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Assessing clinical networks through evidence: an empirical analysis of the effectiveness of cancer networks in improving patients' quality of care and survival

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ABSTRACT

Background: Oncology networks are widespread and widely recognized by professionals and policymakers as a valuable model for promoting multidisciplinary care and its continuity to improve patient care in terms of appropriateness, equity and outcomes. However, empirical evidence on whether cancer networks improve patient health outcomes is lacking. In our study, we evaluated whether patients treated in Italy's oldest oncology network (Piedmont region) receive higher quality care and have better survival rates than patients treated in the same region but outside the network and managed according to usual care.
Methods: A longitudinal cohort study of individuals aged 18 years or older residing in Piedmont with a new diagnosis of cancer of the rectum, colon, bladder, stomach or ovaries between 2010 and 2019 and admitted for curative surgery was analysed. Outcomes included quality indicators, selected based on the international guidelines for each tumour, and survival. Analyses were performed using Administrative health data systematically collected at the regional level were analysed with multivariable logistic models.
Results: From 2010–2019, the proportion of patients treated within the network increased for all malignancies, with wide variations based on tumour type. Overall, the adoption of clinical guidelines, interval times between diagnosis and treatment, and 90-day and 1-year survival displayed better results among patients managed within the network (e.g., 1-year mortality adjusted odds ratio for rectal cancer: 0·73, 95 %CI 0·61–0·88; colon cancer: 0·62, 0·55–0·70; stomach cancer: 0·69, 0·56–0·85).
Conclusion: Empirical evaluation of the effectiveness of cancer networks on health outcomes is challenging, as it depends on a wide variety of factors that are difficult to control for in real-world settings. Our study empirically investigates a large sample of patients treated for common cancers over ten years. Overall, we found a positive association between network patient management with quality of care indicators and survival.

1. Introduction

Cancer is a major public health and economic challenge worldwide. It is a leading cause of premature death worldwide with nearly 10 million deaths in 2020. Its global burden, with 19·3 million new cases in 2020 and expected to reach 30·2 million cases by 2040, has placed cancer at the centre of research and policy agenda (Sung et al., 2021; The Global Cancer Observatory, 2020).

Cancer management requires an integrated approach across primary and secondary care, across different specialties and typically across different settings. Among the strategies developed to support integrated care pathways, clinical networks represent a special form of alignment between different organizations and professionals (Brown et al., 2016). From a patient's perspective, clinical networks are expected to simplify

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access to facilities, improve coordination and continuity of care between specialists, and hopefully achieve better health outcomes.

Among clinical networks, cancer networks have been the most formalized (Carter et al., 2003). Ferlie and Additcott (Ferlie and Addicott, 2004) defined a cancer network as *"a network model of organization (.) adopted to promote communication in the delivery of cancer services across complex patient pathways which may involve a large number of different health care providers."* Globally, cancer networks are present almost everywhere. Examples include the National Comprehensive Cancer Network in the USA, the Cancer Strategic Clinical Network in Canada, and the Agency for Clinical Innovation cancer networks in Australia. In Europe, cancer networks have developed either thanks to national initiatives, or as a response to the European Recommendations for coordinated care in Europe and joint actions. In the Netherlands, for example, a country-wide cancer network was established in 2013, from the merger of nine cancer networks existing since 1978 (OECD, 2013). Similarly, the first experiences of cancer networks in the UK were developed as National Health Service (NHS) initiatives in 2000,[e.g., (Brunet et al., 2006; Livingston and Woods, 2003; Edwards, 2002; Woods, 2001)] and their positive results in terms of resource utilization, centralization of clinical knowledge,[e.g., 9] coordination across different cancer centers [e.g., 8] and better access to care and clinical trials for patients[e.g., (Brunet et al., 2006)] guided the European Commission to launch the European Partnership for Action Against Cancer (EPAAC) in 2009 to promote clinical networks in oncology to strengthen cancer care across Europe. Following these recommendations, several countries invested in cancer networks, in particular England and Italy have been the countries that developed cancer networks the most (OECD, 2013; Prades et al., 2018).

Despite the global proliferation of clinical networks and abundant studies describing models and functions of clinical networks, there is still scarce and inconclusive evidence on the effects of clinical networks on patients' outcomes (Brown et al., 2016; Golla and Kaye, 2022). An attempt to systematically review existing evidence on the impact of clinical networks on the quality of care and/or patient outcomes was performed by Brown et al.[3], who concluded that while there is evidence that clinical networks can improve the delivery of healthcare, only a few studies have attempted to quantitatively measure their impact on patients' outcomes, and even fewer are of high quality. Regarding cancer networks, in particular, three observational studies reported significant improvements in quality-of-care indicators related to the earlier provision of cancer services (Brown et al., 2016). Quality of care has also been assessed in other studies that have made similar discoveries. Waiting time, referral interval, diagnostic interval and treatment interval have been measured by Eggink et al. (2017) and Penel et al. (2016) who found an overall reduction in these process measures with the introduction of cancer networks. Further, higher adoption rates of more innovative surgical approaches have been found by Carpenter et al (Carpenter et al., 2011). and Penel et al. (2016) More evidence exists on the impact of Multidisciplinary Teams (MDTs), that represent a pillar of the supply management of clinical networks. Two recent meta-analyses on specific malignancies (head and neck tumour (Shang et al., 2021) and non-small-cell lung cancer (de Castro et al., 2023)) found that MDT-based patient care was associated with higher overall survival.

International findings should be interpreted and compared considering that the structure and functioning of healthcare systems play a key role in the success of cancer networks. Funding ensures that cancer networks are adequately supported, leading to timely treatment and improved outcomes, as seen in the UK and Netherlands. Governance models also matter; centralized systems like the NHS promote consistent care standards, while decentralized systems, such as in the U.S., can create disparities and variability in care. Healthcare accessibility further impacts efficacy; universal health systems (e.g., UK, Canada) provide equitable access to care, including access to cancer network. In contrast, fragmented systems, like the U.S., face financial and geographic barriers, leading to delays and unequal care. Nevertheless, that results from a given healthcare setting can be informative not only to similar systems but also to different ones, offering insights that may be adapted to improve cancer care across various models.

The case of Italy's oldest regional cancer network (the Piedmont Oncology Network - Rete Oncologica del Piemonte, hereafter ROP) provides a unique opportunity to assess longitudinally, during a 10-year period, the appropriateness of care and health outcomes for patients treated within the same region by comparing patients managed according to the cancer network pathway with those following the more traditional model of care.

1.1. The Italian context and the piedmont oncology network

The Italian NHS was established in 1978, replacing the previous system based on insurance funds, with the declared goal of improving equity by providing uniform and comprehensive healthcare services across the country (Di Novi et al., 2019; Ricciardi and Tarricone, 2021). Until now, several reforms have shaped the Italian NHS into a decentralized healthcare service, shifting the responsibility of both managing and funding the services to regional jurisdictions. The purpose was to improve spending efficiency by increasing regional governments' accountability via fiscal autonomy (Bordignon and Turati, 2009; Ferrario and Zanardi, 2011; Piacenza and Turati, 2014). As a result, these tenuous balance of centralized versus regional control has shifted over time to create not one, but 21, progressively different, health systems.

One example of such a decentralized model is offered by cancer networks. In 2024, in Italy, regional cancer networks present heterogeneous levels of implementation and governance. Piedmont, a North-west region in Italy, with 4·3 million inhabitants and about 30,000 new cancer cases per year, has been the first to establish a cancer network in 2001. The organizational model adopted by the region is *Hub&Spoke,* characterized by a long-lasting inter-professional collaboration and leadership, and by sufficient financial and administrative resources. Plans of action have been formally established by the Region to manage the Network, supported by dedicated funding, governance, facilities and personnel required for the operation of the Network, which ensure the sustainability of business continuity strategies (AGENAS, 2023). According to the latest report issued by the Italian Agency for Regional Health Services (Agenzia Nazionale per i Servizi Sanitari Regionali-AGENAS), the ROP is top performer in terms of its efficacy and effectiveness, based on several indicators such as out-of-region mobility index (i.e., the percentage of patient admissions to network outside their region of residence), and waiting times. Moreover, the high performance of the region is comprehensive and not driven by outstanding single units as observed elsewhere in Italy (AGENAS, 2023).

In the Piedmont region (north-west Italy, with a population of around 4.3 million), the ROP is organized around three key elements. The Reception and Service Centres (Centro Accoglienza Servizi – CAS), which take care of patients, assess their general needs, inform, plan, and manage the entire process of diagnosis and staging, including the multidisciplinary examination, carried out by well-defined groups of specialists for each type of tumor called Interdisciplinary Care Groups (Gruppi Interdisciplinari di Cura – GIC), which represent the second pillar of the ROP. The third key element refers to the role played by the regional hospitals. The abovementioned *Hub&Spoke* model that works in Piedmont distinguishes the reference centres (RC) or Hub hospitals, for each type of tumour - based on the presence of appropriate technologies, skills, and caseload- from the other hospitals (Spoke hospitals) and sets up the rules to ensure the continuity of care and the timely referral of patients to the most appropriate setting at each stage of the treatment process.

It is important to note that the regional oncology network was implemented progressively over time. During the period under consideration in the present analyses (2010–2019), the proportion of patients initially managed according to ROP pathways (identified by CAS and/or GIC access prior to commencing treatment) increased. This provided an opportunity to compare process and outcome indicators between this cohort of patients and those following the traditional care pathway, typically managed by single cancer specialties. Although the clinical and sociodemographic characteristics of these two cohorts, as well as the admitting hospitals, overlapped considerably, we carefully adjusted the comparisons to estimate whether management according to the ROP model was associated with better care and outcomes.

2. Material and methods

We followed STROBE guidelines (Von Elm et al., 2007) for the reporting of observational studies (see Appendix for the checklist).

2.1. Data sources

The latest available data for a 10-year period (2010–2019) before the COVID-19 pandemic were extracted to conduct this research. We extracted data from the Piedmont Hospital Discharge Record (HDR) system, an administrative data set including socio-demographic information and health care data such as a patient's primary and secondary diagnoses, surgical procedures and discharge status (including in-hospital death) from all regional publicly funded hospitals (both public and accredited private ones). Diagnoses and procedures were coded based on the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM). In Italy, the NHS covers the entire population, and exclusive private funding is residual, (Ricciardi and Tarricone, 2021) particularly for life-threatening diseases such as cancer. Providers, both public and private, need to deliver an HDR to be reimbursed by the NHS. Therefore, all in-patient and daycare activities are included in the database for administrative purposes. Patients' HDRs are identified by an encrypted unique identification code. Multiple records of each patient are linked by this encrypted code.

Vital status was obtained from the Piedmont Health Service Register (PHSR), an administrative database including all the population covered by the Regional Health Service. Record linkage between HDR and PHSR was performed using the same encrypted code.

2.2. Selection of cancer cases

Five cancers were considered based upon their epidemiological relevance, involvement of multiple disciplines across the diagnostic and treatment phases (e.g., general surgery, gynaecology, urology, medical oncology, radiotherapy), feasibility of identifying and measuring process and outcome indicators from the administrative database, and medium-high mortality observed at one year. The selected diagnoses include bladder, ovarian, gastric, colon and rectal cancers. All other cancers were excluded either because they are exclusively managed within the ROP (e.g., breast) or because sufficient data were not retrievable through the available administrative databases (e.g., lung, prostate).

For each cancer diagnosis, we identified a cohort of incident cases among the resident population of the Piedmont Region, with the first oncological diagnosis during 2010–2019. We excluded all patients with HDR with a cancer diagnosis during the prior five years. According to the principal diagnosis (or secondary in case of principal diagnosis of chemo/radiation/metastasis) we selected five cancer-specific cohort: Bladder cohort, Ovarian cohort, Gastric cohort, Rectal cohort and Colon cohort. In each cancer specific cohort, we select patients undergoing radical surgery during 2010–2019. Details about diagnosis and procedure codes used in the cohorts' identification are reported in the supplemental materials (Table A1 of the appendix).

2.3. Measures

For each cancer, we identified a few evidence-based recommendations and relative indicators measurable through routine administrative data, covering diagnostic, treatment, and outcome aspects.

2.3.1. Treatment: access to the oncology network

We defined patients as managed by the ROP if they had access to specific out-of-hospital visits before surgery/procedure. More specifically, network patients were those either accessing the reception service centre (CAS), located at the Oncological Services of the Health Authorities of the network and/or those managed by the Interdisciplinary Care Groups (GIC). Both these out-of-hospital visits were tracked by the regional ambulatory database and linked to the patient record by the unique encrypted code. This early contact with the oncology network is expected to result in a more multidisciplinary, integrated and appropriate care pathway and potentially better outcomes. In contrast, the control group consisted of 'non-ROP patients', who were cancer patients residing in the Piedmont Region and receiving treatment at the same facilities. However, they were not referred to CAS or GIC visits and were managed according to the 'usual care pathway', which is typically the responsibility of individual cancer specialties.

Hereafter, we refer to patients treated within the Piedmont Cancer Network as ROP patients and the control group as non-ROP patients. The patients' selection is detailed in Figures A1–A4 in the appendix and further described in 3, comparing their sociodemographic and clinical characteristics at baseline.

2.3.2. Process and outcome indicators

Process indicators were selected by a multidisciplinary focus group to measure quality of care. The experts participating in the focus group were clinicians (Oscar Bertetto, former director of the ROP; Gianpiero Fasola, director of oncological department of Udine University Hospital), that recommended multiple indicators of adherence to current practice international guideline recommendations for each tumour, and discussed each indicator with the Clinical Epidemiology unit in charge of data curation to assess their measurability through the data (Giovannino Ciccone, unit director; and unit statisticians Eva Pagano, Anna Castiglione). The selected process indicators are presented in Table 1, and Table A2 in the appendix shows the data sources and codes used to capture them.

Survival (30 days and one year) was measured from the date of the first surgical intervention with curative intent to the date of death from any cause or to the end of the time interval considered.

2.4. Statistical analysis

Demographic and clinical characteristics of the entire cohorts were summarized using absolute and percent frequencies. To assess the association between access to the oncology network and the selected indicators, we estimated both row (unadjusted) and adjusted odds ratios (ORs) and 95 % confidence intervals (95 %CI) using logistic regression models. Given the observational nature of the study, the comparability of ROP and non-ROP patients may be biased due to patients' self-selection into services based on their observable and unobservable characteristics and this would bias the estimate of the association between being treated within the oncology network and the selected outcome indicators. Therefore, for each cancer cohort the multivariable models included as covariates: age (in 8 strata), sex (except for ovarian cancer), level of education (low, medium, high, not recorded), presence of metastases, Charlson comorbidity index (based on all diagnoses recorded in hospital discharges occurring in the 12 months preceding the index surgical admission (Romano et al., 1993)), days of hospitalization in the year prior to surgery, local health unit (Azienda Sanitaria Locale, ASL) of residence, calendar period and type of hospital of admission (whether hub or spoke). To assess the direction and the impact of confounders included in multivariable models, the ratio of adjusted to row ORs was calculated for all process and outcome measures. Nevertheless, bias due to relevant unmeasured confounders cannot be ruled out, as the available administrative data did not allow us

Table 1
Quality of care performance indicators by cancer type.

Cancer	Treatment Phase	Recommendations	Guidelines	Indicators		Expected effect of cancer network
				Long name	Short name	
Bladder	Treatment	Offer **neoadjuvant chemotherapy** using a cisplatin combination regimen **before radical cystectomy or radical radiotherapy** to people with newly diagnosed muscle-invasive urothelial bladder cancer for whom cisplatin-based chemotherapy is suitable.	NICE 2015	Undergoing radical cystectomy receiving neoadjuvant chemotherapy (NACT)	NACT	Increase
		In general, lower morbidity and (peri-operative) mortality have been observed by **surgeons** and in hospitals with a **higher case load** and therefore more experience	EAU2017	Receiving a radical cystectomy in a Regional reference centre (RC)	Surgery in RC	Increase
		Consider **adjuvant cisplatin combination chemotherapy** after radical cystectomy for people with a diagnosis of muscle-invasive or lymph-node-positive urothelial bladder cancer **for whom neoadjuvant chemotherapy was not suitable**	NICE 2015	Receiving adjuvant chemotherapy after cystectomy for patients who did not receive NACT before surgery	Adjuvant chemotherapy	Increase
	Outcomes			30-day mortality 1-year mortality		Decrease
Gastric	Diagnosis	Only consider F-18 **FDG PET-CT** in people with gastric cancer if metastatic disease is suspected and it will help guide ongoing management.	NICE 2018	Receiving a PET scan in the six months prior to surgery	PET before surgery	Uncertain
	Treatment	Offer **chemotherapy before and after surgery** to people with gastric cancer who are having radical surgical resection.	NICE 2018	Receiving chemotherapy before and after surgery (in patients alive at four months after surgery)	NACT + adjuvant chemotherapy	Increase
		Consider **chemotherapy or chemoradiotherapy after surgery** for people with gastric cancer who did not have chemotherapy before surgery with curative in	NICE 2018	Receiving chemo (CT)- or radio- (RT) therapy within four months (CT) or six months (RT) after surgery for those who did not receive NCT	Adjuvant therapy	Increase
		Ensure curative oesophago-gastric resections **are performed in a specialist surgical unit** by specialist oesophago-gastric surgeons.	NICE 2018	Receiving surgery in a Regional reference centre (RC)	Surgery in RC	Increase
	Outcomes			30-day mortality 1-year mortality		Decrease
Ovarian	Diagnostics	If the ultrasound, serum CA125 and clinical status suggest ovarian cancer, perform a **CT scan of the pelvis and abdomen** to establish the extent of disease. Include the thorax if clinically indicated.	NICE 2021	Having a CT scan of the abdomen and pelvis and a CT scan of the chest in the four months preceding surgery	Diagnostic pattern before surgery	Increase
	Treatment	The majority of patients with EOC benefit from **postoperative chemotherapy**. It should be started **as soon as feasible**, usually within two to four weeks after surgery.	UpToDate 2021	Receiving adjuvant chemotherapy within 2 months of surgery	Adjuvant chemotherapy	Increase
		Surgical cytoreduction should be performed by a **gynecologic oncologist experienced** in this surgery since achieving optimal cytoreduction depends partly on the judgment, experience, skill, and aggressiveness of the surgeon	UpToDate 2021	Receiving surgery in a Regional reference centre	Surgery in RC	Increase
	Outcome			30-day mortality 1-year mortality		Decrease
Rectal	Diagnostics	**Positron emission tomography imaging** using fluorodeoxyglucose (FDG-PET) has not been shown to add significant information to conventional imaging for initial locoregional staging of rectal cancer	UpToDate 2021	Receiving a PET scan in the six months prior to surgery	PET before surgery	Decrease
	Treatment	Offer preoperative **radiotherapy** or **chemoradiotherapy** to people with rectal cancer that is cT1-T2, cN1-N2, M0, or cT3-T4, any cN, M0	NICE 2020	Receiving neoadjuvant radiotherapy or chemoradiotherapy in the six months prior to surgery	Neoadjuvant radiotherapy	Increase
		Hospitals performing major resection for rectal cancer should perform at **least ten of these operations** each year	NICE 2020	Receiving surgery in a Regional reference centre (RC)	Surgery in RC	Increase
	Outcomes			30-day mortality 1-year mortality		Decrease
Colon[§]	Outcomes			30-day mortality 1-year mortality		Decrease

[§] For colon cancer, the initial course of treatment does not present critical decision-making nodes and no prognostically relevant procedures were identified from guidelines that could be measured by current data, hence we considered only survival as an outcome.

to control for important patient characteristics typically captured by other data sources — such as tumour staging or socio-behavioural variables, including basic information like body mass index or smoking status.

3. Results

3.1. Overview

During the period 2010–2019, we identified 19163 new cases of bladder cancer (16 % of which underwent radical cystectomy), 3481 new cases of ovarian cancer (64·9 % of which were managed with debulking surgery), 6093 new cases of gastric cancer (52·4 % of which underwent gastrectomy), 20651 new cases of colon cancer and 8906 cases of rectal cancer (of which 84·4 % and 76·1 % received surgical resection, respectively).

Detailed flow diagrams describing the number of patients included in each analysis by diagnosis are reported in Figures A1–A4.

For patients undergoing surgical treatment, the demographic and clinical characteristics by cancer diagnosis are described in Table 2. For each characteristic the table shows the total number of patients and the percentage of those who have had at least one access to outpatient facilities (either a CAS or GIC visit) in the ROP before surgery. For all surgical cases, the proportion of patients with access to ROP visits is lowest in the last age group (85 +), while it is rather constant in the other age groups. A lower proportion of cases attending the ROP visits is also present for those with a higher Charlson comorbidity index and among those who spent more days hospitalized in the year preceding the index surgical admission. No clear differences in access to ROP were observed for sex, level of education and presence or absence of metastases, with the noticeable exception of ovarian cancer for which 40 % of women with metastasis were attended by ROP vs 30 % of women without metastasis. The proportion of cases managed by ROP highly increased during the 10-year period for all cancers, with the most remarkable change observed for ovarian cancer patients (from 5·4 % attended by ROP in 2010–2011–70·5 % in 2018–2019).

3.2. Quality of care and survival

The row and adjusted odds ratios (ORs) estimating the association between cancer network access and quality-of-care indicators and survival are shown in Figs. 1 and 2, respectively. Tables A3–A11 contain full model results for each cancer and indicator type. The prevalence and 95 % CIs of quality-of-care and outcome indicators within and outside the regional oncology network by period are displayed in figures A5-A13.

For all cancers and across all treatment phases, we observed that network patients had higher odds of receiving the appropriate treatment, as defined by international and regional guidelines, before, during and after surgery (Fig. 1). The only unexpected result pertains to the probability of patients managed by the ROP receiving a Positron Emission Tomography (PET) scan prior to surgery, both for stomach and rectal cancers, despite guidelines recommending this exam only for

Table 2
Demographic and clinical characteristics of cancer cohorts with total number of surgical patients (N) and percent (in columns "yes" and "no") of those managed by the Piedmont cancer network services (% ROP*).

	Bladder			Ovarian			Gastric cancer			Colon cancer			Rectal cancer		
		ROP access			ROP access			ROP access			ROP access			ROP access	
	N	Yes	No	N	Yes	No	N	Yes	No	N	Yes	No	N	Yes	No
Sex															
Male	2466	79.59	80.81	0	0.00	0.00	1945	64.11	59.51	9360	54.05	53.52	4069	61.68	57.81
Female	598	20.41	19.19	2258	100.00	100.00	1246	35.89	40.49	8078	45.95	46.48	2745	38.32	42.19
Age at surgery															
< 55	157	5.71	4.91	730	28.59	34.14	289	10.67	8.32	1361	7.80	7.81	697	11.34	9.15
55–59	172	6.08	5.44	266	11.92	11.71	208	7.58	6.03	1327	8.93	7.04	668	10.38	9.24
60–64	311	9.72	10.31	278	12.87	12.04	282	9.27	8.64	1843	10.85	10.45	803	12.03	11.55
65–69	453	15.80	14.41	301	14.09	12.96	425	13.96	13.03	2534	14.51	14.54	1030	15.34	14.90
70–74	647	20.17	21.46	285	15.18	11.38	598	20.64	17.87	2687	15.18	15.50	1048	16.29	14.50
75–79	683	21.63	22.53	213	10.43	8.95	624	19.54	19.56	3106	19.02	17.30	1130	16.86	16.32
80–84	482	16.65	15.39	132	5.42	6.05	465	12.46	15.54	2803	15.28	16.41	956	12.92	15.10
85 +	159	4.25	5.53	53	1.49	2.76	300	5.88	11.01	1777	8.42	10.95	482	4.83	9.24
Educational level															
Low	2450	80.44	79.79	1570	67.48	70.53	2647	82.95	82.95	13705	77.65	79.00	5360	78.30	79.01
Middle (diploma)	396	12.64	13.03	443	21.14	18.88	337	11.67	10.05	2458	15.03	13.70	973	15.55	13.05
High	149	4.74	4.91	189	8.94	8.09	103	3.29	3.20	937	5.85	5.17	351	4.33	5.95
Not registered	69	2.19	2.28	56	2.44	2.50	104	2.09	3.79	338	1.48	2.14	130	1.82	1.99
Charlson Comorbidity Index															
0	2467	83.72	79.34	2121	94.72	93.55	2596	84.55	79.89	14808	87.73	83.72	5919	88.27	85.50
1	328	8.87	11.38	108	4.07	5.13	414	10.97	13.89	1830	8.70	11.26	653	8.48	10.66
> =2	269	7.41	9.28	29	1.22	1.32	181	4.49	6.22	800	3.59	5.02	242	3.25	3.84
Hospitalization days in the previous year															
0	9	0.61	0.18	103	6.50	3.62	2682	84.75	83.73	14917	86.94	84.95	6027	88.78	88.13
1–14	462	20.66	13.03	1625	73.71	71.12	368	11.57	11.52	1783	9.59	10.50	559	8.27	8.14
15–28	1724	54.92	56.76	356	14.63	16.32	84	2.39	2.74	385	1.94	2.32	122	1.52	2.05
> 28	869	23.82	30.03	174	5.15	8.95	57	1.30	2.01	353	1.53	2.23	106	1.43	1.67
Metastasis															
No	2764	91.86	89.60	1649	66.53	76.18	1966	60.72	62.02	12882	72.87	74.30	5215	75.38	77.65
Yes	300	8.14	10.40	609	33.47	23.82	1225	39.28	37.98	4556	27.13	25.70	1599	24.62	22.35
Period															
2010–2011	493	3.52	20.71	463	3.39	28.82	708	6.08	29.57	3892	6.06	29.26	1574	11.58	34.25
2012–2013	636	4.98	26.55	463	7.99	26.58	714	11.86	27.19	3491	7.99	25.15	1531	15.85	28.88
2014–2015	658	12.76	24.68	416	13.28	20.92	672	19.94	21.57	3396	16.70	20.66	1341	19.76	19.61
2016–2017	643	31.47	17.14	418	27.78	14.01	563	26.22	13.71	3392	28.32	15.67	1215	24.92	10.97
2018–2019	634	47.27	10.93	498	47.56	9.67	534	35.89	7.95	3267	40.93	9.26	1153	27.90	6.30
Regional Reference center															
No	411	6.93	15.80	562	5.96	34.08	490	9.57	18.01	2900	9.62	19.62	1109	10.50	21.86
Yes	2563	90.16	81.26	1640	91.19	63.62	2674	89.63	81.12	14487	90.11	80.08	5677	89.11	77.71
Extra-regional hospitals	90	2.92	2.95	56	2.85	2.30	27	0.80	0.87	51	0.27	0.30	28	0.39	0.43

* ROP: Rete Oncologica del Piemonte

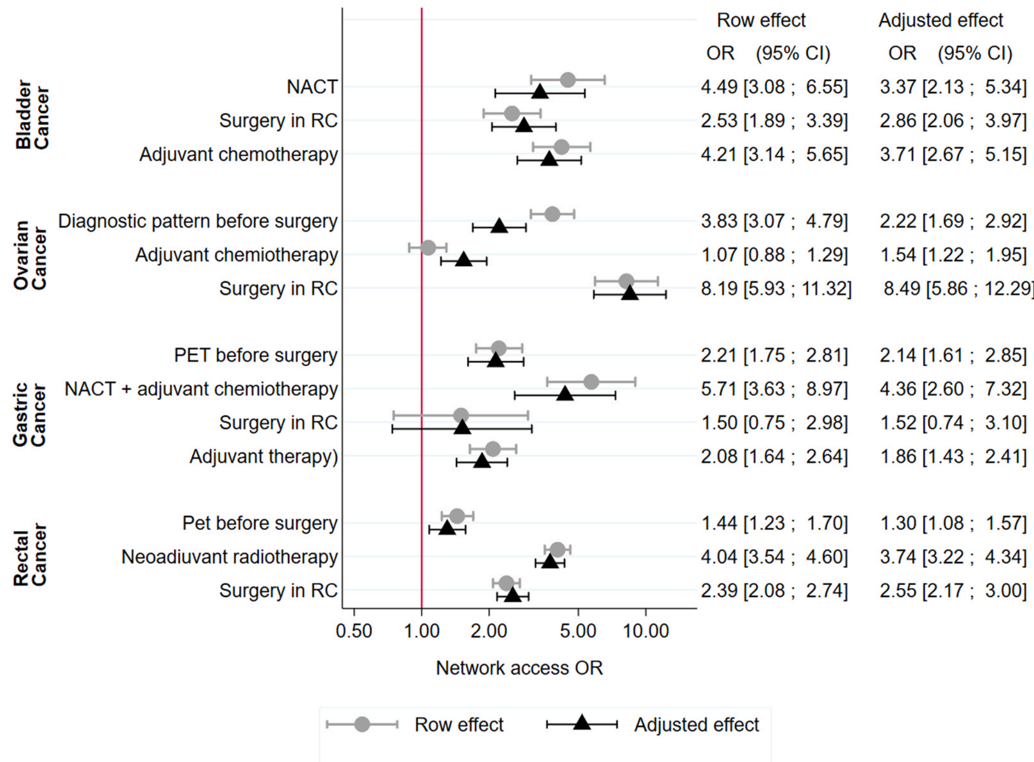

Fig. 1. Row and adjusted effect of the regional cancer network on adherence to quality-of-care performance indicators, by cancer type. NACT=Neoadjuvant Chemotherapy; RC= Reference Centre; PET= Positron Emission Tomography; OR=Odds Ratio; CI=Confidence Interval.

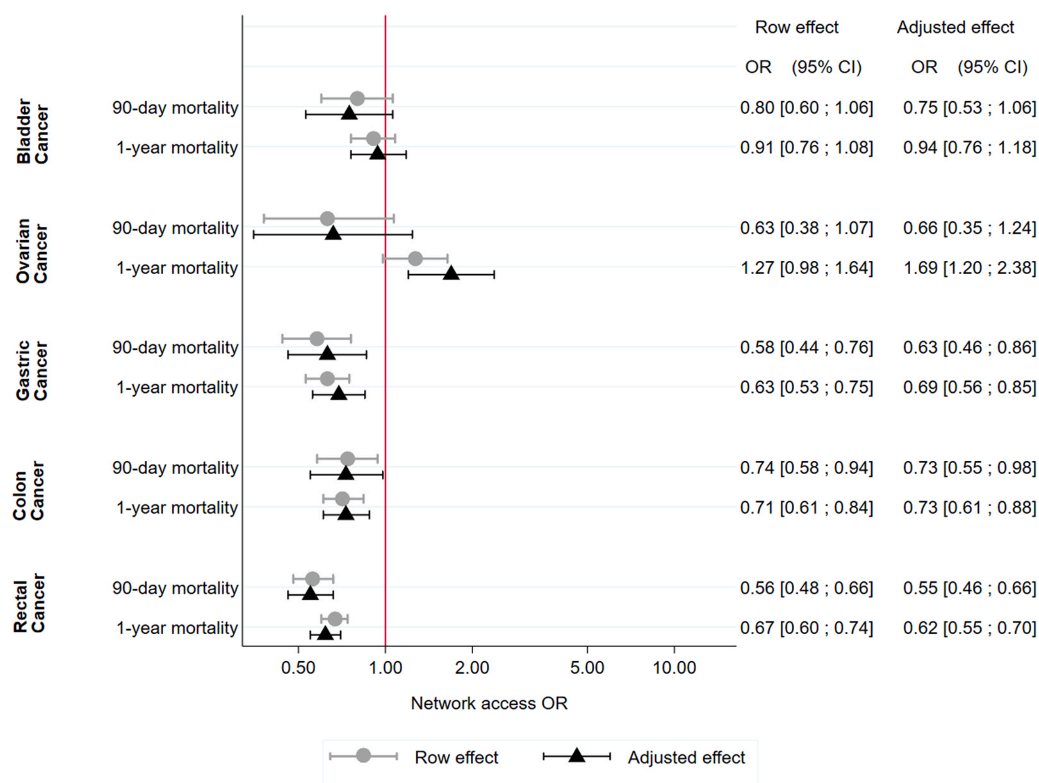

Fig. 2. Row and adjusted effect of the regional cancer network on mortality (90 days and one year), by cancer type. OR=Odds Ratio; CI=Confidence Interval.

selected cases (Macrae et al.; National Guideline Alliance, U.K, 2018). More precisely, F-18 PET is recommended for gastric cancer patients only when their disease is suspected to be metastatic and if it can help decide treatment options. For rectal cancer, FDG-PET has not been shown to add significant information to conventional imaging for the initial locoregional staging of rectal cancer. Interestingly, the percentage of patients with a PET examination for gastric cancer decreased over time from 31·5 % to 19·5 % in patients managed by ROP and increased from 8·9 % to 17·6 % for those without access to ROP (Figure A7). A similar trend, although with smaller differences, was documented for PET examinations for rectal cancer (Figure A11). Despite some imbalances between the groups of patients with and without access to ROP, the adjustment for numerous potential confounders was almost negligible, as the ratio of adjusted vs row ORs were very close to 1 for most outcomes (median ratios of ORs=0.93), confirming a positive association of ROP with a more appropriate cancer care pathway.

Fig. 2 illustrates the ORs of access to the ROP for 90-day and 1-year mortality, with both row and adjusted estimates for individual-level characteristics as described in the Methods section. Tables A7–A11 contain complete model results for each outcome indicator and cancer type.

In three cancer cohorts (gastric, colon and rectal cancers), patients managed within the ROP showed a significant reduction in the risk of dying within 90 days and one year after surgical treatment. For bladder cancer, we observed a less clear reduction in mortality at 90 days and one year between patients treated in and outside the network (OR at 90 days 0·75 95 %CI 0·53–1·06; OR at one year 0·94 95 %CI 0·76–1·18). For ovarian cancer, on the contrary, we observed an increased risk of 1-year mortality for women treated within the network (OR 1·69 95 %CI 1·20–2·38). Even for the survival outcomes, the ratio between the adjusted and row ORs is very close to 1 (median ratio of ORs=1.03), excluding a relevant confounding effect for the various covariates included in the logistic models. The only exception is 1-year mortality for ovarian cancer, which showed a worse adjusted outcome for those managed by the ROP. However, as shown in Figure A10, this effect was largely influenced by the early years of the onset of ROP, when the very low proportion of ovarian cancers referred to ROP (about 5 %) was strongly selected for poor prognosis (with a 1-year mortality of 28 % in 2010–2011), but this excess shows a clear reducing trend with time.

4. Discussion

Demonstrating the effectiveness of clinical networks in terms of quality of care and patient outcomes is challenging, as it depends upon a large variety of factors that are difficult to control in real-world settings, where the feasibility of randomized experiments is rather impossible. Nevertheless, as it happens for health services, procedures and technologies, the impact of organizational models on patients' health needs to be assessed to confirm expectations and before resources, which could otherwise be diverted for competing ends, are allocated. A review by Brown et al. (2016) clearly highlighted that available evidence on the effectiveness of clinical networks is scarce, often of poor quality, and mainly stemming from qualitative study designs aimed at narratively identifying the key features for a network to be successful without measuring its performance. Most studies have explored and reported improvements in service delivery and much fewer on patient outcomes. These studies often cover a limited period, insufficient to assess a complex organizational and cultural process whose implications may need time to be embedded in routine practice. In their review, eight out of 22 studies focused on cancer networks, of which only three were quantitative studies and only two were rated to be of moderate quality (Brown et al., 2016). Patient outcomes were measured in terms of improvement in compliance with clinical guidelines and/or in service delivery (e.g., time interval from referral to initial assessment by the service), and they were mainly in favour of the group of patients treated by networks. Similarly, more recent studies (Eggink et al., 2017; Penel et al., 2016; Carpenter et al., 2011; Brauer et al., 2017) used the same metrics to assess the effectiveness of cancer networks and confirmed previous findings, i.e., compliance to guidelines and patients' waiting times improve when patients are treated within networks.

Our study offers an empirical evaluation of a positive association between network access and quality of care and survival over a period of ten years, with a large sample of common cancers of the entire Piedmont region, thus improving our knowledge on clinical network effectiveness. Overall, our findings support the interpretation that cancer networks are effective in improving compliance to guidelines, reducing interval times between diagnosis and treatments, and, possibly, extending survival.

A few unexpected findings emerged as well, such as an over-prescription of staging PET scans in gastric and rectal cancers and higher mortality at one year in ovarian cancer patients referred to the ROP. However, after analysing these results across the study period of ten years, we identified the first years as the period in which the risk of recording these unexpected effects was greatest, while there is a clear trend of a marked improvement in both performance and outcome indicators among patients managed by the ROP in the following years.

Indeed, our results indicate that the penetration of the oncology network culture in the healthcare system, cantered on the multidisciplinary approach and collaboration between various facilities (e.g., hospital and community care services, rural and urban centres, etc.), is generally a slow process, and one with different speeds and starting points between the various specialties and type of cancer. The observed reduction in this variability over the ten years is also suggestive of the maturity of ROP and the success of this experience, as reducing unwarranted variability and ensuring equity in access and treatment are at the heart of the network concept itself.

These considerations warn of the risks of complex selection bias and insufficient control of confounders that can plague any attempt to evaluate healthcare organizations using observational approaches and administrative data. The selections of patients referred to the network are multiple, with opposing and time-varying effects. During the initial years included in the present analysis, the probability of being referred to the ROP was generally low, especially for older patients and for those with more comorbidities, as these patients were considered unsuitable for active oncological treatments. At the same time, among patients with some therapeutic options, those with more advanced or complex tumours were more frequently referred to ROP. These selections tend to weaken over time, and in more recent years, as the ROP has included most cancer cases. Furthermore, our ability to adjust comparisons for major confounders is a cause for concern. Routine administrative data enhances the scale and policy relevance of the analysis, but lacks important clinical information about diagnosis, such as accurate staging and histology, as well as information about the patient, such as a complete assessment of performance status and personal behaviours of prognostic significance, such as smoking habits. On the other hand, the very small differences for most outcomes between the raw and adjusted ORs suggest that all covariates included in the logistic models, although being strong prognostic factors (e.g. age, presence of metastases, comorbidity and days spent in hospital in the previous year), play a limited role as confounders. However, there are also arguments to support the hypothesis that the potential impact of the ROP could be even greater than that observed. The indicator chosen to label patients as 'managed by the ROP', based on an outpatient CAS or GIC visit prior to the index treatment, does not necessarily imply that all these patients followed the treatment indications or that compliance was optimal during the subsequent course of their disease. Similarly, those initially classified as 'usual care' may have benefited from subsequent ROP visits, leaving a degree of random misclassification between the two groups leading to weaker associations. The results of our study could be interpreted similarly to an analysis of a trial based on an intention to treat approach in presence of bidirectional cross-over of the patients. Therefore, a full implementation of the ROP and higher adherence by both patients and health professionals could lead to even better outcomes than those observed.

Our results are based on internal comparisons in a single region and a selection of common cancers. Caution is therefore warranted in generalizing these findings to other cancers and contexts, as not all cancer networks are the same.

The type of cancer network in Piedmont is known in literature as a managed clinical network and consists of groups of clinicians who deliver services across the boundaries of healthcare professions and different sectors of the health system. They have hierarchical governance and formalized collaborations between different organizations, units and professionals in terms of care processes, support services, and knowledge-sharing models (Ferlie and Addicott, 2004; AGENAS, 2023). These distinctive features are integral to understanding our findings and should inform any interpretation of the observed positive outcomes. While the characteristics of the Piedmont oncology network may serve as a reference model, the positive correlation we found in terms of the quality of cancer care and survival does not guarantee that they can be easily interpreted in terms of causality and replicated in other contexts or for other chronic diseases. Interregional comparisons—particularly between areas similar in healthcare provision and socioeconomic conditions but differing in network maturity—could provide further insight, although data limitations pose a significant challenge.

Despite these contextual specificities, we believe the relevance of this study extends beyond its regional scope. Our analysis contributes to both national and international discussions on cancer care delivery. In Italy, where cancer networks are organized regionally, there is sustained interest in their performance and implementation, as reflected in the recent report Sixth National Survey on Regional Cancer Networks conducted by the National Agency for Regional Healthcare Services (Agenas) (AGENAS, 2023). Our findings contribute to this national benchmarking effort and offers evidence that can inform comparative evaluation across regions.

At the European level, the European Society of Breast Cancer Specialists (EUSOMA) has emphasized the importance of structured "unit" models and shared expertise (Wilson et al., 2013). Our work aligns with this approach by assessing outcomes typically overlooked in favor of process evaluations. Similarly, the more recent experience of the European Reference Networks (ERNs) for rare diseases reflects a shift toward transnational collaboration for rare, low-prevalence diseased and conditions, driven by the same 'unit model' (Directive, 2011). We believe our findings and methods offer useful tools for evaluating and informing such initiatives.

We close with a final consideration: while the question of whether cancer networks represent good value for money fell outside the scope of the present study, it remains a critical issue—one that future research should address to guide resource allocation and system design.

CRediT authorship contribution statement

Benedetta Pongiglione: Writing – review & editing, Writing – original draft, Visualization, Supervision, Methodology, Conceptualization. **Paola Roberta Boscolo:** Writing – review & editing, Writing – original draft, Conceptualization. **Giovannino Ciccone:** Writing – review & editing, Supervision, Methodology, Formal analysis, Conceptualization. **Rosanna Tarricone:** Writing – review & editing, Writing – original draft, Supervision, Project administration, Conceptualization. **Valeria Tozzi:** Writing – review & editing, Conceptualization. **Anna Castiglione:** Writing – review & editing, Visualization, Methodology, Formal analysis, Data curation. **Eva Pagano:** Writing – review & editing, Methodology, Formal analysis, Conceptualization. **Gianpiero Fasola:** Writing – review & editing, Supervision, Conceptualization. **Oscar Bertetto:** Writing – review & editing, Validation, Supervision, Conceptualization. **Marco Gilardetti:** Data curation. **Daniela Di Cuonzo:** Data curation.

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Declaration of Competing Interest

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

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.ssmhs.2026.100194.

Data availability

Partial restrictions to the data and/or materials apply. The ownership of the regional data warehouse analysed belongs to the Department of Health of the Piedmont Region. The authors were authorised to access the data only for the monitoring of quality of care indicators. Authorisation to access the analysed dataset must be requested by the interested researchers directly from the regional health authority.

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