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The impact of performing gastric cancer surgery during holiday periods. A population-based study using Dutch upper gastrointestinal cancer audit (DUCA) data

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A B S T R A C T

Existing literature suggests inferior quality of oncologic surgery during holiday periods. This study aimed to investigate the impact of holiday periods on surgical treatment of gastric cancer in the Netherlands. This nationwide study included all gastric cancer patients undergoing potentially curative surgery registered in the Dutch Upper Gastrointestinal Cancer Audit (DUCA). For each patient it was established whether they underwent surgery during or outside the 11 Dutch holiday weeks, based on date and region of surgery. Separate, single-day holidays were not included. Baseline and treatment characteristics were compared using descriptive statistics. Time from diagnosis to treatment and short-term surgical outcomes were compared using multilevel multivariable logistic regression analyses. To prevent bias from recent advancements, analyses were repeated in a recent cohort of patients (2015-2018). Between 2011-2018, 3440 patients were included in the DUCA. Some 555 (16.1%) patients underwent surgery during 11 holiday weeks. There were no differences in patient, tumor and treatment characteristics and time to treatment between holidays and non-holidays. Tumor-positive resection margins (R1/R2 vs R0) occurred more frequent during holidays (aOR:1.47, 95%CI:1.07-2.04). Subgroup analyses in a recent cohort of patients also found higher

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tumor-positive resection margins (aOR:1.59, 95%CI:1.01-2.43) and higher failure-to-rescue rates (aOR:2.55, 95%CI:1.18-5.49) during holidays. Even though time to treatment and patient, tumor and treatment characteristics were comparable between holidays and non-holidays, tumor-positive resection margin and failure-to-rescue rates were higher during holidays. This suggests that steps must be taken to keep specialized and dedicated gastric cancer expertise up to standard during holiday periods.

Introduction

Gastric cancer ranks fifth in terms of cancer incidence and is the third leading cause of cancer-related death.[1] Curative treatment consists of perioperative chemotherapy and surgical resection.[2,3] Gastric cancer surgery is associated with significant morbidity as postoperative mortality and complication rates hover around 4% and 40% respectively.[4,5] As a volume-outcome relationship has been described at both surgeon and hospital level, gastric cancer surgery is considered to be a procedure requiring specialized surgical expertise, skills and concentration.[6-9] It is hypothesized that well-trained, experienced and dedicated surgeons, operation room staff, residents, intensive care unit staff and (intervention) radiologists deliver better surgical outcomes.

Multiple studies showed that non-procedural factors might influence the outcomes of complex surgical procedures. Elective surgery late in the week or during the weekend was suggested to result in inferior surgical outcomes due to decreased surgeon concentration as the working week progressed or diminished health care resources in the early postoperative period.[10-13] A Swedish national study found inferior prognosis after cancer surgery during holiday periods compared to surgery outside holiday periods.[14] This might be related to the absence of specialized and dedicated medical staff or an increased workload for the remaining hospital personnel during holiday periods. Another study that investigated the impact of holidays on short-term outcomes of pancreatic surgery found longer waiting lists and higher postoperative morbidity rates during holiday periods.[15]

To our knowledge, literature on the impact of holiday periods on short-term outcomes of gastric cancer surgery is lacking. However, current evidence suggests inferior outcomes of complex surgical procedures during holiday periods which might be a result of the availability of less experienced and less specialized surgical teams. Therefore, this study aimed to investigate the impact of holidays on clinical practices, time to treatment and short-term surgical outcomes of gastric cancer surgery in the Netherlands.

Materials and methods

Study design

This population-based cohort study used Dutch Upper Gastrointestinal Cancer Audit (DUCA) data. The DUCA is a mandatory audit in which all esophagogastric cancer patients undergoing surgery with the intent of resection in the Netherlands are registered since 2011.[16] A previous study validated the DUCA database and found a completeness of 99.2% while outcome measure accuracy approximated 95.3%-100%.[17] The DUCA scientific committee approved the current study's protocol. Informed consent/ethical review were not required by Dutch law.

Patient selection

All patients undergoing potentially curative elective gastric cancer surgery in the Netherlands since the audit started (January 01, 2011) and December 31, 2018 were considered for inclusion. Patients undergoing urgent/emergent procedures were excluded. The current Dutch volume threshold is 20 annual resections.[18] To prevent bias by extremely low-volume centers, hospitals performing less than 20 gastrectomies throughout the entire study period were excluded.

Variables for analyses

For school holiday purposes, the Netherlands is divided into 3 regions (North, Mid and South), each having its own holiday schedule consisting of 5 periods: spring (1 week), May (1 week), summer (6 weeks), autumn (1 week) and Christmas (2 weeks). In this study, these periods are referred to briefly as holidays, and all other periods as non-holidays. Thus, in this study separate single-day holidays are not included as generally only emergent/urgent surgery is performed on such days. The exact holiday weeks differ between the regions on a year-to-year basis and are advised centrally by the Dutch government. In the current study, each hospital was assigned to its corresponding region. For each year and each region, the exact 11 weeks of holiday were established. For every patient in the dataset, it was assessed whether the date of biopsy and/or date of surgery were performed during the holiday period.

The baseline characteristics described in *Online Resource* Table 1 were used in multivariable analyses.

Outcome measures

The number of patients undergoing surgery during and outside holiday periods were compared. Thereafter, the outcomes of gastric cancer surgery described in *Online Resource* Table 2 were compared between operations during holiday periods and operations during non-holiday-periods.

Time to treatment

Times to treatment were compared between patients diagnosed during and outside holiday periods. The following times to treatment were investigated: referral time (date of biopsy to date of first outpatient visit in surgical center), time to primary surgery (date of biopsy to date of primary surgery), time to neoadjuvant therapy (date of biopsy to date of start neoadjuvant treatment), and time to treatment (date of biopsy to date of neoadjuvant therapy or date of primary surgery).

Statistics

The expected number of patients undergoing surgery during the holiday period was calculated by dividing the total number of inclusions by 52 and multiplying the result by the number of holiday weeks (11). The expected number was compared with the actual number of patients undergoing surgery during holidays using the χ^2-statistic.

Baseline and treatment characteristics of patients undergoing surgery during and outside holiday periods were compared using descriptive statistics. The previously described outcome measures were compared using multilevel multivariable logistic regression analyses adjusted for the baseline characteristics described above. The 2-level random effect corrected for unmeasured hospital differences. When degrees of freedom were insufficient for the entire correction model (ie, less than 10 (non-)events per factor in the model), confounders were selected based on a $>$10% change in the odds ratio of the holiday variable.[19,20] The statistical relevance of the random effect was assessed using the log-likelihood ratio.

Table 1
Baseline characteristics of gastric cancer patients undergoing surgery in and outside holiday periods.

	Total (N = 3440) N (%)	Surgery outside holiday period (N = 2885) N (%)	Surgery during holiday period (N = 555) N (%)	*P*-value*
Sex				0.437
Male	2149 (62.5)	1810 (62.7)	339 (61.1)	
Female	1287 (37.4)	1071 (37.1)	216 (38.9)	
Missing	4 (0.1)	4 (0.1)	0 (0)	
Age				0.552
<65 y	1075 (31.2)	912 (31.6)	163 (29.4)	
65-75 y	1269 (36.9)	1061 (36.8)	208 (37.5)	
>75 y	1094 (31.8)	910 (31.5)	184 (33.2)	
Missing	2 (0.1)	2 (0.1)	0 (0)	
Preoperative weight				0.593
loss	963 (28.0)	807 (28.0)	156 (28.1)	
None	834 (24.2)	712 (24.7)	122 (22.0)	
1-5 kg	775 (22.5)	647 (22.4)	128 (23.1)	
6-10 kg	386 (11.2)	324 (11.2)	62 (11.2)	
>10kg	482 (14.0)	395 (13.7)	87 (15.7)	
Missing				
BMI				0.928
<20	293 (8.5)	248 (8.6)	45 (8.1)	
20-25	1775 (51.6)	1492 (51.7)	283 (51.0)	
26-30	957 (27.8)	803 (27.8)	154 (27.7)	
>30	343 (10.0)	284 (9.8)	59 (10.6)	
Missing	72 (2.1)	58 (2.0)	14 (2.5)	
CCI†				0.192
0	1681 (48.9)	1403 (48.6)	278 (50.1)	
1	743 (21.6)	613 (21.2)	130 (23.4)	
2+	1016 (29.5)	869 (30.1)	147 (26.5)	
ASA-grade‡				0.306
1-2	2365 (68.8)	1973 (68.4)	392 (70.6)	
3+	1054 (30.6)	894 (31.0)	160 (28.8)	
Missing	21 (0.6)	18 (0.6)	3 (0.5)	
Any previous				0.549
esophageal or gastric	3154 (91.7)	2649 (91.8)	505 (91.0)	
surgery	264 (7.7)	218 (7.6)	46 (8.3)	
No	22 (0.6)	18 (0.6)	4 (0.7)	
Yes				
Unknown/Missing				
Tumor location				0.817
Corpus	1061 (30.8)	897 (31.1)	164 (29.5)	
Fundus	309 (9.0)	260 (9.0)	49 (8.8)	
Antrum	1339 (38.9)	1111 (38.5)	228 (41.1)	
Pylorus	278 (8.1)	237 (8.2)	41 (7.4)	
Total stomach	200 (5.8)	172 (6.0)	28 (5.0)	
Remnant	152 (4.4)	127 (4.4)	25 (4.5)	
stomach/anastomosis	45 (1.3)	35 (1.2)	10 (1.8)	
Unknown	56 (1.6)	46 (1.6)	10 (1.8)	
Missing				
Type of				0.253
adenocarcinoma§	926 (32.2)	780 (32.1)	146 (32.5)	
Diffuse	1305 (45.4)	1089 (44.9)	216 (48.1)	
Intestinal	178 (6.2)	158 (6.5)	20 (4.5)	
Mixed	468 (16.3)	401 (16.5)	67 (14.9)	
Unknow/Missing				
Clinical tumor stage				0.738
T0-2	937 (27.2)	791 (27.4)	146 (26.3)	
T3-4	1690 (49.1)	1410 (48.9)	280 (50.5)	
Tx	757 (22.0)	639 (22.1)	118 (21.3)	
Missing	56 (1.6)	45 (1.6)	11 (2.0)	

(*continued on next page*)

Table 1 (*continued*)

	Total (N = 3440) N (%)	Surgery outside holiday period (N = 2885) N (%)	Surgery during holiday period (N = 555) N (%)	*P*-value[*]
Clinical Node stage				0.603
N0	1714 (49.8)	1429 (49.5)	285 (51.4)	
N+	1303 (37.9)	1104 (38.3)	199 (35.9)	
Nx	369 (10.7)	310 (10.7)	59 (10.6)	
Missing	54 (1.6)	42 (1.5)	12 (2.2)	
Year of surgery				0.818
2011	268 (7.8)	224 (7.8)	44 (7.9)	
2012	323 (9.4)	265 (9.2)	58 (10.5)	
2013	482 (14.0)	413 (14.3)	69 (12.4)	
2014	545 (15.8)	453 (15.7)	93 (16.6)	
2015	454 (13.2)	380 (13.2)	74 (13.3)	
2016	516 (15.0)	438 (15.2)	78 (14.1)	
2017	428 (12.4)	363 (12.6)	65 (11.7)	
2018	424 (12.3)	349 (12.1)	75 (13.5)	
Neoadjuvant therapy				0.799
Chemotherapy	1947 (56.6)	1631 (56.5)	316 (56.9)	
None	1416 (41.2)	1191 (41.3)	225 (40.5)	
Other neoadjuvant therapy	69 (2.0)	56 (1.9)	13 (2.3)	
Missing	8 (0.2)	7 (0.2)	1 (0.2)	
Minimally invasive surgery				0.993
No	1951 (56.7)	1637 (56.7)	314 (56.6)	
Yes	1484 (43.1)	1245 (43.2)	239 (43.1)	
Missing	5 (0.1)	3 (0.1)	2 (0.4)	
Surgical procedure				0.431
Total gastrectomy	1300 (37.8)	1090 (37.8)	210 (37.8)	
Partial gastrectomy	1762 (51.2)	1488 (51.6)	274 (49.4)	
Non-resectional surgery[‖]	283 (8.2)	228 (7.9)	55 (9.9)	
Other[¶]	95 (2.8)	79 (2.7)	16 (2.9)	
Referral from other hospital				0.415
No	1020 (29.7)	848 (29.4)	172 (31.0)	
Yes	2137 (62.1)	1801 (62.4)	336 (60.5)	
Missing	283 (8.2)	236 (8.2)	47 (8.5)	
Hospital volume				0.399
≤20 annual gastric resections	1338 (38.9)	1131 (39.2)	207 (37.3)	
>20 annual gastric resections	2102 (61.1)	1754 (60.8)	348 (62.7)	

[*] *P*-value based on χ^2 statistic. Missing values were excluded from statistical testing when <5%.
[†] Charlson Comorbidity Index
[‡] American Society of Anesthesiologists grade
[§] Based on pathology of the resection specimen, data for patients undergoing non-resectional surgery or in whom pathology data was unavailable is not shown
[‖] Non-resectional surgery: 'open-close' surgery due to intraoperative distant metastasis or local tumor irresectability
[¶] Includes: esophagus-cardia resection, recurrence surgery, bypass surgery (gastroenterostomy) and others

Given the non-normal distributions, times to treatment were dichotomized around the national median into 'long' and 'short'. Thereafter, multilevel multivariable logistic regression was used to compare times to treatment between patients diagnosed during and outside holiday periods.

Statistical significance was assumed when 2-sided *P*-values were ≤0.05. Missing outcome measures were excluded from analyses. Missing/unknown items in baseline characteristics were analyzed as a separate group when exceeding 5%. Multicollinearity was assessed using the variance inflation factor, with a variance inflation factor >2.5 being considered an indication of mul-

Table 2
Multilevel multivariable logistic regression analyses of time to treatment of gastric cancer surgery in and outside holiday periods.

	Surgery during holiday period?	Median in days [IQR]	Outcome incidence (%)	aOR*	95% CI†	*P*-value
Referral time (time from diagnosis to first outpatient clinic visit in surgical center)‡	No	21 [14-30]				
	Yes	20 [14-28]				
Referral time > national median (>21 d)	No		445 (46.9%)	1	0.59-1.10	0.166
	Yes		97 (42.9%)	0.80		
Time from diagnosis to primary surgery§	No	45 [31-63]				
	Yes	48 [34-63]				
Time to primary surgery > national median (>45 d)	No		492 (49.1%)	1	0.87-1.58	0.297
	Yes		141 (53.4%)	1.17		
Time from diagnosis to neoadjuvant treatment‖	No	34 [25-46]				
	Yes	34 [25-43]				
Time to neoadjuvant therapy > national median (>34 d)	No		679 (49.7%)	1	0.75-1.28	0.860
	Yes		145 (49.5%)	0.98		
Time to treatment (primary surgery or neoadjuvant therapy)¶	No	38 [27-55]				
	Yes	40 [28-58]				
Time to treatment > national median (>39 d)	No		1198 (48.2%)	1	0.92-1.36	0.251
	Yes		307 (52.0%)	1.12		

* Adjusted Odds Ratio. Corrected for: sex, age, preoperative weight loss, BMI, Charlson Comorbidity Index, ASA-grade, previous esophageal or gastric surgery, tumor location, clinical tumor stage, clinical Node stage and hospital identification number as random effect factor.
† 95% Confidence interval.
‡ Date of biopsy to date of first outpatient visit in surgical center
§ Date of biopsy to date of primary surgery
‖ Date of biopsy to date of start of neoadjuvant treatment
¶ Date of biopsy to date of start of neoadjuvant treatment or date of primary surgery

ticollinearity. All analyses were performed using R-studio version 3.5.1, the R Foundation for Statistical Computing.[21]

Sensitivity analyses

Since 2011, Dutch clinical practice has changed. For example, an ongoing process of centralization occurred in response to the introduction of volume standards.[22] To check if time and progressive insights did not bias results, these sensitivity analyses repeated the analyses described above, including only patients undergoing surgery between January 01, 2015-December 31, 2018 in centers that still performed gastric cancer surgery on December 31, 2018.

Results

Of patients undergoing potentially curative gastric cancer surgery between 2011-2018, 3440 were included in this study (Fig 1). Some 555(16.1%) patients underwent surgery during holiday periods which was relatively 24% less compared to the remainder of the year ($P < 0.001$). Baseline characteristics of patients undergoing surgery during and outside holiday periods are

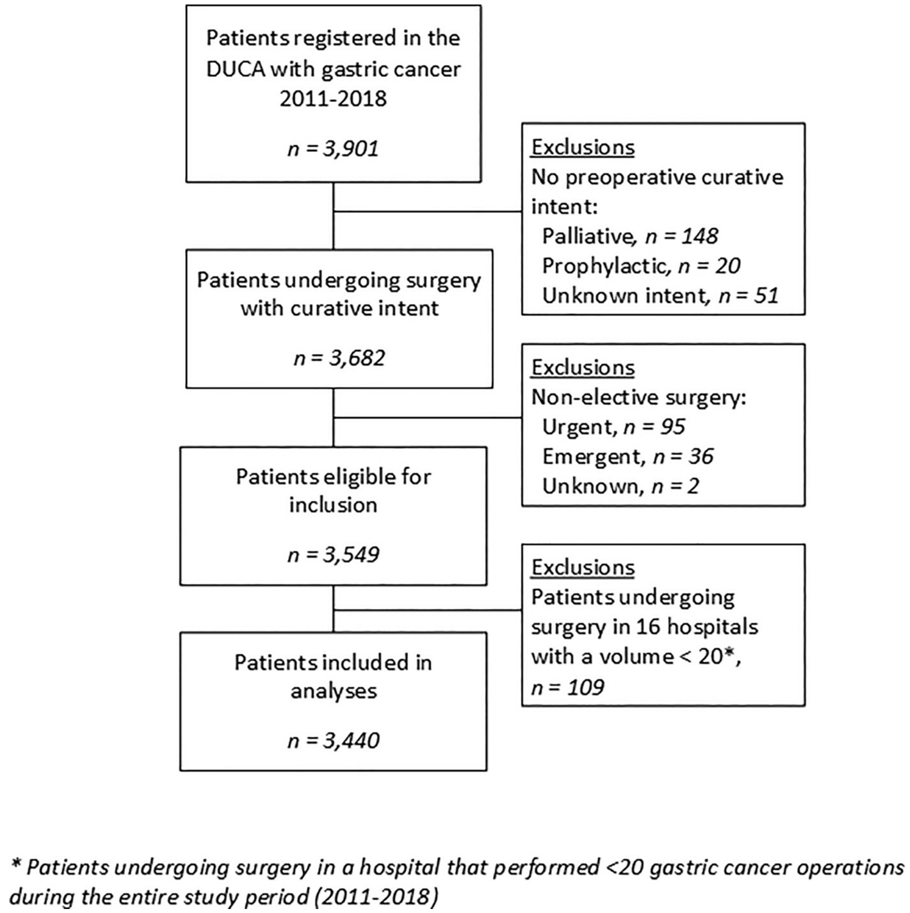

Fig. 1. Flowchart of the study.

presented in Table 1. There were no significant differences in patient and tumor characteristics. Also, treatment decisions during and outside holiday periods were comparable.

Time to treatment

In total, 648 patients undergoing surgery were diagnosed with gastric cancer during holidays while 705 diagnoses were expected (92%, $P = 0.083$). Time to treatment did not increase significantly during holiday periods (Table 2).

Outcomes

Outcomes of gastric cancer surgery during and outside holiday periods are displayed in Table 3. Tumor-positive resection margins occurred more frequently during holidays than outside holiday periods (12.9% vs 10.0%, adjusted odds ratio (aOR):1.47,95%CI;1.07-2.04, $P = 0.019$). There were no significant differences in other outcomes.

Table 3
Multilevel multivariable logistic regression analyses of short-term surgical outcomes after gastric cancer surgery in and outside holiday periods.

	Surgery during holiday period?	Outcome incidence	%	aOR[*]	95% CI[†]	*P*-value
Lymph node yield (>15)	No	1860 / 2433	77.6%	1	0.73-1.25	0.740
	Yes	348 / 454	76.7%	0.96		
Tumor-positive resection margins (R1/R2) (yes)	No	244 / 2427	10.0%	1	1.07-2.04	0.019
	Yes	57 / 441	12.9%	1.47		
Futile surgery ('open-close')[c] (yes)	No	209 / 2682	7.8%	1	0.85-1.71	0.291
	Yes	47 / 508	9.3%	1.21		
Postoperative complications (yes)	No	1041 / 2679	38.9%	1	0.84-1.26	0.774
	Yes	200 / 508	39.4%	1.03		
Anastomotic leakage (yes)	No	185 / 2678	6.9%	1	0.58-1.23	0.390
	Yes	31 / 508	6.1%	0.85		
Pulmonary complication[‡] (yes)	No	385 / 2677	14.4%	1	0.98-1.66	0.070
	Yes	87 / 508	17.1%	1.27		
Severe postoperative complication[§] (yes)	No	480 / 2682	17.9%	1	0.84-1.38	0.545
	Yes	96 / 508	18.9%	1.08		
Prolonged length of hospital stays (>8 d) (yes)	No	1302 / 2663	48.8%	1	0.91-1.35	0.322
	Yes	255 / 504	50.6%	1.11		
ICU/MCU admission for at least 1 d (yes)	No	1009 / 2452	41.2%	1	0.89-1.39	0.354
	Yes	201 / 468	42.9%	1.11		
30-d hospital readmission (yes)	No	303 / 2638	11.5%	1	0.91-1.61	0.194
	Yes	67 / 501	13.4%	1.21		
30-d/in-hospital mortality (yes)	No	128 / 2665	4.8%	1	0.71-1.62	0.681
	Yes	26 / 499	5.2%	1.09		
Failure to rescue[‖] (yes)	No	117 / 521	22.5%	1	0.77-2.03	0.351
	Yes	24 / 93	26.1%	1.26		
Textbook outcome[¶] (yes)	No	1102 / 2221	49.6%	1	0.68-1.06	0.152
	Yes	189 / 404	46.8%	0.85		

[*] Adjusted Odds Ratio. Corrected for: sex, age, preoperative weight loss, BMI, Charlson Comorbidity Index, ASA-grade, previous esophageal or gastric surgery, tumor location, clinical tumor stage, clinical Node stage and hospital identification number as random effect factor. When degrees of freedom were insufficient for correction for all possible confounders, only confounders leading to a 10% change in OR were included for analyses. The random effect was added to the model in case the log-likelihood ratio test showed a better fit compared to the original univariable model.

[†] 95% Confidence interval. l

[‡] Previous esophageal or gastric cancer surgery variable was removed from analyses due to multicollinearity with the tumor location variable.

[§] Clavien-Dindo grade III or higher.

[‖] 30-d/in-hospital mortality in patients with a complicated postoperative course (a postoperative complication leading to prolonged length of hospital stay (>21 d), a reinterventions or mortality).

[¶] R0 resection, ≥15 lymph nodes, length of hospital stay ≤21 d and no intra- or severe postoperative complication, readmission (to the ICU), or mortality.

Sensitivity analyses

In centers that currently still perform gastrectomies, 1624 patients underwent surgery between January 01, 2015-December 31, 2018. Of these, 254 (15.6%) underwent surgery during holiday periods, which is significantly less than the 344 patients that were expected to undergo surgery during holidays ($P < 0.001$). Patient, tumor, treatment and hospital characteristics were not different during and outside holiday periods (Table 4). However, surgery was less often radical during holidays, with tumor-positive resection margins of 12.4% during holidays and 8.2% during non-holidays (aOR:1.59,95%CI;1.01-2.43, $P = 0.039$) (Table 5). In addition, failure-to-rescue rates during holiday periods were 31.7% whereas this was 19.5% outside holidays (aOR:2.55,95%CI;1.18-5.49, $P = 0.015$).

Discussion

To our knowledge, this is the first study comparing short-term surgical outcomes after gastric cancer surgery performed during and outside holiday periods. It showed that during holidays, compared to the remainder of the year, less gastric cancer resections were performed. Baseline characteristics of patients undergoing surgery during and outside holidays were comparable. Treatment decisions and time to treatment were also similar. However, tumor-positive resection margins were higher during holiday periods. Also, in a recent cohort of patients positive resection margin rates were lower during holidays. In addition, in this cohort, failure-to-rescue rates were substantially higher after holiday surgery.

Multiple studies investigated the impact of weekday of complex surgery on surgical outcomes and the suspicion was raised that deteriorating surgeon or surgical team precision late in the week and diminished health care resources in the early postoperative period in the weekend might lead to inferior surgical results.[10-13,23,24] This triggered a number of studies hypothesizing that a similar relationship might be found when comparing results of complex surgery performed outside and during holidays when staffing might be downscaled and dedicated personnel might be unavailable. A Swedish population-based study found inferior survival rates after surgery during holidays for hepatobiliary, colorectal, head-neck, thyroid, breast, kidney-bladder and prostate cancer.[14] They did not perform separate analyses of gastric cancer patients but performed pooled analyses of 6124 patients with esophagogastric cancer which did not reveal long-term survival differences between surgery during and outside holidays. This contrasts with the current study's results as higher tumor-positive resection margins and failure-to-rescue rates during holidays suggest inferior long-term survival. Another Swedish population-based study investigated the holiday effect in esophageal cancer surgery.[25] It also did not identify any differences in short-term or long-term mortality between surgery during holidays and non-holidays.

A mono-center Italian study, investigated the holiday effect on short-term surgical outcomes of 2748 Whipple procedures.[15] It found that medical personnel density reached a nadir during the summer holidays and in December. This resulted in increased surgical waiting lists complication rates. A Spanish study including general and gastrointestinal surgical procedures also found an increase in complications during holidays.[26] The current study did not confirm these results for gastric cancer surgery as complication rates and lead teams inside and outside holidays were comparable.

The current study showed that relatively fewer (24%) patients underwent surgery during holidays than outside holidays which might, next to lower patient presentation rates, reflect downscaling of health care staffing during holidays. Even though the number of staff is probably reduced, surgery during holidays was not restricted to low-risk patients since patient, tumor and treatment characteristics during and outside holiday periods were comparable. In addition, time to treatment did not increase during holidays. Therefore, it seems that gastric cancer care in the Netherlands is properly organized assuring adequate time to treatment even though staffing is reduced. Results on the optimal interval between neoadjuvant therapy and surgery are equivocal,

Table 4
Current gastrectomy centers, 2015-2018.

	Total (N = 1624) N (%)	Surgery outside holiday period (N = 1370) N (%)	Surgery during holiday period (N = 254) N (%)	*P*-value*
Sex				0.836
Male	998 (61.5)	843 (61.5)	155 (61.0)	
Female	622 (38.3)	523 (38.2)	99 (39.0)	
Missing	4 (0.2)	4 (0.3)	0 (0)	
Age				0.702
<65 y	475 (29.2)	406 (29.6)	69 (27.2)	
65-75 y	604 (37.2)	508 (37.1)	96 (37.8)	
>75 y	543 (33.4)	454 (33.1)	89 (35)	
Missing	2 (0.1)	2 (0.1)	0 (0)	
Preoperative weight				0.829
loss	503 (31.0)	429 (31.3)	74 (29.1)	
None	451 (27.8)	382 (27.9)	69 (27.2)	
1-5 kg	373 (23.0)	308 (22.5)	65 (25.6)	
6-10 kg	196 (12.1)	167 (12.2)	29 (11.4)	
>10kg	101 (6.2)	84 (6.1)	17 (6.7)	
Missing				
BMI				0.978
<20	133 (8.2)	112 (8.2)	21 (8.3)	
20-25	847 (52.2)	718 (52.4)	129 (50.8)	
26-30	472 (29.1)	396 (28.9)	76 (29.9)	
>30	163 (10.0)	137 (10.0)	26 (10.2)	
Missing	9 (0.6)	7 (0.5)	2 (0.8)	
CCI†				0.150
0	760 (46.8)	644 (47.0)	116 (45.7)	
1	375 (23.1)	305 (22.3)	70 (27.6)	
2+	489 (30.1)	421 (30.7)	68 (26.8)	
ASA-grade‡				0.237
1-2	1105 (68.0)	924 (67.4)	181 (71.3)	
3+	518 (31.9)	445 (32.5)	73 (28.7)	
Missing	1 (0.1)	1 (0.1)	0 (0)	
Previous				0.524
esophageal or	1472 (90.6)	1239 (90.4)	233 (91.7)	
gastric surgery	138 (8.5)	119 (8.7)	19 (7.5)	
No	14 (0.9)	12 (0.9)	2 (0.8)	
Yes				
Unknown/Missing				
Tumor location				0.276
Corpus	518 (31.9)	437 (31.9)	81 (31.9)	
Fundus	138 (8.5)	115 (8.4)	23 (9.1)	
Antrum	651 (40.1)	538 (39.3)	113 (44.5)	
Pylorus	147 (9.1)	130 (9.5)	17 (6.7)	
Total stomach	89 (5.5)	80 (5.8)	9 (3.5)	
Remnant stom-	76 (4.7)	67 (4.9)	9 (3.5)	
ach/anastomosis	4 (0.2)	3 (0.2)	1 (0.4)	
Unknown	1 (0.1)	0 (0)	1 (0.4)	
Missing				
Type of				0.677
adenocarcinoma§	445 (32.9)	368 (32.3)	77 (36.2)	
Diffuse	691 (51.1)	585 (51.4)	106 (49.8)	
Intestinal	96 (7.1)	82 (7.2)	14 (6.6)	
Mixed	120 (8.9)	104 (9.1)	16 (7.5)	
Unknown/Missing				
Clinical tumor stage				0.532
T0-2	481 (29.6)	408 (29.8)	73 (28.7)	
T3-4	857 (52.8)	727 (53.1)	130 (51.2)	
Tx	286 (17.6)	235 (17.2)	51 (20.1)	

(*continued on next page*)

Table 4 (*continued*)

	Total (N = 1624) N (%)	Surgery outside holiday period (N = 1370) N (%)	Surgery during holiday period (N = 254) N (%)	*P*-value*
Clinical Node stage				0.567
N0	818 (50.4)	689 (50.3)	129 (50.8)	
N+	671 (41.3)	571 (41.7)	100 (39.4)	
Nx	135 (8.3)	110 (8.0)	25 (9.8)	
Neoadjuvant				0.350
therapy	951(58.6)	801 (58.5)	150 (59.1)	
Chemotherapy	635 (39.1)	540 (39.4)	95 (37.4)	
None	38 (2.3)	29 (2.1)	9 (3.5)	
Other				
neoadjuvant				
therapy				
Minimally invasive				0.481
surgery	659 (40.6)	561 (40.9)	98 (38.6)	
No	965 (59.4)	809 (59.1)	156 (61.4)	
Yes				
Surgical procedure				0.914
Total gastrectomy	605 (37.3)	507 (37.0)	98 (38.6)	
Partial	847 (52.2)	715 (52.2)	132 (52.0)	
gastrectomy	123 (7.6)	106 (7.7)	17 (6.7)	
Non-resectional	49 (3.0)	42 (3.1)	7 (2.8)	
surgery‖				
Other¶				
Referral to other				0.571
hospital	362 (22.3)	302 (22.0)	60 (23.6)	
No	1251 (77.0)	1059 (77.3)	192 (75.6)	
Yes	11 (0.7)	9 (0.7)	2 (0.8)	
Missing				
Hospital volume				0.348
≤20 annual	249 (15.3)	215 (15.7)	34 (13.4)	
gastric resections	1375 (84.7)	1155 (84.3)	220 (86.6)	
>20 annual				
gastric resections				
Year of surgery				0.454
2015	348 (21.4)	292 (21.3)	56 (22.0)	
2016	442 (27.2)	381 (27.8)	61 (24.0)	
2017	410 (25.2)	348 (25.4)	62 (24.4)	
2018	424 (26.1)	349 (25.5)	75 (29.5)	

Baseline and treatment characteristics of gastric cancer patients undergoing surgery in and outside holiday periods.

* *P*-value based on χ^2 statistic. Missing values were excluded from statistical testing when <5%

† Charlson Comorbidity Index

‡ American Society of Anesthesiologists grade

§ Based on pathology of the resection specimen, data for patients undergoing non-resectional surgery or in whom pathology data was unavailable is not shown

‖ Non-resectional surgery: 'open-close' surgery due to intraoperative distant metastasis or local tumor irresectability

¶ Includes: esophagus-cardia resection, recurrence surgery, bypass surgery (gastroenterostomy) and others

prolonging the interval until after the holiday period is not recommended, given the potential impact on oncological outcomes and patient anxiety.[27-29]

In the era of far-reaching surgeon specialization, the question whether complex surgical procedures can be performed safely during holidays is increasingly relevant. Alongside the introduction of minimally invasive surgery, centralization of complex surgical procedures towards dedicated surgeons, surgical teams and hospitals has led to ongoing specialization of surgical teams. When dedicated and specialized surgical teams are unavailable during holidays, smaller surgical teams or teams with decreased procedural caseload might take over. This might explain why tumor-positive resection margin rates during holidays are higher than during non-holidays. Different pathologists performing frozen section analyses may also play a role. This study also

Table 5
Current gastrectomy centers, 2015-2018. Multilevel multivariable logistic regression analyses of short-term surgical outcomes after gastric cancer surgery in and outside holiday periods.

	Surgery during holiday period?	Outcome incidence	%	aOR*	95% CI†	*P*-value
Lymph node yield (>15)	No	1050/1229	85.4%	1	0.90-2.17	0.139
	Yes	204/229	89.1%	1.40		
Tumor-positive resection margins (R1/R2) (yes)	No	101/1226	8.2%	1	1.01-2.43	**0.039**
	Yes	28/226	12.4%	1.59		
Futile surgery (‘open-close’) (yes)	No	102/1344	7.6%	1	0.49-1.42	0.503
	Yes	17/248	6.9%	0.83		
Postoperative complications (yes)	No	553/1343	41.2%	1	0.75-1.32	0.961
	Yes	100/248	40.3%	0.99		
Anastomotic leakage (yes)	No	103/1342	7.7%	1	0.56-1.55	0.852
	Yes	17/248	6.9%	0.95		
Pulmonary complication‡ (yes)	No	208/1342	15.5%	1	0.84-1.76	0.307
	Yes	43/248	17.3%	1.21		
Severe postoperative complication§ (yes)	No	249/1344	18.5%	1	0.65-1.35	0.721
	Yes	42/248	16.9%	0.94		
Prolonged length of hospital stays (>8 d) (yes)	No	576/1343	43.9%	1	0.71-1.27	0.724
	Yes	99/247	40.1%	0.95		
ICU/MCU admission for at least 1 d (yes)	No	503/1341	37.5%	1	0.98-1.84	0.064
	Yes	100/248	40.3%	1.34		
30-d hospital readmission (yes)	No	158/1317	12.0%	1	0.75-1.67	0.545
	Yes	32/241	13.3%	1.13		
30-d/in-hospital mortality (yes)	No	58/1342	4.8%	1	0.70-2.35	0.353
	Yes	13/246	5.3%	1.33		
Failure to rescue‖ (yes)	No	53/272	19.5%	1	1.18-5.39	**0.015**
	Yes	13/41	31.7%	2.55		
Textbook outcome¶ (yes)	No	639/1133	56.4%	1	0.71-1.33	0.870
	Yes	119/209	56.9%	0.97		

* Adjusted Odds Ratio. Corrected for: sex, age, preoperative weight loss, BMI, Charlson Comorbidity Index, ASA-grade, previous esophageal or gastric surgery, tumor location, clinical tumor stage, clinical Node stage and hospital identification number as random effect factor. When degrees of freedom were insufficient for correction for all possible confounders, only confounders leading to a 10% change in OR were included for analyses. The random effect was added to the model in case the log-likelihood ratio test showed a better fit compared to the original univariable model.

† 95% Confidence interval. l

‡ Previous esophageal or gastric cancer surgery variable was removed from analyses due to multicollinearity with the tumor location variable.

§ Clavien-Dindo grade III or higher.

‖ 30-d/in-hospital mortality in patients with a complicated postoperative course (a postoperative complication leading to prolonged length of hospital stay (>21 d), a reinterventions or mortality).

¶ R0 resection, ≥15 lymph nodes, length of hospital stay ≤21 d and no intra- or severe postoperative complication, readmission (to the ICU), or mortality.

shows that failure to rescue, which is a proxy for early identification and adequate treatment of complications, was significantly higher during holiday periods. Next to the increased workload for the depleted hospital personnel (nurses, residents, etc.) during holidays, the ongoing specialization of medical specialists might also play a role in this finding; endoscopic and radiologic interventions are becoming increasingly important in early treatment of complications; as a result, endoscopists and radiologists, next to surgeons, are also becoming more and more dedicated to specific diseases and complications. Unavailability of these dedicated and specialized endoscopists or radiologists might contribute to higher failure-to-rescue rates. As a surgeon and hospital volume-outcome relationship has been described in gastric cancer surgery,[6-9] this study is not a plea against centralization or specialization of care. It should rather be seen as a plea for better and more extensive collaboration between super specialists of different hospitals within the same region or a sufficient scale of hospitals, so appropriate care can be ensured during holiday periods. Especially in a country like the Netherlands with relatively small travelling distances, regionalization might, next to centralization, solve the holiday-effect problem: referral of patients in need of complex care to other hospitals whenever the required specialists are unavailable or exchanging (super) specialists between hospitals during holiday periods should become common practice. In one way or another, treatment by dedicated personnel should be preferred over care delivered by less experienced stand-ins. Hospitals should ensure that specialized and dedicated upper gastrointestinal surgeons are available for supervising when less experienced stand-ins encounter difficulties during surgery. This clearly underscores that coordination of holiday scheduling of senior upper gastrointestinal surgeons within a hospital or a hospital region is of the utmost importance.

This population-based study, using the accurate and complete DUCA data, has some limitations. The holiday-effect is probably only a potential marker of other problems, which are difficult to capture in retrospective (nor prospective) studies. Exact dates of complications are not registered in the DUCA (only whether they occurred during the first 30 d/hospital admission), therefore this study could not assess whether the fatal complications causing higher failure-to-rescue rates after holiday surgery actually occurred during or right after the holidays. In the scope of physician anonymity, the DUCA registers at hospital rather than surgeon level. Therefore, potential confounders for higher tumor-positive resection margin and failure-to-rescue rates during holidays (surgeon subspecialty, age, training background, gastrectomy volume, number of surgeons performing the gastrectomy, availability of a senior gastric cancer surgeon, number and dedication of operative assistants and residents, number of (dedicated) upper gastrointestinal surgeons per hospital, etc.) could not be accounted for in the current study. These are, however, important aspects of the holiday effect in gastric cancer surgery. The current DUCA database does not contain long-term follow-up data. Therefore, the holiday effect on long-term survival could not be investigated in the current study. However, given increased tumor-positive resection margins and failure-to-rescue rates during holidays, long-term survival is expected to be inferior.

Given the limitations described above and especially the unavailability of surgeon details, the current study cannot provide clear leads to improve quality of care; it can only speculate on the mechanisms of the holiday effect. Therefore, this study rather aims to promote discussion on how quality and expertise of gastric cancer care can be maintained adequately all year long. The results of this large nationwide cohort study should have a signaling effect and trigger individual hospitals to perform a detailed investigation of the quality of care during holidays in their center. This investigation at hospital level should include the surgeon data described above but also the way surgery staffing is handled during holidays: is the staffing the same, is surgery performed with fewer staff or do surgeons not routinely performing gastric surgery cross-cover?

Conclusions

This nationwide cohort study is the first to investigate the safety of gastric cancer surgery during holiday periods. Relatively less patients underwent gastric cancer surgery during holiday periods compared to the remainder of the year. Even though time to treatment and patient, tumor and treatment characteristics were comparable between holidays and non-holidays, tumor-positive resections margins occurred more often during holidays. Subgroup analyses including only recent-year data suggested that failure-to-rescue rates were also higher during holidays. This indicates that steps must be taken to keep specialized and dedicated gastric cancer expertise up to standard during holiday periods.

Ethics

The DUCA scientific committee approved the current study. Informed consent and/or ethical review was not required by Dutch law.

Conflicts of interest

MIvBH is consultant for Mylan, Johnson & Johnson, BBraun, Alesi Surgical and Medtronic, and received research grants from Olympus and Stryker. RvH and JPR are consultants for Medtronic and proctoring surgeons for Intuitive Surgical Inc., and train other surgeons in robot-assisted minimally invasive esophagectomy. For the remaining authors no conflicts of interest were declared.

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Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.currproblcancer.2022.100850.

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