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ORIGINAL ARTICLE

Does socioeconomic status influence the choice of surgical technique in abdominal rectal cancer surgery?

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Abstract

Aim: This study aimed to estimate the impact of socioeconomic status on the probability of receiving open (OPEN) or minimally invasive surgery (MIS) for curative abdominal rectal cancer resection.

Methods: All patients diagnosed with rectal cancer clinical Stage I–III during the period 2010–2021 who underwent curative abdominal resection surgery, MIS or OPEN, were included. Patients were identified in the Colorectal Cancer Database, a register-linkage based on the Swedish Colorectal Cancer Register and linked to several national Swedish health-related and demographic registers. Socioeconomic factors, sex, patient and tumour characteristics, number of previous surgical procedures and category of hospital were collected. Exposures were level of education (categorized as 6–9, 10–12, >12 years), household income (quartiles 1–4) and country of birth (Sweden, Nordic countries outside Sweden, Europe outside the Nordic countries, outside Europe), and outcome was MIS or OPEN. Multivariable logistic regression models were fitted for each exposure, adjusted for age, sex, cT and cN, level of tumour, and number of previous abdominal surgical procedures.

Results: A total of 13 778 patients were included of whom 43.6% underwent MIS ($n = 6007$) and 56.4% OPEN ($n = 7771$). Highest level of education (OR for highest vs. lowest level of education 1.15; 95% CI 1.03–1.29) and highest household income quartile (OR for highest vs. lowest household income quartile 1.27; 95% CI 1.12–1.44) increased the likelihood of receiving MIS.

Conclusion: Despite the tax-financed healthcare system in Sweden, rectal cancer patients with the highest level of education and the highest household income had an increased probability of receiving MIS.

KEYWORDS
laparoscopy, MIS, rectal cancer, socioeconomy

INTRODUCTION

In Sweden, colorectal cancer is the third most common type of malignancy, with around 7000 cases yearly, of which approximately 2000 are rectal cancer. Despite the development of various neoadjuvant treatment modalities, surgery remains the cornerstone in curative treatment for rectal cancer, which is one of the most technically demanding colorectal procedures [1].

Previous studies comparing minimally invasive surgery (MIS) with the open technique (OPEN) for rectal cancer have demonstrated superior short-term postoperative outcomes such as less pain, less need for analgesics, faster recovery and shorter hospital stay. It has also been shown that long-term oncological outcome in MIS is not inferior to OPEN [2–8].

A limited number of previous publications assessing rectal cancer have demonstrated that individuals with a higher socioeconomic status (SES) have an increased probability of receiving more advanced neoadjuvant therapy, as well as having a higher likelihood of receiving restored bowel continuity. Previous studies have also demonstrated an association between a lower SES and an increased risk of shorter life expectancy in patients with colorectal cancer. The reasons for these differences are not fully understood, but access to medical care, tumour stage at diagnosis, comorbidity, as well as lifestyle factors such as diet, alcohol and smoking habits, may play a role [9–16]. Furthermore, similar results have also been found regarding the surgical treatment of benign and malignant conditions in gynaecology, urology, cardiology, upper gastrointestinal system as well as inguinal hernia [17–21].

Sweden has a tax-funded healthcare system, which assumes that healthcare of similar quality should be available to all. The proportion of abdominal rectal cancer surgery performed by MIS in Sweden has increased steadily from 7% in 2010 to 85% in 2023 [22]. This study presents a time period during which a new surgical technique was introduced, in this case MIS, and aims to assess whether level of education, household income and country of birth influenced the choice between MIS and OPEN.

What does this paper add to the literature?

This nationwide study comparing patients undergoing minimally invasive or open curative rectal cancer surgery found that patients with the highest level of education or highest household income had an increased probability of receiving minimally invasive surgery, a finding previously not described from a country with a tax-financed healthcare system.

METHOD

The study population included all patients in Sweden diagnosed with rectal Union Internationale Contre le Cancer (UICC) cancer Stage I–III during the period 1 January 2010 to 31 December 2021 and who underwent curative abdominal resection surgery for adenocarcinoma of the rectum. All Swedish residents have a personal identification number, which enables identification and subsequently linkage to several registers [23].

Patients were identified in the Colorectal Cancer Database (CRCBaSe) [24], a register-linkage based on the Swedish Colorectal Cancer Registry (SCRCR) [25], which includes rectal cancer diagnoses since 1995 and colon cancer diagnoses from 2007, and is a nationwide register in which registration is mandatory and nearly all colorectal cancers are registered (>99%). The SCRCR entails detailed data on tumour and treatment characteristics, and has been validated on several occasions [26, 27].

All patients diagnosed with rectal cancer clinical Stage I–III during the period 2010–2021 who underwent curative abdominal resection surgery, MIS or OPEN, were included. Exclusion criteria for the present study were metastatic disease upon initial diagnosis, patients who underwent urgent or unplanned rectal resection (<0.5%), as well as those who underwent local excision procedures such as transanal endoscopic microsurgery or open transanal excision.

The treatment of rectal cancer in Sweden (mean population 2010–2021: 9.85 million) is administered by 21 healthcare regions. These regions all offer diagnostic work-up and treatment which is financed by their own regional taxes. All regions have the possibility to refer selected cases to any of the tertiary referral centres (i.e., university hospitals). A small proportion (<5%) of rectal cancer surgery is performed by private healthcare providers, which receive tax-financed payment compensation, and, as it is mandatory, register diagnosed patients in the SCRCR. Treatment recommendations in the form of national guidelines are published regularly by the Swedish National Board of Health and Welfare.

The factors of interest were annual household income, educational level and country of birth, retrieved from the Longitudinal Integrated Database for Health Insurance and Labour Market Studies (LISA) database, which started in 1990 and comprises all individuals residing in Sweden aged ≥16 years (since 2010 ≥15 years) [28].

A compulsory 6-year school attendance was introduced in Sweden in 1882, a 7-year compulsory school attendance was introduced in 1946, and a 9-year compulsory school attendance was introduced in 1972. The level of education at the rectal cancer diagnosis was classified into three categories based on the Swedish educational system: primary school (mandatory education 6–9 years, depending on year of birth), gymnasium (10–12 years) and university education (>12 years).

Annual household income was adjusted for inflation and categorized into quartiles (Q1–Q4, with the category Q4 representing households with the highest income). Information on migration, marital status and country of birth (Sweden, Nordic countries outside of Sweden, European countries outside of the Nordic countries, countries outside of Europe) was retrieved from the Register of the Total Population.

The outcome of interest was MIS or OPEN rectal cancer surgery, and the information was collected from the SCRCR. Data on previous abdominal surgery was retrieved from the National Patient

Register [29, 30] and categorized into none, one, two or more abdominal surgeries.

The proportion of missing data was limited, and exact numbers are denoted in Tables 1 and 2. The present study was reported in accordance with the STROBE statement [31].

Study hypothesis

The hypothesis of the present study was that household income, level of education and country of birth may influence the decision by the surgical team in the choice of OPEN or MIS for rectal cancer surgery.

Statistical analysis

Descriptive statistics are shown as frequencies and percentages for categorical variables and mean and standard deviation and/or median and interquartile range for continuous variables.

Only individuals with non-missing data on the regression covariates were included in the regression analyses ($N = 13\,778$). The socioeconomic variables investigated were length of education (6–9 years, 10–12 years, >12 years), household income quartile and country of birth (Sweden, Nordics outside of Sweden, Europe outside of Nordics, outside of Europe). Adjustment covariates were age (continuous variable), sex, clinical T stage (T1–3, T4), clinical N stage (N0, N1–2), number of previous abdominal surgeries (none, one, two or more) and calendar time of the surgical procedure.

Multivariable binary logistic regression models were fitted for each socioeconomic variable, providing estimates of ORs for receiving MIS as well as 95% CIs and *P* values, adjusting for the covariates listed above. Finally, all socioeconomic variables and adjustment covariates were included in a multivariable binary logistic regression model, included in Supporting Information, Tables.

The linear assumption of age and calendar time on the log-odds was evaluated by comparing the Bayesian information criterion (BIC) of models using restricted cubic splines (RCS) for age and calendar time with varying number of knots. The linear assumption was found adequate for age, while for calendar time RCS with three knots were chosen.

Interaction terms between the RCS-transformed calendar time and socioeconomic variables were added, assessing the BIC to determine the added value of the interaction terms.

The possible mediation by neoadjuvant therapy (chemoradiotherapy, radiotherapy or chemotherapy) of the effect of socioeconomic variables on receiving MIS was investigated in three steps: (1) evaluating whether each socioeconomic variable was statistically significantly associated with receiving MIS, (2) evaluating whether the statistically significant socioeconomic variables were associated with receiving neoadjuvant therapy and (3) re-evaluating the association to MIS for socioeconomic variables showing statistically significant association with neoadjuvant therapy.

P values below 5% were considered statistically significant. The statistical software SAS was used for data processing. The statistical software R version 4.3.2 was used for descriptive statistics and regression analyses. The study was approved by the Stockholm Regional Ethics Vetting Board (DNR: 2014/71-31, 2018/328-32) and by the national Ethical Committee (DNR: 2021-00342, 2023-03305-02).

RESULTS

Patient characteristics

A total of 13 778 clinical UICC cancer Stage I–III patients were included of whom 43.6% (6007/13 778) underwent MIS and 56.4% (7771/13 778) OPEN (Table 1). Age, body mass index and sex were comparable between the groups. Patients with OPEN had a higher proportion of American Society of Anesthesiologists score ≥3 (26.8% vs. 23.6%), a higher proportion of cT4 (21.0% vs. 11.2%) and more often received any neoadjuvant treatment (68.0% vs. 56.9%). Previous abdominal surgery was more common in the OPEN group (25.4% vs. 22.4%).

Socioeconomic status

The distributions of different socioeconomic factors are depicted in Table 2. Patients with the highest level of education, compared with the lowest level of education, and patients within the highest income quartile, compared with the lowest income quartile, had a higher proportion of MIS. With regard to hospital category, district, regional or university hospitals, the proportions of MIS and OPEN were comparable, as shown in Table 3.

Multivariable logistic regression analysis

The highest level of education, compared with the lowest, and the highest income quartile, compared with the lowest, were associated with an increased probability of receiving MIS (OR 1.15, 95% CI 1.03–1.29, and OR 1.27, 95% CI 1.12–1.44, respectively) (Table 4). In these multivariable regression models, adjusted for age, sex, clinical T and N stage, previous abdominal surgeries and calendar time, socioeconomic variables were analysed one at a time. In another multivariable regression model, all socioeconomic variables were analysed together (Table S1).

No socioeconomic variable was statistically significantly associated with receiving any kind of neoadjuvant treatment. Interaction terms between socioeconomic variables and calendar time did not improve model BIC.

DISCUSSION

This nationwide study comprising all patients diagnosed with UICC cTNM I–III rectal cancer in Sweden during 2010–2021 and

TABLE 1 Patient demography, tumour characteristics, neoadjuvant and surgical treatment in patients undergoing curative resection for rectal cancer in Sweden between 2010 and 2021 by open (OPEN) or minimally invasive surgery (MIS).

	OPEN (*n* = 7771)	MIS (*n* = 6007)
Age, median (Q1; Q3)	69.9 (62.2; 76.5)	70.4 (62.2; 76.7)
Women	2985 (38.4%)	2451 (40.8%)
BMI, median (Q1; Q3)	25.5 (23.0; 28.4)	25.5 (23.3; 28.4)
Missing (*n*)	196	55
ASA score		
1	1349 (17.6%)	1062 (17.9%)
2	4269 (55.6%)	3464 (58.5%)
3	1953 (25.4%)	1340 (22.6%)
4	107 (1.4%)	58 (1.0%)
Missing (*n*)	91	81
Charlson Comorbidity Index		
0	5501 (70.8%)	4414 (73.5%)
1	807 (10.4%)	615 (10.2%)
2	954 (12.3%)	685 (11.4%)
>2	509 (6.6%)	293 (4.9%)
Number of previous abdominal surgeries		
0	5798 (74.6%)	4663 (77.6%)
1	1658 (21.3%)	1179 (19.6%)
≥2	315 (4.1%)	165 (2.7%)
Tumour height, cm		
Median (Q1; Q3)	8 (5; 11)	8 (5; 11)
Mean (SD)	8.17 (3.85)	8.28 (3.82)
Missing (*n*)	138	54
Clinical cancer stage		
cT1–3	5877 (79.0%)	5233 (88.8%)
cT4	1558 (21.0%)	657 (11.2%)
Missing (*n*)	336	117
Clinical nodal stage		
cN0	3168 (43.2%)	2785 (47.0%)
cN1–2	4161 (56.8%)	3143 (53.0%)
Missing (*n*)	442	79
Preoperative MDT		
Yes	7560 (97.4%)	5972 (99.6%)
No	203 (2.6%)	25 (0.4%)
Missing (*n*)	8	10
Neoadjuvant therapy		
None	2476 (32.0%)	2580 (43.1%)
Radiotherapy only	3269 (42.3%)	2397 (40.0%)
Chemoradiotherapy	1984 (25.7%)	1009 (16.9%)
Missing (*n*)	42	21
Type of surgical procedure		
Anterior resection	3832 (49.3%)	3141 (52.3%)
Hartmann's procedure	1081 (13.9%)	619 (10.3%)
Abdominoperineal resection	2858 (36.8%)	2247 (37.4%)

Note: Missing data denoted where applicable.

Abbreviations: ASA, American Society of Anesthesiologists; BMI, body mass index; MDT, multidisciplinary team conference; Q1, first quartile; Q3, third quartile; SD, standard deviation.

TABLE 2 Marital status, household income, education and country of birth of patients undergoing curative resection for rectal cancer in Sweden between 2010 and 2021 by open (OPEN) or minimally invasive surgery (MIS).

	OPEN (*n* = 7771)	MIS (*n* = 6007)
Marital status		
Unmarried	1060 (13.9%)	828 (13.9%)
Married	4310 (56.6%)	3435 (57.7%)
Widow/er	980 (12.9%)	709 (11.9%)
Divorced	1265 (16.6%)	986 (16.5%)
Missing (*n*)	156	49
Duration of education		
6–9 years	2551 (33.2%)	1659 (27.9%)
10–12 years	3352 (43.6%)	2567 (43.2%)
>12 years	1785 (23.2%)	1711 (28.8%)
Missing (*n*)	83	70
Household income		
Lowest quartile	2067 (26.7%)	1368 (22.8%)
Lower middle quartile	2062 (26.6%)	1373 (22.9%)
Upper middle quartile	1907 (24.6%)	1530 (25.5%)
Highest quartile	1715 (22.1%)	1720 (28.7%)
Missing (*n*)	20	16
Country of birth		
Sweden	6779 (87.2%)	5187 (86.3%)
Nordic countries outside of Sweden	377 (4.9%)	273 (4.5%)
Europe outside the Nordic countries	405 (5.2%)	341 (5.7%)
Countries outside of Europe	210 (2.7%)	206 (3.4%)

Note: Missing data denoted where applicable.

subsequently undergoing curative abdominal rectal resection demonstrated that patients with university education as well as patients in the top household income quartile had an increased probability of receiving MIS instead of OPEN. The present study highlights that new techniques may not be equally available to all citizens from the start, and furthermore addresses the question of whether this finding should be regarded as a surprise or not.

These results are in line with previous research which has shown that level of education, income, marital status and ethnic origin may influence the choice of therapeutic options such neoadjuvant treatment, restored bowel continuity, surgical technique and adjuvant therapy [10, 14–16, 32, 33]. Moreover, similar findings regarding socioeconomic factors have been noted for patients undergoing surgical treatment for gynaecological, urological, upper gastrointestinal and thoracic malignancy as well as hernia repair [17–21].

Similar to the present results, a recent retrospective cohort study from the United States by Patel et al. showed that patients operated for colon cancer and representing the highest income bracket had a 39% relative increase regarding the probability of receiving MIS compared with the lowest income bracket [33]. The present study showed no statistically significant association between country of birth and the proportion receiving MIS procedures, which is line with an American study of non-metastasized rectal cancer [32, 33]. In contrast, another study from the United States showed that white patients had the highest probability of receiving MIS compared to patients with other ethnical backgrounds [34]. These findings suggest that factors other than ethnical background may play a more influential role in determining access to MIS. No socioeconomic variable was statistically significantly associated with receiving any kind of neoadjuvant treatment. No interaction term between socioeconomic variables and calendar time was demonstrated, and it is therefore unlikely that the effect of socioeconomic variables on receiving MIS is mediated by neoadjuvant treatment. Moreover, adding interaction terms between socioeconomic variables and calendar time did not yield results which support that any socioeconomic variable odds ratio varied over calendar time.

Regarding hospital category, Freischlag et al. in a nationwide retrospective register study showed that category of hospital is associated with the implementation of MIS, as academic and teaching hospitals had a higher proportion of MIS compared with other hospitals [35]. This contrasted with the present study in which the proportion of MIS was not higher in university hospitals compared with regional and district hospitals. It is noteworthy that during the study period 2010–2021 hospitals with a yearly caseload of 25–50 or >50 abdominal rectal cancer cases performed the vast majority of all abdominal rectal cancer surgery, between 80% and 90%, and the total number of hospitals performing rectal cancer surgery dropped during the studied period from 45 to 30 [36]. In previous randomized controlled trials such as COLOUR II and COREAN, which have had a substantial impact on the development of MIS worldwide, cT4 was an exclusion criterion. It is therefore unsurprising that cT4 was less common in the MIS group compared with the OPEN group in the present study cohort [2, 3]. Rectal cT4 tumours comprise cT4a as well as cT4b, of which the latter includes both intra-abdominal and extra-abdominal overgrowth. Intra-abdominal cT4b most probably influenced the choice of MIS or OPEN, whereas cT4b represented by overgrowth on the levators probably did not. The present study has several limitations. First, there are those generally associated with registry-based investigations in which residual confounding cannot be completely ruled out. Examples here are that the employed registers do not provide any information on lifestyle habits such as smoking, alcohol consumption and level of physical fitness. Second, there is no information on the indication for choosing MIS or OPEN for the individual patient. An example of patient selection which may have influenced the choice of surgical technique noted as OPEN had an increased proportion of cT4.

This study also comprises several strengths. First, the population-based setting comprised a large number of patients from an entire nation during a substantial period of time representing real-life treatment of rectal cancer. Presumably the generalizability of the present study is notable, as there are several countries which have similar tax-financed healthcare systems. Second, the degree of

TABLE 3 Category of hospitals performing curative resection for rectal cancer in Sweden between 2010 and 2016 by open (OPEN) or minimally invasive surgery (MIS).

	OPEN ($n=7771$)	MIS ($n=6007$)
Hospital category		
District hospital	1884 (24.2%)	1258 (20.9%)
Regional hospital	3233 (41.6%)	2679 (44.6%)
University hospital	2654 (34.2%)	2070 (34.5%)

TABLE 4 Logistic regression analysis of patients undergoing curative resection for rectal cancer in Sweden between 2010 and 2021 by open (OPEN) or minimally invasive surgery (MIS).

Duration of education	
6–9 years	1.00 (Ref)
10–12 years	1.0 (0.90–1.10; $P=0.95$)
>12 years	1.15 (1.03–1.29; $P=0.014$)
Household income	
Lowest quartile	1.00 (Ref)
Lower middle quartile	0.99 (0.88–1.11; $P=0.81$)
Upper middle quartile	1.12 (1.00–1.27; $P=0.056$)
Highest quartile	1.27 (1.12–1.44; $P=0.00015$)
Country of birth	
Sweden	1.00 (Ref)
Nordic countries outside Sweden	0.99 (0.81–1.20; $P=0.88$)
Europe outside the Nordic countries	1.11 (0.93–1.34; $P=0.25$)
Outside Europe	1.13 (0.87–1.45; $P=0.36$)

Note: OR for MIS. Multivariable OR (95% CI; *P*). Adjustment covariates were age, legal sex, clinical T stage (T1–3, T4), clinical N stage (N0, N1– 2), number of previous abdominal surgeries (none, one, two or more) and calendar time of the procedure. One socioeconomic variable evaluated at a time.

completeness of data is high from the SCRCR as well as several other national registries with relation to healthcare with linkage to the recently introduced CRCBaSe.

The present study cannot provide data which explain why higher level of education and household income would give better access to minimally invasive rectal cancer surgery. Although speculative, it may be that higher SES was associated with an increased awareness of the possibility of receiving MIS, and subsequently may have influenced decision making. To what proportion such decision making was surgeon-dependent or represented shared decision making is clearly of interest although not possible to answer.

CONCLUSION

In conclusion, this nationwide study demonstrated that rectal cancer patients in Sweden with university education and patients in the highest income quartile had an increased likelihood of receiving MIS. These findings raise a general concern regarding the equality of healthcare provided by the Swedish tax-financed system. Future measures with the ambition of understanding, and subsequently preventing, this outcome are needed.

AUTHOR CONTRIBUTIONS

Kaveh Dehlaghi Jadid: Conceptualization; investigation; funding acquisition; writing – original draft; methodology; writing – review and editing; formal analysis; visualization; supervision. **Soran Gadan:** Writing – review and editing; conceptualization; investigation. **Göran Wallin:** Conceptualization; investigation; writing – review and editing. **Caroline Nordenvall:** Conceptualization; investigation; writing – review and editing; methodology; formal analysis; project administration. **Sol Erika Boman:** Conceptualization; writing – review and editing; validation; methodology; software; formal analysis; data curation. **Ida Hed Myrberg:** Conceptualization; writing – review and editing; validation; methodology; software; formal analysis; data curation; visualization. **Peter Matthiessen:** Supervision; conceptualization; investigation; funding acquisition; writing – original draft; methodology; writing – review and editing; visualization; formal analysis.

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CONFLICT OF INTEREST STATEMENT

There is no conflict of interest by the authors.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

ETHICS STATEMENT

Permission was obtained from the Ethics Vetting Board (DNR: 2014/71-31, 2018/328-32) and by the national Ethical Committee (DNR: 2021-00342, 2023-03305-02).

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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