa et al., 2021; Haleem et al., 2021; Lindenfeld et al., 2023; Anawade et al., 2024). Their definitions and main applications are summarized in Table 1.

Table 1. Core telemedicine modalities considered in this study (adapted from established telemedicine classifications and definitions in the literature; Haleem et al., 2021; Barbosa et al., 2021; Lindenfeld et al., 2023; Shende and Wagh, 2024)

Modality	Definition	Primary applications
Televisit	Real-time audiovisual clinical encounter between patient and clinician	Follow-ups, chronic disease management, prescription renewal, and mental health
Teleconsultation	Remote clinician-to-clinician advice (synchronous or asynchronous)	Triage support, specialist review, and multidisciplinary case discussions

Modality	Definition	Primary applications
Telemonitoring	Continuous or scheduled transmission of physiological data from home devices	Chronic disease monitoring, post-acute follow-up, and early decompensation detection
Teleassistance	Real-time remote support provided by healthcare personnel to patients or caregivers during clinical or care-related activities	Nursing guidance, rehabilitation, and device-assisted examinations

Telemedicine may yield positive and negative social implications across stakeholder groups. For patients and caregivers, it can enhance access to care and reduce travel-related burdens; however, it may also reinforce digital exclusion or heighten reliance on caregiver mediation. For healthcare professionals, telemedicine can support flexible service delivery and new digital competencies, while also introducing workload redistribution, technostress, and workflow fragmentation. At the organizational level, remote care may strengthen resilience and innovation capacity; however, it also increases governance, interoperability, and data protection requirements. Finally, local communities may benefit from reduced mobility-related externalities; however, these benefits demand systematic monitoring to be demonstrated.

The adoption of a structured Social Life Cycle Assessment (S-LCA) framework that can assess service deployment, social performance, equity, working conditions, governance, and community-level effects is justified by these stakeholder-specific implications.

From a clinical and organizational viewpoint, telemedicine may enhance access to care, support continuity for chronic patients, diminish unnecessary visits, and facilitate more flexible service delivery models (Sicotte et al., 2011; Roberts et al., 2012; DeHart et al., 2022; Rahman and Rahman, 2024). However, expanding telemedicine also raises critical social sustainability challenges, including digital exclusion, unequal access to devices and connectivity, caregiver mediation reliance, changes in professional workload, technostress, data protection concerns, and possible transformations of the therapeutic relationship (Arora et al., 2024; DeHart et al., 2022; Zammit et al., 2023; Mir et al., 2024).

Despite the multidimensional significance of telemedicine, its social dimension remains less systematically assessed than its clinical, economic, and environmental dimensions. Instead of adopting a standardized framework capable of evaluating social performance across stakeholder groups and organizational processes, existing studies have frequently centered on isolated indicators, including access, patient satisfaction, time savings, or avoided travel costs (Papavero et al., 2023; Savoldelli et al., 2024b; Messmann et al., 2024). This scenario restricts the ability of healthcare organizations to determine social hotspots, compare performance over time, and integrate social sustainability into quality-improvement and strategic planning.

Existing telemedicine studies have provided valuable evidence on specific social dimensions, including access to care, patient satisfaction, time savings, caregiver burden, professional workload, and environmental co-benefits. However, this evidence remains fragmented across indicators, clinical domains, and stakeholder groups, and is infrequently organized through a standardized social life cycle framework. In S-LCA, stakeholder selection is inherently context-specific and should reflect the structure of the product or service system being evaluated. Therefore, this study does not address the absence of stakeholder consideration in telemedicine research but the lack of an ISO 14075-aligned approach capable of systematically selecting, documenting, and assessing stakeholder-relevant social performance categories within a real-world organizational telemedicine system.

S-LCA offers a suitable methodological basis for addressing this gap. It extends the life cycle perspective to social and socio-economic impacts influencing stakeholders along the life cycle of a product, process, or service. Compared with environmental LCA, which focuses on physical flows (e.g., emissions, energy, and materials), S-LCA evaluates how activities impact individuals, organizations, and communities. The recent publication of ISO 14075:2024 represents a crucial step toward S-LCA standardization, offering a formal framework aligned with the ISO 14040/44 life cycle approach. In particular, ISO 14075 enables impact pathway-based Social Life Cycle Impact Assessment and performance-based Social Life Cycle Performance Assessment (S-LCPA). S-LCPA is particularly relevant for complex service systems, including healthcare, where social outcomes are frequently context-dependent, partly qualitative, and challenging to model through linear causal pathways.

Telemedicine represents a particularly significant field for implementing ISO 14075 as it reorganizes associations among patients, caregivers, clinicians, administrative staff, healthcare organizations, technology infrastructures, and local communities. Therefore, the social performance of telemedicine cannot be assessed solely by counting remote visits or estimating avoided travel but also necessitates consideration to whether digital services are accessible to users with frailty or older adults, whether clinicians are sufficiently trained and supported, whether privacy and ethical governance are institutionalized, and whether community-level benefits are monitored. Therefore, a performance-based S-LCA approach can assist in discriminating between institutional readiness, operational implementation, and realized or indicative social outcomes.

This study applies ISO 14075:2024 to the telemedicine services delivered by ASST Bergamo Est, a public healthcare organization located in Lombardy, Italy. ASST Bergamo Est caters a heterogeneous territory, encompassing urban, semi-rural, and mountain areas, where aging, chronicity, and mobility constraints make remote care particularly relevant. Its telemedicine ecosystem comprises televisits, teleconsultations, teleassistance, and telemonitoring across various specialties, supported by a

dedicated telemedicine unit and integrated with regional digital health infrastructures, including the "Fascicolo Sanitario Elettronico" (FSE; electronic health record [EHR]), the Italian digital health record system employed for accessing and sharing clinical documents and care-related information within national and regional healthcare systems. Therefore, the case offers an information-rich setting for exploring how ISO 14075 can be operationalized in an advanced real-world healthcare organization.

This study has methodological and empirical contributions. Methodologically, it operationalizes ISO 14075 through a performance-based S-LCPA framework tailored to telemedicine services. Empirically, it applies this framework to a real-world healthcare organization, incorporating organizational data, interviews, governance documents, regional statistics, and literature-based evidence. This study aims to assess organizational maturity and indicative social performance across relevant stakeholder groups rather than demonstrating causal social impacts of telemedicine.

Accordingly, the following are the study objectives: to (1) operationalize ISO 14075 in a digital healthcare context; (2) define a stakeholder-based Social Life Cycle Inventory (S-LCI) for telemedicine services; (3) assess social performance through five-level Performance Reference Points (PRPs); (4) recognize social hotspots and improvement priorities; and (5) discuss the implications of S-LCA for governance, digital inclusion, workforce organization, and sustainability planning in hybrid healthcare systems.

The remainder of the paper is organized as follows. The materials and methods, including the case study, goal and scope definition, system boundaries, stakeholder selection, data sources, and PRP-based scoring procedure, are discussed in Section 2. The S-LCI and S-LCPA results are reported in Section 3. The findings in relation to governance maturity, stakeholder outcomes, methodological transferability, and practical implications are presented in Section 4. The summary of the main contributions, limitations, and directions for future research is tackled in Section 5.

2. Methods

This section operationalizes the ISO 14075 S-LCA framework for the telemedicine services provided by ASST Bergamo Est.

The integration of stakeholder groups (patients and caregivers, healthcare professionals, healthcare organization, and local community) within the telemedicine program of ASST Bergamo Est is illustrated in figure 1. A performance-based S-LCPA approach using five-level PRPs was employed for assessing social performance. This performance-based approach was adopted as linear causality is challenging to demonstrate in the healthcare services sector, rendering the use of S-LCPA more effective and robust. Several data sources, including interviews, organizational records, and literature,

support the S-LCI. Six social impact categories, encompassing access, quality of life, working conditions, community development, data protection, and ethics, structured the assessment. The framework facilitated the identification of social hotspots and organizational maturity in telemedicine services.

Following the standard, the methodology was structured into four major phases:

1. Goal and Scope Definition
2. S-LCI
3. S-LCPA
4. Interpretation

2.1. Goal and Scope Definition

The goals of this study were to apply a complete ISO 14075-conformant S-LCA to the telemedicine services delivered by ASST Bergamo Est; generate a stakeholder-based social performance profile using S-LCPA; evaluate strengths, weaknesses, and improvement priorities in the social sustainability of telemedicine; and yield a replicable methodology for digital healthcare assessment. No public comparative assertions were made; results were intended for internal improvement and academic dissemination.

The ASST Bergamo Est telemedicine governance team, hospital management and strategic planning units, and regional health-system policymakers constituted the primary users.

Academic researchers in S-LCA, digital health, sustainability, healthcare professionals, and community stakeholders were the secondary users.

Consistent with ISO 14075, the functional unit was defined as: one service year of telemedicine delivered by ASST Bergamo Est (e.g., televisits, teleconsultations, teleassistance, and telemonitoring). This definition generated a stable temporal basis for normalizing inputs and outputs.

The reference flow encompassed all organizational, technological, human, and digital resources required to deliver 1 year of telemedicine: platform licenses and updates, network/cloud services and cybersecurity systems, patient devices and clinical peripherals, clinician and staff time, training activities, governance, reporting, and data protection processes.

The activity variable was the total number of telemedicine services delivered in the reference year. For 2024, it accounted for 3,304 services (televisits, teleconsultations, teleassistance, telemonitoring).

The reference year adopted was 2024 as it represents the most recent complete year for which consolidated organizational data were available during the assessment. Moreover, 2024 reflects a post-emergency phase of telemedicine implementation, following the rapid expansion associated with the COVID-19 pandemic, and therefore offers a more stable basis for assessing routine service delivery rather than temporary crisis-driven adoption. Aligning with the functional unit, all PRP scores referred to the maturity and performance of the telemedicine service in 2024. Data from 2022 to 2023 were utilized only as contextual trend information to describe the organizational trajectory leading to the 2024 configuration and were not used as alternative reference years. For example, changes in the number of enabled staff between 2022 and 2023 were reported to document the institutionalization process of telemedicine before the 2024 reference year.

System boundaries, figure 2, encompassed the complete telemedicine service cycle:

A. Upstream

- Platform acquisition and maintenance
- Device procurement
- Connectivity infrastructure
- Staff training
- Cybersecurity systems
- Vendor services

B. Core Processes

- Scheduling
- Televisit execution
- Teleconsultation (specialist–specialist or GP–specialist)
- Teleassistance (remote nurse/clinician support)
- Telemonitoring (device-based remote measurement)
- Documentation and EHR integration
- Clinical decision-making

C. Downstream

- Data storage and archiving
- Technical assistance
- End-of-life of devices
- Organizational reporting
- Quality monitoring

2.2. Exclusions

The following were excluded in accordance with ISO guidelines: research-only telemedicine pilots not part of routine service, nonhealthcare digital services (e.g., administrative portals), and emergency telemedicine used during crisis peaks (nonrepresentative). This exclusion referred only to experimental or research-only pilots that were not embedded in routine clinical service delivery. Operational pilots or transitional telemedicine pathways implemented within ASST Bergamo Est and involving real service delivery were only considered contextual internal evidence when relevant to document service maturity or patient-reported outcomes. External pilots and analogous telemedicine programs reported in the literature were not included in the foreground system boundaries; they were exclusively used as secondary contextual evidence where local routine indicators were unavailable.

Following ISO 14075 and UNEP Guidelines (2020), stakeholders were selected on the basis of relevance, social influence, and expected exposure to impacts. Four stakeholder groups were included (Table 2).

Table 2. Stakeholder groups included in the S-LCA

Stakeholder group	Rationale for inclusion
Patients and Caregivers	Direct beneficiaries/users; impacts on access, well-being, and equity
Healthcare professionals	Telemedicine alters workload, skill requirements, and stress
ASST organization	Responsible for governance, data protection, training, and ethics
Local community	Impacted by traffic, emissions, mobility patterns, and inclusiveness

The excluded stakeholders (e.g., upstream IT vendors) were not assessed owing to the lack of direct influence within ASST's control. Building on ISO 14075 and UNEP S-LCA Guidelines, six social impact categories and 14 subcategories were defined. The inclusion of carbon dioxide (CO_2) reduction, traffic, and pollution-related indicators within the community development category

necessitated elucidation. These indicators were not intended to represent a full environmental Life Cycle Assessment nor were they treated as environmental impact categories in the strict LCA sense. Rather, they were included as community-level co-benefits and territorial externalities associated with reduced mobility for healthcare access. In the setting of telemedicine, avoided patient and caregiver travel could impact local communities through reduced congestion, lower exposure to traffic-related pollutants, and enhanced territorial accessibility. Therefore, from a social sustainability perspective, these indicators were interpreted as indirect effects on community well-being and local quality of life. Their assessment remains indicative and proxy-based, and the results should not be interpreted as a substitute for a dedicated environmental LCA.

We utilized a mixed-methods approach consistent with ISO 14075. The primary data encompassed: interviews with clinicians, nurses, and administrative staff; organizational telemedicine records (2022–2024); training participation logs; governance and privacy documentation; and patient transport and scheduling data (when available). The secondary data included: ISTAT digital inclusion statistics, peer-reviewed telemedicine studies, environmental factors for CO_2 estimation, regional Air Quality Report (Arpa Lombardia, 2024), and literature on staff stress and digital burden.

A structured content-mapping approach was employed for reviewing interview notes. Relevant statements were mapped to the predefined S-LCA categories and used for triangulating evidence from organizational records, governance documents, and literature. The interviews were not intended to yield a standalone qualitative study but to support the interpretation of organizational maturity and stakeholder-relevant implementation issues.

Following ISO 14075, explicit transparency was ensured regarding several major methodological aspects. Temporal representativeness covered the period 2022–2024. The year 2024 was adopted as the reference year for the functional unit and PRP assessment, whereas 2022–2023 data were solely utilized for contextualizing the organizational development and stabilization of telemedicine services. Historical information before 2022 was exclusively employed when necessary for describing the organizational development of the telemedicine service and was excluded from the temporal boundary used for PRP scoring. The geographical scope of the assessment was the service territory of ASST Bergamo Est, located within Lombardy, Italy. Lombardy provided the institutional and regulatory context; however, the results referred only to the ASST Bergamo Est catchment area and were not intended to represent the entire regional healthcare system. Data completeness was considered high, medium, and low-to-medium for governance-related indicators, patient-reported outcome measures (PROMs), and digital inclusion metrics, respectively. The harmonization of

indicators helped maintain methodological consistency, whereas uncertainty was qualitatively documented, particularly regarding variability in the available evidence on PROMs. PRPs and S-LCPA. PRPs enable integrating heterogeneous evidence, comparing social performance across categories, and identifying social "hotspots," aligning with ISO's reference-scale requirement. The PRP model uses five ordinal levels (0–4), which describe the maturity of social performance, not its quantity.

Table 3. PRP levels (general definition)

PRP level	General meaning
0	No evidence, not in place, and nonexistent
1	Ad hoc or pilot activity, unstructured, and episodic measurement
2	Structured foundations, partial implementation, and incomplete metrics
3	Routine program, organization-wide adoption, and regular monitoring
4	Program with verification, audited indicators, and institutionalized continuous improvement

The levels shown in

Table 3 are NOT linear and do not imply proportional improvements. They represent degrees of organizational maturity, as per ISO 14075.

2.3 PRP scoring procedure and reproducibility

For improved transparency and reproducibility, a structured evidence-based procedure was used for assigning PRP scores. For each subcategory, all available evidence was initially mapped according to the S-LCI and classified into four evidence types: (1) primary ASST data, including routine organizational records and interviews; (2) internal ASST contextual evidence, encompassing operational pilot data when associated with real service delivery; (3) external literature evidence from comparable telemedicine programs; and (4) proxy estimates or assumptions. When assigning PRP scores, primary ASST data and internal organizational evidence were prioritized over external literature and proxy estimates. External evidence and proxy assumptions were solely utilized for supporting interpretation, assessing uncertainty, or justifying conservative scoring where local routine data were unavailable.

The research team assigned each PRP score through a two-step process. First, the available evidence for each subcategory was reviewed against the five-level PRP scale. Second, a consensus meeting involving the authors with expertise in S-LCA, healthcare service assessment, and telemedicine implementation discussed the proposed score. Disagreements were resolved through discussion until consensus was reached. As the scoring was not based on independent blind ratings but on a consensus-based expert assessment, no formal statistical inter-rater reliability coefficient was calculated, which is acknowledged as a methodological limitation.

The scoring followed predefined decision rules. A score of PRP 0 was assigned when evidence or practice was absent. PRP 1 was designated when evidence was episodic, pilot-based, no standardized, or mainly derived from external/analogous cases. PRP 2 was allocated when structured foundations existed but implementation was partial, indicators were incomplete, or monitoring was not routine. PRP 3 was assigned when practices were routinely implemented across the organization and supported by regular internal monitoring. PRP 4 was assigned only when practices were institutionalized, formally documented, periodically verified, or supported by audited indicators and continuous improvement mechanisms.

Rather than numerical aggregation, a weight-of-evidence logic was used for integrating qualitative and quantitative evidence. Quantitative indicators, including the number of services, number of active specialties, enabled staff, time–use estimates, or emission factors, were employed for documenting the existence and scale of practices. Qualitative evidence, including interviews, governance documents, and literature-based interpretation, was utilized for assessing institutionalization, stakeholder relevance, and implementation maturity. The score was conservatively assigned when evidence was conflicting or heterogeneous across sources, prioritizing local routine data and minimizing the PRP level when evidence was indirect, noncomparable, or not systematically collected.

The S-LCI compiles all social data pertinent to the telemedicine service for the reference year (2024), organized by stakeholder group, impact category, subcategory, and indicator. The S-LCI aligns with ISO 14075 requirements for data source transparency, documentation of assumptions, explicit linkage to stakeholder concerns, representation of qualitative and quantitative evidence, and traceability to the functional unit (one service year). Evidence was categorized into four types to avoid ambiguity: (1) primary ASST data, encompassing routine organizational records and interviews; (2) internal ASST contextual evidence, including operational pilot data when associated with real service delivery; (3) external literature evidence from comparable telemedicine programs; and (4) proxy

estimates or assumptions. Only categories (1) and (2) were considered internal evidence, whereas categories (3) and (4) were used for supporting interpretation and uncertainty assessment Table 4.

Table 4. S-LCI indicators: definition, unit, stakeholder, and data source

Category	Subcategory	Indicator	Unit/Metric	Stakeholder	Evidence type and data source
Access to care	Geographic accessibility	Telemedicine reach (specialties, services, and operators)	Count, % change	Patients and caregivers	ASST activity data 2022–2024
	Digital inclusion	Internet access baseline, device availability, and caregiver mediation	% households 65+ with internet and qualitative	Patients and caregivers	ISTAT 2024, interviews, and literature
Quality of life and well-being	Travel burden	Avoided travel time and cost	min/visit; €/visit	Patients and caregivers	S-LCA study and transport assumptions
	Comfort and adherence	Evidence of adherence improvement and UX perceived ease	qualitative score	Patients and caregivers	Peer-reviewed Italian cases
	Patient satisfaction	Usability/satisfaction scores	Likert/perceived	Patients and caregivers	Local pilots and analogous studies
Working conditions	Skills and training	Trained staff, training hours, and telemedicine team growth	Count and hours	Healthcare professionals	PIAO, logs, and interviews
	Workload	Clinician time per televisit and perceived change	Minutes and qualitative	Healthcare professionals	Interviews and operational times
	Stress	Perceived stress sources and digital burden	Qualitative	Healthcare professionals	Interviews and PIAO well-being initiatives
Community development	Mobility-related CO_2 co-benefit	Proxy estimate of avoided mobility-related emissions as community co-benefit	kg CO_2/visit and annual total	Local community	LCA literature factors
	Traffic and pollution-related community externalities	Proxy evidence of reduced mobility pressure and traffic-related community burden	Qualitative	Local community	Travel Burden links; ARPA 2024
Privacy and data security	Confidentiality	Existence of DPO, protocols, breach mgmt, and transparency	PRP maturity	ASST	Governance documents

Category	Subcategory	Indicator	Unit/Metric	Stakeholder	Evidence type and data source
Ethics and innovation	Fair practices and responsible innovation	Inclusivity metrics, digital access enablers, and anti-corruption	PRP maturity	ASST	PIAO and governance reports

PRP use aims not to quantify causal social influences but to assess the maturity and institutionalization of social practices within the telemedicine service. Consistent with ISO 14075, the PRP-based S-LCPA offers a transparent and replicable approach for complex service systems, where social outcomes are context-dependent and cannot be reliably modeled through linear cause–effect chains. This methodological choice enables social hotspot and governance gap identification and maintains consistency with international S-LCA standards.

3. Results and discussion

The findings of the S-LCA and S-LCPA conducted for the telemedicine services at ASST Bergamo Est are presented in this section. Results are organized according to the ISO 14075 framework and mirror the stakeholder–category–subcategory architecture established in Section 3. The findings are structured in four parts: S-LCI narrative (stakeholder-by-stakeholder), assignment of PRP scores, summary table of PRP levels (Table 7), and graphical interpretation and social hotspots. Throughout the Results section, evidence is explicitly interpreted according to its source type. Routine ASST Bergamo Est organizational data-based findings are distinguished from internal contextual evidence, external literature evidence, and proxy estimates or assumptions. Only routine ASST data are interpreted as local observed outcomes, whereas external and proxy evidence are utilized for supporting interpretation and conservative PRP scoring.

3.1. Patients and caregivers

3.1.1. Geographic accessibility

In the 2024 reference year, telemedicine deployment at ASST Bergamo Est demonstrated robust territorial penetration, with 30 specialties active on the enterprise telemedicine platform, 3,304 telemedicine services delivered to 3,020 patients, and 74.8% of the patients aged ≥65 years, corroborating the significance of the service for groups with frailty. Contextual trend data further revealed that the number of enabled staff increased from 33 operators in 2022 to 114 in 2023, documenting the organizational consolidation that preceded the 2024 assessment year. However, the PRP score was assigned on the basis of the 2024 service configuration and maturity. These aspects indicate a routine multispecialty service with stable governance, consistent with a PRP 3 level.

3.1.2. Digital inclusion

Evidence suggests the following: approximately 60.6% of households in Italy aged ≥65 years have home internet access (ISTAT 2024), older adults still experience substantial device- and usability-related challenges, caregiver mediation is common and frequently crucial, no structured institutional reporting on digital inclusion exists at ASST Bergamo Est, onboarding activities exist but lack stratified KPIs, and digital inclusion thus remains at PRP 2 (structured foundation).

3.2. Quality of life and well-being

3.2.1. Travel burden reduction

For the 2024 reference year, ASST Bergamo Est did not systematically collect local routine data on avoided travel time and costs. Therefore, this subcategory was assessed using proxy estimates derived from previous S-LCA modeling of a heart failure telemedicine pathway and standard transport assumptions. These estimates show a potential reduction in travel-related burden per visit, with average travel time decreasing from 195 to 49 min for patients and from 155 to 40 min for caregivers, and travel-related costs decreasing from €98.57 to €24.01 for patients and from €78.97 to €19.60 for caregivers. These values were treated as proxy evidence because they are modeled estimates rather than routinely observed ASST-wide outcomes. As avoided travel burden is not yet institutionalized as a routine annual indicator, this subcategory was assigned PRP 2.

3.2.2. Comfort and therapeutic adherence

In the 2024 reference year, routine local PROMs on comfort and therapeutic adherence were not available for ASST Bergamo Est. Therefore, evidence from comparable telemedicine programs in Italy was exclusively used as external contextual support, suggesting that remote monitoring can be associated with positive adherence and usability outcomes in similar clinical pathways. However, these results were not considered direct outcomes of the ASST Bergamo Est telemedicine service. The absence of standardized routinely collected local PROMs led to the assignment of PRP 1.

3.2.3. Patient satisfaction

In the 2024 reference year, patient satisfaction was not evaluated using a standardized organization-wide instrument. Available evidence comprised limited internal operational pilot data and external evidence from analogous telemedicine experiences. These sources were solely employed as contextual support and were deemed not equivalent to routine ASST-wide satisfaction monitoring. This subcategory was assigned PRP 1 as satisfaction measurement remains episodic, heterogeneous across tools, and noncomparable over time. Overall, results for patients and caregivers indicate that

telemedicine at ASST Bergamo Est is structurally effective in enhancing access and mitigating travel-related burdens, while remaining weak in systematically capturing patient-reported social outcomes. This finding suggests that service expansion has outpaced patient-centered measurement tool development.

3.3. Healthcare professionals

3.3.1. Skills and training

Training-related evidence for the 2024 reference year reveals that telemedicine skills development was embedded in organizational planning documents, with digital skills identified as a strategic priority in the PIAO and structured support available across the telemedicine service. Furthermore, interviews indicated some heterogeneity in training uptake across specialties. Historical information on the expansion of the telemedicine team from 5 to 15 members between 2020 and 2023 was exclusively utilized as contextual evidence of the organizational trajectory leading to the 2024 service configuration and was excluded from the temporal boundary of the S-LCA assessment. Overall, this subcategory was assigned PRP 3, reflecting a routine program with structured support but without formal certification or audited training outcomes.

3.3.2. Workload

Quantitative evidence suggests the following: televisit takes 12.2 min less than in-person consult; 3.14 h/week are dedicated to televisits per participating clinician; and 60%, 20%, and 20% of the participants report decreased workload, observe no change, and state increased workload due to bureaucratic duplication and limited interoperability, respectively. Considering structured time–use insight but incomplete routine analytics, this subcategory was assigned PRP 2.

3.3.3. Stress management

Findings underscored frustration caused by non-integrated applications, further administrative burden, stress associated with manual tasks required from clinicians, and organizational PIAO encompassing staff well-being initiatives but not telemedicine-specific tracking. Therefore, stress management was designated PRP 2.

For healthcare professionals, telemedicine exhibited intermediate social performance, with workload redistribution and digital stress partially offsetting benefits in skills development, emphasizing the significance of organizational integration rather than further technological expansion.

3.4. Local community

3.4.1. Mobility-related CO_2 co-benefit

This indicator was included not as a full environmental LCA impact category but rather as a community-level co-benefit associated with avoided healthcare-related mobility. Using literature-based emission factors, in-person follow-up was approximately 9.77 kg CO_2/visit, compared with approximately 0.41 kg CO_2/visit for a televisit. Based on approximately 3,300 services, this suggests an indicative annual avoided mobility-related emission of approximately 9,000 kg CO_2. However, these values are proxy estimates originating from standard factors rather than an internal environmental LCA procedure. This subcategory was assigned PRP 2 as no uncertainty analysis or routine organizational reporting is currently available.

3.4.2. Traffic and pollution

This indicator was considered an indirect community-level externality associated with diminished patient and caregiver travel. Decreased vehicle-kilometers may contribute to lower local-level congestion and traffic-related exposure, whereas ARPA Lombardia 2024 data provide contextual information on regional pollutants, including NOx, PM2.5, and PM10. However, to date, ASST Bergamo Est does not collect hospital-site traffic proxies, including parking occupancy, peak access flows, or local mobility data. Subsequently, this subcategory was assigned PRP 2 as the interpretation remains indirect and proxy-based.

3.5. *ASST Organization*

3.5.1. Confidentiality

Strong evidence: formal DPO role with defined responsibilities, updated privacy policy (May 2024), board-approved whistleblowing regulation (Delib. 556/2023), published access registers (“Registro degli Accessi”) updated biannually, and GDPR alignment across systems. This score reflects compliance and governance maturity rather than a directly measured stakeholder outcome, as perceived trust and user experience associated with data protection were not systematically evaluated.

3.5.2. Fair practices and responsible innovation

Evidence: PIAO 2024–2026 encompassed strategic telemedicine targets, quantified telemedicine expansion metrics (services, specialties, and staff), digital access enablers (FSE 2.0, CDA2 publication), and anti-corruption and transparency compliance; inclusion initiatives existed but lacked external auditing. Therefore, this category was assigned PRP 3.

The PRP results across all categories are summarized in Table 5.

Table 5. Summary of the maturity results across all categories

Stakeholder	Category	Subcategory	PRP score
Patients and caregivers	Access	Geographic accessibility	3
	Access	Digital inclusion	2
	QOL and well-being	Travel burden	2
	QOL and well-being	Comfort and adherence	1
	QOL and well-being	Satisfaction	1
Healthcare professionals	Working conditions	Skills and training	3
	Working conditions	Stress management	2
	Working conditions	Workload	2
Local community	Community development	CO_2 reduction	2
	Community development	Traffic and pollution	2
ASST organization	Privacy and data security	Confidentiality	4
	Ethics & innovation	Fair practices and responsible innovation	3

The radar chart synthesizes the findings across the six main social impact categories assessed using the S-LCPA, figure 3. Privacy and data protection emerged as the strongest dimension, achieving the highest performance level, reflecting a high degree of institutional maturity and regulatory compliance. Moreover, access to care and working conditions demonstrated a relatively strong performance, supported by the broad territorial deployment of telemedicine services and structured training initiatives for healthcare professionals.

Community development and workforce well-being displayed intermediate performance levels, indicating consolidated foundations while underscoring the significance of more systematic monitoring and institutionalization of benefits at the community-level. By contrast, the weakest performance was noted in patient-centered outcome dimensions, particularly comfort, therapeutic adherence, and satisfaction, which are currently assessed in an ad hoc and nonsystematic manner.

These results indicate misalignment between the organizational maturity of telemedicine services and the routine measurement of patient-reported social outcomes.

3.5.3. Social hotspots

Following ISO 14075, the S-LCPA facilitated the identification of social hotspots, defined as areas where social performance is comparatively weak, uneven, or inadequately institutionalized compared with the overall maturity of the service. No PRP 0 scores were observed in the present case study, indicating the absence of critical gaps or nonexistent practices. However, several domains consistently scored at PRPs 1–2, revealing priority areas for improvement as telemedicine transitions from an operationally mature service to a socially optimized one.

3.5.3.1. Hotspot 1: Patient-Reported Outcomes (PRP 1)

Patient-centered outcome dimensions, including comfort, therapeutic adherence, and satisfaction, demonstrated the weakest performance. Although indirect evidence from comparable telemedicine programs in Italy suggests positive effects on adherence and usability, ASST Bergamo Est does not yet implement telemedicine-specific standardized routine PROMs. Data collection remains episodic, heterogeneous across pilots, and noncomparable over time. Consequently, patient experience is inadequately captured despite the structural maturity of service delivery. This hotspot emphasizes misalignment between service expansion and the systematic measurement of lived patient experience.

3.5.3.2. Hotspot 2: Digital Inclusion (PRP 2)

Digital inclusion represented a structurally sensitive area, particularly considering the high proportion of older adults served by the telemedicine program. Although onboarding activities and caregiver mediation partially mitigated access barriers, digital inclusion was not monitored through stratified indicators (e.g., age, education, rurality, and device availability). The absence of routine KPIs restricted the organization's ability to detect exclusion risks or assess equity outcomes longitudinally. This hotspot is especially relevant from a social sustainability and health-equity perspective.

3.5.3.3. Hotspot 3: Workforce Stress and Bureaucratic Burden (PRP 2)

For healthcare professionals, interviews revealed that telemedicine-related stress was not principally driven by clinical complexity but by organizational friction, including platform fragmentation, manual scheduling, and data entry duplication. Although general staff well-being initiatives were in place, telemedicine-specific stressors were not systematically monitored or addressed through dedicated indicators. This hotspot suggests that further technological expansion without parallel organizational integration can aggravate workload-related stress.

3.5.3.4. Hotspot 4: Community-Level Monitoring (PRP 2)

Literature-based estimates and contextual environmental data supported community-level advantages, including decreased CO_2 emissions and traffic congestion. Current assessments remain preliminary estimates despite the establishment of a formal green team for implementing environmental improvements. The benefits were not institutionalized through internal monitoring systems or routinely reported at organizational level. Consequently, positive externalities remained indicative rather than measurable, restricting their integration into territorial sustainability planning.

Overall, these hotspots do not demonstrate service underperformance but rather reflect domains where social sustainability assessment has not yet achieved comparable level of institutional maturity as governance, data protection, and service deployment.

These indicators should be interpreted as community-level social co-benefits associated with diminished healthcare mobility, not as a substitute for a dedicated environmental LCA. Their low-to-intermediate PRP score indicates the lack of routine local monitoring rather than the absence of potential community benefits.

3.5.4. Strengths and emerging areas

S-LCPA results enabled the classification of social performance areas according to their degree of institutional maturity, offering a structured overview of strengths, emerging domains, and weakly developed aspects of telemedicine at ASST Bergamo Est.

3.5.4.1. Strengths (PRP 3–4)

Domains associated with organizational governance and structural service integration showed high social performance levels. Telemedicine demonstrated robust territorial accessibility, supported by multispecialty deployment and stable operational routines. Skills development and training for healthcare professionals were embedded within organizational planning instruments, albeit with some heterogeneity across specialties. Privacy, data protection, and transparency represented the most mature dimension, with audited procedures, formal accountability roles, and full alignment with GDPR requirements. Moreover, ethical governance and responsible innovation practices were well established, reflecting the institutional consolidation of telemedicine within strategic planning frameworks.

3.5.4.2. Emerging Areas (PRP 2)

Several domains exhibited structured foundations but lacked systematic measurement or full institutionalization. Digital inclusion, workforce workload analytics, and community-level

environmental co-benefits fall within this category. In these areas, relevant practices existed; however, indicators remained partial, indirect, or nonstandardized. These domains represent the most immediate opportunities for targeted improvement, as incremental investments in monitoring and integration could yield considerable gains in social sustainability performance.

3.5.5. Weak Domains (PRP 1)

The least developed aspects of social sustainability were concentrated in patient-centered experiential dimensions, including comfort, adherence, and satisfaction. The absence of standardized PROMs tailored to telemedicine prevented the routine capture of patient perspectives, despite evidence of service effectiveness in terms of access and efficiency. This weakness highlights the significance of complementing governance-driven digital transformation with human-centered design and outcome measurement.

Collectively, the findings demonstrated a structural asymmetry in the social sustainability of telemedicine: although ASST Bergamo Est exhibited high performance in "systemic sustainability" (Privacy, Ethics, and Governance), it revealed a lag in "lived sustainability" (Patient Comfort, Adherence, and Stress management). Governance, compliance, and organizational integration reached advanced levels of maturity, whereas patient-centered outcomes and equity-related dimensions remained weakly institutionalized. This finding suggests a "top–down" digital transformation where regulatory compliance and technological deployment have been prioritized over human-centered feedback loops. This asymmetry reflects a broader pattern in digital healthcare systems, where technological and regulatory infrastructures evolve faster than mechanisms for capturing lived social experience. The system is efficient in its "output" (e.g., the number of follow-ups); however, its "social quality" remains unoptimized. Addressing this disparity represents a crucial step toward socially resilient and equitable hybrid care models.

3.5.6. Governance maturity, operational implementation, and stakeholder outcomes

The need to distinguish between institutional readiness, operational implementation, and realized stakeholder outcomes represents a major methodological implication of the PRP-based S-LCPA. In this study, high PRP scores in categories, such as privacy, data protection, and responsible innovation, mainly reflect the maturity of governance structures, formal accountability mechanisms, compliance procedures, and organizational documentation. For example, the PRP 4 score assigned to confidentiality indicates that ASST Bergamo Est has institutionalized privacy-related responsibilities, procedures, and transparency mechanisms. However, this score should not be interpreted as direct

evidence indicating that all stakeholders experience improved trust, perceived security, or digital well-being.

By contrast, operational implementation denotes the extent to which telemedicine practices are routinely embedded in service delivery. Indicators, including the number of active specialties, the volume of telemedicine services, the availability of trained staff, and the integration of telemedicine into organizational planning, provide evidence that remote care has shifted beyond isolated experimentation. These indicators support intermediate-to-high PRP scores for geographical accessibility, skills development, and responsible innovation. Nevertheless, operational implementation does not automatically imply that all intended social benefits are realized across stakeholder groups.

Realized social outcomes denote the lived outcomes of telemedicine on patients, caregivers, healthcare professionals, and communities. These outcomes encompass patient comfort, therapeutic adherence, satisfaction, perceived ease of use, caregiver burden, professional stress, workload experience, digital inclusion, and community-level benefits. In the present case, these outcomes are less systematically measured than governance and implementation indicators. Therefore, patient-reported outcomes and several community- and workforce-related dimensions received lower PRP scores. This distinction explains why the strongest results of the assessment concern institutional and organizational maturity, whereas the weakest areas involve stakeholder experience and routine outcome monitoring.

Therefore, the findings suggest that ASST Bergamo Est has achieved a relatively advanced governance and operational maturity level in telemedicine; however, the measurement of realized social outcomes remains less institutionalized. This finding is crucial to interpreting the S-LCPA: high scores in compliance-related categories should be interpreted as evidence of organizational readiness and risk-control capacity, whereas lower scores in patient-, workforce-, and community-related categories reveal where additional monitoring is required for verifying whether telemedicine yields the intended social value in practice.

3.6. Limitations and transferability of the case study

The findings of this study should be interpreted in light of the characteristics of the selected case study. ASST Bergamo Est represents a relatively advanced and digitally mature healthcare organization, with a dedicated telemedicine unit, multispecialty telemedicine deployment, formal governance structures, and integration with regional digital health infrastructures. These features

make the case particularly appropriate for exploring ISO 14075 operationalization in a real-world healthcare setting; however, they also limit the direct generalizability of the empirical PRP scores.

Therefore, the findings should not be interpreted as representative of all healthcare organizations or of the entire Lombardy healthcare system. Organizations with lower digital maturity, weaker interoperability, fewer trained professionals, limited governance capacity, or resource constraints may generate diverse PRP profiles and encounter more substantial barriers in areas, including digital inclusion, workflow integration, data protection, and patient-reported outcome monitoring.

Consequently, methodological rather than statistical implication represents the primary transferable contribution of this study. The proposed ISO 14075-aligned S-LCPA framework, encompassing the stakeholder structure, evidence classification, PRP scoring logic, and hotspot identification process, can be adapted to other healthcare settings. However, the specific PRP scores attained in this case should be considered context-dependent and should not be generalized without additional case studies. Therefore, future research should apply the framework to a broader range of healthcare organizations, including smaller providers, less digitally mature institutions, rural healthcare systems, and resource-constrained contexts.

The qualitative component also constitutes another limitation. Interviews were conducted with key informants selected for their direct involvement in telemedicine implementation; therefore, they offer contextual insight rather than statistically representative evidence of all healthcare professionals or stakeholders.

3.7. Practical implications

The application of ISO 14075:2024 to the telemedicine system offers actionable insights extending beyond theoretical assessment. The results reveal a “maturity gap” warranting specific strategic interventions at the organizational and systemic levels.

For hospital managers and digital health officers, the S-LCPA results serve as a diagnostic tool to evolve from emergency-driven telemedicine to socially optimized care models. For example, the social indicators identified (e.g., digital inclusion rates and clinician workload redistribution) should be integrated into the hospital’s organizational plan. Shifting beyond purely clinical or financial KPIs, managers should adopt the S-LCA radar chart as a balanced scorecard for monitoring the social “health” of digital services.

Furthermore, this study underscores “workforce stress” as a primary hotspot driven by bureaucratic duplication. Practical utility lies in eliminating double data entry between telemedicine platforms and EHRs. Following this necessity, consistent with the objectives of Mission 6 of the PNRR, the

Lombardy Region has developed and deployed a single unified regional platform commencing in 2026, aiming to create a shared and interoperable healthcare data ecosystem. The platform facilitates collaboration among public hospitals and integrates both the reservation system (CUP) for bookings and reporting, and the regional EHR (FSE) for clinical reporting, thereby improving interoperability across services. To date, public hospitals are in a transitional phase, adapting their workflows to the novel application.

To overcome the "digital inclusion" hotspot, hospital management should formalize the role of caregivers or volunteers. This action generates a structured "human-in-the-loop" layer that ensures equitable access for older adults, transforming a potential social risk into a community development asset.

At a systemic level, using ISO 14075-aligned assessments provides a replicable model for regional and national health authorities (e.g., in the context of Italy's PNRR - National Recovery and Resilience Plan). The current policy frequently incentivizes the quantity of telemedicine activities. Policymakers should transition toward Value-Based Healthcare models where reimbursement rates are partially associated with social performance maturity. Standardizing how "comfort" and "perceived ease of use" are assessed will enable benchmarking across various hospitals, fostering a culture of continuous social improvement.

As ISO 14075:2024 becomes the international benchmark, health authorities should consider social sustainability assessments as mandatory components of the "Health Technology Assessment" process for any new digital health intervention. This plan would support healthcare systems that are environmentally sustainable and socially resilient.

4. Conclusions

Here, the social sustainability of telemedicine services delivered by ASST Bergamo Est was assessed by applying the ISO 14075:2024 S-LCA framework. Rather than seeking to demonstrate causal social impacts, this study evaluated the organizational maturity and indicative social performance of telemedicine through the performance-based S-LCPA approach.

The findings reveal that relatively mature governance, privacy, data protection, and organizational integration mechanisms support telemedicine at ASST Bergamo Est. Confidentiality, responsible innovation, skills development, and geographical accessibility exhibited high PRP scores, suggesting that the service has transitioned beyond isolated experimentation toward routine organizational implementation. Simultaneously, the assessment identified several areas where social performance remains only partially institutionalized. These areas encompass digital inclusion, community-level

monitoring, workforce workload and stress, and, especially, patient-reported outcomes (e.g., comfort, therapeutic adherence, and satisfaction).

These findings should therefore be interpreted as evidence of organizational maturity and social sustainability readiness, rather than as proof of direct improvements in satisfaction, adherence, equity, or reduced burden. In particular, as routine ASST-wide monitoring was not available for all social outcome dimensions, some indicators were based on proxy estimates, internal contextual evidence, or external literature. This limitation reinforces one of the main findings of this study: telemedicine services may be operationally mature despite lacking systematic mechanisms for capturing lived stakeholder experience.

From a managerial viewpoint, this study suggests that healthcare organizations should complement telemedicine deployment with structured social monitoring systems. The development of telemedicine-specific PROMs, routine digital inclusion indicators, workload and technostress monitoring for healthcare professionals, and systematic assessment of community-level co-benefits represent priority actions. Integrating these indicators into organizational planning and quality-improvement processes would facilitate the evaluation of telemedicine in terms of service volume or technical implementation and social performance.

This study is limited by its single-case design, the advanced digital maturity of the selected organization, and the uneven availability of primary social outcome data. Future research should apply the proposed ISO 14075-aligned framework to several healthcare organizations, including less digitally mature or resource-constrained settings, and strengthen the empirical measurement of patient, caregiver, professional, and community outcomes. Furthermore, longitudinal applications would support the monitoring of social sustainability improvements over time.

Overall, this study demonstrates the applicability of ISO 14075 to telemedicine as a complex healthcare service, providing a structured basis for identifying social hotspots and improvement priorities. As telemedicine becomes increasingly entrenched in hybrid care models, its sustainability should be evaluated through clinical, economic, or environmental indicators, and transparent and stakeholder-oriented social performance frameworks.

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Declaration of interests

☐ 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.

☒ The authors declare the following financial interests/personal relationships which may be considered as potential competing interests:

Landi Daniele reports was provided by University of Bergamo. Daniele Landi reports a relationship with University of Bergamo that includes: employment. If there are other authors, they declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

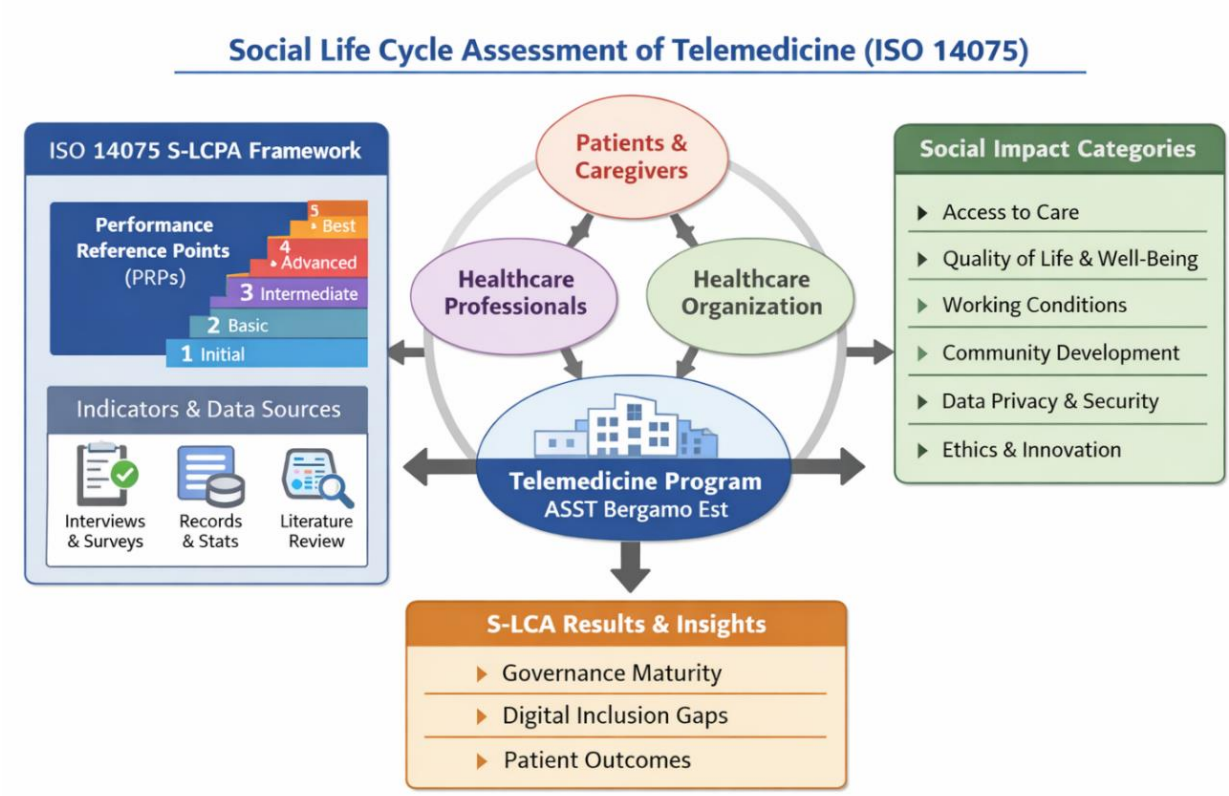

Figure 1. Social Life Cycle Assessment approach

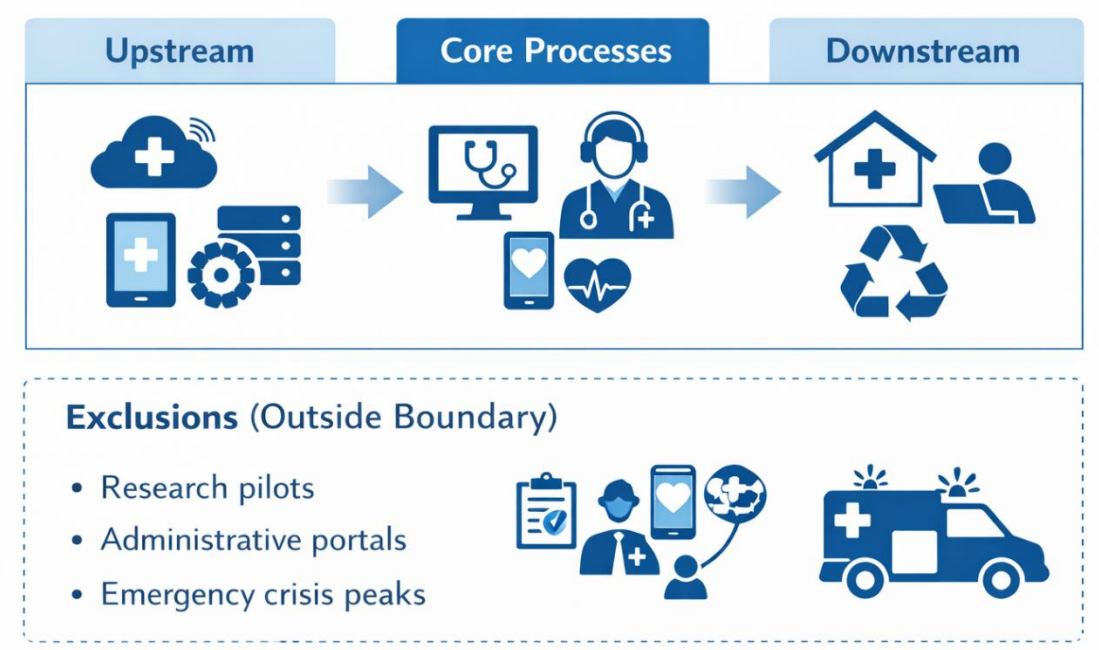

Figure 2. ***System boundaries of the telemedicine S-LCA***

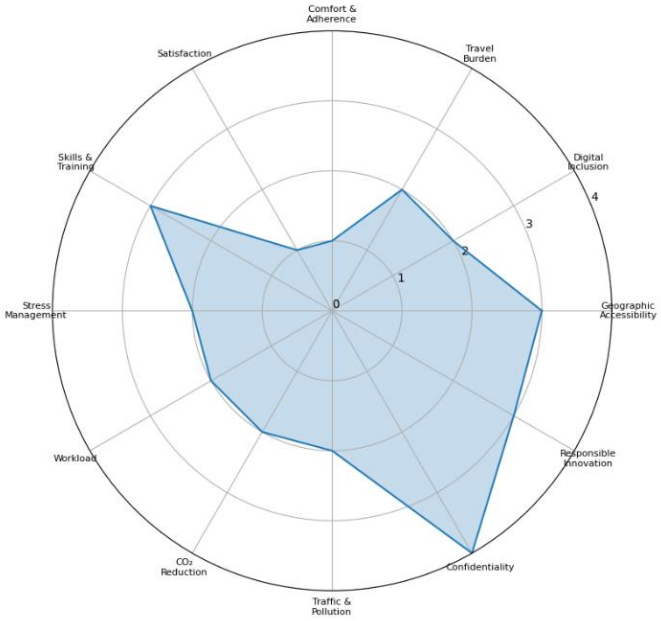

Figure 3. Radar chart of PRP results (descriptive graphic)

Figure 3. Heatmap of PRP scores by stakeholder (descriptive graphic)

A 4 × 6 matrix heatmap:

- **Dark green (PRP 4)**: confidentiality
- **Green (PRP 3)**: accessibility, skills and training, and responsible innovation
- **Yellow (PRP 2)**: digital inclusion, workload, stress, CO_2, and traffic
- **Orange (PRP 1)**: comfort, adherence, and patient satisfaction
- **White (PRP 0)**: none (no PRP 0 scores)