Health Policy xxx (2018) xxx–xxx

Contents lists available at ScienceDirect

Health Policy

journal homepage: www.elsevier.com/locate/healthpol

Centralisation of cancer surgery and the impact on patients' travel burden

S.E. Versteeg[a], V.K.Y. Ho[b], S. Siesling[b,c], M. Varkevisser[d,*]

[a] Netherlands Institute for Health Services Research (NIVEL), Utrecht, The Netherlands
[b] Department of Research, Netherlands Comprehensive Cancer Organisation (IKNL), Utrecht, The Netherlands
[c] Department of Health Technology and Services Research, Technical Medical Centre, University of Twente, Enschede, The Netherlands
[d] Erasmus School of Health Policy & Management (ESHPM), Erasmus University, Rotterdam, The Netherlands

ARTICLE INFO

Article history:
Received 17 March 2017
Received in revised form 11 June 2018
Accepted 1 July 2018

Keywords:
Centralisation
Travel burden
Cancer surgery

ABSTRACT

Recent years have seen increasing trends towards centralisation of complex medical procedures, including cancer surgery. The impact of these trends on patients' travel burden is often ignored. This study charts the effects of different scenarios of centralising surgery on the travel burden for patients with cancer of the digestive tract, particularly among vulnerable patient groups. Our analyses include all surgically treated Dutch patients with colorectal, stomach or oesophageal cancer diagnosed in 2012–2013. After determining each patient's actual travel burden, simulations explored the impact of continued centralisation of cancer surgery under four hypothetical scenarios. Compared to patients' actual travelling, simulated travel distances under relatively 'conservative' scenarios did not necessarily increase, most likely due to current hospital bypassing. Using multivariable regression analyses, as a first exercise, it is examined whether the potential effects on travel burden differ across patient groups. For some cancer types, under more extreme scenarios increases in travel distances are significantly higher for older patients and those with a low SES. Given the potential impact on vulnerable patients' travel burden, our analysis suggests a thorough consideration of non-clinical effects of centralisation in health policy.

1. Introduction

Over the last decades, the association between hospital treatment volumes and outcomes of treatment has been widely reported, most notably with respect to complex surgical treatment and surgery-related outcome measures like postoperative mortality [1–4]. Although the exact mechanisms underlying a volume-outcome relationship remain to be elucidated [5], observations of this association across different types of cancer surgery appeared to have provided ample warrant for the trend towards centralising these procedures in many Western countries [6–10]. The Netherlands is no exception to this international trend. Centralisation in cancer care started here in the years following the publication of national as well as international scientific evidence and took off after the Dutch Health Inspectorate started setting minimum volume thresholds [28,33]. These were introduced in 2003 and since then the number of low-volume Dutch hospitals performing complex surgeries has effectively decreased.

However, notwithstanding the clinical benefits generally attributed to limiting the conduct of surgery to fewer (geographically dispersed) health care providers, centralisation may also produce undesirable effects that are often neglected. There are concerns, for instance, that decreasing competition reduces market incentives for hospitals to improve quality and/or lower prices. Hence, a significant reduction in hospital competition may very well erase the gains in consumer welfare from regionalisation [27].

Perhaps the most prominent side effect of reducing the number of hospitals that provide a particular intervention would be the impact on travel burden for patients requiring treatment. Significant prolongation of travel time has been shown to compromise patient outcomes due to ensuing delay in diagnosis or impaired continuity of care [11]. For example, a recent study found that increased travel burden for the surgical resection of extrahepatic biliary malignancies, caused by the centralisation of these surgeries in high-volume centres, was associated with decreased overall survival [30]. In addition, travel burden may impact patients' financial situation and decrease patient utility. For some subsets of patients, increased travelling may even substantially limit their access to good quality cancer care [29].

* Corresponding author.
E-mail address: varkevisser@eshpm.eur.nl (M. Varkevisser).

https://doi.org/10.1016/j.healthpol.2018.07.002
0168-8510/

From the patient choice literature, travel burden represents a main factor determining patients' choice for visiting a particular hospital for their health problems [12,32]. However, in the Netherlands the willingness amongst patients to bypass the nearest hospitals – and thus to travel larger distances – appears higher in the face of waiting times and seems to decrease with patients' age [13]. Overall, from the empirical literature about patient mobility it can be concluded that elderly and low socioeconomic groups are less likely to travel beyond their nearest provider implying there is potentially an equity issue when centralising health care services [12]. In the English NHS, for example, it is found that patients living in the most deprived areas do not travel as far for their elective care as patients from more affluent areas [31]. Hence, increases in travel burden caused by centralisation may disproportionately affect the more vulnerably patients groups in terms of age and socioeconomic status.

A deeper understanding of the potential impact of centralising complex surgeries is therefore urgently needed. However, thus far only few studies have charted the implications that centralisation of care may entail for patients' travel burden. For example, a study about the hypothetical centralisation of acute obstetric care in the Netherlands explicitly took into account the impact on average patient travel times [14]. This study concluded that in order to develop an optimal centralisation strategy, all positive and negative effects – including increased travel time – need to be considered. Another study showed that in Germany hypothetical minimum volume standards for centralising cancer surgery would increase average travel times for patients but without compromising overall access [15]. For the Kyoto Prefecture in Japan, simulations of health care services centralisation showed reduced average travel time for most patients and improvements in equality of access [16].

The present study aims to extend the abovementioned analyses. First, it provides an insight in the actual travel burden (in terms of travel distance and time) faced by cancer patients seeking surgical treatment in the Netherlands, where centralisation of cancer surgery has continued at a faster pace in recent years. Second, it extrapolates these findings under different assumptions regarding future centralisation processes. The study thus explores a spectrum of possible future scenarios for cancer patients' travel burden. Consequently, despite its focus on the Netherlands the outcomes of our pioneering research clearly contribute to a more comprehensive assessment of the effects of centralisation from the patients' perspective, providing focus points for health policy in other countries as well.

2. Patients and methods

2.1. Data

Information on cancer patients was abstracted from the Netherlands Cancer Registry (NCR), which is hosted by the Netherlands Comprehensive Cancer Organisation (IKNL). Since its establishment in 1989, this nationwide population-based registry has registered all primary malignancies diagnosed among the Dutch population [17]. For this registry information on patient and disease characteristics, diagnostics and therapy is collected from hospital records by trained registry personnel upon notification by PALGA, the Dutch network and registry of histo- and cytopathology. Subsequently, case ascertainment is provided by the national hospital discharge database, which receives discharge diagnoses of all patients admitted in Dutch hospitals. Consent for the design, data abstraction process and storage protocols is obtained from the national supervisory committee of the NCR.

Data collected for the NCR include patients' age at diagnosis, histological subtype of the tumour, tumour grade, and tumour stage. In addition, the 4-digit postal code of patients' home addresses at the time of cancer diagnosis is routinely registered for administrative purposes. From the Netherlands Institute for Social Research (SCP) we obtained a social status score for each 4-digit postal code. Using factor analysis, SCP derived the social economic status (SES) from a number of characteristics of the people living there: average income level, the percentage of people having a low income, the percentage low educated and the percentage unemployed [18]. The higher the score, the higher the social status of the postal code. The postal codes were also used to calculate patients' travel distances and times.

2.2. Patient travelling

The Netherlands is a small (41.543 km^2) and densely populated (17 million inhabitants) country, located in Western Europe. The number of hospitals has long been relatively high (>100) but decreased from 2000 onwards, mostly due to mergers [19].

To determine patients' travelling for cancer surgery, the GeoDan Drive Time Matrix [20] was used to approximate the travel distances from the postal codes of patients' home addresses to those of their hospitals of surgery. The GeoDan Drive Time matrix provides the shortest routes in travel distance and fastest routes in travel time between all 4-digit postal code combinations in the Netherlands. Following our country's geography, the geographic areas defined by these codes are rather small (i.e. ranging from about 1 km^2 in urban areas to about 8 km^2 in rural areas). As a result, the difference between the postal code centroid and the actual location is about 500–1000 meters in urban areas – where almost all hospitals are located – and 2000–3000 meters in rural areas. Please note that the Netherlands is one of the most urbanised countries in the OECD, with about 75 percent of its population living in predominantly urban regions. Hence, especially from an international perspective, even the few predominantly rural areas in the Netherlands have a relatively high population density.

In case of multiple locations falling under the same hospital institution, the exact location of surgery was obtained by asking hospital experts. For the cases in which exact locations could not be determined, surgery was allocated to the hospital locations closest to patients' homes. The calculation of corresponding travel costs was then performed by multiplying travelled distances by €0.19 per kilometre. This 'cost price' for travelling by car accounts for fuelling, depreciation, maintenance, tax and insurance costs, and is commonly used in Dutch cost-effectiveness health studies [21] and in reimbursement by Dutch health insurers [22]. Note that the indirect costs of travelling – such as the opportunity costs of travel time – are not included. Hence, we here use a conservative estimate of patients' total travel costs.

Lastly, in determining patients' travel times and distances for their surgery, the number of trips to the hospital was set at one return trip. Following expert opinions, for the calculation of the total costs travel distances were multiplied by four to take into account that patients must visit the hospital several times. That is, when preparing for their surgery with surgical staff and for follow-up visits afterwards. In the Dutch health care setting, these events usually occur in the hospital where surgery takes place.

2.3. Patient selection

From the NCR database, we selected patients diagnosed with cancer of the colon, stomach or oesophagus between January 2012 and December 2013. Our choice for these tumour sites was motivated by the differing degree of centralisation with respect to surgery aimed at these malignancies during our study period. For oesophageal cancer surgery, major steps towards centralisation had already been taken in the Netherlands with the publication of

Table 1
Patients and hospital characteristics of selected patients with colon, stomach and oesophagus cancer between 2012–2013.

	Colon (n = 20,314)	Stomach (n = 1011)	Oesophageal (n = 1422)
Mean age (SD), years	69.3 (11.1)	67.7 (11.8)	63.7 (8.9)
Range age, years	20–99	19–91	25–86
Age group (%)			
< 65 years	30.7	33.4	49.9
65–75 years	37.7	38.7	41.8
>75 years	31.6	27.9	8.4
Male (%)	55.3	61.7	78.1
Socioeconomic status (SES) (%)			
High	30.6	32.7	32.6
Medium	38.5	38.3	36.5
Low	30.9	29.0	30.9
Stage (%)			
Unknown	0.3	3.5	0.4
1–3	86.7	88.5	97.1
4	13.0	8.0	2.5
Number of operating hospitals	92	63	25
Number of hospitals satisfying volume norm (%)	91 (98.9%)	24 (38.1%)	22 (88.0%)
University hospital (%)	7.7	25.6	46.6
Mean travel distance (SD), km	24.5 (33)	44.4 (49.3)	62.9 (57.6)
Range travel distance, km	0–548	0–456.2	0–461.4

stringent volume norms prior to the period under study. The norms for stomach cancer surgery, in contrast, had been less demanding, and centralisation only just started in 2012. Lastly, the volume norms for colon cancer surgery have hardly spurred new initiatives for centralisation.

The analyses included patient's aged ≥18 years who underwent surgery, at the time of their cancer diagnosis were living in the Netherlands and were treated in a Dutch hospital. We excluded patients with invalid postal codes.

2.4. Centralisation scenarios

In the simulation analyses, the distances actually travelled by patients were used as reference point for calculating (hypothetical) scenarios according to which centralisation process may potentially progress. Similar to previous studies [14–16], in all of the scenarios summarised below we divert patients who initially visited a hospital that is now assumed to be 'closed' to the nearest hospital that is still 'open'.

- Scenario 1: surgical treatment is exclusively provided by a single healthcare provider, situated in the geographical centre of the Netherlands.
- Scenario 2: surgical treatment is restricted to the university hospitals, including a dedicated cancer centre (n = 9).
- Scenario 3: surgical treatment is only provided by hospitals that in 2013 met the new hypothetical volume norms resulting when current volume norms are increased by 50% (colon cancer: n = 62, stomach cancer: n = 7, oesophageal cancer: n = 12).
- Scenario 4: surgical treatment is performed in university and tertiary teaching hospitals (n = 49).

Though scenario 1 may look too extreme, in the Netherlands this has actually happened in the field of paediatric oncology with the establishment of the Princess Máxima Center. To improve children's recovery prospects and reduce health problems, both during and after treatment, all care and top research is recently concentrated in one national – and therefore centrally located (Utrecht) – paediatric oncology centre.

2.5. Differences across patient groups

Descriptive statistics were applied to describe the patient populations in this study. To examine whether the changes in travel burden – measured in distance – between the actual situation and the simulated scenarios impacted unevenly on patients of different age and socioeconomic status, as a first test some basic multivariate linear regression analyses were performed. These were based on the following simple regression model:

$$\triangle Travel\ distance = f\,(age,\ SES,\ province)$$

The explanatory variables were tested for multicollinearity (Appendix C in Supplementary material). P-values below 0.05 (two-sided) were considered statistically significant for all tests. All analyses were performed with Stata/SE 14®.

3. Results

3.1. Descriptive statistics

During the study period, 20,314 patients were diagnosed with colon cancer and underwent surgery for this, and the same was true for 1,011 patients with stomach cancer and 1,422 patients with oesophageal cancer (Table 1). Compared to patients with colon cancer and stomach cancer, operated patients with oesophageal cancer were younger, having a mean age of 63.7 years (versus 69.3 and 67.7 years, respectively), and displayed a larger male dominance (78% versus 55% and 62%, respectively). For all conditions, the majority of patients lived in a postal area associated with medium socioeconomic status.

In Table 1, the number of hospitals performing surgery reflect the degree of centralisation that has occurred for the three cancer types. Surgery for colon cancer was carried out by all Dutch hospitals offering cancer surgery (n = 92), whereas only just over a quarter of them operated on oesophageal cancer (n = 25). Surgery for stomach cancer was performed in over two-third of hospitals (n = 63) (for more information on the centralisation over the period 2005–2013, see Appendix A.1 in Supplementary material).

The proportion of hospitals meeting the current minimum volume standards was relatively high for colon (99%) and oesophageal cancer (88%). These norms are 50 and 20 surgeries per year,

Please cite this article in press as: Versteeg SE, et al. Centralisation of cancer surgery and the impact on patients' travel burden. Health Policy (2018), https://doi.org/10.1016/j.healthpol.2018.07.002

Table 2
Simulation scenarios colon cancer (n = 20,314).

	Actual situation (2012 & 2013)	Actual situation with no hospital bypassing	Scenario 1 1 hospital provider	Scenario 2 Only academic hospitals	Scenario 3 Higher volume norm (+50%)	Scenario 4 Academic + teaching hospitals
Number hospitals (n)	92	92	1	9	62	49
Volume treatment - Mean (range)	221 (8–4 82)	177 (31–443)	20314	2257.1 (523–5419)	228.2 (55–599)	414.6 (96–850)
Mean travel distance (SD), km	24.5 (33)	16.0 (13)	191.5 (89.2)	83.0 (59.1)	20.1 (17.1)	35.4 (34.7)
Range travel distance, km	0–548.2	0–142.8	0–457.1	0–330.2	0–142.8	0–285.3
Mean travel time (SD), minutes	26.7 (23)	20.5 (13.0)	131.6 (51.2)	67.4 (39.0)	24.3 (16.3)	34.1 (23.6)
Range travel time, minutes	4–432	0–342	0–494	0–420	0–344	0–344
Δ Total travel costs (€)	0	−131*k*	2,58*m*	903*k*	−68*k*	168*k*

Table 3
Simulation scenarios stomach cancer (n = 1,011).

	Actual situation (2012 & 2013)	Actual situation with no hospital bypassing	Scenario 1 1 hospital provider	Scenario 2 Only academic hospitals	Scenario 3 Higher volume norm (+50%)	Scenario 4 Academic + teaching hospitals
Number hospitals (n)	63	63	1	9	7	49
Volume treatment - Mean (range)	16.0 (1–87)	64.3 (17–174)	1011	112.3 (26–237)	144.4 (98–212)	20.4 (2–50)
Mean travel distance (SD), km	44.4 (49.3)	21.4 (18.1)	194.3 (95.6)	77.6 (56.5)	81.2 (53.8)	33.2 (30.6)
Range travel distance, km	0–456.2	0–110.2	2.8–434.8	0–302.4	0–336.7	0–263
Mean travel time (SD), minutes	40.5 (31.1)	24.8 (15.4)	132.8 (54.5)	64.0 (37.2)	64.5 (32.8)	32.9 (21.1)
Range travel time, minutes	0–292	0–166	10–346	0–220	0–228	0–176
Δ Total travel costs (€)	0	−18*k*	115*k*	26*k*	28*k*	−9*k*

respectively. For stomach cancer, in contrast, less than half of hospitals (38%) performed the number of surgeries that is minimally required. While almost half of the patients with oesophageal cancer was treated in university hospitals (47%), this only concerned about a quarter (26%) of stomach cancer patients and 8% of colon cancer patients.

3.2. Scenario analysis

Simulations on the average travel distances and travel times for patients were carried out separately for colon (Table 2), stomach (Table 3) and oesophageal cancer (Table 4). (For detailed information regarding travel times see Appendix B in Supplementary material). In 2012–2013 (i.e. the actual situation), the mean travel distance and travel time were highest for patients with oesophageal cancer (distance: 63 km; time: 53 min). Of all patients, more than a quarter (29%) had travelled ≥60 min for their surgery. For stomach cancer and colon cancer, these proportions were 18% and 5%, respectively. Across all diseases, travel times and distances would be considerably lower in the absence of hospital bypassing (i.e. when all patients seek care at the nearest hospital). As shown by the second column in Tables 2–4, travel distances then drop by 35%, 52% and 42% for colon, stomach, and oesophageal cancer, respectively.

As expected, the average travel distances, times and costs were in general inversely related to the number of hospitals offering cancer surgery. If cancer surgery would only be offered by academic hospitals (Scenario 2), average travel burden also increases across cancer types compared to the actual situation. For colon, stomach, and oesophageal cancer patients, travel distances would increase by 339%, 175% and 129%, respectively. Travel times would increase by 252%, 158% and 127%, respectively.

While under Scenario 3 only 51% of patients with stomach cancer and 70% of oesophageal cancer patients would have a travel time <60 min, this would be the case for 98% of patients with colon cancer. However, for the latter, travel burden is not necessarily inversely related to the number of care suppliers. Here patients' travel burden would decrease (18% in travel distance and 9% in travel time) despite of 30 fewer hospitals in comparison to the actual situation. This is a direct effect of diverting patients from a 'closed' hospital to the nearest hospital still offering the treatment; i.e. some patients currently seek care in a lower-volume hospital located further away. For these patients, this centralisation scenario in our study seems to be in contrast with their current preferences. Despite the decrease in travel burden, it may therefore result in decreased patient utility.

For oesophageal cancer surgery, Scenario 4 would represent a situation where more hospitals would be available for patients than in the actual situation. While the decreases in average travel distance (27.1 km: 43%) and time (18.2 min: 34%) are substantial, the measures would be no different from current ones in the absence of hospital bypassing. For colon cancer and stomach cancer, this scenario would increase patients' travel burden as compared to the actual situation.

Under almost all centralisation scenarios considered here, the calculated changes in patients' travel costs are quite modest.

3.3. Regression analysis

Considering the potential impact of the scenarios, the results of the linear regressions do indicate that travel burden resulting from continued centralisation may vary significantly between specific patient subgroups and cancer types (Table 5). Regarding colon cancer, the effects of further centralising surgery would more heavily impact elderly patients (65–75 and >75 years compared to <65 years) and those with a medium or low SES for most scenarios. While the same would be true for the impact of centralising stomach cancer surgery with respect to age groups, effects would only be different for patients with a medium or low SES in Scenarios 1 and 3. In oesophageal cancer, simulated changes in travel distances differed less across patient groups. Please note that for a precise examination of the differences across patient groups, more detailed information is required allowing the use of more sophisti-

Table 4
Simulation scenarios oesophageal cancer (n = 1,422).

	Actual situation (2012 & 2013)	Actual situation with no hospital bypassing	Scenario 1 1 hospital provider	Scenario 2 Only academic hospitals	Scenario 3 Higher volume norm (+50%)	Scenario 4 Academic + teaching hospitals
Number hospitals (n)	25	25	1	9	12	49
Volume treatment - Mean (range)	56.9 (1–153)	43.1 (3–108)	1422	158 (30–331)	118.5 (56–204)	29 (3–86)
Mean travel distance (SD), km	62.9 (57.6)	44.4 (35.2)	182.6 (86.8)	81.3 (57.4)	62.2 (44.4)	35.8 (32)
Range travel distance, km	0–461.4	0–273.7	2.8–428.2	0–295.8	0–295.8	0–256.5
Mean travel time (SD), minutes	52.8 (36.2)	40.8 (23.7)	126.7 (49.6)	66.8 (37.7)	53.0 (28.8)	34.6 (21.3)
Range travel time, minutes	0–292	0–196	10–284	0–214	0–212	0–174
Δ Total travel costs (€)	0	−20*k*	129*k*	20*k*	−757*k*	−29*k*

Table 5
Results of regression analyses (dependent variable = difference in travel distance).

Colon cancer

	Scenario 1 N = 20,314 R-squared = 0.72			Scenario 2 N = 20,314 R-squared = 0.51			Scenario 3 N = 20,314 R-squared = 0.02			Scenario 4 N = 20,314 R-squared = 0.30		
Variables	Coeff.	Std. error		Coeff.	Std. error		Coeff.	Std. error		Coeff.	Std. error	
Age												
- <65	Ref	–		Ref	–		Ref	–		Ref	–	
–65–75	6.32	0.85	*	5.82	0.76	*	4.74	0.53	*	4.81	0.61	*
–>75	9.38	0.89	*	8.07	0.80	*	7.84	0.56	*	7.69	0.64	*
SES												
- High	Ref	–		Ref	–		Ref	–		Ref	–	
- Medium	3.03	0.88	*	7.25	0.79	*	0.50	0.55		3.11	0.63	*
- Low	12.66	0.94	*	5.54	0.84	*	0.08	0.59		3.13	0.67	*

Stomach cancer

	Scenario 1 N = 1011 R-squared = 0.66			Scenario 2 N = 1011 R-squared = 0.43			Scenario 3 N = 1011 R-squared = 0.30			Scenario 4 N = 1011 R-squared = 0.08		
Variables	Coeff.	Std. error		Coeff.	Std. error		Coeff.	Std. error		Coeff.	Std. error	
Age												
- <65	Ref	–		Ref	–		Ref	–		Ref	–	
–65–75	11.60	4.38	*	11.87	3.77	*	11.87	4.08	*	13.36	3.31	*
- >75	16.87	4.75	*	15.84	4.09	*	18.38	4.43	*	16.35	3.59	*
SES												
- High	Ref	–		Ref	–		Ref	–		Ref	–	
- Medium	–1.22	4.62		2.24	3.98		11.27	4.31	*	2.57	3.49	
- Low	12.97	4.90	*	6.11	4.22		17.08	4.56	*	4.77	3.70	

Oesophageal cancer

	Scenario 1 N = 1422 R-squared = 0.58			Scenario 2 N = 1422 R-squared = 0.43			Scenario 3 N = 1422 R-squared = 0.11			Scenario 4 N = 1422 R-squared = 0.08		
Variables	Coeff.	Std. error		Coeff.	Std. error		Coeff.	Std. error		Coeff.	Std. error	
Age												
- <65	Ref	–		Ref	–		Ref	–		Ref	–	
–65–75	4.09	3.39		4.05	2.68		3.22	2.46		2.11	2.53	
- >75	11.7	6.03		10.8	4.78	*	9.84	4.37	*	7.81	4.50	
SES												
- High	Ref	–		Ref	–		Ref	–		Ref	–	
- Medium	0.10	4.01		0.15	3.18		–2.29	2.91		–2.61	2.99	
- Low	13.67	4.25	*	5.49	3.36		7.38	3.08	*	1.89	3.17	

Note: All regressions control for province people live in.
*Denotes significance at 5%.

cated regression models. This is, however, beyond the scope of the preliminary analysis presented here.

4. Conclusion

While centralising treatment to few centres may not represent a tenable option for more common diseases, such a scenario is well possible and, according to some, preferable for rare diseases including rare cancers [23,24]. For these diseases, the clustering of professional expertise and availability of technical equipment (following from economies of scale and scope) should aid in improving patient care [25]. Also, the higher case volumes resulting from centralisation would enhance research possibilities that are otherwise difficult to attain. In general, a higher degree of centralisation will be associated with increased travelling for patients.

Our study provides the first population-based insights in the travel burden Dutch patients encounter for surgery of colon cancer, stomach cancer and oesophageal cancer. We compare actual travelling to travel distances and travel times under four different hypothetical centralisation scenarios.

An important strength of our study is that we use the Geodan Drive Time matrix which is based on historic speed profiles. It therefore gives an extremely realistic picture of travel times and distances between all postal codes in the Netherlands. That is, we did not need to approximate patients' travel burden from geographic straight-line distances. The latter measurements are known to considerably underestimate distances (sometimes by at least 30% to 40%) [15]. Additionally, because we were able to attain national data from a near-complete national registry, our estimations do not suffer from a sample selection bias.

For all cancer types, a substantial amount of hospital bypassing is observed. That is, a substantial number of patients currently travels beyond the nearest hospital for cancer surgery. This mitigates the potential effects of the centralisation scenarios on patients' mean travel distances and travel times. Although the exact reasons for this remain to be elucidated, studies have shown that patients may value hospitals on characteristics other than the amount of travel and, for these reasons, may be willing to literally 'go the extra mile' [26]. Moreover, the bypassing could be a reflection of agreements between hospitals with regard to their shared care pathways, which may not be limited by the geographic distances between them.

For future research, we recognize that some of the assumptions underlying our analyses do merit further investigation. First, we only examined the direct costs of individual travelling undertaken by cancer patients, leaving additional expenses, such as parking costs and costs for patients' accompanying relatives as well as the opportunity costs of travel time, unaccounted for. Second, in order to assess the full burden of travelling for cancer patients, subsequent studies should also include travels for treatment modalities other than surgery (e.g. radiation/chemo therapy) in case these cancer treatments are centralised as well. Particularly, schedules for systemic therapy and also cancer irradiation are highly intensive and may require very frequent hospital visits. For instance, according to curative schedules for stomach and oesophageal cancer, patients are to receive chemotherapy or combined treatment with radiotherapy and chemotherapy prior to their surgery, which may require them to travel to their hospital consecutively for a number of weeks. In the case of stomach cancer, surgery is to be followed by another round of adjuvant treatment with chemotherapy. Given these treatment schedules, it could be foreseen that adherence to them depends (at least in part) on the amount of travel patients need to undertake. In addition to that, a correction for unforeseen complications that generate more visits to the hospital might need to be taken into account.

Our findings suggest that further centralisation of cancer surgery does not necessarily increase Dutch patients' travel burden. And when it does, this increase most often has a modest effect on travel costs. The preliminary results of a simple regression analysis, however, suggest that the precise effects seem unevenly distributed over patient groups, with the biggest impact on vulnerable patients' travel distances. More research in this area, however, is highly recommended. For future analyses, it should be investigated whether it is feasible to link microdata from Statistics Netherlands (CBS) with data from the NCR. The microdata sets of CBS include detailed information at the level of individuals about important socio-economic indicators such as education, income, and health.

To conclude, when designing health care policies regarding centralisation, the main challenge consists of adequately balancing the benefits of centralised treatment (higher quality) against the effects on patients' travel burden. Hence, our analysis indicates that thorough consideration of non-clinical effects of centralisation is important for health policy.

Acknowledgements

We thank two anonymous reviewers for their constructive comments, which helped us to substantially improve the manuscript. The authors thank the data managers of the Netherlands Comprehensive Cancer Organisation (IKNL) for the collection of data for the Netherlands Cancer Registry (NCR). This research is conducted as part of the Research Master Health Sciences, specialisation Health Economic Analysis, that is offered by ESHPM in cooperation with NIHES. It did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. On 19 October 2017, at the yearly IACR (International Association of Cancer Registries) meeting, the Enrico Anglesio Prize for a young cancer epidemiology researcher was awarded to Simone Versteeg for her presentation of this study.

Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.healthpol.2018.07.002.

References

[1] Birkmeyer JD, Siewers AE, Finlayson EV, Stukel TA, Lucas FL, Welch HG, et al. Hospital volume and surgical mortality in the United States. The New England Journal of Medicine 2002;346:1128–37.
[2] Luft HS, Bunker JP, Enthoven AC. Should operations be regionalized? The empirical relation between surgical volume and mortality. The New England Journal of Medicine 1979;301:1364–9.
[3] Pieper D, Mathes T, Neugebauer E, Eikermann M. State of evidence on the relationship between high-volume hospitals and outcomes in surgery: a systematic review of systematic reviews. Journal of the American College of Surgeons 2013;216:1015–25.
[4] Reames BN, Ghaferi AA, Birkmeyer JD, Dimick JB. Hospital volume and operative mortality in the modern era. Annals of Surgery 2014;260:244–51.
[5] Mesman R, Westert GP, Berden BJMM, Faber MJ. Why do high-volume hospitals achieve better outcomes? A systematic review about intermediate factors in volume–outcome relationships. Health Policy 2015;119:1055–67.
[6] Begg CB, Cramer LD, Hoskins WJ, Brennan MF. Impact of hospital volume on operative mortality for major cancer surgery. JAMA 1998;280:1747–51.
[7] Birkmeyer JD, Sun Y, Wong SL, Stukel TA. Hospital volume and late survival after cancer surgery. Annals of Surgery 2007;245:777–83.
[8] Hillner BE, Smith TJ, Desch CE. Hospital and physician volume or specialization and outcomes in cancer treatment: importance in quality of cancer care. Journal of Clinical Oncology 2000;18:2327–40.
[9] MWJM Wouters, Gooiker GA, Van Sandick JW, Tollenaar RAEM. The volume-outcome relation in the surgical treatment of esophageal cancer: a systematic review and meta-analysis. Cancer 2012;118:1754–63.
[10] Iversen LH, Harling H, Laurberg S, Wille-Jorgensen P. Influence of caseload and surgical specialty on outcome following surgery for colorectal cancer: a review of evidence. Part 2:long-term outcome. Colorectal Disease 2007;9:38–46.
[11] Birkmeyer JD, Siewers AE, Marth NJ, Goodman DC. Regionalization of high-risk surgery and implication for patient travel times. JAMA 2003;290:2703–8.
[12] Aggarwal A, Lewis D, Mason M, Sullivan R, Van der Meulen J. Patient mobility for elective secondary health care services in response to patient choice policies: a systematic review. Medical Care Research and Review 2017;74(4):379–403.
[13] Varkevisser M, Van der Geest S. Why do patients bypass the nearest hospital? An empirical analysis for orthopaedic care and neurosurgery in the Netherlands. The European Journal of Health Economics 2007;2007(8):287–95.
[14] Poeran J, Borsboom GJJM, De Graaf JP, Birnie E, Steegers EAP, Mackenbach JP, et al. Does centralisation of acute obstetric care reduce intrapartum and first-week mortality? An empirical study of over 1 million births in the Netherlands. Health Policy 2014;117:28–38.
[15] Hentschker C, Mennicken R. The volume-outcome relationship and minimum volume standards- empirical evidence for Germany. Health Economics 2014;4:644–58.
[16] Kobayashi D, Otsubo T, Imanaka Y. The effect of centralization of health care services on travel time and its equality. Health Policy 2015;119(3):298–306.
[17] Netherlands Comprehensive Cancer Organisation (IKNL). Over cijfers. https://www.iknl.nl/cijfers/over-cijfers [Accessed 27 March 2016].

[18] SCP. Statusscores. https://www.scp.nl/Onderzoek/Lopend_onderzoek/A_Z_alle_lopende_onderzoeken/Statusscores [Accessed 14 January 2018].
[19] Schut FT, Varkevisser M. Competition policy for health care provision in the Netherlands. Health Policy 2017;121(2):126–33.
[20] GeoDan. Drive time matrix; 2013. Amsterdam.
[21] Zorginstituut Nederland. Kostenhandleiding: Methodologie van kostenonderzoek en referentieprijzen voor economische evaluaties in de gezondheidszorg. https://www.zorginstituutnederland.nl/over-ons/publicaties/publicatie/2016/02/29/richtlijn-voor-het-uitvoeren-van-economische-evaluaties-in-de-gezondheidszorg [Accessed 14 January 2018].
[22] Zorg Instituut Nederland. Vervoer Zvw. https://www.zorginstituutnederland.nl/Verzekerde+zorg/v/vervoer-zvw [Accessed 14 January 2018].
[23] Taruscio D, Gentile AE, Evangelista T, Frazzica RG, Bushby K, Montserrat AM. Centres of expertise and European reference networks: key issues in the field of rare diseases. The EUCERD Recommendations. Blood Transfusion 2014;12(Suppl. 3):s621–5.
[24] Aymé S, Rodwell C. The European Union Committee of experts on rare diseases: three productive years at the service of the rare disease community. Orphanet Journal of Rare Diseases 2014;9:30.
[25] Gandjour A, Lauterbach KW. The practice-makes-perfect hypothesis in the context of other production concepts in health care. American Journal of Medical Quality 2003;18:171–5.
[26] Varkevisser M, van der Geest SA, Schut FT. Do patients choose hospitals with high quality ratings? Empirical evidence from the market for angioplasty in the Netherlands. Journal of Health Economics 2012;31:371–8.
[27] Ho V, Town RJ, Heslin MJ. Regionalization versus competition in complex cancer surgery. Health Economics, Policy and Law 2007;2(1):51–71.
[28] Mesman R, Faber MJ, Berden BJJM, Westert GP. Evaluation of minimum volume standards for surgery in the Netherlands (2003–2017): a successful policy? Health Policy 2017;121:1263–73.
[29] Stitzenberg KB, Sigurdson ER, Egleston BL, Starkey RB, Meropol NJ. Centralization of cancer surgery: implications for patient access to optimal care. Journal of Clinical Oncology 2009;27(28):4671–8.
[30] O'Connor SC, Mogal H, Russell G, Ethun C, Fields RC, Jin L, et al. The effects of travel burden on outcomes after resection of extrahepatic biliary malignancies: results from the US extrahepatic biliary consortium. Journal of Gastrointestinal Surgery: Official Journal of the Society for Surgery of the Alimentary Tract 2017;21(12):2016–24.
[31] Propper C, Damiani M, Leckie G, Dixon J. Impact of patients' socioeconomic status on the distance travelled for hospital admission in the English National Health Service. Journal of Health Services Research & Policy 2007;12:153–9.
[32] Victoor A, Delnoij DM, Friele RD, Rademakers JJ. Determinants of patient choice of healthcare providers: a scoping review. BMC Health Services Research 2012;12:272.
[33] Kilsdonk MJ, Siesling S, van Dijk BAC, Wouters MW, van Harten WH. What drives centralisation in cancer care? PLoS One 2018;13(4):e0195673.

Please cite this article in press as: Versteeg SE, et al. Centralisation of cancer surgery and the impact on patients' travel burden. Health Policy (2018), https://doi.org/10.1016/j.healthpol.2018.07.002