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# Socioeconomic inequalities in the use of radiotherapy for rectal cancer: A nationwide study

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ABSTRACT

Preoperative radiotherapy (PRT) in rectal cancer reduces the risk of local recurrence by at least half but the influence of the socioeconomic status of patients on the use of PRT is little investigated in Europe.

*Methods:* Individually attained data on civil status, education and income were linked to the Swedish Rectal Cancer Registry 1995–2005 ($n = 16,713$) and analysed by logistic regression.

*Results:* Forty-six percentage of the patients received PRT and the crude rate varied with age, gender, civil status, education and income as well as with sublocalisation, stage, type of hospital and health care region. In a multivariate analysis, all civil status groups had PRT to a lesser extent compared with married patients; odds ratio (OR) for unmarried patients was 0.67 (95% confidence interval (CI) 0.59–0.76). Patients with secondary and university education had PRT to the same extent as those with compulsory school (OR 1.04 (0.94–1.15) and 0.92 (0.81–1.06)). The use of PRT was associated with income; OR for patients with income Q1 versus Q4 was 0.76 (0.67–0.86). The inequalities by civil status and income remained unchanged also in groups with a relatively stronger indication for adjuvant radiotherapy, i.e. younger patients and in low rectal cancer.

*Conclusion:* Unmarried and low-income patients are at increased risk for not receiving PRT in rectal cancer. Comorbidity may explain some differences but increased awareness of the role of non-medical variables for the use of PRT is warranted.



## 1. Introduction

Treatment for rectal cancer has changed substantially over the past decades. A refined surgical technique (total mesorectal excision, TME) has been introduced[1] and (neo)adjuvant radiotherapy has become an integrated part of rectal cancer treatment.[2,3] Preoperative radiotherapy (PRT) specifically reduces the risk of local recurrence by at least half and improves disease free-survival.[4,5] In Sweden, PRT has been advocated since many years.[3]

However, PRT has side-effects, both immediate complications[6] and a long-term health impact.[7] The optimal selective use is yet not identified[8,9] and for the time, the factors guiding the use of PRT are age of the patient, clinical stage of the disease and distance of the tumour from the anal verge. Nevertheless, an under-utilisation of radiotherapy in rectal cancer

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based on race has been reported from the United States.[10] Inequalities in the use of adjuvant radiotherapy in rectal cancer, except for age,[11] are little investigated from a European perspective. We hypothesised that the socioeconomic background of patients influences the decision on PRT, also in a population covering health care system, but that the association would be less clear in groups of patients with a relatively stronger indication for PRT, i.e. in younger patients and in low rectal cancer. Female rectal cancer patients have been reported to receive radiotherapy less often than men,[12–14] and we hypothesised that socioeconomic factors contribute to this gender related inequality. We therefore linked individually obtained data on civil status, education and income to a nationwide quality registry for rectal cancer. Our aim was to clarify the use of PRT in rectal cancer in relation to socioeconomic variables in a country with full coverage public health insurance.

## 2. Material and methods

### 2.1. The Swedish Rectal Cancer Registry

The Swedish Rectal Cancer Registry (SRCR) was initiated in 1995.[15] All surgical departments deliver diagnostic, clinical, surgical and pathological data on patients with rectal cancer, in addition to the compulsory report to the Swedish Cancer Registry. Six regional oncology centres administer the data initially, check them for completeness and accuracy and then submit the reports to the national centralised SRCR. Annually, approximately 1500 new patients with an invasive adenocarcinoma of the rectum are added to the registry, resulting in a coverage rate of 98%. All data within the registry are linked to a unique personal 10-digit identity number.

### 2.2. Study population and variables from the SRCR

All patients registered in the SRCR between the years 1995 and 2005 were included ($n = 16{,}713$). During this time period, information on how radiotherapy was given is available for 85% of patients and almost all, 90%, had $5 \times 5$ Gy, and approximately 90% of these had immediate surgery, 6% had long-term preoperative irradiation and others had palliative radiotherapy (Dr. M. Kressner, Ersta Hospital, Stockholm). Data on chemotherapy is not available for the study period. Clinical stage was not recorded during this time either and pathological stage is used for this study. Distance of the rectal cancers from the anal verge is registered in the SRCR and only cancers with the lower border below 15 cm are included. Type of hospital is registered as university, general district or district hospital. Finally there are six administrative health care regions in Sweden (Stockholm, Uppsala/Örebro, Gothenburg, Lund/Malmö (Southern), Linköping (South East) and Umeå (Northern)). PRT has been more strongly advocated in the Uppsala/Örebro and Stockholm regions and they are reported separately.

### 2.3. Socioeconomic variables

At Statistics Sweden, several high-quality socioeconomic registries can be used for data linkage, based on the personal 10-digit identity number. For this study, we used the Total Population Register for information about civil status categorised as married, unmarried, divorced or widowed the year before diagnosis. Information about education was collected for all years before diagnosis from the Education Registry and it was categorised as compulsory, further (secondary) or university education. For elderly citizens, data in this registry are, to some extent, based on self-reports whereas in the case of younger individuals there is direct input from educational institutions. Finally, we used the Registry of Income and Wealth for information about income the year before diagnosis. Numerical information was adjusted for inflation using base amounts and it was categorised into quartiles (Q1–Q4).

### 2.4. Statistical methods

$\chi^2$-tests were used to test for differences in proportions. Logistic regression was used for multivariate analysis and the effect of the variables was expressed as odds ratio (OR) with 95% confidence interval. The variables were chosen in advance based on their clinical relevance and all three socioeconomic factors (civil status, education and income) were included in the model initially and then removed stepwise. Age and distance from the anal verge were used as continuous variables in the basic analysis and categorised for subanalyses. For this purpose, patients were divided into three age groups, arbitrarily at 65 years (still in the workforce) and at the age of 80 years (elderly). Based on distance from the anal verge, cancers were divided into low rectal cancer (0–5 cm from the anal verge), mid-rectal cancer (6–10 cm) or high rectal cancer (11–15 cm). For patients with stage IV cancer, no information was available to what extent the metastases were diagnosed previous to the decision on PRT or not. All logistic regressions models were therefore performed both including and excluding stage IV cancer. $p$-values were two-sided and considered significant if $<0.05$. All analyses were calculated in SPSS 17.0. The study was approved by the ethical committee at Karolinska Institutet, Stockholm.

## 3. Results

### 3.1. Baseline characteristics

The majority of patients (57.1%) were men (Table 1). Median age was 72 (range 20–100) years, and one in four patients was 80 years or older. Mid-rectum was the most common sublocalisation (38.8%). Pathological stage was available for just below 90% and 1/6 of the patients had generalised disease at diagnosis. For patients below the age of 75, information on education was available in 94.2% but for patients above the age of 75 years, it was lacking for the majority (84%). Information about disposable income the year before diagnosis was available for 16,692 (99.9%) patients, and median income was 2.5 base amounts (IQ range 2.3–3.9).

### 3.2. Rate of PRT

PRT was delivered to 7370 (44.1%), not delivered to 8799 (52.6%) and information was lacking for 544 (3.3%) patients. The crude rate of PRT varied with age and was the highest

**Table 1 – Characteristics of 16,713 rectal cancer patients in Sweden 1995–2005 and the rate of preoperative radiotherapy (PRT) in each subgroup. Values in parentheses are percentages.**

| | All patients | PRT | $p$[a] |
|---|---|---|---|
| *Age (years)* | | | |
| –65 | 4972 (29.7) | 3109 (63.8) | <0.001 |
| 66–79 | 7673 (45.9) | 3701 (49.6) | |
| 80– | 4068 (24.3) | 560 (14.6) | |
| *Sex* | | | |
| Men | 9551 (57.1) | 4460 (48.3) | <0.001 |
| Women | 7162 (42.8) | 2910 (42.0) | |
| *Sublocalisation*[b] | | | |
| 0–5 cm | 5259 (31.5) | 2760 (54.2) | <0.001 |
| 6–10 cm | 6480 (38.8) | 3082 (49.0) | |
| 11–15 cm | 4620 (27.6) | 1474 (32.7) | |
| *Missing* | *354 (2.1)* | | |
| *Stage* | | | |
| I | 3398 (20.3) | 1503 (44.6) | <0.001 |
| II | 4224 (25.3) | 2342 (55.7) | |
| III | 4257 (25.5) | 2403 (56.8) | |
| IV | 2781 (16.6) | 847 (32.2) | |
| *Missing* | *2053 (12.3)* | | |
| *Type of hospital* | | | |
| University | 4401 (26.3) | 2036 (47.2) | 0.001 |
| General District | 7042 (42.1) | 3054 (44.9) | |
| District | 4434 (26.5) | 1830 (43.2) | |
| *Missing* | *836 (5.0)* | | |
| *Region* | | | |
| Uppsala/Örebro | 3882 (23.2) | 2087 (57.2) | <0.001 |
| Stockholm | 3151 (18.9) | 1586 (50.3) | |
| Lund/Malmö (Southern) | 3032 (18.1) | 1064 (36.6) | |
| Gothenburg | 3030 (18.1) | 1048 (35.5) | |
| Linköping (South East) | 1980 (11.8) | 842 (44.3) | |
| Umeå (Northern) | 1638 (9.8) | 743 (46.1) | |
| *Civil status* | | | |
| Married | 9279 (55.5) | 4600 (51.0) | <0.001 |
| Widowed | 3602 (21.6) | 992 (29.0) | |
| Divorced | 1970 (11.8) | 967 (50.3) | |
| Unmarried | 1834 (11.0) | 798 (44.9) | |
| *Missing* | *28 (0.17)* | | |
| *Education ⩽ 75 years (n = 10,179)* | | | |
| Compulsory | 4558 (44.3) | 2483 (56.1) | <0.001 |
| Further | 3442 (33.5) | 2167 (60.2) | |
| University | 1679 (16.3) | 1048 (60.4) | |
| *Missing* | *600 (5.8)* | | |
| *Income* | | | |
| Q1 | 4173 (25.0) | 1389 (34.8) | <0.001 |
| Q2 | 4173 (25.0) | 1573 (39.2) | |
| Q3 | 4173 (25.0) | 2008 (49.6) | |
| Q4 | 4173 (25.0) | 2389 (58.4) | |
| *Missing* | *21 (1.2)* | | |

[a] $\chi^2$-test.
[b] Distance from the anal verge.

among patients below 65 years, 63.8% compared to 14.6% among patients aged 80 years or older (Table 1). More than half of all patients with low rectal cancer, (54.2%) had PRT compared with one third of patients with high rectal cancer (32.7%) (Table 1). The crude rate of PRT was also higher in men, at university hospitals and in the Uppsala/Örebro region (Table 1). Median age in those who received RT was 68 years versus 76 in patients that did not receive PRT ($p < 0.001$). Civil status, education and in particular income were all significantly associated with the crude rate of PRT.

### 3.3. *Logistic regression analysis for all patients*

We found that unmarried, divorced and widowed patients all received PRT less often compared with married patients (Table 2). Patients with the lowest income Q1 compared with Q4 income also had PRT to a lesser extent. Women received PRT less often compared with male patients and patients treated at general district and district hospitals had PRT to a lesser extent compared with patients treated at university hospitals. There was no association between education and the use of PRT.

The model was tested using stepwise removal of the socioeconomic covariates. Income was excluded first but odds ratios for civil status and education were unchanged (data not shown). Civil status was then excluded as well, but odds ratios for further and university education remained the same (1.09 and 1.02, respectively), indicating that there is no association between education and the use of PRT in the Swedish population.

**Table 2 – Estimated odds ratio (OR) from a logistic regression model to predict radiotherapy in 16,713 patients with rectal cancer. Values in parentheses are 95% confidence intervals (CIs).**

| | Odds ratio | $p$-Value |
|---|---|---|
| Age | 0.96 (0.95–0.96) | <0.001 |
| *Men (ref)* | | |
| Women | 0.89 (0.82–0.97) | 0.006 |
| Tumour sublocalisation (cm) | 0.88 (0.87–0.88) | <0.001 |
| *Stage I (ref)* | | |
| Stage II | 1.96 (1.77–2.18) | <0.001 |
| Stage III | 1.85 (1.66–2.05) | <0.001 |
| Stage IV | 0.55 (0.48–0.62) | <0.001 |
| *University hospital (ref)* | | |
| GDH | 0.89 (0.82–0.98) | 0.01 |
| District hospital | 0.88 (0.79–0.97) | 0.009 |
| *Uppsala/Örebro (ref)* | | |
| Stockholm | 0.70 (0.62–0.79) | <0.001 |
| All other regions | 0.43 (0.40–0.47) | <0.001 |
| *Married (ref)* | | |
| Widowed | 0.75 (0.67–0.83) | <0.001 |
| Divorced | 0.84 (0.74–0.94) | 0.003 |
| Unmarried | 0.67 (0.59–0.76) | <0.001 |
| *Compulsory education (ref)* | | |
| Further | 1.04 (0.94–1.15) | 0.44 |
| University | 0.92 (0.81–1.06) | 0.26 |
| *Income Q4 (ref)* | | |
| Income Q1 | 0.76 (0.67–0.86) | <0.001 |
| Income Q2 | 0.89 (0.79–1.00) | 0.05 |
| Income Q3 | 0.91 (0.82–1.02) | 0.10 |

### 3.4. Subanalyses by age groups, sublocalisation and gender

In order to further clarify whether the inequalities related to SES were restricted to groups of patients with the most relative indication for PRT, we performed separate logistic regression analyses in a few subgroups. We found a consistent pattern with unmarried and low-income patients receiving PRT to a lesser extent in all age groups (Table 3), and in all sublocalisation groups (Table 4). In younger patients (up to 65 years), OR for PRT in unmarried patients was 0.8 (0.66–0.97) and that for income Q1 patients was 0.62 (0.49–0.77). In low rectal cancer (0–5 cm), OR for unmarried patients was 0.66 (0.52–0.82) and that for income Q1 patients was 0.72 (0.57–0.91).

Interestingly, there were no significant differences in the use of PRT between men and women in low and high rectal cancer but only in mid-rectal cancer (OR 0.86; 0.76–0.98) (Table 4).

Finally, we found that unmarried men and women had PRT to a lesser and fairly equal extent (Table 5). However, among divorced patients, women had PRT to a lesser extent (OR 0.73; 0.61–0.89) compared with married women whereas for men there was no difference in the use of PRT between married and divorced patients. Being widowed was negatively associated with the use of PRT in both sexes, although the association was most pronounced in women (OR 0.68; 0.58–0.79). Education was not associated with PRT for either sex. In men only the lowest income group Q1 had PRT less often compared with income groups Q2–Q4 whereas for women the situation was the opposite as all income groups (Q1–Q3) had PRT less often compared with Q4.

### 3.5. PRT and metastatic disease

All analyses were then performed excluding stage IV cancer, and for all practical purposes the results were the same (data not shown).

## 4. Discussion

In this study, we found very robust results of socioeconomic inequalities in the use of PRT. Unmarried patients and those with the lowest income consistently received PRT less often compared with other groups. A relatively stronger indication for PRT, i.e. younger patients and low rectal cancer, did not change the pattern.

This is the first in-depth analysis on the use of PRT in rectal cancer in relation to socioeconomic background of patients from a country with universal health care. Our findings are based on almost complete data. The SRCR includes nearly all patients with rectal cancer in Sweden, the socioeconomic variables were individual information collected for administrative purposes before diagnosis and were

**Table 3 – Estimated OR to predict preoperative radiotherapy in 4972 patients up to 65 years, 7673 patients 66–79 years and 4068 patients from the age of 80 years and older. Values in parentheses are 95% confidence intervals.**

| | –65 years | | 66–79 years | | 80 years– | |
|---|---|---|---|---|---|---|
| | OR | *p* | OR | *p* | OR | *p* |
| *Male (ref)* | | | | | | |
| Women | 0.92 (0.79–1.05) | 0.22 | 0.92 (0.82–1.04) | 0.21 | 1.02 (0.81–1.29) | 0.86 |
| Tumour sublocalisation (cm) | 0.86 (0.85–0.88) | <0.001 | 0.87 (0.86–0.88) | <0.001 | 0.90 (0.88–0.92) | <0.001 |
| *Stage I (ref)* | | | | | | |
| Stage II | 2.34 (1.92–2.85) | <0.001 | 1.83 (1.59–2.12) | <0.001 | 2.17 (1.16–2.93) | <0.001 |
| Stage III | 2.15 (1.78–2.60) | <0.001 | 1.84 (1.59–2.13) | <0.001 | 1.79 (1.31–2.44) | <0.001 |
| Stage IV | 0.57 (0.47–0.70) | 0.001 | 0.53 (0.49–0.63) | 0.001 | 0.98 (0.67–1.42) | 0.90 |
| *University hospital (ref)* | | | | | | |
| GDH | 0.94 (0.80–1.10) | 0.44 | 0.88 (0.78–1.00) | 0.04 | 0.91 (0.71–1.16) | 0.43 |
| District hospital | 0.98 (0.82–1.17) | 0.81 | 0.87 (0.76–1.00) | 0.04 | 0.76 (0.58–0.99) | 0.04 |
| *Uppsala/Örebro (ref)* | | | | | | |
| Stockholm | 0.95 (0.76–1.19) | 0.66 | 0.68 (0.58–0.81) | <0.001 | 0.33 (0.24–0.44) | <0.001 |
| All other regions | 0.54 (0.46–0.64) | <0.001 | 0.46 (0.41–0.52) | <0.001 | 0.22 (0.18–0.28) | <0.001 |
| *Married (ref)* | | | | | | |
| Widowed | 0.87 (0.61–1.23) | 0.43 | 0.81 (0.70–0.93) | 0.004 | 0.65 (0.51–0.83) | 0.001 |
| Divorced | 0.82 (0.68–0.98) | 0.03 | 0.89 (0.75–1.05) | 0.17 | 0.86 (0.56–1.34) | 0.50 |
| Unmarried | 0.80 (0.66–0.97) | 0.02 | 0.73 (0.60–0.88) | 0.001 | 0.56 (0.37–0.85) | 0.006 |
| *Compulsory education (ref)* | | | | | | |
| Further | 1.12 (0.96–1.31) | 0.13 | 1.14 (0.99–1.30) | 0.06 | [a] | |
| University | 0.95 (0.78–1.15) | 0.58 | 1.12 (0.91–1.37) | 0.29 | [a] | |
| *Income Q4 (ref)* | | | | | | |
| Income Q1 | 0.62 (0.49–0.77) | <0.001 | 0.78 (0.65–0.93) | 0.006 | 0.70 (0.49–1.02) | 0.06 |
| Income Q2 | 0.90 (0.72–1.12) | 0.33 | 0.86 (0.73–1.02) | 0.08 | 0.88 (0.62–1.27) | 0.50 |
| Income Q3 | 0.76 (0.64–0.90) | 0.001 | 0.93 (0.79–1.09) | 0.38 | 1.13 (0.78–1.65) | 0.51 |

[a] Missing data.

**Table 4 – Estimated OR to predict the use of preoperative radiotherapy in 5259 with low, 6480 with middle and 4620 patients with high rectal cancers. Values in parentheses are 95% confidence intervals.**

| Distance from the anal verge | 0–5 cm | | 6–10 cm | | 11–15 cm | |
|---|---|---|---|---|---|---|
| | OR | *p* | OR | *p* | OR | *p* |
| Age | 0.95 (0.94–0.96) | <0.001 | 0.96 (0.95–0.97) | <0.001 | 0.96 (0.95–0.97) | <0.001 |
| *Men (ref)* | | | | | | |
| Women | 0.93 (0.80–1.08) | 0.33 | 0.86 (0.76–0.98) | 0.02 | 0.94 (0.80–1.11) | 0.50 |
| *Stage I (ref)* | | | | | | |
| Stage II | 2.33 (1.92–2.82) | <0.001 | 2.07 (1.75–2.44) | <0.001 | 1.55 (1.26–1.91) | <0.001 |
| Stage III | 2.06 (1.70–2.49) | <0.001 | 1.97 (1.67–2.32) | <0.001 | 1.53 (1.24–1.89) | <0.001 |
| Stage IV | 0.45 (0.36–0.56) | <0.001 | 0.61 (0.50–0.73) | <0.001 | 0.57 (0.44–0.73) | <0.001 |
| *University hospital (ref)* | | | | | | |
| GDH | 0.92 (0.78–1.08) | 0.30 | 0.98 (0.86–1.13) | 0.83 | 0.73 (0.61–0.87) | <0.001 |
| District hospital | 0.80 (0.67–0.96) | 0.02 | 0.96 (0.82–1.12) | 0.60 | 0.84 (0.70–1.02) | 0.08 |
| *Uppsala/Örebro (ref)* | | | | | | |
| Stockholm | 0.52 (0.42–0.65) | <0.001 | 0.67 (0.56–0.82) | <0.001 | 0.98 (0.80–1.22) | 0.88 |
| All other regions | 0.46 (0.39–0.55) | <0.001 | 0.48 (0.42–0.55) | <0.001 | 0.34 (0.29–0.40) | <0.001 |
| *Married (ref)* | | | | | | |
| Widowed | 0.70 (0.58–0.84) | 0.001 | 0.82 (0.69–0.97) | 0.02 | 0.74 (0.59–0.93) | 0.01 |
| Divorced | 0.76 (0.61–0.95) | 0.02 | 0.87 (0.72–1.04) | 0.13 | 0.89 (0.72–1.11) | 0.30 |
| Unmarried | 0.66 (0.52–0.82) | <0.001 | 0.62 (0.51–0.76) | <0.001 | 0.79 (0.61–1.01) | 0.06 |
| *Compulsory education (ref)* | | | | | | |
| Further | 0.92 (0.76–1.12) | 0.42 | 1.11 (0.95–1.30) | 0.18 | 1.07 (0.89–1.29) | 0.48 |
| University | 0.72 (0.55–0.94) | 0.02 | 1.06 (0.85–1.32) | 0.61 | 1.00 (0.78–1.27) | 0.98 |
| *Income Q4 (ref)* | | | | | | |
| Income Q1 | 0.72 (0.57–0.91) | 0.005 | 0.81 (0.67–0.98) | 0.03 | 0.72 (0.58–0.91) | 0.009 |
| Income Q2 | 0.94 (0.76–1.17) | 0.60 | 0.90 (0.75–1.08) | 0.24 | 0.82 (0.66–1.02) | 0.09 |
| Income Q3 | 0.98 (0.79–1.20) | 0.82 | 0.93 (0.79–1.10) | 0.41 | 0.82 (0.70–1.00) | 0.06 |

**Table 5 – Estimated OR to predict the use of preoperative radiotherapy in 9551 male and 7162 female patients with rectal cancer. Values in parentheses are 95% confidence intervals.**

| | Men | | Women | |
|---|---|---|---|---|
| | OR | *p* | OR | *p* |
| Age | 0.95 (0.95–0.96) | <0.001 | 0.96 (0.95–0.97) | <0.001 |
| Sublocalisation (cm) | 0.88 (0.87–0.89) | <0.001 | 0.88 (0.86–0.89) | <0.001 |
| *Stage I (ref)* | | | | |
| Stage II | 1.87 (1.63–2.16) | <0.001 | 2.08 (1.76–2.45) | <0.001 |
| Stage III | 1.78 (1.55–2.05) | <0.001 | 1.92 (1.63–2.26) | <0.001 |
| Stage IV | 0.49 (0.42–0.58) | <0.001 | 0.62 (0.52–0.76) | <0.001 |
| *University hospital (ref)* | | | | |
| GDH | 0.89 (0.79–1.00) | 0.04 | 0.90 (0.79–1.04) | 0.15 |
| District hospital | 0.85 (0.75–0.97) | 0.02 | 0.91 (0.78–1.06) | 0.21 |
| *Uppsala/Örebro (ref)* | | | | |
| Stockholm | 0.74 (0.63–0.86) | <0.001 | 0.66 (0.54–0.79) | <0.001 |
| All other regions | 0.46 (0.41–0.52) | <0.001 | 0.40 (0.35–0.46) | <0.001 |
| *Married (ref)* | | | | |
| Widowed | 0.82 (0.69–0.97) | 0.02 | 0.68 (0.58–0.79) | <0.001 |
| Divorced | 0.91 (0.78–1.06) | 0.24 | 0.73 (0.61–0.89) | 0.001 |
| Unmarried | 0.65 (0.55–0.76) | <0.001 | 0.70 (0.57–0.88) | 0.002 |
| *Compulsory education (ref)* | | | | |
| Further | 1.06 (0.92–1.20) | 0.42 | 1.03 (0.87–1.21) | 0.74 |
| University | 0.98 (0.82–1.17) | 0.81 | 0.84 (0.67–1.05) | 0.12 |
| *Income Q4 (ref)* | | | | |
| Income Q1 | 0.78 (0.66–0.93) | 0.005 | 0.68 (0.55–0.83) | <0.001 |
| Income Q2 | 0.92 (0.80–1.07) | 0.29 | 0.82 (0.66–1.01) | 0.06 |
| Income Q3 | 1.00 (0.87–1.13) | 0.90 | 0.78 (0.64–0.95) | 0.01 |

lacking only as regards education among elderly patients. In all, the validity of data was high and we conclude that the results are solid. On the other hand, in the interpretation of our findings, a weakness of the study is that we cannot adjust for several confounding factors. Comorbidity is the most important and even though it contributes to the differences found we can only make general assumptions as to which extent. However, in a Dutch study, age appeared to be a stronger predictor for the use of radiotherapy than comorbidity and for rectal cancer in particular, the number of comorbid conditions did not significantly influence the proportion of patients that received radiotherapy.[11]

To our knowledge, only one previous study from Europe (Ireland) has investigated the use of radiotherapy in rectal cancer in relation to age, sex and married/unmarried.[12] In this study, very few patients had preoperative radiotherapy (7.9%) and in stage II rectal cancer, female patients had radiotherapy to a lesser extent (OR 0.72, 95% confidence interval (CI) 0.53–0.97), in stage III unmarried patients had radiotherapy less often, OR 0.77 (95% CI 0.60–1.01) and in all stages radiotherapy decreased with age. We found that civil status was clearly associated with the use of PRT but, somewhat surprising, this was not the case for education. On the contrary, we found university educated patients to receive PRT to a lesser extent in low rectal cancer. We have no plausible explanation for this, as the model already adjusts for differences in stage distribution, and until further notice, we interpret it as a random finding.

What is the cause of unmarried and low-income patients receiving PRT to a lesser extent, if not fully explained by differences in comorbidity? Social support is one important possibility.[16] Having children is another confounding factor that we cannot control for and this might contribute to the consistently lower odds ratios found for unmarried patients. Access to treatment is another aspect.[17] Patients treated at local hospitals received PRT less often, and a contributing cause is probably the lack of a radiotherapy unit, which was found also in Norway.[18] In our study, low-income might be associated with lack of access to a private car. Transport to the radiotherapy unit is subsidised in Sweden but it is not completely free of charge.

It is not known to what extent the differences in the use of PRT are caused by preferences of patients themselves. The socioeconomic background of patients influences the doctor–patient communication as patients from lower social classes receive less information, less directions and less socio-emotional utterances from their doctor.[19] More educated patients generally participate more actively in medical consultations.[20,21] From the perspective of social interaction, it is further surprising there was no association at all between educational level of patients and the use of PRT.

Several results of the study were expected. PRT has been more strongly advocated in the Uppsala/Örebro and Stockholm regions, probably because of a strong tradition to participate in trials in these regions.[22,23] Differing opinions about the value of PRT in general and in various subgroups (e.g. the age of patients) between surgeons is another important reason for the notable differences in PRT use between the six health care regions. Referral of locally advanced (clinical stage T4) cancers to university hospitals contribute to the higher rate of patients receiving PRT at these hospitals but we do not know to what extent. Stage II and III were given PRT to a greater extent than stage I, but still 45% of the pathological stage I cancers had received PRT. To some extent this can be explained by down-staging after PRT, as clinical stage was not reported to the SRCR during the study period. This is also the reason for including all stage I cancer in all analyses. Finally, the differences in PRT by sublocalisation were expected since the absolute risk of local failure, and thus the absolute gain from PRT, is less for high rectal cancer.

Our result questions whether the potential benefit of PRT is fully exploited. A parallel situation has been reported for colon cancer stage III, as adjuvant 5-FU-based chemotherapy has at least the same effect in women and in elderly patients but these groups are less frequently treated.[24] Clinicians' disagreement on the importance of age and comorbidity contributes to this inequality in care.[25] The indication for PRT in rectal cancer is relative, balancing gains for relatively few against the risks of adverse effects for all. It is notable that socioeconomic differences were not less in groups with a relatively stronger indication. We believe that the clinical decision making on PRT in rectal cancer needs to be further elucidated. A better understanding of patient preferences and patient–provider interactions was also called for in connection with the findings of underuse of radiotherapy in black rectal cancer patients.[26] The impact of nowadays common multi-disciplinary team decision making on socioeconomic inequalities needs to be evaluated as well.[27,28] For immediate clinical purposes though, we have identified unmarried and low-income patients as risk groups for not receiving PRT in rectal cancer.

## Conflict of interest statement

None declared.

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