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Patterns and determinants of patient sharing in end-of-life health services: Empirical evidence from the Italian National Health Service

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ABSTRACT

End-of-life (EoL) care is critical for cancer patients, who tend to have high service needs that are dispersed across organizations and different levels of care. Although EOL has been widely studied, little is known about the patterns of coordination among EoL health care providers and how they contribute to the care of cancer patients. This study adopts a network perspective to examine the complex patterns of patient sharing among health care providers involved in EoL care, using data on the use of EoL health care services by 266 cancer patients in a large Local Health Authority in Italy. We conducted a social network analysis of the structural properties of the emerging network and used logistic regression-quadratic assignment procedures (LR-QAP) to explore how characteristics of health care providers, their collaborative network, and their distances predict the likelihood of observing patient sharing relationships. Our results show that complementarities in terms of medical specialization and co-location of services positively predict the likelihood of cancer patient sharing. This probability is also positively related to the difference in terms of eigenvector centrality as well as the degree of network transitivity. We discuss the policy implications of our findings.

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1. Introduction

In modern health care systems, the provision of high-quality services to patients with complex health needs calls for network forms of health care delivery, that is, the convergence of a plurality of specialized actors coordinating and integrating their activities to respond to patients' needs and expectations [1]. This is particularly true for cancer care, whose management involves surgery, chemotherapy, radiotherapy and other treatments provided by different healthcare professionals in diverse settings (hospital, domiciliary care, hospice) [2]. The presence of a plurality of institutional actors requires that they integrate their own specialized skills and competencies, embracing a multidisciplinary approach [3] to offer high quality and efficient care in response to patient needs. However, integration among care providers implies the existence of effective coordination mechanisms that have been proven to result in a more appropriate use of healthcare services and in a reduction of costs [4]. Coordination and multidisciplinarity are particularly critical for end-of-life (EoL) cancer patients [5–7], when most of the available therapeutic options fall short in providing any impact on survival and the main goal becomes preserving as much quality of life as possible. During the last phase of the cancer, in fact, individuals tend to heavily use health-care services [8], posing great challenges for the delivery of health care services. Some services, such as the Emergency Department or Intensive Care Units, are generally overused. Others, such as hospice, are in contrast generally underutilized [9]. In addition, this increased demand for healthcare services during EoL place pressure on the effective integration and coordination [10] among multiple individual and organizational actors [11] with different clinical specialties [12]. Failures in coordination may otherwise result in fragmented and ineffective care [11] with increased costs for healthcare systems and a decreased quality of life for the patient. Despite the aforementioned relevance of coordination and service integration during EoL [13], those aspects seem to be largely unexplored by health service research. In

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particular, it seems that little research exists on the role played by the various institutional actors and their interdependencies.

Existing managerial studies on EoL are mainly focused on the role of primary care physicians and domiciliary care in reducing hospital service utilization [14–16], on antecedents of hospice admission [17] and on the relationship between palliative care and healthcare use [18–22]. Research has also made attention on factors for improving care strategies to reduce unnecessary admissions and associated costs during this critical phase of the disease. In particular, recent studies paid attention to emergency room access [23,24] and hospital access [25–30]. Other scholars, adopting a more 'systemic approach', have compared the utilization of multiple health services in patients' last year before death [31], describing how access to EoL services may affect patients' place of death [32], and examining costs, resource utilization and quality of care of EoL journeys [33–37]. In this vein, some researcher had provided evidence of the end-of-life care patterns, emphasizing the importance of understanding the different types of care received and the factors influencing care preferences or access barriers [38,39]. In exploring possible precursors of service utilization during EoL, Keating and colleagues [40] have pointed out the significant role of peer influence on the intensity of end-of-life care. Research on EoL, thus, has traditionally focused on understanding factors that determine care pattern. A great attention has been devoted to understanding how access to a specific service, such as primary care setting or domiciliary care [14–17] may influence the use of healthcare services [18–22].

Social Network Analysis (SNA) presents a remarkably fitting approach for examining the nuanced dynamics within healthcare service delivery. Broadly speaking, SNA is employed to investigate the structural characteristics of connections – such as interactions, exchanges, and dependencies – among a defined group of entities. The adoption of SNA's tools and theoretical frameworks in scrutinizing healthcare delivery represents a burgeoning field within health services research, as highlighted by DuGoff and colleagues [41]. Utilizing Social Network Analysis, we endeavour to decrypt the complex patterns of healthcare service usage by cancer patients nearing end-of-life (EoL), pinpointing the crucial roles of different health services within the overarching system of healthcare delivery. While comprehensive insights into care patterns have been illuminated by previous research on networks of professionals and organizational entities, the nuanced contributions of specific actors, i.e. service providers, within this sphere warrant further investigation.

Our paper aims to contribute to the dialogue on EoL care by introducing a detailed perspective to examine the intricate system of local service delivery comprehensively. We seek to clarify the roles played by each institutional actor in the service provision network and to dissect the factors influencing patient sharing among these entities. This endeavour strives to deepen our understanding of cooperative care approaches at EoL. Moreover, our analysis will delve into factors that either facilitate or hinder the exchange of patients amongst a variety of institutional actors, spanning across different health services. This holistic examination is poised to unveil the intertwined nature of EoL care, shedding light on potential strategies to fortify patient-centred care while fostering more effective service collaboration. Despite the broad application of SNA in various healthcare contexts, encompassing networks of professionals [42–44] and organizational bodies [45], its utilization in the domain of EoL care remains scant [46]. This oversight presents a unique opportunity to expand the application of SNA, thereby enriching the fabric of EoL research with novel insights and perspectives on the dynamic interplay of healthcare service provision at the end of life.

This study contributes to the existing literature in three ways. First, we offer a more comprehensive description of how EoL services actually function in the context of a large and complex Local Health Authority (LHA). Although there is a rich literature on EoL, the role of actors offering a diverse range of health services during this critical phase of cancer care remains underexplored [8]. Second, we developed a novel approach to study the complex interdependencies among the diverse actors involved in EoL service provision, increasing our understanding of the actors involved, the role they play in the overall network of health providers and determinants of their patient sharing. In doing so, we bypass the widespread focus on physicians or hospitals by offering a more granular emphasis on health services providers and also considering Emergency Rooms, hospices and domiciliary care [41]. Third, our study can contribute to policymaking as it can support the reorganization of EoL services through the development of pathways and guidelines to foster cooperation among actors in this delicate healthcare field.

2. Theoretical background

Relationships among healthcare providers are a fundamental aspect of any healthcare system, given the complexity of patient needs. This complexity necessitates that physicians depend on their peers for patient referrals, clinical advice, and updates on the latest advancements in clinical practice [47]. Recently, reforms in delivery systems, including the adoption of patient-centred models, have highlighted the need for sophisticated techniques and theories to comprehend the dynamics between individuals and groups within the healthcare sector. Furthermore, these reforms underscore the importance of understanding how these interconnections impact outcomes [41]. This evolving landscape emphasizes the critical role of collaboration and networking in enhancing the quality of patient care and in navigating the intricacies of modern healthcare delivery.

Early contributions in this area employed administrative data to identify networks of physicians and compared the care delivered within these networks. Landon and colleagues [48] underscored the distinctions between community-based networks and hospital-based networks. In other research, scholars compare shared patient networks from different healthcare payers in the context of United States [49]. Other contributions [50] emphasized the importance of considering network composition when selecting insurance plans and guiding regulatory oversight composition and quality of insurance networks.

Further investigations have expanded the scope of analysis to include antecedents of patient sharing, delving into the factors that foster such collaborations. Geisseler and colleagues [51] demonstrated that pairs of primary care physicians within the same contracting networks, medical groups, and practice locations were more inclined to engage in patient-sharing relationships compared to their counterparts without these shared connections. Echoing this perspective, Linde [52] explored the dynamics underpinning the formation of physician-patient sharing networks. This research focused on a multitude of driving forces, including institutional affiliations, physician homophily, knowledge complementarity, geographical proximity, and participation in the same insurance networks. These studies underscore the complex landscape of patient-sharing, highlighting the multifaceted influences that contribute to the establishment and maintenance of such relationships.

A leading area of research connects patient sharing network characteristics or physicians' roles within these networks to healthcare outcomes. Researcher [53] illustrated that the degree of network integration and the centrality of hospital physicians are indicative of care coordination levels, which correlate with healthcare costs and intensity of care provided. Further analysis by Flemming and colleagues [54] revealed that networks centred around a key physician, specifically an expert in the relevant pathology, result in benefits for patients such as reduced hospitalization rates and increased adherence to treatment guidelines. Evidence has consistently shown that the density of patient-sharing among office-based physicians positively influences hospitalization rates [55,56], as well as the rates of adverse events and readmissions [57]. It also encourages the involvement of necessary specialists [58], collectively leading to enhanced patient outcomes and reduced healthcare costs. Recent studies have underscored the significance of the structure of provider networks in mediating healthcare disparities and outcomes. For instance, in networks where primary care physicians play a pivotal role, a reduction in racial disparities has been observed [59]. Additionally, the impact of patient-sharing networks has been assessed from the vantage point of patient experience. Moen & Bynum [60] discovered that higher density and clustering within physician group practices are associated with better patient perceptions of care coordination, highlighting the multifaceted benefits of well-structured provider networks in improving healthcare delivery and patient satisfaction.

Scholars have also explored the determinants and consequences of the enduring nature of patient-sharing connections among healthcare providers. DuGoff and colleagues [61] delved into the persistence of these connections, identifying factors such as demographic similarities between physicians, and analysing their impact on healthcare utilization. Furthering this line of inquiry, other research [62] revealed that consistently stable patient-sharing networks enhance communication and information sharing among providers. This, in turn, fosters more effective care coordination, leading to a reduction in unnecessary healthcare utilizations, such as emergency hospital admissions.

Expanding the scope of investigation, studies have aggregated patient sharing connections between physician pairs into broader networks. These larger groups of connected physicians may display similar practice styles or trends in the diffusion of treatments, possibly as a result of social influence or shared professional contexts. Some authors [63] examined the influence of collaboration and professional networks on the uptake of new medications among physicians. Keating and colleagues [40] investigated the social dynamics affecting end-of-life care intensity for cancer patients, showing that a physician's practice patterns and the intensity of care they provide are significantly influenced by the care approaches of their peers in the preceding year. Other contribution [64] illuminated the importance of a physician's professional network, suggesting that the nature of these connections can influence patient care by affecting physicians' practice behaviours. Moreover, Geva and colleagues [65] discovered that patients with healthcare providers highly connected within their professional networks are less likely to experience readmission following hospitalization for heart failure. These findings collectively underscore the significant impact of professional networks and patient-sharing connections on healthcare practices and patient outcomes.

While a significant portion of the existing literature focuses on patient-sharing among individual healthcare providers, several researchers have adopted a more expansive view, considering patient-sharing practices across healthcare organizations, such as hospitals and community centres. In this context, some studies [66] have explored provider networks, classifying them based on structural, compositional, and other characteristics to offer a holistic overview of the healthcare landscape. Galanter and colleagues [67] ventured into quantifying the degree of patient sharing and the fragmentation of inpatient care amongst patients discharged from a group of hospitals, shedding light on the complexities and variations in patient care coordination across different healthcare facilities. In another notable study, scholars [68] investigated the impact of hospitals' participation in Medicare Accountable Care Organizations (ACOs) on their relationships with other hospitals and on patterns of patient sharing. Lomi and colleagues [69] conducted an analysis centred around patient transfers between hospitals, utilizing hospital readmission rates as a proxy for a hospital's capacity to deliver effective patient care. In another research, authors [70] found that organizational centrality in the overall referral network and ego-network density have opposing effects on the likelihood of readmission events within hospitals. Finally, recent studies [71] examining the role of structural and social network ties, demonstrating that both structural and social ties between organizations are significantly associated with a higher number of shared patients.

These contributions collectively highlight the importance of examining patient sharing not only at the level of individual healthcare providers but also across broader organizational structures. By doing so, researchers can uncover valuable insights into the dynamics of healthcare delivery and coordination on a larger scale. Building upon our previous research, the present study delves into the interdependencies among health services, shedding light on the factors influencing patient sharing at the end of life. Employing a dual-phase methodology, we commence by providing a detailed exposition of measures at both the patient-provider and provider levels. Subsequently, we explore the determinants of patient sharing across health provider at the local level for EoL, thereby addressing a gap in the research landscape, noted by DuGoff and colleagues [41], regarding the theoretical underpinnings of patient sharing networks. Our exploration is guided by a multifaceted model, designed to capture the intricacies and diverse determinants affecting patient flow and sharing practices among hospital wards. This model comprises three principal dimensions of health service providers: general attributes, health service network characteristics, and health service geographical attributes, each contributing uniquely to patient sharing dynamics. Health Service attributes are delineated by three critical aspects: specialization, location, and size. Our analysis enriches the discourse by highlighting the propensity of physicians, embedded in hospital ward or services, to engage in patient referrals based on complementary expertise. This element is pivotal, especially for directing patients to more specialized providers for intricate treatments [72], facilitating interactions between co-located physicians [51], and understanding the impact of a provider's scale, as indicated by the number of beds [53]. In terms of network characteristics, our study lends focus to the structural aspects of a single health service network by examining centrality and transitivity. These measures, consistent with existing literature [41], provide insights into its prominence within the network and the likelihood of interconnected referrals, respectively. Finally, we check for the travel distance between service as a factor driving patient sharing [61].

Through this comprehensive analytical approach, we aim to contribute novel insights into the determinants of patient sharing, particularly at the EoL stage. By integrating the dimensions of health service attributes with network and geographical characteristics, we endeavour to articulate a holistic understanding of the dynamics at EoL, offering valuable perspectives for healthcare providers and policymakers alike in optimizing patient care pathways.

3. Materials and methods

3.1. The setting

In Italy healthcare service is provided by the Italian National Health Service (I-NHS), a three-level universal healthcare system, free at the point of care. The national level is responsible for ensuring the core benefit package of services to be guaranteed to all citizens, while the regional level is responsible for healthcare organization and planning. The local level is structured on a territorial basis and involves a network of local health authorities (LHAs) and is responsible for the organization and the provision of primary, secondary and tertiary care in a given area. Healthcare services are also provided by hospital trusts (public and accredited private), which overall represent the third level.

We have the unique opportunity to access the data on cancer patients belonging an Italian LHA responsible for providing care to 535,000 inhabitants. At the time of the study, the LHA provided hospital services to cancer patients through several facilities, comprising a large hospital trust, five public hospitals directly managed by the LHA, and two private hospitals. Outpatient services for cancer patients were provided through domiciliary care programmes and by two hospices. Table 1 reports the main characteristics of the institutional actors involved in this study.

3.2. Data

Through the provincial cancer registry and using a retrospective approach, we identified 2266 patients (age

Table 1. Main characteristics of the institutional actors considered in the study.

	N. staffed beds	*N*. hospital wards	Emergency room	Type
Hospital 1	791	54	Yes	Hospital Trust
Hospital 2	207	6	Yes	Public, Directly Managed By LHA
Hospital 3	296	7	Yes	Public, Directly Managed By LHA
Hospital 4	397	11	Yes	Public, Directly Managed By LHA
Hospital 5	211	6	Yes	Public, Directly Managed By LHA
Hospital 6	168	5	Yes	Public, Directly Managed By LHA
Hospital 7	710	23	No	Private
Hospital 8	283	8	No	Private
Hospice 1	12	n.a	n.a	Private
Hospice 2	14	n.a	n.a	Public, Directly Managed By LHA

> 18 years) who died of cancer in 2015 and 2016 and were residents of the province. Only patients with a single tumour were selected. For each patient, we collected information on their contact with health services during the last 12 months of life through record linkage procedures with various administrative databases (hospital discharge, emergency room accesses, domiciliary care and hospice admission). In particular, we collected information on the number, type and date of access to health services and facilities. Pseudo-anonymization of patients was ensured through a unique code assigned to patients across the various databases. Multiple accesses to the same health service on the same day were counted only once. This mentioned approach to examining end-of-life patterns of care is not novel and helps to provide a more comprehensive picture of EoL patterns of health service utilizations [9].

Data on the LHA's facilities was extracted from official sources. For the information on ward specialization and on inpatient ordinary beds and day hospital beds, we used official data published by the Italian Ministry of Health. Given the negligible differences between the figures for inpatient and day hospital beds across 2015 and 2016, the 2015 data were employed for analysis. For emergency services, our focus was on beds designated for short-stay observation. Additionally, we compiled information regarding the travel distances between hospital entities within the LHA. This involved collecting details about the addresses of each facility as listed on the LHA's official website and utilizing latitude and longitude coordinates. Subsequently, we employed the Stata Command 'Georoute' [73] to calculate dyadic travel distances (expressed in kilometres) between these facilities.

3.3. Analytical approach

SNA is used to study the connections (called 'ties') within a given set of social actors (called 'nodes') [34]. SNA relies on relational data, which are typically represented in the form of either squared 'n x n' or rectangular 'n x m' matrices [74]. Rectangular matrices are used to represent networks formed by two sets of different nodes, with ties existing only between nodes belonging to different sets [75,76]. In the present study, we have adopted a comprehensive approach, considering both one-mode networks and two-mode networks.

We initially built a 'n x m' (*patient* x *health service*) network in which a given cell x_{ij} assumes value 1 if a given patient i accessed health service j during the EoL journey, and 0 otherwise. Health Services comprise all services involved in EoL provision of care and in particular ward-by-hospital combinations ($n = 69$), emergency rooms ($n = 6$), Hospice ($n = 2$), Domiciliary Care and 'Other LHA'. We used the label 'Other LHA' for instances in which patients accessed services or facilities not included under the jurisdiction of the LHA.

To better understand the structure of patient sharing among the EoL facilities, we transformed the two-mode network into a one-mode 'm x m' network (facilities x facilities). In these network types, rows and columns represent the different facilities and the generic cell x'_{ij} gives the number of patients accessing the same pair of facilities, therefore capturing the intensity of patient sharing among facilities in the network. Figure 1 provides an illustration about the procedure we followed for the transformation of two-mode networks in one-mode networks.

We were interested in the interdependencies among health services; thus, we include only those patients who a time frame between death and cancer diagnosis of 12 months ($n = 1155$). We were thus able to reconstruct the entire care pathway avoiding bias due to treatments prior to the observation period [77].

In SNA, several network centrality indicators can be used to capture the prominence that actors or nodes assume in the whole network based on the number and structure of ties or relationships existing between them. We employed two measures to evaluate network centrality of each actor in the network: *degree centrality and eigenvector centrality*. *Degree centrality* is used to understand the strategic importance, or prominence, of a given node in the network [78]. For two-mode networks, Everett and Borgatti [79] distinguish between 'actors' and 'events', suggesting that 'the degree centrality for an actor is simply the number of events they attend and for an event it is the number of actors attending that event'. In the context of our study, centrality simply counts the number that a patient uses one of the health services examined. The degree measure is normalized according to the overall number of sampled patients, such that, for example, a node degree of 0.10 means that – on average – 10% of total accesses occurred at that node. *Eigenvector centrality* is a

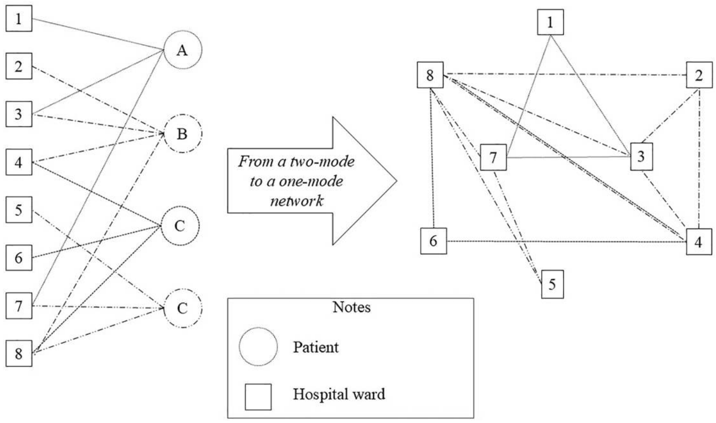

Figure 1. The conversion from a two mode to a one mode matrix.

measure of centrality that, unlike degree, considers not only the number of direct connections but also the centrality of the connected actors to the focal actor, taking into consideration the entire pattern in the network [80]. The underlying assumption is the centrality of some nodes not only depends only on the number of directly connected nodes, but also in turn on the value of their centrality. To offer a more compelling analysis of all the aforementioned centrality indicators, we reconstructed six tumour specific networks (haematological, lung, pancreas, stomach, colon and liver). These tumours together constitute more than our sample than 50% of the initial sample and were chosen on the basis of their mortality and complexity in treatment in terms of a multidisciplinary approach. Then, we calculated the centrality indicators for each of the tumour specific networks.

A pivotal goal of this study was to investigate the factors influencing patient sharing among healthcare services at the local level. To achieve this, we employed a logistic regression-quadratic assignment procedure (LR-QAP). The LR-QAP represents a variant of the multiple regression quadratic assignment procedure (MR-QAP), tailored for scenarios involving a binary dependent variable (i.e. the presence or absence of a network tie) [81]. We omitted Domiciliary Care from this analysis due to its broad spectrum of services with varied objectives, which could potentially skew the results [82].

In this study, the dependent variable is dichotomous, represented by a one-mode patient sharing network which indicates whether two different health services have shared cancer patients [42]. The independent variables in our model encompass attributes of the services (*Same Medical Specialization*, *Same Facility*, and *Staffed Beds Homophily*), characteristics of the network (*Patient Sharing Transitivity* and *Eigenvector Centrality* Homophily), and geographical distances measured in kilometres.

The *Same Medical Specialization* variable was determined based on the medical specialization of each health service, with services categorised into 7 homogeneous groups according to their specialties. For instance, all surgical wards were coded identically, while all specialties not related to cancer were grouped together. A matrix was then constructed to describe the similarity in medical specialization, assigning a value of 1 to cells where services shared the same medical specialties, and 0 otherwise. For *Same Facility*, we aimed to identify health services that are located within the same facility. Each service was assigned a code reflecting its association with one of the various facilities within the Local Health Authority's territory. A matrix was constructed, with rows and columns representing different wards, and a value of 1 was assigned to cells where wards were situated in the same building, and 0 otherwise. *Staffed Beds Homophily* was captured via a service-by-service matrix, where the cells represent the absolute differences in the number of staffed beds between each pair of services. *Patient Sharing Transitivity* is predicated on the likelihood that if ward A shares patients with both wards B and C, then wards B and C are also likely to share patients. This concept of social network transitivity, often summarized as 'friends of my friends are my friends', is a well-documented characteristic of social networks [83] and has been previously applied to patient sharing among physicians [41]. It was calculated using pre-defined functions provided by the UCINET software during the LR-QAP analysis. For *Eigenvector Centrality Homophily*, we utilized a squared matrix that included both rows and columns representing services, with cells indicating the absolute differences in eigenvector centrality scores in each service dyad. Lastly, *Travel Distance* was considered a significant predictor of patient sharing, as evidenced by prior research, highlighting the impact of geographical proximity on the likelihood of patient sharing between services [77]. All matrix operations and network indicators were performed by using the UCINET 6 software package [84]. The collection and manipulation of data was performed by using SAS EG software version 8.2 [85] and Stata SE 16.1.

4. Results

The results of this study are presented in a two-step procedure. First, we present the results of the centrality measures both for two mode – networks (degree) and for one – mode networks (eigenvector centrality). Then, we report results of LR-QAP regression.

4.1. Analysis of network centrality

Table 2 illustrates the degree centrality for the most frequently utilized nodes within the patient care pathway, including the Emergency Room (ER), Internal Medicine, General Surgery, Long-Term Care Wards, pathology-related departments (Oncology, Haematology, Pulmonology, and Gastroenterology), Hospice, and Domiciliary Care. This comprehensive view allows for an analysis of differences in centrality degrees among various services involved in patient care.

The nodes of Domiciliary Care, the ER, and the Internal Medicine and Oncology departments of Hospital 1 emerge with the highest degree centrality values, highlighting their pivotal roles in patient care pathways. Additionally, the analysis uncovers that ERs and Internal Medicine departments in Hospitals 4 and 6 serve important, though less central, roles within the network.

Notably, the Internal Medicine department in Hospital 1 exhibits a pronounced centrality for patients with haematological tumours, more so than for other types of cancer. Distinct specializations within Internal Medicine departments are also evident; for instance, those in Hospitals 6 and 2 show significant centrality within the lung cancer network (with centrality scores of 0.209 and 0.186, respectively). Internal Medicine of Hospital 2 is central to the pancreatic cancer management network (0.159), while Hospital 4's Internal Medicine shows a higher centrality for stomach cancer (0.157). Variations in centrality degree based on cancer types were also observed in General Surgery and Long-Term Care settings. Finally, approximately 15% of end-of-life care accesses occurred in Hospice 1, with 11% in Hospice 2, displaying relative stability across the six examined types of tumours, with the exception of haematology. In conclusion, within the specialized domains of pathology-related hospital disciplines like Haematology, Pulmonology, and Gastroenterology, a pronounced centrality is observed, underscoring their importance in the treatment of specific cancers.

Table 3 highlights the eigenvector centrality values for the key nodes involved in patient care processes: the Emergency Room (ER), Surgery, and Internal Medicine. Beginning with the ER, Hospital 1 displays the highest eigenvector centrality values across all types of tumours, as well as when analysing six other specific cancers. Notable distinctions in eigenvector centrality were observed for the ERs of Hospitals 3 and 5. In the domain of surgery, excluding the surgery ward of Hospital 1, Hospital 4 demonstrates elevated eigenvector centrality for stomach and colon cancers. Hospitals 5 and 6, on the other hand, are identified as more central within the colon cancer network. When examining Internal Medicine, the department at Hospital 2 exhibits elevated eigenvector centrality for lung and stomach cancers; Hospital 3's Internal Medicine department shows higher values for haematological and lung cancers. The Internal Medicine wards of Hospitals 5 and 6 appear to occupy strategic positions across all cancer networks, with the exception of colon cancer for Hospital 5 and haematology for Hospital 6. It is also crucial to acknowledge significant differences observed in the long-term care wards, indicating variations in their roles across different cancer care networks.

4.2. LR-QAP analysis

Table 4 outlines the findings from the LR-QAP. The results reveal a negative and statistically significant relationship between the Patient Sharing Network and Same Specialization, suggesting that hospital wards are less inclined to share patients with another unit possessing the same medical specialization ($\beta = -1.225$, $P = 0.001$). This finding confirms the expectation that diversity in specialization fosters patient sharing across services. Furthermore, the analysis identifies a strong inclination for services to share patients with units within the same facility ($\beta = 1.283$, $P = 0.03$), illustrating the significant role of physical proximity and institutional affiliation in patient sharing practices. Contrastingly, there was no statistically significant association between the dependent variable and the absolute difference in the number of staffed beds within a unit ($\beta = .001$, $P = 0.423$), indicating that the size or capacity of a unit, as measured by staffed beds, does not significantly influence patient sharing tendencies. Examining network characteristics, Patient Sharing Network Transitivity exhibits a positive and significant relationship with the outcome ($\beta = .359$, $P < 0.001$), while Eigenvector Centrality Difference also shows a positive and significant correlation ($\beta = .759$, $P = 0.013$). These results suggest a pronounced propensity for patient sharing among services that exhibit considerable differences in centrality, reinforcing the importance of network position and connectivity in facilitating patient flow within the healthcare system. Lastly, the analysis found that travel distance between services does not significantly affect patient sharing patterns ($\beta = .020$,

Table 2. Two mode network degree of the most accessed facilities.

		All Tumours ($n = 2267$)	Lung ($n =$ 397)	Pancreas ($n = 195$)	Stomach ($n = 133$)	Colon ($n =$ 152)	Haematological ($n = 184$)	Liver ($n =$ 128)
Emergency room	Hospital 1	0.832	0.690	0.836	0.373	0.359	0.848	0.38
	Hospital 2	0.105	0.106	0.092	0.052	0.033	0.168	0.062
	Hospital 3	0.096	0.086	0.046	0.045	0.065	0.114	0.047
	Hospital 4	0.177	0.126	0.062	0.119	0.124	0.196	0.124
	Hospital 5	0.097	0.088	0.123	0.037	0.059	0.049	0.062
	Hospital 6	0.169	0.202	0.108	0.045	0.072	0.185	0.07
General surgery	Hospital 1	0.073	0.009	0.097	0.164	0.203	0.043	0.047
	Hospital 2	0.007	–	–	0.007	0.007	–	–
	Hospital 3	0.026	0.023	0.005	0.09	0.026	0.005	–
	Hospital 4	0.007	0.003	–	0.007	0.065	0.005	–
	Hospital 5	0.004	0.005	0.01	–	0.007	–	–
Internal medicine	Hospital 1	0.514	0.345	0.733	0.358	0.281	0.717	0.364
	Hospital 2	0.113	0.186	0.159	0.067	0.026	0.141	0.062
	Hospital 3	0.063	0.081	0.067	0.037	0.052	0.103	0.031
	Hospital 4	0.154	0.169	0.067	0.157	0.144	0.092	0.085
	Hospital 5	0.062	0.06	0.056	0.052	0.033	0.038	0.062
	Hospital 6	0.136	0.209	0.072	0.037	0.059	0.141	0.078
	Hospital 7	0.001	–	0.005	–	–	–	–
Long term ward	Hospital 1	0.076	0.073	0.077	0.06	0.052	0.098	0.054
	Hospital 2	0.039	0.030	0.051	0.045	0.02	0.043	0.039
	Hospital 3	0.031	0.045	0.015	0.045	0.033	0.038	0.023
	Hospital 4	0.110	0.008	–	0.007	0.013	0.016	0.016
	Hospital 5	0.026	0.015	0.031	0.015	0.007	0.011	0.008
	Hospital 6	0.029	0.025	0.046	0.015	0.033	0.038	0.016
	Hospital 7	0.027	0.023	–	0.022	0.046	0.038	–
Oncology	Hospital 1	0.232	0.239	0.395	0.246	0.196	–	0.140
Pneumology	Hospital 1	0.122	0.448	0.005	0.007	0.020	0.038	0.008
Haematology	Hospital 1	0.075	–	0.005	–	–	0.821	–
Gastroenterology	Hospital 1	0.022	0.005	0.108	0.030	0.020	0.005	0.047
Hospice	Hospice 1	0.144	0.118	0.138	0.142	0.118	0.006	0.101
	Hospice 2	0.113	0.146	0.103	0.104	0.150	0.065	0.109
Domiciliary care	–	0.897	0.814	0.928	0.552	0.510	0.826	0.45

Table 3. Eigenvector centrality for ER, Internal Medicine, Surgery and Long-Term Ward.

	Hospital	All Tumours ($n = 2267$)	Lung ($n = 397$)	Pancreas ($n = 195$)	Stomach ($n = 133$)	Colon ($n = 152$)	Haematological ($n = 184$)	Liver ($n = 128$)
Emergency room	Hospital 1	2.738	2.653	2.121	2.037	2.376	2.299	2.206
	Hospital 2	1.017	0.541	0.395	0.401	0.439	0.271	0.233
	Hospital 3	1.625	1.345	0.339	0.525	0	1.333	0.471
	Hospital 4	1.682	1.079	1.17	0.771	1.391	1.501	1.063
	Hospital 5	1.521	1.327	1.688	0.535	1.304	0.752	0.658
	Hospital 6	1.631	1.214	1.301	1.17	1.275	0.847	1.218
Surgery	Hospital 1	2.158	0.705	1.829	2.306	2.31	–	0.524
	Hospital 2	0.547	–	–	0.401	0.439	–	–
	Hospital 4	0.650	0.414	0.101	0.813	1.211	0.438	–
	Hospital 5	0.755	0.319	–	–	1.304	–	–
	Hospital 6	0.734	0.266	0.049	–	0.319	–	–
	Hospital 7	0.422	–	–	–	–	–	–
Internal medicine	Hospital 1	2.729	2.246	2.143	2.289	2.032	2.616	2.467
	Hospital 2	1.212	1.015	0.524	1.137	0.439	0.271	0.025
	Hospital 3	1.293	0.998	0.339	0.309	0	0.967	0.396
	Hospital 4	1.54	1.053	1.152	1.276	1.391	1.467	1.063
	Hospital 5	1.45	1.23	1.133	1.177	0.565	0.965	0.72
	Hospital 6	1.701	1.532	1.301	0.735	0.84	0.538	1.38
	Hospital 7	0.144	–	0.197	–	–	–	–
Long term	Hospital 1	1.93	1.537	1.23	0.908	1.02	1.418	0.822
	Hospital 2	1.003	0.852	0.524	0.401	0.442	0.271	0.003
	Hospital 3	1.331	1.002	0.395	0.666	0	0.421	0.396
	Hospital 4	0.633	0.241	–	–	0.801	1.117	0.359
	Hospital 5	1.211	0.979	0.998	0.781	0.565	–	–
	Hospital 6	1.228	0.495	0.655	0.598	0.676	0.538	1.218
	Hospital 7	1.04	0.96	–	0.233	1.483	0.769	–

Table 4. Results of LR-QAP.

Parameters	Coefficient	*P* (Sign)*
Intercept	−4.084	
Service attributes		
Same medical specialization	−1.225	***0.001***
Same facilities	1.283	***0.003***
Staffed bed homophily	0.001	0.423
Network characteristics		
Patient sharing network transitivity	0.359	***0.001***
Eigenvector centrality difference	0.751	***0.013***
Geographical attributes		
Travel distance	−0.020	0.140
Observation	*2080*	
Permutations	*10,000*	
Model *P* value	*0.000*	
R-squared	*0.510*	

*Bold and italics signify the results being statistically significant at 95% level.

$P = 0.140$), implying that geographical distance, within the context of this study, is not a major determinant of patient sharing decisions.

5. Discussion

This research aims to illuminate the patterns of healthcare service use among cancer patients at the end of life, the strategic role each service plays within the network of health service delivery, and the factors driving patient sharing among services during this pivotal phase for cancer patients. By addressing these inquiries, our study contributes new insights to the EoL and health service literature, offering a detailed exploration of how EoL services operate within the context of a large and complex Local Health Authority. Our nuanced analysis of patient sharing between health services provides clarity on the distinct roles and influence of various actors in the health service provision network.

Our study confirms, in alignment with prior research [86], the frequent use of Emergency Rooms (ERs) by EoL patients. However, we note significant variations in ER utilization across hospitals, with Hospital 1's ER being utilized by 83.2% of patients, in stark contrast to lower usage rates observed in other ERs.

Additionally, our findings underscore the substantial involvement of acute hospital services during the last stages of cancer care [28,87]. Delving deeper than previous studies, our focus on specific health services rather than hospitals as a whole reveals that Internal Medicine is the most accessed hospital service by EoL patients, considerably more so than specializations such as Oncology or Haematology. Considering all cancer types, 51.4% of patient use Internal Medicine ward, while only 23.2% access to oncology ward. These results reflect the existing organization of EoL: specialized services, such as Oncology, are involved in the first phases of the disease, providing diagnosis and treatments while when all available therapeutic options fail patients are sent to Internal Medicines wards. Further consideration on the appropriateness of a such approach should be conducted, basing on the fact that internal medicine wards are characterized by a heterogeneity of the clinical condition of patients and lack of specific training in end-of-life care [88].

Our research highlights disparities among hospital services, pointing out that certain services, depending on their hospital affiliation, experience marked differences in use intensity. These differences may stem from unexplored factors like geographical location or service catchment areas. Moreover, we observed that service centrality within specific cancer networks varies, indicating a nuanced specialization by certain health service toward particular cancer types, thereby underlining their strategic clinical focus within the broader healthcare ecosystem. For instance, the Internal Medicine wards of hospitals 6 and 2 have emerged as significantly central within the lung cancer network, with centrality scores of 0.209 and 0.186, respectively. Additionally, the Internal Medicine department of hospital 2 assumes a pivotal role in the management of pancreatic cancer, boasting a centrality of 0.159. Similarly, the internal medicine department of hospital 4 reveals a pronounced centrality in the network for stomach cancer, with a score of 0.157.

An in-depth examination of eigenvector centrality reveals a detailed view of each service's role in the network. We distinguished health services that function as hubs, characterized by their abundance of connections and their links to other central services, from those operating more as spokes, which are also highly specialized in managing specific cancer types. For instance, the surgical department of hospital 1 stands out with an eigenvector centrality of 2.158, a figure triple that of surgery of hospital 2, and its internal medicine ward showcases an even higher eigenvector centrality of 2.279. Hospital 2, however, appears to excel in offering care to patients with lung and stomach cancer, as reflected by the eigenvector centrality scores of its internal medicine department – 1.015 and 1.137, respectively. Meanwhile, hospital 3 assumes a more pivotal position in the network concerning lung and haematological cancers, with its Internal Medicine Department reporting eigenvector centralities of 0.998 and 0. 967. Our findings suggest an intricate web of patient sharing that extends beyond simple dyadic relationships, reflecting the complex coordination required in EoL care delivery within a hub-and-spoke organization model. In particular, our analysis has empirically underscored the notion that structures functioning as spokes are often distinctly specialized in the treatment and management of specific cancer types. It appears that clinicians have, through informal mechanisms, orchestrated patient sharing to enhance coordination and specialized care. This strategy aims to meet the escalating demand for specialized skills and dedicated technologies within a hub-and-spoke model [89]. Such practices underscore the feasibility of adopting a focus factory approach [90] in the EoL context, where patient segmentation based on cancer type and the establishment of tailored activities could bolster precision medicine and further personalize care. This approach not only highlights the adaptive strategies healthcare professionals employ to optimize EoL care but also suggests a pathway towards more systematically integrated and patient-centric healthcare delivery models.

The application of LR-QAP facilitated the analysis of the interdependencies among specialized health services involved in the EoL care journey of cancer patients. Through this examination, we explored the influence of health service attributes, network characteristics, and geographical proximity on patient sharing among different healthcare entities. It was observed that services often share patients with others that possess a different specialization. This finding reveals the importance of diversified expertise within efficient oncology organizations and aligns with contemporary approaches to EoL care. Proximity emerged as a significant determinant of patient sharing, with services within the same hospital demonstrating a preference for inter-departmental patient transfers. Interestingly, our analysis identified a 'transitivity effect' in patient sharing patterns, indicating that if Health Service A shares a patient with Services B and C, there is a likelihood that Services B and C also share a patient. This pattern suggests that patient sharing in EoL care is multifaceted, extending beyond simplistic dyadic relationships [69]. This complexity is reflective of the collaborative coordination essential in healthcare, which often mandates seamless interaction across multiple institutional actors [91], each with expertise in specific medical disciplines such as oncology, radiotherapy, or surgery. Additionally, we noted a 'popularity effect' among network nodes, where health providers preferentially share patients with well-connected partners. This tendency supports the efficacy of a hub-and-spoke organizational model in facilitating patient sharing. Contrary to expectations, the geographical distance between health services did not significantly impact patterns of patient sharing, highlighting the overriding importance of institutional relationships and service specialization over physical proximity.

Our research offers groundbreaking insights into the management of end-of-life care, scrutinizing the roles various healthcare services play during this critical phase. We incorporate Social Network Analysis as a novel methodological approach to ascertain the effective cooperation among these services. This expands upon existing scholarship, which has predominantly focused on the impact of single services on care patterns [14–30] without extensively exploring the interconnections and collaborative dynamics between different healthcare services. By presenting new data on the involvement and interdependencies of healthcare services in EoL care, our study broadens the conversation beyond patient- centred approaches to incorporate the perspectives of healthcare providers. This shift enables a more comprehensive understanding of EoL care delivery, emphasizing the contributions of individual services to the overall care continuum and their collective impact on patient outcomes.

Historically, research in this domain has often been limited to the examination of treatment pathways and their determinants, a valuable but incomplete approach from a policymaking perspective. Critical aspects such as patient sharing have been overlooked, despite their significance within healthcare delivery. Although chronic illnesses [53,54,62,63,65] and care for the elderly [64] have received considerable attention, the specific challenges of EoL care, particularly within oncology, have been underrepresented in scholarly discourse.

Prevailing theoretical models have predominantly focused on the influence of a physician's peer network on end-of-life care intensity [40], neglecting the intricate web of interdependencies among diverse health services. Our study responds to this gap by emphasizing patient sharing at the level of healthcare service delivery, offering a unique lens through which to view the EoL care landscape.

Additionally, our research addresses the need for a more precise definition of geographical boundaries, as highlighted by DuGoff and colleagues [41]. Rather than relying on broad categorizations such as hospital affiliation or referral regions, we concentrate on a specific population within a clearly defined geographical area, under the purview of a Local Health Authority. This approach not only contributes to a deeper understanding of patient sharing mechanisms but also enriches the ongoing dialogue regarding effective care coordination at the end of life.

Our research provides meaningful implications for policymakers and healthcare administrators tasked with organizing and managing end-of-life services. By highlighting the structures and services that serve as central nodes within the healthcare network, as opposed to those that assume more peripheral roles, our analysis offers a foundation for rethinking and potentially redesigning organizational models for EoL care at the local level. For instance, recognizing facilities that play a pivotal role in patient care can inform the strategic selection of 'hubs' – centres designated as reference points for patients with specific types of cancer and at particular stages of their EoL journey, considering factors such as the availability of resources (number of beds, cutting-edge technology) and the expertise of healthcare professionals.

Moreover, examining the determinants of patient sharing among healthcare services can uncover discrepancies between actual care patterns and those formally envisioned by Local Health Authorities. This insight is crucial for identifying misalignments with organizational goals and can guide efforts to standardize care practices, including the implementation of clinical pathways to ensure consistency across the care continuum.

However, our study is subject to limitations that warrant acknowledgment. A primary limitation arises from the absence of detailed clinical data on the patients included in our study due to the constraints of the administrative databases used. We recognize the potential impact of clinical conditions on EoL care patterns and coordination and encourage future research to delve into these aspects. Additionally, the granularity of our analysis may affect the interpretation of results, especially given the aforementioned constraints on available data. This limitation extends to a lack of insight into the specific reasons behind patient sharing decisions and the technological and professional capabilities of individual healthcare services. Furthermore, the specific context of the Italian National Health Service and the LHA may limit the generalizability of our findings to other healthcare systems and settings. We invite subsequent studies to investigate whether similar patterns and outcomes are observable in diverse healthcare environments, thereby broadening the applicability of our insights.

6. Conclusion

This study documents that cancer patients during their last year of life heavily rely on ER and hospital services. Within hospitals, internal medicine is the medical specialization mostly involved in the delivery of EoL services. At the same time, we found that domiciliary care and services provided in hospices are far from being fully exploited. In addition, the findings also suggested that peripheral structures have characterized their activity based on a specialization towards one or more types of tumours. Finally, we attest that health service share patients based on common specialization, same hospital, network transitivity and eigenvector difference. The methodologies applied in this research can support policy makers in the assessment and (re)organization of EOL services.

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Data availability statement

Research data are confidential, for this reason data cannot be shared or published.

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