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# Choice of hospital and long-distances: evidence from Italy

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## Abstract

Long-distance hospitalizations may represent an important phenomenon, especially with severe pathologies. In this work, we investigate patients' elective admissions for cancers of the digestive system distinguishing between "local" hospitals (located in the region of residence) and "distant" hospitals (located in long-distances non-boundary regions). We model patient mobility towards alternative hospitals as a discrete choice process determined by geographical distance, clinical quality and other hospital-level characteristics and control for patients' heterogeneity. We exploit data on admissions of patients residing in insular Italy, occurred in 2013 either locally or in central-northern hospitals, and estimate a willingness to travel of at least 14 km to be cured in a distant hospital for a quality increase from the 75$^{th}$ to the 25$^{th}$ percentile. Higher values are found for younger and more educated patients. Clinical quality does not affect the choice of local hospitals. Hospital choice significantly depends on characteristics that proxy hospital attractiveness, with differences between local and distant providers: commitment to research and private ownership show a positive role only for the latter.

**Keywords**: hospital choice; access to care; distance, quality of care; patient mobility

**JEL codes**: C25, I11, I18.

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## 1 Introduction

Patient mobility for hospital care is a remarkable phenomenon, particularly in those national healthcare systems where policies that promote free choice have been introduced and citizens are entitled to choose any public or private provider in the country (e.g. Italy, Denmark, England, the Netherlands, and Sweden). Studying patient choice is particularly interesting in contexts where healthcare is publicly funded and where it combines with specific features of the system, such as decentralization, the level of competition between providers and the development of hub-and-spoke hospital networks (e.g., Beckert et al., 2012; Costa-Font and Turati, 2018). In those settings, and especially when health needs are severe and require highly specialized treatments, patients' choice patterns might represent a challenge to universalism and equity at the country level.

The extant literature on hospital choice model has deeply examined the key roles of both distance and quality by using patient-episode level data and investigating the demand for specific elective treatments (e.g., Varkevisser et al., 2012; Gutacker et al., 2016). Patients' choice significantly depends on clinical quality but is also limited by distance, so that patients' willingness to travel beyond the nearest hospital for their care is essentially restricted to local hospitals. These findings derive mostly from studies that have analyzed mainly hospitalizations that - because of the healthcare context or the treatment under analysis - are characterized by relatively short distances between patients and hospitals included in the patient's choice set. The resulting patients' choice sets include a manageable number of local hospitals embracing the nearest hospital and hospitals located in contiguous areas (for a review, see Aggarwal et al., 2017).

In this paper, the choice set of the patient is defined by considering even very distant hospitals. Studying long-distance hospital mobility has special policy relevance in national healthcare settings where a non-negligible share of patients is observed to travel long distances for specific treatments required for severe pathologies, and where the hospital's catchment area is very large (e.g., because of mobility across non-bordering regions). To the best of our knowledge, the peculiarities of long-distance mobility have not been investigated within a hospital choice framework. The inclusion of very distant hospitals originates new research questions about the interplay between distance and quality. Is the (relatively low) demand for distant high-quality institutes the simple outcome of the offsetting disutility deriving from higher distances, or does the demand effect of distance and quality change with faraway providers, thus making more likely the choice of long-distance hospitalization?

Understanding long-distance hospital mobility is also key to nourish the debate about quality improvements arising from the centralization of complex treatments in high volume centers (e.g., Gaynor et al., 2005; Learn and Bach, 2010; Avdic et al., 2019) and policies of hospital consolidation and closure (e.g., Buchmueller et al., 2006; Carroll, 2019). The overall effectiveness of such policies largely depends on the accessibility and the actual use of specialized care facilities by the whole population.

In our empirical application, we study the demand for local and distant elective hospital care in the Italian National Healthcare Service (NHS). The NHS is a regionally decentralized tax-funded system with free-patient choice, comprising 21 autonomous regional health services (RHS), in which patients can be admitted free of charge in any (public or licensed private) hospital of the country. Admissions usually follow a general practitioner or a specialist referral. Otherwise, they might take place after accessing the hospital emergency services or be due to inter-hospital patient transfers. In case of admissions taking place outside the RHS of enrolment, hospital reimbursement is regulated by interregional compensation schemes centered on diagnosis-related group (DRG)-based national tariffs.[1] Over time, regional heterogeneity has fostered quality differentials which have nourished a high and persistent interregional patient mobility. Mobility patterns are characterized by patient flows from southern regions towards hospitals located in very distant regions of central–northern Italy, despite the related costs of traveling. Data from the Italian

[1] See Levaggi and Zanola (2004) for a more detailed description of the institutional background; and Balia et al. (2018) for specific analyses of interregional patient mobility in Italy.

Ministry of Health (2017) show that, in 2016, 4.8% of overall hospital admissions of residents in the southern - and poorest - regions (the Italian *Mezzogiorno*) took place in the northern regions, particularly for complex care, with an average distance (considering the provincial centroids) of about 725 km.

The Italian case is compelling because the typical periphery-center pattern characterizing hospitalizations at the local level is *de facto* replicated on the national scale. By law, a full set of services and treatments - the so-called LEA (*Livelli Essenziali di Assistenza*, essential levels of care) - must be made available in the region of residence. However, the most important hospitals are located where the population and economic activities are more concentrated. Likewise, teaching hospitals and research hospitals providing specialized treatment are generally located close to universities, which are mostly located in the main cities of the northern and, in part, central regions.

We use data on elective admissions in 2013 for neoplasms of the digestive system, which are one of the first two causes of cancer-related deaths in OECD countries. Elective cancer treatments often require a high level of specialization and are usually based on a previously planned hospitalization and related outpatient treatments. Nationwide indicators of outcome quality, namely post-discharge 30-day mortality rate, are available at the hospital level for digestive system cancers.



To have a clear geographic distinction of closeness and distance, we take advantage of the insularity condition of two regions from Mezzogiorno (Sardinia and Sicily) and only consider admissions of residents in the local hospitals of these two islands and the hospitals of the central-northern regions. The rationale for adopting this strategy is threefold. First, the *size and direction of the phenomenon*. Even though central-northern hospitals are very distant from the islands and patients who reside on them need to take a flight or a ferry to reach them, in 2013, outflows for elective care from Sardinia and Sicily toward central-northern hospitals accounted for 5.7% of total admissions. The discharge records used in this work show that the outflow rate of digestive system cancer patients is almost twice as large (10.7%). On the other hand, the share of patients residing in central-northern regions and moving to the islands is negligible (0.16%). Second, the *preservation* *of the representativity of the actual choice set*. As said before, all southern regions are characterized by important outflows, but only the two insular regions do not accidentally "trade" patients between each other because of the absence of typical bilateral flows that characterize bordering "mainland" regions. Imposing no restrictions on the distance range, this yields a choice set of alternative hospitals that at the same time ensures the representativity of the phenomenon and is manageable for empirical modeling. Third, and this rationale is related to the previous one, the *minimization of spatial autocorrelation and bordering confounding effects.* Focusing on patient regions of residence that are not contiguous to the areas where extra-regional hospitals are located allows us to avoid the econometric issues related to spatial proximity and regional bordering effects (which, otherwise, would drive a vital part of interregional patient mobility; see e.g., Balia et al., 2018), with a negligible loss in the actual choice set (only 0.34% of patients living in Sardinia and Sicily seek hospital care in the remaining southern regions).

We model hospital admissions within a mutually exclusive choice framework based on an individual utility function where the parameters of hospitals' attributes are allowed to vary between "local" and "distant" hospitals and unobservable heterogeneity in individual preferences is addressed by estimating unordered discrete choice regression models. Observable heterogeneity is captured by allowing hospital-level parameters to vary with individual socioeconomic characteristics. Special attention is paid to changes in the substitution pattern between clinical quality and distance when potential hospitals in the choice set are located at long distances (in the order of several hundred km). We find that, considering long-distance hospitalizations, the reference patient (aged 75 or older and with low educational achievement) is willing to travel at least 14 km for a decrease in 30-day mortality rate from the 75$^{th}$ to the 25$^{th}$ percentile, well above the effects detected from the existent literature. The willingness to travel is higher for younger and more educated patients.

## 2 Related literature

Considering hospital choice within a standard framework of product differentiation, each "provider" is characterized in terms of both location (distance from the patient) and quality. Quality typically has a multidimensional characterization where, according to a classification by Donabedian (2003), structure, process, and outcome factors play concurrent roles. The first two are easily interpreted as inputs of a healthcare production function whose outcome is typically summarized by objective clinical indicators.

Though structure and process factors are crucial determinants of a hospital's ability to attract patients (Luft et al., 1990; Tay, 2003), most studies have focused on the demand effects of clinical quality. Special attention has been given to the advantages of disseminating information on hospital-level quality, intended to increase demand responsiveness and, ultimately, improve health outcomes. When hospital quality measures are not publicly available, and local information or social interactions influence patients' choices, competition among providers does not necessarily lead to better health outcomes (Berta et al., 2016). Conversely, important effects of clinical quality are usually found when public reports on hospital outcomes are released (e.g., Pope, 2009; Varkevisser et al., 2012; Chou et al., 2014).



Some studies have raised doubts about the primacy of clinical quality vis-à-vis different outcome measures, and both structure and process factors. Goldman and Romley (2008) found that an increase of one standard deviation in an aggregate measure of "amenities" in hospitals in the greater Los Angeles leads to an increase in hospital demand (pneumonia patients) of approximately 38.5%, whereas analogous variations in clinical quality yield much smaller variations. Gutacker et al. (2016) found that self-reported outcome measures play a prominent role in patient choice for hip replacement, whereas hospital demand is less responsive to clinical quality indicators (death or emergency readmission rates) that, for hip replacement, represent extremely rare events.

A stream of literature has focused on the trade-off between quality and distance that arises when considering the interplay between centralization of specialized treatments, hospital closures and effective access to care. The closure of small hospitals usually involves an increase in average quality. Nonetheless, for some population components (seniors, low-income, ethnic minorities, and less educated people) distance may represent a serious hurdle. Buchmueller et al. (2006) do not find negative effects in terms of access for pathologies for which timely care is relatively less crucial (cancers and chronic heart diseases), whereas less optimistic results are found for preventive care (e.g., Lu and Slutsky, 2016) and time-sensitive treatments (e.g Avdic et al, 2016; Carroll, 2019).

Most previous studies compare the impact of quality on demand to the (negative) effect of distance. In part, this comparison is performed because empirical analyses are based on a discrete choice econometric framework, which identifies effects up to a scale factor, consequently requiring an interpretation of the results in terms of marginal rates of substitution (MRS), which measure the patient's willingness to travel (WTT) to receive better care. In part, this also depends on the fact that hospital care is an industry in which - differently from most primary and manufactured goods - the "service" can only be purchased in the place of production, so that geographical distance is crucial in the consumers' decision process. The existing evidence, based on relatively short movements, demonstrates that patients are not very willing to travel to be treated in higher quality hospitals. For example, in Romley and Goldman (2011), Medicare patients' WTT for pneumonia treatment ranged from 2.41 to 3.94 miles to be treated in a hospital with quality at the 75$^{th}$ percentile of distribution rather than at the 25$^{th}$ percentile. In Chandra et al. (2016), AMI Medicare patients' WTT for an increase of 1 percentage point in risk-adjusted survival and readmission rates ranged from 1.1 to 1.8 miles. Moscelli et al. (2016) found that patients' WTT for hip replacement surgery to avoid a deterioration of one standard deviation in quality, was up to 0.5 km. Raval and Rosenbaum (2018) found that choosing a hospital at the 75$^{th}$ percentile of the quality distribution instead of one at the 25$^{th}$ percentile was worth traveling up to 17 additional minutes (which is a 98.7% increase in travel time).

## 3 Empirical approach

The decision about whether and where to be hospitalized is a complex process where the patient, her family/friends, and GP can play a role. Henceforth, for simplicity, we will refer to the patient's choice. However, as in most existing studies, we cannot observe who actually "drives" hospital choice.

We model patients' demand for elective hospital care for digestive system cancers by considering each hospital admission as the result of a "choice" by patient $i$ over a set of $h = 1, 2, \dots, H$ mutually exclusive hospitals. This choice is described by a random utility specification:

$$U_{ih} = \boldsymbol{\beta}'_d \boldsymbol{d}_h + \beta_q q_h + \boldsymbol{\lambda}' \boldsymbol{x}_h + \boldsymbol{\theta}'_d (\boldsymbol{z}_i \otimes \boldsymbol{d}_h) + \boldsymbol{\theta}'_q (q_h \boldsymbol{z}_i) + \boldsymbol{\theta}'_x (\boldsymbol{z}_i \otimes \boldsymbol{x}_h) + \varepsilon_{ih} \quad (1)$$

where $\boldsymbol{d}_h$ is the distance (expressed as an $n$-order polynomial) between the hospital and the patient's place of residence, $q_h$ is a measure of the hospital's clinical quality, and $\boldsymbol{x}_h$ includes other hospital attributes. All these variables are interacted with the observable individual characteristics $\boldsymbol{z}_i$ (age, education, and gender) to allow for observable preference heterogeneity among types of patients as captured by the parameter vectors $\boldsymbol{\theta}_d$, $\boldsymbol{\theta}_q$, and $\boldsymbol{\theta}_x$.

Because we aim to assess whether patients' utility is differently affected by hospital characteristics depending on hospitals being in the area of residence or at long distances, we propose an augmented version of equation (1), where parameters are allowed to vary between two groups of alternatives, represented by local hospitals on the two islands, and distant hospitals in the Center-North of Italy. The new utility specification includes a set of interactions between hospital attributes and an indicator variable $L_h$, which equals 1 if the hospital is in the patient's region of residence:

$$U_{ih} = \boldsymbol{\beta}'_d \boldsymbol{d}_h + \boldsymbol{\beta}'_{Ld} (L_h \boldsymbol{d}_h) + \beta_q q_h + \beta_{Lq} (L_h q_h) + \boldsymbol{\lambda}' \boldsymbol{x}_h + \boldsymbol{\lambda}'_{Lx} (L_h \boldsymbol{x}_h) +$$
$$+ \boldsymbol{\theta}'_d (\boldsymbol{z}_i \otimes \boldsymbol{d}_h) + \boldsymbol{\theta}'_q (q_h \boldsymbol{z}_i) + \boldsymbol{\theta}'_x (\boldsymbol{z}_i \otimes \boldsymbol{x}_h) + \varepsilon_{ih} \quad (2)$$

For the reference patient who opts for long-distance hospitalization, the marginal utilities of distance, clinical quality, and other hospital attributes are respectively recovered from the parameters $\boldsymbol{\beta}_d$, $\beta_q$, and $\boldsymbol{\lambda}$. For patients choosing local hospitals, the analogous marginal utilities are obtained from the algebraic sums $\boldsymbol{\beta}_d + \boldsymbol{\beta}_{Ld}$, $\beta_q + \beta_{Lq}$, and $\boldsymbol{\lambda} + \boldsymbol{\lambda}_{Lx}$.

By assuming that the individual random components, $\varepsilon_{ih}$, capturing the unobservable determinants of a patient's $i$ choice, are independently and identically distributed (i.i.d.), with the type 1 extreme value distribution, equation (1) can be estimated using the "conditional logit" model. The previous assumption leads to the independence of the irrelevant alternatives (IIA) property, which may prove very strong when the number of alternatives is large. In general, it is advisable to test for the IIA and estimate models that are robust to its violation. Therefore, we estimate a "heteroscedastic conditional logit," which fully relaxes the IIA by allowing the variance of the unobserved heterogeneity to vary across individuals. Following Hensher et al., (1999) and Hole (2006), the scale parameter is modeled as a function of observable individual characteristics, yielding the so-called parametrized heteroscedastic multinomial logit model.[2]

Flexibility in the random utility model can also be obtained with the "mixed logit" model, which obviates the IIA limitation by allowing for random taste variation and unrestricted substitution patterns (Train, 2009). We propose a specification that addresses unobserved patients' heterogeneity in preferences over quality and distance. Effects related to quality might capture individuals' diverse abilities to receive and process information about the clinical quality of care. Those related to distance might capture differences in preferences for traveling for care deriving from the presence of a support network (family or friends) close to a hospital. The source of knowledge provided by similar networks can lessen the disutility of distance by reducing the costs of getting information about the hospital and the costs of accommodation.[3]

[2] The "nested logit", which only partially relaxes the IIA property and presents serious drawbacks in the case of many choice alternatives (e.g. Bath, 1995, for details) is not considered appropriate in this application.

[3] As discussed in the Introduction, in the Italian case, inter-regional migration dynamics are characterized by large flows of people from southern regions, particularly Sardinia and Sicily, towards northern-central regions.

## 4 Data

We use patient-level data from the Italian hospital discharge records (SDO) on admissions for treatments for digestive system cancers of patients enrolled in Sardinia and Sicily, the two main Italian islands located in the South of the country, occurring in the year 2013. Our working sample is 4,508 elective admission episodes in 46 different public and private Italian hospitals. We enrich the SDO data with information from other administrative sources. We assign an indicator of geographical distance (between patients and hospitals) to each admission record, calculated as the (Euclidean) distance in kilometers (km) between the centroid of the LHA of enrollment of patients *i* and hospital *h*. Hospitals in the choice set can be located within the region of residence (within the LHA of enrollment or in one of the others) or in any region of the north-central region of Italy. An accurate specification of the relationship between distance and the probability of choosing from a large choice set of hospitals is crucial to obtain reasonable estimates of the MRS between distance and hospital quality. Non-linear specifications of the distance effect have been proposed by existing studies: either quadratic specifications (e.g. Beckert et al., 2012) or cubic specifications (e.g. Moscelli et al., 2016). Distance is expected to affect a patient's choice negatively: it should capture the disincentive effect of seeking hospital care out of their Local Health Authorities, or even region, generated by the cost of mobility.

We include a measure of clinical quality released by the National Agency for Regional Health Services. This measure is the 30-day risk-adjusted mortality rate after malignant neoplasm colon surgery, calculated at the hospital level for admissions that occurred between January 1, 2007, and November 30, 2012.[4] The timing is particularly convenient because it guarantees that the current choices (i.e., hospitalization occurred in 2013) cannot affect health outcomes and hence the level of quality adopted, thus ruling out the risk of endogeneity. Even the time at which the quality indicator was released (end of the year 2013) is relevant because we can reasonably assume that it was not available to patients to make an informed choice. Nonetheless, because information about quality

[4] See Appendix A.1 for additional details and discussion on this clinical quality indicator and the source of data.

differences among hospitals is spread among the population, at least through informal networks, we expect that the lower the value of the quality indicator, the lower the probability of a hospital being chosen.

We control for potential hospital size effects by using the information on the number of beds and distinguish between teaching and research hospitals (either public or private) and licensed private hospitals. Compared with other hospitals, teaching clinics might attract more patients because their mission and commitment to research make them more likely to provide state-of-the-art treatments using advanced technologies. Private ownership might influence hospital attractiveness through more flexible management of waiting lists,[5] the availability of more personalized care plans, and the provision of both more and better amenities. Private hospitals are also known to have strategic incentives to attract extra-regional patients (e.g., Fattore et al., 2014; Brenna and Spandonaro, 2015). Finally, because we expect that patients seek hospitals specializing in complex cases, mainly if their health condition is severe, we include the hospital case-mix index (CMI).

## 5 Results

### 5.1 Summary statistics

Table 1 shows how patients moved for hospital care. Approximately 22.1% of patients chose a "local hospital," i.e., stayed in their region, but chose a hospital belonging to an LHA different from that of their enrollment. The fraction of patients bypassing the closest hospitals decreases with distance but is still very high for longer distances: 41.3% of patients bypassed hospitals located 10 km from the closest one, 29.4% bypassed those at 30 km, and 26.2% bypassed those at 50 km.

The average distance to local hospitals is 42.3 km; the closest hospital is approximately 3 km away, and the most distant hospital is located 212.4 km away. These figures clarify that restricting the choice set at a specific threshold distance (e.g., 30 or 50 km) would impose an arbitrary

[5] Information on waiting time for the Italian NHS is usually available only at the regional level (e.g., see Riganti et al, 2017).

selection to the data. The fraction of patients choosing one of the (extra-regional) distant hospitals is quite high (approximately 16.9%). These hospitals are at an average distance of 759.9 km, from a minimum of 285.7 km up to a maximum of 1099.1 km.[6]

Admissions also differ regarding both quality and other hospital characteristics. For all admissions, the average 30-day mortality rate in the chosen hospital is approximately 5.7%. This value is 0.32 percentage points higher in local hospitals and approximately 1.6 points lower in distant hospitals. The average hospital size is larger in the group of "distant" admissions. The same applies to the CMI index, meaning that patients traveling farther for care end up in hospitals specializing in complex cases. Only 31.1% of "close" admissions occurred in teaching and research hospitals, compared with 69.7% in the group of "distant" admissions. Similarly, the share of admissions occurring in licensed private hospitals is higher in distant hospitals (42.7% *vs.* 0.04%).

Considering patients' characteristics, we note that 44% of patients are women, and this sex composition is constant between admissions to local hospitals and distant hospitals. Most admissions refer to individuals aged 65–74 years old (45.6%). In line with the well-known socioeconomic gradient in health, most admissions are of people with low levels of education (none to lower secondary education). Long-distance hospitalizations are characterized by a much smaller share of the oldest individuals (13.4% vs. 29.5% for local hospitals) and a consequent higher share of younger age classes. Conversely, the fraction of individuals with low levels of education is more substantial in local hospitals, whereas the fraction of highly educated individuals (those with tertiary education) is almost double in distant hospitals. Table 2 also shows that the proportion of admissions in distant hospitals decreases with age but increases with education. The oldest and least educated patients appear to be less likely to travel for care.

[6] This is the distance between north-east Sardinia and the closest hospital in Lazio. It can be covered only by ferry or airplane.

### 5.2 Estimation results

Table 3 first reports estimates from a conditional logit model for a baseline specification that only includes clinical quality, distance, and other hospital attributes (Model 1). All coefficients are interpretable (up to some adjustment) as marginal utilities (or disutilities). As expected, the "gravitational pull" of a hospital is positively affected by both its size and specialization in complex cases. The coefficient of teaching and research hospitals, as well as private hospitals, is positive and significant, consistent with the arguments presented above. The disutility of distance is confirmed by the negative sign of the coefficients and is significantly shaped by the cubic specification. The estimation of a third-order polynomial allows us to detect the existence of non-linearities in the shape of the marginal disutility of distance. The coefficient of the 30-day mortality indicator does not exhibit the expected negative sign. This counterintuitive result is confirmed when estimating a model consistent with equation (1) that includes interactions between individual characteristics and all hospital attributes (Model 2). For this and all the subsequent models, the reference patient is an elderly (75 years or older) male with a low level of education (up to primary education).

The last three columns of Table 3 show the results from the estimation of equation (2), where interactions between hospital characteristics and the indicator variable for hospital location are included, thus yielding separate coefficients for hospital characteristics of distant hospitals (upper part of the table) and local hospitals (bottom part of the table).[7] All models (the conditional logit in Model 3, the heteroscedastic conditional logit in Model 4, and the mixed logit in Model 5 where the polynomial of distance and clinical quality are allowed to vary randomly across observations) provide evidence of a substantial change in the estimated coefficient of clinical quality.[8] The 30-day mortality rate is significant and negative in the case of distant hospitalizations: as the mortality rate



[7] For sake of completeness, point estimates for all regressors are reported in the Appendix.

[8] The mixed logit has been estimated assuming normally distributed random coefficients for quality and distance. This choice is useful when there is no *a priori* on the signs of the squared and cubic term of the polynomial of distance. We have nonetheless estimated two alternative specifications: a first one, where only quality is lognormally distributed; a second one where even the polynomial terms are lognormally distributed. In the latter specification the first and third terms of the polynomial, with a negative sign in the conditional logit model, have been transformed into positive variables. Results are unaffected by changing the specification of the random variables.

increases (quality decreases) the probability that a distant hospital *j* is chosen by patient *i* decreases (hence, the marginal utility of quality is positive). However, clinical quality does not exert the same effect in local hospitals, for which the coefficient is not statistically significant and can be interpreted as a null marginal utility of quality. The quality signal not only does not vanish with distance but also seems to strengthen for long-distance mobility. Though the McFadden-Hausman test in Models 3 strongly rejects the IIA property, results hold even when relaxing it in both Models 4 and 5.[9]

Models 3 to 5 provide evidence of other differences between distant and local hospitals. For the former, the complexity of treated cases seems more important than for local hospitals in increasing the likelihood of a hospital to be chosen (the coefficient is twice as large), whereas hospital size has a larger effect for local hospitals (the coefficient is approximately three times that of distant hospitals). Teaching and research hospitals and private hospitals have a significant positive probability of being chosen only if located in the central-northern regions. This result can be explained by the role played by these types of providers in Northern Italy, where they are often at the forefront of medical research (many of them are universities).



### 5.3 Robustness analysis

We assess the robustness of the previous findings by briefly extending the analysis by considering: i. an additional, more specific, indicator of long-distance accessibility; ii. all types of hospital admissions. For the sake of brevity, only the estimates from the mixed logit model are reported.

The first check is motivated by the fact that the simple use of the Euclidean distance (in kilometers) between patients' residences and hospitals may be criticized on the basis that it fails to capture the actual accessibility difficulties of a given destination. As a refinement, and because of the importance of flight transportation on long distances, we have estimated a specification of the

[9] Similar results, available on request, were obtained from the estimation of a nested logit model where the alternatives were framed within two mutually exclusive nests for distant and intra-regional hospitals and patient characteristics were included to model the choice between the two nests.

model that includes a connection dummy, which takes value 1 when there is an airport both in the LHA of enrollment of patients *i* and in the LHA of hospital *h*.[10] As reported in column (6) of Table 4, the coefficients of the polynomial terms of distance are largely unaffected by the inclusion of this connection dummy, which is positive and statistically significant as expected. The main results and conclusions derived from Models 3 to 5 are overall confirmed even for the other variables considered in the model.

With the results reported in column (7) of Table 4, we can verify whether our main findings display a more general validity, even when considering (non-elective) admissions ensuing a referral from other hospitals and emergency services. Not only these hospitalizations represent a large part of admissions, mainly at the local level, but also might substantially differ from elective admissions because of the major role played by hospital doctors (or headquarters of the regional emergency care service) choosing a hospital-to-hospital transfer (or a destination hospital of the ambulance). These decisions are based on an information set that is not directly available to patients and, in principle, could change the overall role of clinical quality, distance and other hospital characteristics. As can be seen, the main results from Models 3 to 5 in Table 3 are confirmed. For distant hospital attributes, the estimated effects in column 7 are slightly smaller for clinical quality - perhaps because non-elective admissions typically occur in regional hospitals – and slightly higher for the case-mix index and the private nature of hospitals. For local hospitals, clinical quality does not seem to drive the choice even when considering non-elective admissions, while the probability of a local hospital to be chosen significantly decreases when the hospital is either devoted to teaching and research or is a licensed private hospital.

## 5.4 Willingness to travel

Estimates from discrete choice models are often used to measure the WTT of the reference patient. The WTT is the MRS between quality and distance and is usually evaluated using the mean

[10] We thank an anonymous referee for suggesting us this specification. Regarding 2013, we could not recover the actual map of direct flights that were in place between the Italian airports in that year. However, connections are certainly favored even when only flights with an intermediate stop are available.

or median sample distance: $WTT = -\beta_q/MDD$ (i.e., the number of km a patient is willing to travel for a one-unit change in quality), where $MDD = \beta_d + \frac{2\beta_{d^2}}{100} d_{perc} + \frac{3\beta_{d^3}}{1000}\left(d_{perc}\right)^2$ is the "marginal disutility of distance" computed at a given distance percentile ($d_{perc}$). Because the evaluation point matters when dealing with a non-linear specification of distance, we calculate the WTT all along with the whole distance distribution. As in Romley and Goldman (2001), Chandra et al. (2016), and Raval and Rosenbaum (2018), we also simulate the effects of changing the clinical quality from the $75^{th}$ to the $25^{th}$ percentile.

Table 5 compares the WTT calculated all along with the distance distribution for hospitals in the central-northern regions, using the conditional logit, the heteroscedastic conditional logit, and the mixed logit. Results suggest that estimates are reasonably stable, with the mixed logit yielding the lowest values. For lower distances, the reference patient is willing to travel between 59.3 and 65.1 km more (at the $5^{th}$ distance centile) and between 77.5 and 89.1 km more (at the $10^{th}$ distance centile) to be cured in a hospital whose mortality rate moves from the $75^{th}$ to the $25^{th}$ percentile. For more considerable distances, the WTT decreases, as it takes values between 21.6 and 36.6 km at the $95^{th}$ centile, and between 14 and 21.7 km at the maximum distance. Results from the robustness analysis (last two columns of Table 5) do not affect the general findings on patients' WTT.

The overall behavior of the WTT can be appraised at the bottom graph of Figure 1, which also reports the disutility of distance (top graph), and the MDD (central graph). The Figure is based on the most conservative estimates (those from the mixed logit) and considers two types of patients: the reference individual and a 'young' individual (0–49 years old) with tertiary education. The shape of the MDD is in line with the existing literature. We highlight that the MDD curve is characterized by a nonsignificant area between the $20^{th}$ and the $46^{th}$ centile of the distance distribution, in the neighborhood of the inflection point of the cubic function (as shown in the top graph), corresponding to the local maximum of the MDD function in the central graph. MDD decreases (in absolute value) with distance at the left of the nonsignificant area (i.e., for relatively shorter distances), whereas it increases at the right (relatively longer distances) for both the reference patient and the younger, more educated individual. However, for each distance interval where estimates are statistically significant, the younger, more educated patient always has a smaller disutility of distance.

The bottom graph illustrates the shape of the WTT and the range where our estimates are significantly different from zero. The nonsignificant area of the WTT is between the 18th and 48th centile of the distance distribution.[11] Because of the different sign of the slope of the MDD curve at the left and right of the nonsignificant area, the WTT curve increases with distance at the left part and decreases at the right. The WTT of the comparison patient is always higher, following the smaller MDD commented previously. This result extends to long-distance hospitalizations existing findings that highly educated individuals better exploit the concentration of cancer treatments in specialized centers (e.g., see Fiva et al., 2014).

## 6 Conclusions

Our analysis of the mobility for neoplasms of the digestive system mainly supports our conjecture that long-distance hospitalization is a partially distinct phenomenon vis-à-vis short-distance mobility. Based on an individual random utility framework where the hospitals' attribute parameters can vary between "local" and "distant" hospitals, we find that patients' choices are sensitive to variations in a hospital's clinical quality, even if it is located several hundred kilometers away, as is the case when considering the distance between the two main Italian insular regions (Sardinia and Sicily) and the Center-North of Italy. As reported in our descriptive analysis, on average the quality differential between these two areas of the country is relevant. Albeit in 2013 public release of information was lacking, patients seem to have been able to collect this kind of information and look outside their neighborhoods to receive better care. Conversely, clinical quality does not seem to be relevant in the choice of local hospitals. This raises concerns about those

[11] Considering the conditional logit, the heteroscedastic conditional logit and the mixed logit all together this area ranges between the 18th and 57th centiles.

patients who choose local hospitals for elective care (mostly low educated and very old individuals, as shown in the summary statistics section) because they might be less likely to exploit better healthcare services. For these individuals, capillary referral services are needed to complement the free patient choice mechanism.

The marginal disutility of distance for distant hospitalizations is lower than that for local hospitals and is hump-shaped. This finding indicates that patients are initially less concerned with additional traveling distance. The effect intensifies only when extremely long distances are involved. Combined with the high sensitivity to long-distance clinical quality, this yields substantial values of WTT, as reported above. A clear positive education gradient in WTT is found. This confirms concerns about patients' ability to access the best available care for severe pathologies, and consequently on health outcomes, when providers are located faraway for either geographical reasons or planning policies.

In some respects, the previous findings are good news, because they outline the possibility to activate the benefits arising from hospital competition even on long-distance. For other respects, serious concerns arise depending on the institutional framework considered. Notwithstanding that the existing strong quality differential should motivate the peripheric RHSs to reduce the gap, their actual capability is likely to be hampered when financial resources follow patients' flows. This is the case for the Italian NHS where each region of origin reimburses the full cost of care when patients are admitted to an extra-regional hospital. Substantial financial transfers towards the most performing regions (in our case, Northern Italy) contribute, at least in part, to the persistence of quality differentials. Considering that only a share of the population - mostly young and highly educated individuals - is likely to react to lower quality by taking long-distance journeys, while the frailest individuals might remain captive of the local services, the universality principle of the NHS might be challenged.

We finally point out that the high values of our WTT estimates for long-distance hospitalizations could be partly determined by the need for receiving the best available treatments and services for cancer – by definition, a very severe pathology – not analogous to that of other treatments. Future research is needed to assess differences between local and long-distance mobility with more standard medical and surgical treatments where patients have a lower incentive to seek better services outside their region of residence.

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# Tables and figures

**Table 1** Descriptive statistics

| | All admissions (N=4508) | | Admissions in local hospitals (N=3746) | | Admissions in distant hospitals (N=762) | |
|---|---|---|---|---|---|---|
| | mean | s.d. | mean | s.d. | mean | s.d. |
| ***Choice*** | | | | | | |
| Distance to chosen hospital (km) | 163.624 | 282.386 | 42.330 | 28.573 | 759.905 | 199.530 |
| Distance to potential hospitals in choice set (km) | 590.658 | 42.912 | 91.099 | 20.630 | 813.423 | 87.789 |
| % patients choosing a "close" hospital bypassing the LHA of enrollment | 0.221 | 0.415 | | | | |
| % patients choosing a hospital located more than: | | | | | | |
| 3 km away from the closest hospital | 0.595 | 0.491 | 0.513 | 0.500 | | |
| 5 km away from the closest hospital | 0.555 | 0.497 | 0.464 | 0.499 | | |
| 10 km away from the closest hospital | 0.413 | 0.493 | 0.294 | 0.456 | | |
| 30 km away from the closest hospital | 0.294 | 0.456 | 0.150 | 0.357 | | |
| 50 km away from the closest hospital | 0.262 | 0.440 | 0.112 | 0.316 | | |
| % patients choosing a "close" hospital | 0.831 | 0.375 | | | | |
| ***Hospital characteristics*** | | | | | | |
| Clinical quality (risk adjusted mortality rate) | 5.718 | 3.049 | 6.037 | 3.124 | 4.145 | 2.012 |
| Hospital size (number of beds) | 623.738 | 346.021 | 568.286 | 269.022 | 896.343 | 513.221 |
| Case-mix index (CMI) | 1.076 | 0.077 | 1.062 | 0.064 | 1.147 | 0.092 |
| Teaching and research hospitals | 0.376 | 0.484 | 0.311 | 0.463 | 0.697 | 0.460 |
| Licensed private hospitals | 0.106 | 0.307 | 0.040 | 0.197 | 0.427 | 0.495 |
| ***Patient characteristics*** | | | | | | |
| *Gender* (=1 if the patient is female) | 0.440 | 0.496 | 0.442 | 0.497 | 0.429 | 0.495 |
| *Age classes* | | | | | | |
| 0-49 | 0.116 | 0.320 | 0.110 | 0.313 | 0.144 | 0.352 |
| 50-64 | 0.161 | 0.367 | 0.154 | 0.361 | 0.193 | 0.395 |
| 65-74 | 0.456 | 0.498 | 0.441 | 0.497 | 0.529 | 0.499 |
| 75 and older | 0.268 | 0.443 | 0.295 | 0.456 | 0.134 | 0.341 |
| *Education level* (isced classification) | | | | | | |
| none or primary | 0.415 | 0.493 | 0.438 | 0.496 | 0.302 | 0.459 |
| lower secondary | 0.294 | 0.456 | 0.302 | 0.459 | 0.253 | 0.435 |
| upper secondary | 0.206 | 0.405 | 0.187 | 0.390 | 0.302 | 0.459 |
| tertiary education | 0.085 | 0.279 | 0.073 | 0.261 | 0.143 | 0.350 |

*Note*. Local hospitals are located in the region of residence (either Sardinia or Sicily); Distant hospitals are located in a northern or central Italian region.

**Table 2** Patient characteristics by location of the chosen hospital percentage distributions



| | chosen hospital is local | chosen hospital is distant |
|---|---|---|
| *Gender* | | |
| male | 82.8 | 17.2 |
| female | 83.5 | 16.5 |
| *Age classes* | | |
| 0-49 | 79.0 | 21.0 |
| 50-64 | 79.7 | 20.3 |
| 65-74 | 80.4 | 19.6 |
| 75 and older | 91.6 | 8.5 |
| *Education level* | | |
| none or primary | 87.7 | 12.3 |
| lower secondary | 85.4 | 14.6 |
| upper secondary | 75.3 | 24.7 |
| tertiary education | 71.6 | 28.4 |

**Table 3** Choice models for elective digestive system cancer admissions



| | (1) | (2) | (3) | (4) | (5) |
|---|---|---|---|---|---|
| *Hospital characteristics* | (*Cond. logit*) | (*Cond. logit*) | (*Cond. logit*) | (*Het. Cond. logit*) | (*Mixed logit*) |
| | Coeff. (Std. Err) | Coeff. (Std. Err) | Coeff. (Std. Err) | Coeff. (Std. Err) | Coeff. (Std. Err) |
| | *All characteristics* | | *Characteristics of distant hospitals* | | |
| Mortality rate (adj.) | 0.034 *** | 0.023 * | -0.098 *** | -0.098 *** | -0.094 *** |
| | (0.005) | (0.012) | (0.024) | (0.027) | (0.024) |
| Distance | -0.041 *** | -0.051 *** | -0.036 *** | -0.039 *** | -0.038 *** |
| | (0.001) | (0.002) | (0.003) | (0.006) | (0.003) |
| Squared distance (/100) | 0.008 *** | 0.009 *** | 0.005 *** | 0.006 *** | 0.006 *** |
| | (0.0002) | (0.0005) | (0.0007) | (0.001) | (0.0007) |
| Cubic distance (/1000) | -0.00004 *** | -0.00005 *** | -0.00003 *** | -0.00003 *** | -0.00003 *** |
| | (0.000001) | (0.000003) | (0.000004) | (-0.00001) | (0.000005) |
| Case-mix index | 2.969 *** | 2.340 *** | 3.878 *** | 3.945 *** | 3.868 *** |
| | (0.217) | (0.517) | (0.694) | (0.817) | (0.696) |
| Hospital size | 0.001 *** | 0.001 *** | 0.0004 ** | 0.0005 ** | 0.0004 ** |
| | (0.0001) | (0.0002) | (0.0002) | (0.0002) | (0.0002) |
| Teaching and research hospitals | 0.526 *** | 0.167 * | 0.267 ** | 0.277 ** | 0.270 ** |
| | (0.039) | (0.095) | (0.133) | (0.141) | (0.133) |
| Licensed private hospitals | 0.583 *** | 0.222 | 0.922 *** | 0.969 *** | 0.919 *** |
| | (0.060) | (0.152) | (0.185) | (0.218) | (0.185) |
| | | | *Characteristics of local hospitals* | | |
| Mortality rate (adj.) | | | 0.015 | 0.017 | 0.014 |
| | | | (0.012) | (0.013) | (0.012) |
| Distance | | | -0.045 *** | -0.047 *** | -0.045 *** |
| | | | (0.005) | (0.007) | (0.005) |
| Squared distance (/100) | | | -0.004 | -0.002 | -0.004 |
| | | | (0.005) | (0.005) | (0.005) |
| Cubic distance (/1000) | | | 0.0005 *** | 0.0004 * | 0.0005 *** |
| | | | (0.0002) | (0.0002) | (0.0002) |
| Case-mix index | | | 1.826 *** | 1.885 *** | 1.813 *** |
| | | | (0.516) | (0.578) | (0.518) |
| Hospital size | | | 0.001 *** | 0.001 *** | 0.001 *** |
| | | | (0.0002) | (0.0002) | (0.0002) |
| Teaching and research hospitals | | | 0.032 | 0.028 | 0.034 |
| | | | (0.096) | (0.102) | (0.096) |
| Licensed private hospitals | | | -0.212 | -0.152 | -0.207 |
| | | | (0.163) | (0.172) | (0.163) |
| Inter. with patient characteristics | NO | YES | YES | YES | YES |
| *Patient characteristics* | | | | | |
| Female gender | | | | 0.098 * | |
| | | | | (0.059) | |
| Age class: 50-64 | | | | -0.187 * | |
| | | | | (0.114) | |
| Age class: 65-74 | | | | -0.136 | |
| | | | | (0.099) | |
| Age class: 75 and older | | | | -0.041 | |
| | | | | (0.119) | |
| Lower secondary education | | | | 0.083 | |
| | | | | (0.121) | |
| Upper secondary education | | | | 0.130 | |
| | | | | (0.119) | |
| Tertiary education | | | | 0.235 | |
| | | | | (0.151) | |
| *St.dev. of random parameters* | | | | | |
| Mortality rate (adj.) | | | | | 0.001 |
| | | | | | (0.014) |
| Distance | | | | | 0.0003 |
| | | | | | (0.0005) |
| Squared distance (/100) | | | | | 0.00002 |
| | | | | | (0.00009) |
| Cubic distance (/1000) | | | | | 0.000001 ** |
| | | | | | (0.0000006) |
| *McFadden-Hausman IIA test* | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| Chi-square | | | 120.45 | | |
| prob. | | | 0.0003 | | |
| *log-likelihood* | -11085 | -10828 | -10540 | -10536 | -10539 |
| *AIC* | 22186 | 21785 | 21224 | 21229 | 21229 |
| *BIC* | 22267 | 22432 | 21952 | 22028 | 21998 |
| Observations | 4508 | 4508 | 4508 | 4508 | 4508 |
| *Number of hospitals* | 46 | 46 | 46 | 46 | 46 |

*Note*. Models 2–5 include interactions of all hospital characteristics with patients' characteristics (gender, age, and education dummies); Models 3–5 also include interactions of all hospital characteristics with a location dummy (equal to 1 if the hospital is in the patient's region of residence). Reported estimates for local hospitals are obtained as a linear combination of coefficients. Model 5 has been estimated using 50 Halton draws and assuming normally distributed random coefficients. Level of significance: *** p<0.01, ** p<0.05, * p<0.1

**Table 4** Robustness analysis – mixed logit models



| Hospital characteristics | (6) (*Mixed logit with connection dummy*) Coeff. (Std. Err) | | (7) (*Mixed logit on extended sample*) Coeff. (Std. Err) | |
|---|---|---|---|---|
| | | *Characteristics of distant hospitals* | | |
| Mortality rate (adj.) | -0.076 | ** | -0.070 | *** |
| | (0.015) | | (0.020) | |
| Distance | -0.036 | *** | -0.039 | *** |
| | (0.0003) | | (0.003) | |
| Squared distance (/100) | 0.005 | *** | 0.006 | *** |
| | (0.0001) | | (0.001) | |
| Cubic distance (/1000) | -0.00003 | *** | 0.000 | *** |
| | (0.000001) | | (0.000004) | |
| Case-mix index | 3.447 | *** | 2.984 | *** |
| | (0.697) | | (0.572) | |
| Hospital size | 0.000 | ** | 0.001 | *** |
| | (0.0002) | | (0.0002) | |
| Teaching and research hospitals | 0.259 | ** | 0.371 | *** |
| | (0.133) | | (0.113) | |
| Licensed private hospitals | 0.851 | *** | 0.723 | *** |
| | (0.186) | | (0.161) | |
| | | *Characteristics of local hospitals* | | |
| Mortality rate (adj.) | 0.013 | | -0.008 | |
| | (0.013) | | (0.009) | |
| Distance | -0.045 | *** | -0.038 | *** |
| | (0.004) | | (0.004) | |
| Squared distance (/100) | -0.005 | | -0.011 | ** |
| | (0.005) | | (0.0002) | |
| Cubic distance (/1000) | 0.0005 | ** | 0.001 | *** |
| | (0.0002) | | (0.0002) | |
| Case-mix index | 1.888 | *** | 0.923 | ** |
| | (0.519) | | (0.379) | |
| Hospital size | 0.001 | *** | 0.002 | *** |
| | (0.0002) | | (0.0001) | |
| Teaching and research hospitals | 0.027 | | -0.519 | *** |
| | (0.096) | | (0.141) | |
| Licensed private hospitals | -0.194 | | -0.661 | *** |
| | (0.163) | | (0.141) | |
| Inter. with patient characteristics | YES | | YES | |
| **Connection** | 0.560 | *** | | |
| | (0.186) | | | |
| *St.dev. of random parameters* | | | | |
| Mortality rate (adj.) | 0.002 | | 0.001 | |
| | (0.015) | | (0.012) | |
| Distance | 0.000001 | | 0.0001 | |
| | (0.0003) | | (0.0004) | |
| Squared distance (/100) | -0.00002 | | 0.00001 | |
| | (0.0001) | | (0.0001) | |
| Cubic distance (/1000) | 0.000001 | | 0.000001 | |
| | (0.000001) | | (0.000001) | |
| *Log-likelihood* | -10519 | | -16129 | |
| *AIC* | 21193 | | 32409 | |
| *BIC* | 21971 | | 33228 | |
| Observations | 4508 | | 7295 | |
| *Number of hospitals* | 46 | | 55 | |

*Note*: Model 6 estimates an augmented specification of the mixed logit (Model 5 of Table 3) where a connection dummy has been included; Model 7 estimates Model 5 on an extended sample that includes also non-elective admissions (hospital-to hospitals and emergency referrals). Level of significance: *** p<0.01, ** p<0.05, * p<0.1

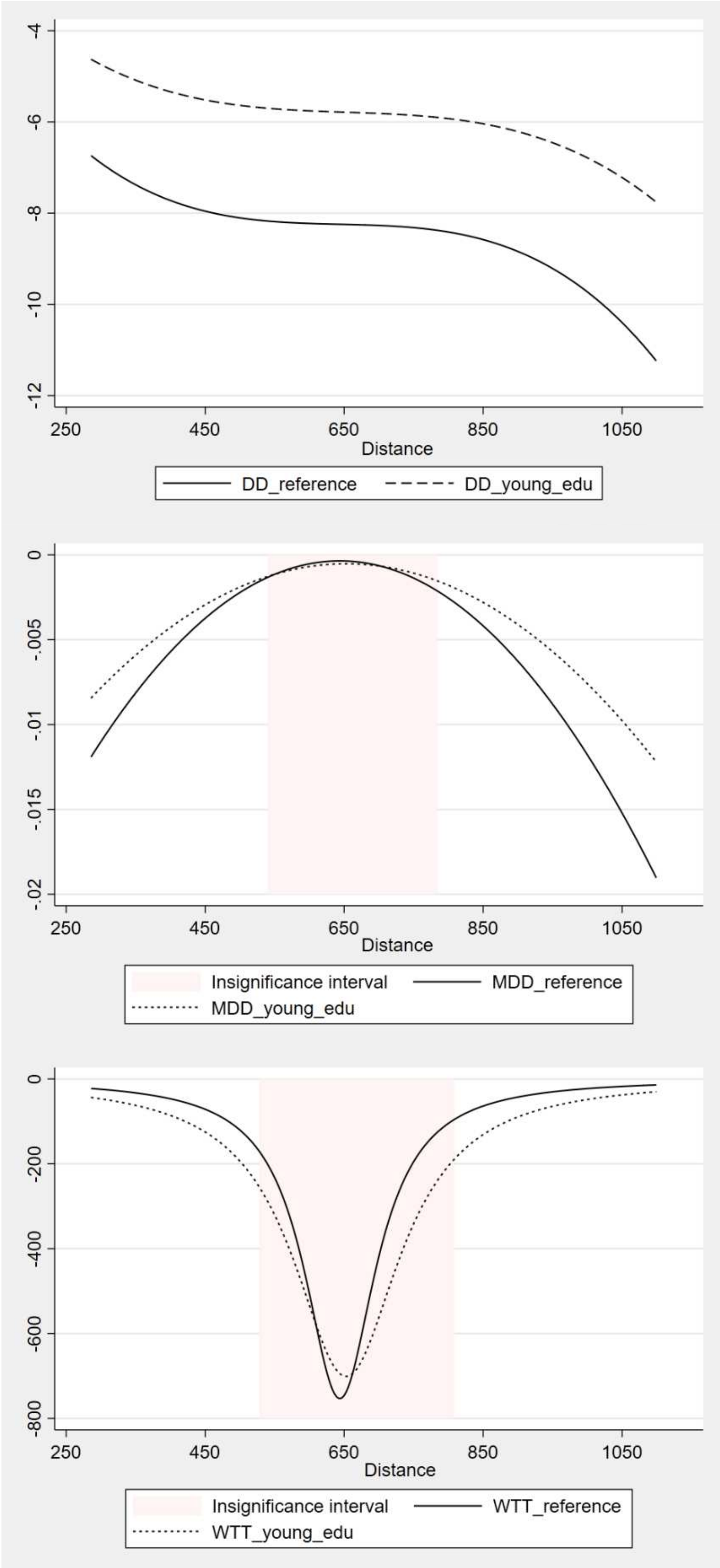
**Table 5** Estimated willingness to travel (WTT) for reference individuals evaluated at different percentiles of the distribution of distance for distant hospitals

| | | Conditional logit | | | Heteroschedastic conditional logit | | | Mixed logit | | | Mixed logit with connection dummy | | | Mixed logit on extended sample | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Distance (centiles)** | **Distance (km)** | **WTT** | | **Std. Err** | **WTT** | | **Std. Err** | **WTT** | | **Std. Err** | **WTT** | | **Std. Err** | **WTT** | | **Std. Err** |
| 1 | 318.9 | -27.2 | *** | 7.6 | -27.5 | *** | 7.7 | -27.1 | *** | 7.9 | -22.6 | *** | 8.0 | -18.0 | *** | 5.6 |
| 5 | 431.6 | -59.3 | *** | 19.8 | -65.1 | *** | 22.6 | -60.5 | *** | 21.4 | -51.2 | *** | 21.2 | -38.4 | *** | 13.1 |
| 10 | 460.8 | -77.5 | * | 28.8 | -89.2 | ** | 36.4 | -79.2 | ** | 31.4 | -68.0 | ** | 31.1 | -51.2 | *** | 18.7 |
| 75 | 919.1 | -74.3 | ** | 33.9 | -59.1 | ** | 25.1 | -37.2 | ** | 17.5 | -41.3 | ** | 24.8 | -55.9 | | 36.3 |
| 95 | 1008.5 | -36.6 | *** | 13.9 | -29.8 | *** | 11.4 | -21.6 | ** | 9.1 | -22.4 | * | 11.4 | -26.4 | ** | 13.0 |
| 100 | 1099.1 | -21.7 | *** | 7.6 | -18.0 | *** | 6.6 | -14.0 | ** | 5.5 | -14.0 | ** | 6.5 | -15.5 | ** | 6.7 |

*Note*. WTT is obtained as the ratio between the marginal disutilities for the mortality rate and distance. Standard errors are calculated using the delta method.
Level of significance: *** p<0.01, ** p<0.05, * p<0.1

**Figure 1**: Absolute disutility (DD), marginal disutility of distance (MDD), and willingness to travel (WTT) for reference (older and less educated) individuals and comparison (younger and more educated) of individuals for a clinical quality change [from the 75th to the 25th centile]






*Note*. Shaded internal areas depict intervals where values are not significantly different from zero

# Appendix

## A.1 Additional information on data sources and key variables

***Sample of admissions for elective cancer treatments***

The SDO data are derived from the “Schede di Dimissione Ospedaliera” and are released by the Ministry of Health. These data register each admission episode in every licensed public and private hospital of the NHS and contain information about the hospital type, local health authority (LHA), and the region where the admission occurred, as well as patients’ LHA and region of enrollment. Each hospitalization is classified using the ICD-9-CM international classification of diseases and procedures. The SDO data also provide information on a limited set of patients’ sociodemographic characteristics: gender, age class, and education level.

We use hospital discharge data related to digestive system cancers: all malignant neoplasms of digestive organs and the peritoneum (ICD9 codes 150–159), all benign neoplasms of other parts of the digestive system (ICD9 code 211), all secondary malignant neoplasms of the digestive system (ICD9 codes 197.4–197.8), carcinoma in situ in digestive organs (ICD9 code 230), neoplasms of uncertain behavior of the digestive system (ICD9 code 235), and neoplasms of unspecified behavior of the digestive system (ICD9 code 239.0).



To deal only with admissions for elective treatments, we exclude emergency admissions and inter-hospital patient transfers from the analysis, which allows us to focus on actual patient choice for this specific group of cancer treatments. To ensure proper representativeness of outflows and avoid the volatility of very sparse admission episodes, we only consider hospitals that have a minimum of five discharges of Sardinian and Sicilian residents and for which the risk-adjusted quality measure is available. This consideration yields a sample of 4,508 elective admission episodes of patients treated in 46 different public and private Italian hospitals during 2013. Without imposing any further selection on the data, our sample does not contain admission episodes of Sardinian (Sicilian) residents in Sicilian (Sardinian) hospitals. The original SDO data only recorded three admissions of the first type and two of the second type.

***Additional information on key variables***

*Quality* - Our measure of clinical quality of hospital care for digestive system cancers is calculated and released by the National Agency for Regional Health Services within the Outcomes Evaluation National Program (*Programma Nazionale Esiti,* PNE). The PNE is similar to other international monitoring programs, such as the “NHS Outcomes Framework Indicators” in the UK. By delivering “objective” indicators at the hospital, LHA, or regional level, the PNE is believed to empower patients with new and detailed information about health outcomes and, therefore, quality of care. This information should help them make more informed healthcare decisions. At the same time, public reporting of outcomes should create an incentive at the hospital level to improve the performance and overall quality of care. One issue that we encounter when using PNE data is that the coverage of this recent source of public information is not always accurate because it relies on the availability of a minimum number of cases for each specific specialty within each hospital to provide reliable risk-adjusted statistics. Besides, a synthetic clinical outcome indicator in the area of cancers of the digestive system does not exist, and hospital-level information needed to adjust the potentially available row mortality (or readmission) rates is unavailable. For these reasons, we had to proxy the outcome of the clinical quality of treatments for cancers of the digestive system with the risk-adjusted mortality rate (within 30 days) after malignant neoplasm colon surgery.[12] This indicator is available for most hospitals and is calculated based on admissions that occurred between January 1, 2007, and November 30, 2012.

*Case-mix index* – The CMI is a publicly available indicator at the hospital level that reflects clinical complexity (measured concerning the financial and physical resources allocated to treat all admitted hospital patients) of treated cases. The indicator is calculated as the ratio between the average weight of admissions in a specific hospital and the average weight of admissions in the whole NHS, using the SDO data on total discharges of each hospital. Average weights are

[12] The statistical procedure for risk-adjustment is described in Agenas, 2013. Programma Nazionale Valutazione Esiti – PNE, Ed. 2013, SDO 2005-2012 Metodi Statistici, http://95.110.213.190/PNEed13/

calculated using the DRG weights, which proxy the complexity of a specific admission. A value greater than 1 indicates a mix of cases being more resource-intensive than average and identifies more specialized hospitals.

### A.2. Point estimates of Models 3-5 in Table 3.

For the sake of completeness, Table A.1 below reports the full set of parameters estimated with Model 3. The main results of note are the higher sensitivity to clinical quality for younger individuals and the significant effects of age classes on the distance polynomial, which mostly involve a higher concavity of the MDD function when different education categories, compared with the reference individual (low education), are considered. The coefficients of the interaction between distance and tertiary education are used to create the comparison individual presented in Figure 1 of the paper

**Table A.1** Full set of estimated parameters for Models 3–5 included in Table 3.



| | (3) | | | (4) | | | (5) | | |
|---|---|---|---|---|---|---|---|---|---|
| | (*Cond. logit*) | | | (*Het. Cond. logit*) | | | (*Mixed logit*) | | |
| VARIABLES | Coeff. | | Std. Err | Coeff. | | Std. Err | Coeff. | | Std. Err |
| Mortality rate (adj.) | -0.098 | *** | 0.024 | -0.098 | *** | 0.027 | -0.094 | *** | 0.024 |
| Distance | -0.036 | *** | 0.003 | -0.039 | *** | 0.006 | -0.038 | *** | 0.003 |
| Squared distance (/100) | 0.005 | *** | 0.001 | 0.006 | *** | 0.001 | 0.006 | *** | 0.001 |
| Cubic distance (/1000) | -0.00003 | *** | 0.000004 | -0.00003 | *** | -0.00001 | -0.00003 | *** | 0.000005 |
| Case-mix index | 3.878 | *** | 0.694 | 3.945 | *** | 0.817 | 3.868 | *** | 0.696 |
| Hospital size | 0.0004 | ** | 0.0002 | 0.001 | ** | 0.0002 | 0.0004 | ** | 0.0002 |
| Teaching and research hospitals | 0.267 | ** | 0.133 | 0.277 | ** | 0.141 | 0.270 | ** | 0.133 |
| Licensed private hospitals | 0.922 | *** | 0.185 | 0.969 | *** | 0.218 | 0.919 | *** | 0.185 |
| Mortality rate (adj.)*L | 0.112 | *** | 0.021 | 0.115 | *** | 0.024 | 0.108 | *** | 0.021 |
| Distance*L | -0.009 | * | 0.005 | -0.009 | * | 0.005 | -0.007 | | 0.005 |
| Squared distance (/100)*L | -0.009 | * | 0.005 | -0.008 | | 0.005 | -0.010 | * | 0.005 |
| Cubic distance (/1000)*L | 0.005 | *** | 0.0002 | 0.0005 | ** | 0.0002 | 0.001 | *** | 0.0002 |
| Case-mix index*L | -2.053 | *** | 0.520 | -2.060 | *** | 0.552 | -2.055 | *** | 0.523 |
| Hospital size*L | 0.001 | *** | 0.0001 | 0.001 | *** | 0.0002 | 0.001 | *** | 0.0001 |
| Teaching and research hospitals*L | -0.235 | ** | 0.106 | -0.249 | ** | 0.108 | -0.236 | ** | 0.106 |
| Licensed private hospitals*L | -1.134 | *** | 0.140 | -1.121 | *** | 0.198 | -1.127 | *** | 0.141 |
| Sex*Mortality rate | -0.005 | | 0.011 | -0.008 | | 0.011 | -0.005 | | 0.011 |
| Age 0-49*Mortality rate | -0.055 | *** | 0.021 | -0.049 | ** | 0.02 | -0.055 | *** | 0.021 |
| Age 50-64*Mortality rate | -0.013 | | 0.018 | -0.009 | | 0.019 | -0.013 | | 0.018 |
| Age 65-74*Mortality rate | 0.012 | | 0.014 | 0.013 | | 0.014 | 0.012 | | 0.014 |
| Lower secondary*Mortality rate | 0.021 | | 0.014 | 0.018 | | 0.015 | 0.021 | | 0.014 |
| Upper secondary*Mortality rate | 0.021 | | 0.015 | 0.018 | | 0.016 | 0.021 | | 0.015 |
| Tertiary education*Mortality rate | 0.020 | | 0.022 | 0.012 | | 0.020 | 0.020 | | 0.022 |
| Sex*distance | -0.003 | * | 0.002 | 0.001 | | 0.003 | -0.003 | * | 0.002 |
| Age 0-49*distance | 0.004 | | -0.003 | 0.004 | | 0.005 | 0.004 | | 0.003 |
| Age 50-64*distance | 0.001 | | -0.003 | -0.004 | | 0.005 | 0.001 | | 0.003 |
| Age 65-74*distance | 0.001 | | 0.002 | -0.003 | | 0.004 | 0.0005 | | 0.002 |
| Lower secondary*distance | 0.007 | *** | 0.002 | 0.011 | ** | 0.005 | 0.007 | *** | 0.002 |
| Upper secondary*distance | 0.010 | *** | 0.002 | 0.015 | *** | 0.004 | 0.01 | *** | 0.002 |
| Tertiary education*distance | 0.009 | *** | 0.003 | 0.017 | *** | 0.005 | 0.008 | *** | 0.003 |
| Sex*Squared distance | 0.001 | ** | 0.0004 | 0.0001 | | 0.001 | 0.001 | * | 0.0004 |
| Age 0-49*Squared distance | 0.00008 | | 0.001 | -0.0002 | | 0.001 | -0.00007 | | 0.001 |
| Age 50-64*Squared distance | 0.0004 | | 0.001 | 0.001 | | 0.001 | 0.0005 | | 0.001 |
| Age 65-74*Squared distance | 0.001 | | 0.001 | 0.001 | | 0.001 | 0.001 | | 0.001 |
| Lower secondary*Squared distance | -0.002 | *** | 0.001 | -0.003 | *** | 0.001 | -0.002 | *** | 0.001 |
| Upper secondary*Squared distance | -0.003 | *** | 0.001 | -0.003 | *** | 0.001 | -0.003 | *** | 0.001 |
| Tertiary education*Squared distance | -0.002 | *** | 0.001 | -0.003 | *** | 0.001 | -0.002 | *** | 0.001 |
| Sex*Cubic distance | -0.00001 | ** | -0.000003 | -0.000002 | | 0.000003 | -0.000005 | ** | 0.000003 |
| Age 0-49*Cubic distance | -0.000002 | | 0.000005 | -0.0000009 | | 0.000005 | -0.000002 | | 0.000005 |
| Age 50-64*Cubic distance | -0.000004 | | 0.000004 | -0.000008 | | 0.000006 | -0.000005 | | 0.000004 |
| Age 65-74*Cubic distance | -0.000005 | | 0.000003 | -0.000008 | * | 0.000004 | -0.000005 | | 0.000003 |
| Lower secondary*Cubic distance | 0.00001 | *** | 0.000003 | 0.00002 | *** | 0.000006 | 0.00002 | *** | 0.000003 |
| Upper secondary*Cubic distance | 0.00002 | *** | 0.000004 | 0.00002 | *** | 0.000005 | 0.00002 | *** | 0.000004 |
| Tertiary education*Cubic distance | 0.00001 | *** | 0.000005 | 0.00002 | *** | 0.000006 | 0.00001 | *** | 0.000005 |
| Sex*Case-mix index | 1.009 | ** | 0.437 | 0.729 | | 0.466 | 1.016 | ** | 0.438 |
| Age 0-49*Case-mix index | -0.042 | | 0.554 | -0.189 | | 0.629 | -0.034 | | 0.555 |
| Age 50-64*Case-mix index | 0.716 | | 0.602 | 0.362 | | 0.698 | 0.723 | | 0.604 |
| Age 65-74*Case-mix index | 2.138 | *** | 0.800 | 1.247 | | 0.942 | 2.109 | *** | 0.802 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Lower secondary*Case-mix index | -1.860 | ** | 0.798 | -1.816 | ** | 0.865 | -1.861 | ** | 0.799 |
| Upper secondary*Case-mix index | -0.800 | | 0.716 | -0.413 | | 0.798 | -0.805 | | 0.718 |
| Tertiary education*Case-mix index | -0.427 | | 0.556 | -0.182 | | 0.601 | -0.427 | | 0.558 |
| Sex*Hospital size | -0.0001 | | 0.0001 | -0.0002 | | 0.0001 | -0.0001 | | 0.0001 |
| Age 0-49*Hospital size | -0.0003 | | 0.0002 | -0.0003 | * | 0.0002 | -0.0002 | | 0.0002 |
| Age 50-64*Hospital size | -0.001 | *** | 0.0002 | -0.001 | *** | 0.0002 | -0.001 | *** | 0.0002 |
| Age 65-74*Hospital size | -0.0003 | | 0.0002 | -0.001 | ** | 0.0002 | -0.0003 | | 0.0002 |
| Lower secondary*Hospital size | 0.00003 | | 0.0002 | 0.00002 | | 0.0002 | 0.00003 | | 0.0002 |
| Upper secondary*Hospital size | 0.0003 | | 0.0002 | 0.0004 | | 0.0002 | 0.0003 | | 0.0002 |
| Tertiary education*Hospital size | 0.0004 | ** | 0.0002 | 0.0005 | ** | 0.0002 | 0.0004 | ** | 0.0002 |
| Sex*Teach. and res. hospital | 0.004 | | 0.080 | -0.049 | | 0.084 | 0.0001 | | 0.08 |
| Age 0-49*Teach. and res. hospital | 0.853 | *** | 0.100 | 0.811 | *** | 0.174 | 0.852 | *** | 0.1 |
| Age 50-64*Teach. and res. hospital | 0.674 | *** | 0.110 | 0.608 | *** | 0.167 | 0.674 | *** | 0.11 |
| Age 65-74*Teach. and res. hospital | 0.171 | | 0.148 | 0.107 | | 0.147 | 0.169 | | 0.148 |
| Lower secondary*Teach. and res. hospital | 0.054 | | 0.142 | 0.010 | | 0.157 | 0.057 | | 0.142 |
| Upper secondary*Teach. and res. hospital | -0.306 | ** | 0.131 | -0.216 | | 0.157 | -0.303 | ** | 0.131 |
| Tertiary education*Teach. and res. hospital | -0.308 | *** | 0.101 | -0.253 | ** | 0.123 | -0.307 | *** | 0.102 |
| Sex* Licensed private hospital | 0.380 | *** | 0.126 | 0.260 | * | 0.137 | 0.377 | *** | 0.126 |
| Age 0-49* Licensed priv. hospital | -0.095 | | 0.166 | -0.150 | | 0.182 | -0.097 | | 0.166 |
| Age 50-64* Licensed priv. hospital | 0.175 | | 0.172 | 0.030 | | 0.200 | 0.176 | | 0.172 |
| Age 65-74* Licensed priv. hospital | 0.426 | ** | 0.215 | 0.205 | | 0.237 | 0.425 | ** | 0.216 |
| Lower secondary* Licensed priv. hospital | -1.022 | *** | 0.245 | -0.965 | *** | 0.290 | -1.020 | *** | 0.246 |
| Upper secondary* Licensed priv. hospital | -0.135 | | 0.206 | 0.001 | | 0.231 | -0.129 | | 0.206 |
| Tertiary education* Licensed priv. hospital | -0.161 | | 0.167 | -0.072 | | 0.178 | -0.156 | | 0.167 |
| Female | | | | 0.098 | * | 0.059 | | | |
| Age 0-49 | | | | -0.187 | * | 0.114 | | | |
| Age 50-64 | | | | -0.136 | | 0.099 | | | |
| Age 65-74 | | | | -0.041 | | 0.119 | | | |
| Lower secondary | | | | 0.084 | | 0.121 | | | |
| Upper secondary | | | | 0.130 | | 0.119 | | | |
| Tertiary education | | | | 0.235 | | 0.151 | | | |
| *St.dev. of random parameters* | | | | | | | | | |
| Mortality rate (adj.) | | | | | | | 0.001 | | (0.014) |
| Distance | | | | | | | 0.0003 | | (0.0005) |
| Squared distance (/100) | | | | | | | 0.00002 | | (0.00009) |
| Cubic distance (/1000) | | | | | | | 0.000001 | ** | (0.0000006) |
| *Log-likelihood* | -10540 | | | -10536 | | | -10539 | | |
| Observations | 4508 | | | 4508 | | | 4508 | | |
| *Number of hospitals* | 46 | | | 46 | | | 46 | | |

*Note.* Model 5 has been estimated using 50 Halton draws and assuming normally distributed random coefficients. Level of significance: *** p<0.01, ** p<0.05, * p<0.1

# Choice of hospital and long-distances: evidence from Italy

*Research highlights*

- Long-distance patient mobility is a relevant phenomenon for severe pathologies
- We study patients' elective admissions for digestive system cancers distinguishing between local and distant hospitals
- Clinical quality has a relevant role only in the choice of distant hospitals
- Reference patient is willing to travel at least 14 km to get better care in hospitals located at not less than 286 km
- Willingness to travel is larger for younger and more educated patients