Case-mix adjustment to compare hospital performances regarding complications after cytoreductive surgery for ovarian cancer

Case-mix adjustment to compare hospital performances regarding complications after cytoreductive surgery for ovarian cancer: a nationwide population-based study

Marc Daniël Algera ,[1,2,3] Nishita M S Baldewpersad Tewarie,[2,4] Willemien J van Driel,[5] Maaike A P C van Ham,[4] Brigitte F M Slangen,[1,3] Roy F P M Kruitwagen ,[1,3] Michel W J M Wouters,[2,6] Participants of the Dutch Gynecological Oncology Audit Collaborator Group

For numbered affiliations see end of article.

Correspondence to
Marc Daniël Algera, Gynecologic Oncology, Maastricht University Medical Centre+, Maastricht, 2333, The Netherlands; m.algera@nki.nl

MDA and NMSBT contributed equally.

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ABSTRACT

Objective Complication rates after cytoreductive surgery are important quality indicators for hospitals that treat patients with advanced-stage ovarian cancer. Case-mix factors are patient and tumor characteristics that may influence hospital outcomes such as the complication rates. Currently, no case-mix adjustment model exists for complications after cytoreductive surgery; therefore, it is unclear whether hospitals are being compared correctly. This study aims to develop the first case-mix adjustment model for complications after surgery for advanced-stage ovarian cancer, enabling an accurate comparison between hospitals.

Methods This population-based study included all patients undergoing cytoreductive surgery for advanced-stage ovarian cancer registered in the Netherlands in 2017–2019. Case-mix variables were identified and assessed using logistic regressions. The primary outcome was the composite outcome measure 'complicated course'. Patients had a complicated course when at least one of the following criteria were met: (1) any complication combined with a prolonged length of hospital stay; (2) complication requiring reintervention; (3) any complication with a prolonged length of stay in the intensive care unit; or (4) 30-day mortality or in-hospital mortality during admission following surgery. Inter-hospital variation was analyzed using univariable and multivariable logistic regressions and visualized using funnel plots.

Results A total of 1822 patients were included, of which 10.7% (n=195) had a complicated course. Comorbidity and tumor stage had a significant impact on complicated course rates in multivariable logistic regression. Inter-hospital variation was not significant for case-mix factors. Complicated course rates ranged between 2.2% and 29.1%, and case-mix adjusted observed/expected ratios ranged from 0.20 to 2.67 between hospitals. Three hospitals performed outside the confidence intervals for complicated course rates. These hospitals remained outliers after case-mix adjustment.

Conclusion There is variation between hospitals regarding complicated course rates after cytoreductive surgery for ovarian cancer in the Netherlands. While comorbidity and tumor stage significantly affected the complicated course rates, adjusting for case-mix factors did not significantly affect hospital outcomes. The limited impact of case-mix adjustment could be a result of the Dutch centralized healthcare model.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Case-mix factors such as patient and tumor characteristics could influence hospital outcomes such as complication rates. Surgical case-mix studies that have been published showed significant effects of case-mix adjustment models on hospital outcomes. No case-mix adjustment model currently exists for complications after cytoreductive surgery for patients with advanced-stage ovarian cancer.

WHAT THIS STUDY ADDS

⇒ The current study describes the first national case-mix adjustment model for complications after cytoreductive surgery for advanced-stage ovarian cancer. Comorbidity and tumor stage were case-mix factors that had a significant impact on complication rates. The effect of case-mix adjustment on hospital outcomes was less than expected in the current study, probably because of the centralized healthcare for ovarian cancer in the Netherlands and therefore evenly distributed case-mix. However, the case-mix adjustment model enabled a more accurate hospital comparison.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ When hospital outcomes regarding complications after cytoreductive surgery for advanced-stage ovarian cancer are compared, comorbidity and tumor stage should be considered as significant factors. The current case-mix adjustment model could significantly impact hospital outcomes in a different healthcare system with more heterogeneous hospital populations. Other quality indicators should be considered when hospital outcomes are compared.

INTRODUCTION

Post-operative complications are common in patients undergoing cytoreductive surgery for advanced-stage

ovarian cancer. These complications could delay the start of adjuvant chemotherapy, which is undesirable since a delayed start of adjuvant chemotherapy is associated with worse overall survival in patients with advanced-stage ovarian cancer.[1] Therefore, strategies to diminish complication rates are essential to improve the quality of healthcare for these patients.

Clinical auditing (through clinical quality registries) has been described as an important tool for improving the quality of care.[2] In clinical auditing, quality indicators such as post-operative outcomes are defined. Subsequently, hospital data are collected and reported back annually to describe each hospital's performance and provide (national) benchmarks. As a result, participating centers can compare their outcomes among themselves. Consequently, clinical auditing allows outliers to be identified and acted on when differences in the quality of healthcare are observed.[3 4]

The Dutch Gynecological Oncology Audit has performed clinical auditing since 2014. In this registry, all surgical treatments for gynecological malignancies in the Netherlands are registered. The audit was initiated following an increased demand for insight into the variation in care and its influence on the quality of healthcare.[5] Currently, the Dutch quality indicator set includes indicators on structure, processes, and outcomes. These quality indicators, especially outcome indicators, may be influenced by differences in patient and tumor characteristics between hospitals. These so-called case-mix factors could positively or negatively impact indicator results of individual hospitals.[6–9]

Case-mix adjustment is the adjustment of individual hospital outcomes for patient and tumor characteristics by using a multivariable logistic regression model. The goal of case-mix adjustment is to compare hospital outcomes accurately. When hospitals are compared accurately, clinical auditing could encourage clinicians to improve their outcomes. Surgical case-mix adjustment studies have been published reporting on the effect of case-mix adjustment on post-operative complication rates.[6–9] In these studies, the case-mix adjustment models significantly changed hospital outcomes. Currently, only one risk-adjustment model comparing hospital outcomes regarding cytoreductive surgery for ovarian cancer has been published.[10] This retrospective study compared the post-operative outcomes of three hospitals.[10] A nationwide assessment of the effect of case-mix adjustment on hospital outcomes has not yet been published in gynecological oncology.

The Dutch Gynecological Oncology Audit monitors post-operative complication rates after cytoreductive surgery for advanced-stage ovarian cancer in a national quality indicator. To accurately compare hospitals, it seems rational to adjust for case-mix factors. Therefore, this study aimed to develop the first nationwide case-mix adjustment model in gynecological oncology, which enables an accurate comparison between hospitals regarding complications after cytoreductive surgery for advanced-stage ovarian cancer.

METHODS

Study Design

This population-based study used data from the Dutch Gynecological Oncology Audit registry. This population-based and prospectively maintained quality registry facilitated by the Dutch Institute for Clinical Auditing contains reliable detailed clinical data of all patients with any form of treatment for ovarian cancer in the Netherlands. Since January 2014, the audit has been a mandatory registry for all Dutch hospitals treating ovarian cancer and other gynecological malignancies.[5] According to Dutch legislation, ethical approval or informed consent was not required for this study.

Patient Selection

All cases of primary and interval cytoreductive surgery for advanced-stage ovarian cancer (International Federation of Gynecology and Obstetrics (FIGO) stage IIB–IV) performed in the 21 Dutch ovarian cancer centers between January 1, 2017 and December 31, 2019 were included. Exclusion criteria were FIGO stage I–IIA, missing FIGO stage, borderline ovarian tumors, and palliative surgeries.

Primary Outcome

The primary outcome was the occurrence of a complicated course following cytoreductive surgery for advanced-stage ovarian cancer. A 'complicated course' is a composite outcome measure frequently used in surgical oncology.[6 11 12] The definition of complicated course used in the current study was derived from the literature and defined as: any complication combined with a prolonged length of hospital stay (>14 days), and/or complication requiring surgical, endoscopic, or radiological intervention, and/or any complication combined with prolonged intensive care unit stay (>1 day), and/or death within 30 days after the procedure, and/or death during hospital admission following surgery. The combination of any complication with prolonged length of hospital stay distinguishes complications without any effect on further treatment (eg, simple urinary tract infection) from complications which could affect subsequent treatment. Complications are registered in detail in the registry with the following information: type of complication (infections, operative injuries, wound defects, peri-operative bleeding, thromboembolic events, systemic and/or technical complications); severity (requiring re-intervention yes/no); type of re-intervention (endoscopic, radiological, and/or surgical); and length of stay in the intensive care unit.

Case-Mix Factors

Variables for analysis in the case-mix model were selected based on the literature and expert opinion. The following patient and tumor characteristics were identified as case-mix factors: age (<70 and ≥70 years), World Health Organization (WHO) Performance Status (0–1 and 2–4), body mass index (<25 and ≥25 kg/m^2), Charlson Comorbidity Index (0 and 1+), FIGO stage (IIB, III, and IV), histology (epithelial and non-epithelial/mixed), and whether previous abdominal surgery had been performed before the surgery.[13]

Treatment Characteristics

Additionally, in a separate analysis, treatment characteristics such as type of cytoreductive surgery (primary vs interval) and result of surgery (complete vs incomplete) were included in the model. Patients undergoing primary surgery initially underwent surgery followed by adjuvant chemotherapy. Patients undergoing interval surgery initially received neoadjuvant chemotherapy followed by surgery and adjuvant chemotherapy. Complete cytoreduction was defined as no macroscopic disease present after surgery. Incomplete cytoreduction was defined as residual disease after surgery.

The type of surgery was additionally included as a variable in the model since data from a prior study showed that patients are

Table 1 Patient, tumor, and treatment characteristics of patients undergoing cytoreductive surgery for advanced-stage ovarian cancer in 2017–2019, registered in the Dutch Gynecological Oncology Audit Registry

	No complicated course (n=1627)	Complicated course (n=195)	Total (n=1822)
Patient and tumor characteristics			
Age			
Median (Q1, Q3)	67 (58, 73)	69 (60, 74)	67 (58, 73)
<70 years	959 (58.9%)	106 (54.5%)	1065 (58.5%)
≥70 years	668 (41.1%)	89 (45.6%)	757 (41.5%)
WHO performance status			
WHO 0–1	1291 (79.3%)	152 (77.9%)	1443 (79.2%)
WHO 2–4	98 (6.0%)	12 (6.2%)	110 (6.0%)
Unknown	238 (14.6%)	31 (15.9%)	269 (14.8%)
Body mass index, kg/m2			
<25	837 (51.4%)	95 (48.7%)	932 (51.2%)
≥25	772 (47.4%)	99 (50.8%)	871 (47.8%)
Missing	18 (1.1%)	1 (0.5%)	19 (1.0%)
Charlson Comorbidity Index			
0	1071 (65.8%)	110 (56.4%)	1181 (64.8%)
1+	556 (34.2%)	85 (43.6%)	641 (35.2%)
FIGO (2014) pathology			
Stage IIB	172 (10.6%)	13 (6.7%)	185 (10.2%)
Stage III	1038 (63.8%)	149 (76.4%)	1187 (65.1%)
Stage IV	417 (25.6%)	33 (16.9%)	450 (24.7%)
Histology			
Epithelial	1545 (95.0%)	181 (92.8%)	1726 (94.7%)
Non-epithelial	82 (5.0%)	14 (7.2%)	96 (5.3%)
Previous abdominal surgery			
No	885 (54.4%)	107 (54.9%)	992 (54.4%)
Yes	739 (45.4%)	88 (45.1%)	827 (45.4%)
Unknown	3 (0.2%)	0 (0%)	3 (0.2%)
Treatment characteristics			
Type of cytoreductive surgery			
Primary	638 (39.2%)	89 (45.6%)	727 (39.9%)
Interval (neoadjuvant chemotherapy)	989 (60.8%)	106 (54.4%)	1095 (60.1%)
Result of cytoreductive surgery			
Complete (no macroscopic disease)	1138 (69.9%)	127 (65.1%)	1265 (69.4%)
Incomplete (residual disease)	474 (29.1%)	68 (34.9%)	542 (29.8%)
Missing	15 (0.9%)	0 (0%)	15 (0.8%)

FIGO, International Federation of Gynecology and Oncology; WHO, World Health Organization.

known to have a complicated course more frequently after primary compared with interval cytoreductive surgery.[14] Moreover, neoadjuvant chemotherapy may reduce the risk of certain post-operative complications.[15] The result of surgery was included because extensive procedures (ie, bowel surgeries, upper abdominal surgery, splenectomy) could result in complete cytoreduction, but may also result in increased complication rates.[10]

Statistical Analysis

Data were analyzed using RStudio version 1.4.1106 (RStudio, Boston, USA, 2021). Missing data below 5.0% were excluded from analysis. To determine the variation in case-mix factors between hospitals, the mean percentages, including the minimum and maximum for each variable, were calculated. Furthermore, univariable logistic regression analyses were performed to determine whether the mean distribution was significantly different in the various hospitals for the case-mix factors. In addition, a violin graph

was plotted to show the distribution of the case-mix factor in the hospitals.

The association of case-mix factors and treatment characteristics with complicated course was analyzed using univariable and multivariable logistic regression. For the multivariable logistic regression, all possible case-mix variables were selected. Multicollinearity was tested using the Variance Inflation Factor and considered non-multicollinear when <2.0.

Hospital variation in complicated course rates before and after case-mix adjustment were plotted in unadjusted and case-mix adjusted funnel plots. The unadjusted funnel plot showed the proportion of patients with a complicated course per hospital. The case-mix adjusted funnel plot was visualized by an observed versus expected ratio. The observed/expected ratio was calculated as follows: the number of actually observed patients with a complicated course divided by the number of patients that were expected to have a complicated course. This expected number of patients was based on the multivariable regression of the case-mix factors. If the observed/expected ratio was >1, the hospital had higher complicated course rates than expected; conversely, if the ratio was <1, the hospital had fewer patients with a complicated course after surgery than expected. The 95% confidence intervals (CI) were calculated to indicate whether the observed/expected ratios of the hospitals were statistically significantly different.

RESULTS

Patient Selection, Patient and Tumor Characteristics

The patient selection flowchart is shown in online supplemental figure 1. A total of 1822 patients with advanced-stage ovarian cancer who underwent cytoreductive surgery between 2017 and 2019 were included in the study protocol. Of these patients, 39.9% underwent primary surgery (n=727) and 60.1% underwent interval surgery (n=1095). Patient and tumor characteristics are shown in Table 1. Complicated course after surgery was observed in 10.7% (n=195) of the patients.

Hospital Variation in Case-Mix Factors

Differences in case-mix factors and treatment characteristics between hospital populations are shown in Table 2 and Figure 1. The proportion of patients undergoing primary surgery differed significantly between hospitals (range 25.0–57.6%, p=0.001, univariable logistic regression analysis). The other hospital populations' case-mix factors and treatment characteristics did not differ significantly between hospitals (ranges shown in Table 2 and Figure 1).

Case-Mix Factors for Complicated Course

Case-mix factors and their association with a complicated course after surgery are shown in the univariable and multivariable logistic regression analyses in Table 3. Patients with one or more comorbidities (Charlson Comorbidity Index 1+) had a significantly higher risk for a complicated course (univariable: OR 1.49, 95% CI 1.10 to 2.01, p=0.010; multivariable: OR 1.47, 95% CI 1.07 to 2.01, p=0.016). FIGO stage III was significantly associated with a complicated course (univariable: OR 1.90, 95% CI 1.09 to 3.59, p=0.033; multivariable: OR 1.95, 95% CI 1.12 to 3.69, p=0.028). Therefore, comorbidity and FIGO stage were considered the most important factors for case-mix adjustment. The case-mix factors age, WHO performance status, body mass index, histological type, and previous abdominal surgery did not significantly differ in either the univariable or multivariable analyses but were included in the adjustment model.

The additional analyses on case-mix factors, including treatment characteristics type and result of cytoreductive surgery, showed similar results as the analyses in Table 3: Charlson Comorbidity Index 1+ and FIGO stage III were associated with increased complicated course rates. Type of cytoreductive surgery (primary vs interval) and result of surgery (complete vs incomplete) were not associated with complicated course rates: no association was observed between complicated course and primary surgery, and no association was observed between complicated course and complete cytoreduction (see online supplemental table 1).

Table 2 Mean distribution (and minimum–maximum) of case-mix and treatment factors in the 21 ovarian cancer hospitals in the Netherlands

				Univariable logistic regression
Patient and tumor characteristics	**Mean, %**	**Missing, %**	**Min–Max, %**	**P value***
Age ≥70 years	41.5	0.0	26.6–48.9	0.110
WHO performance status ≥2	6.0	14.8	1.5–12.9	0.919
Body mass index ≥25 kg/m^2	47.8	1.0	35.9–57.6	0.105
Charlson Comorbidity Index 1+	35.2	0.0	23.4–42.3	0.347
FIGO stage IV	24.7	0.0	9.9–35.1	0.847
Non-epithelial histology	5.3	0.0	0.0–11.3	0.727
Previous abdominal surgery	45.4	0.2	25.8–61.1	0.822
Treatment characteristics				
Primary cytoreductive surgery	39.9	0.0	25.0–57.6	0.001
Complete cytoreduction	69.4	0.8	52.5–81.6	0.094

*P values were calculated using univariable logistic regression analyses, with the case-mix factors (and treatment factors) as dependent variables and the hospitals as an independent variable.
FIGO, International Federation of Gynecology and Oncology; WHO, World Health Organization.

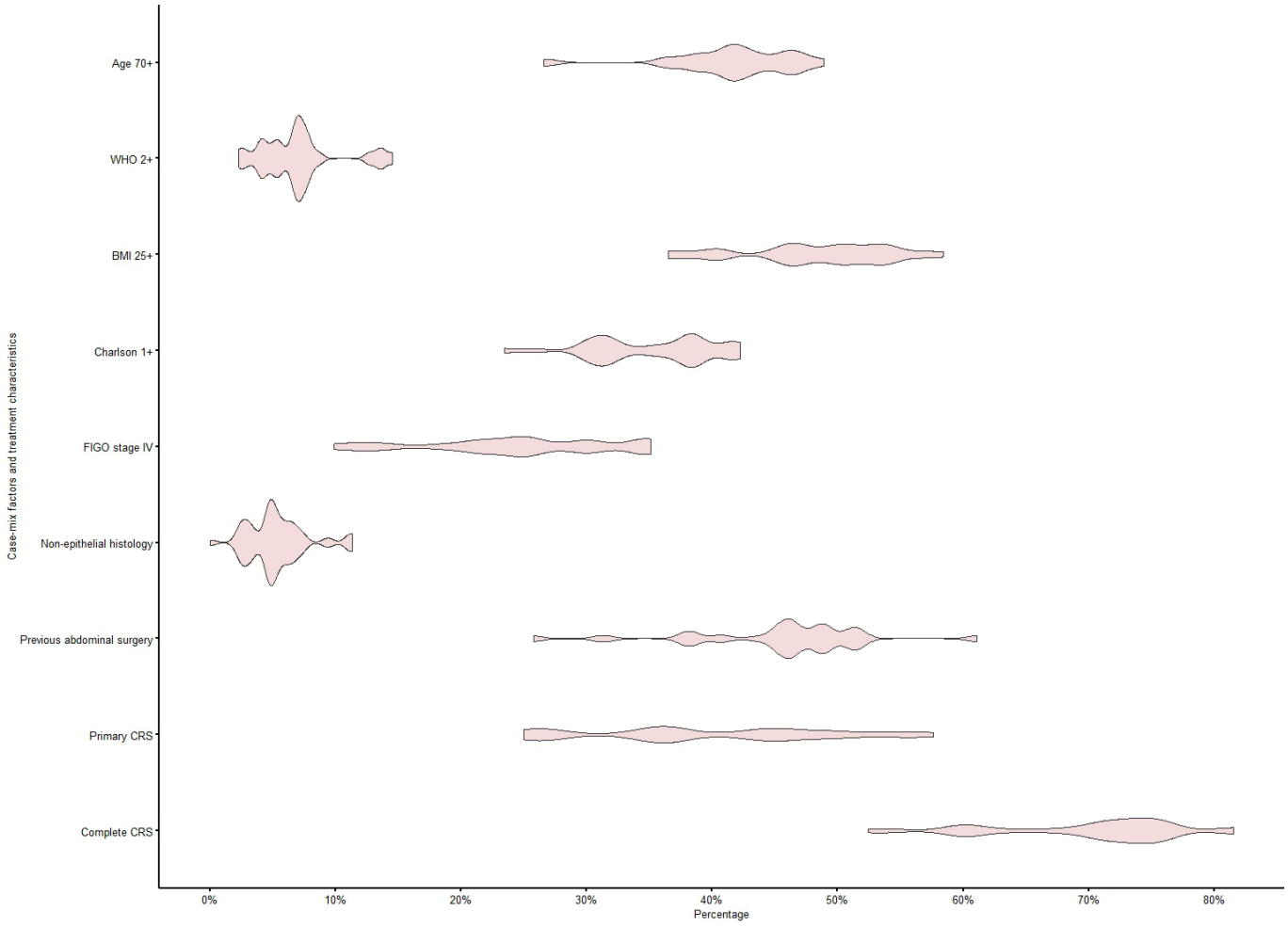

Figure 1 Violin graph showing the distribution of mean percentages (range) of case-mix variables per hospital in the Netherlands in patients who underwent cytoreductive surgery for advanced-stage ovarian cancer between 2017 and 2019.

Due to sufficient events (n=195), no restrictions were needed in the case-mix model. Variation Influence Factors were below 2.0 for all variables, so multicollinearity was ruled out.

Hospital Variation for Complicated Course

Unadjusted complicated course rates after surgery are shown in Figure 2A. Complicated course rates ranged from 2.2% to 29.1% between hospitals. Three hospitals performed outside the 95% CI. One hospital had significantly higher complicated course rates (29.1%) and two hospitals had significantly lower complicated course rates (both hospitals 2.2%).

Figure 2B shows the hospital variation for complicated course after surgery with case-mix adjustment. After case-mix adjustment, the same hospitals performed outside the 95% CI as in the unadjusted results (range of observed/expected ratios 0.20–2.67). When the treatment characteristics type and the result of cytoreductive surgery were added into the case-mix model, the observed/expected ratios did not alter significantly (data not shown).

DISCUSSION

Summary of Main Results

The current study showed hospital variation in the Netherlands regarding complicated course rates after cytoreductive surgery for ovarian cancer. Three hospitals performed outside the confidence intervals in the unadjusted and case-mix adjusted analyses. Case-mix factors associated with increased complicated course rates were having one or more comorbidity and FIGO stage III. The hospital populations of the individual hospitals did not show significant variation in case-mix factors and treatment characteristics, except for the type of surgery (primary vs interval). Adding the treatment characteristics 'type of surgery' and 'result of surgery' to the adjustment model did not result in significantly different hospital outcomes. However, the hospital outcomes were compared more accurately because of the case-mix adjustment.

Results in the Context of Published Literature

The current study is the first nationwide case-mix adjustment study in a gynecological oncology population. Previous surgical case-mix adjustment studies reported reduced hospital variation in post-operative outcomes after case-mix adjustment.[6–9] However, the effect of the current case-mix adjustment model on hospital outcomes was less than expected, as the outliers remained outliers after adjustment for the case-mix. A possible explanation for the limited impact of the case-mix adjustment model could be the centralized healthcare system for ovarian cancer in the Netherlands. Centralization of surgical procedures may have resulted in more evenly distributed case-mix factors in the various gynecological

Table 3 Logistic regression analysis: association of case-mix factors with complicated course after cytoreductive surgery for advanced-stage ovarian cancer

		Univariable logistic regression			Multivariable logistic regression		
Case-mix factors	**No of patients (%)**	**OR**	**95% CI**	**P value***	**OR**	**95% CI**	**P value***
Age (continuous, per 10 years)	1822 (100)	1.08	0.95 to 1.24	0.273	1.05	0.92 to 1.21	0.463
WHO performance status							
0–1	1443 (79.2)	1			1		
2–4	110 (6.0)	1.04	0.53 to 1.87	0.902	0.87	0.43 to 1.60	0.669
Missing	269 (14.8)	1.11	0.72 to 1.65	0.629	1.09	0.71 to 1.63	0.689
Body mass index							
<25 kg/m^2	932 (51.2)	1			1		
≥25 kg/m^2	871 (47.8)	1.12	0.84 to 1.52	0.422	1.08	0.80 to 1.47	0.615
Missing†	19 (1.0)						
Charlson Comorbidity Index							
0	1181 (64.8)	1			1		
1+	641 (35.2)	1.49	1.10 to 2.01	**0.01**	1.47	1.07 to 2.01	**0.016**
FIGO (2014) pathology							
Stage IIB	185 (10.2)	1			1		
Stage III	1187 (65.1)	1.9	1.09 to 3.59	**0.033**	1.95	1.12 to 3.69	**0.028**
Stage IV	450 (24.7)	1.05	0.55 to 2.11	0.892	1.11	0.58 to 2.25	0.76
Histology							
Epithelial	1726 (94.7)	1			1		
Non-epithelial/mixed	96 (5.3)	1.46	0.78 to 2.54	0.209	1.49	0.79 to 2.63	0.186
Previous abdominal surgery							
No	992 (54.4)	1			1		
Yes	827 (45.4)	0.98	0.73 to 1.33	0.92	0.89	0.66 to 1.21	0.472
Missing†	3 (0.2)						

*P values were calculated using univariable and multivariable logistic regression analyses, with the case-mix factors as dependent variables and the complicated course as an independent variable.
†Not analyzed.
FIGO, International Federation of Gynecology and Obstetrics; WHO, World Health Organization.

oncology hospitals, each serving a geographic region. Following regional centralization, the number of hospitals that performed surgery for ovarian cancer was reduced from >70 hospitals in 2010 to 21 hospitals in 2019.[5 16] Because of this regionally organized and centralized care, hospital populations (and case-mix) are probably more similar.[17] The current study confirms this theory as the hospital populations' case-mix factors did not differ significantly between hospitals. Therefore, the case-mix adjustment probably impacted individual hospital outcomes less than expected.

In the current cohort, patients with one or more comorbidities were associated with increased complicated course rates. Previous surgical case-mix studies found a similar association.[6 9] In addition, patients with FIGO stage III had an increased risk for a complicated course in the current study. Initially, the explanation for this result was that patients with FIGO stage III more frequently underwent primary surgery compared with patients with FIGO stage IV, and patients undergoing primary surgery are known to have increased risks of certain complications.[14 15] However, in the current analysis, primary surgery was not significantly associated with complicated course in multivariable analysis. Presumably, the significant association between FIGO stage III and complicated course was therefore caused by the complexity of surgery. Patients with FIGO stage III are known to undergo more extensive surgical procedures than patients with FIGO stage IIB or IV. Unfortunately, no data on complexity of the surgery were available in the registry, so the reason why FIGO stage III was associated with a complicated course remains unclear.

The hospital with a complicated course rate of 29.1% in the unadjusted analysis of the current study achieved complete cytoreduction in 82% of their patients (the largest proportion of complete cytoreduction of all hospitals). The two hospitals with significantly fewer patients with a complicated course (2.2%, unadjusted analysis) achieved complete cytoreduction in 59% of their patients, which is substantially below the national benchmark. The possible interaction between these outcomes—complete cytoreduction and complications—indicates that the quality of healthcare should be evaluated using more than one quality indicator.

A promising tool to evaluate the quality of care on multiple quality indicators is the composite outcome measure 'textbook outcome'. Textbook outcome has been described in surgical oncology

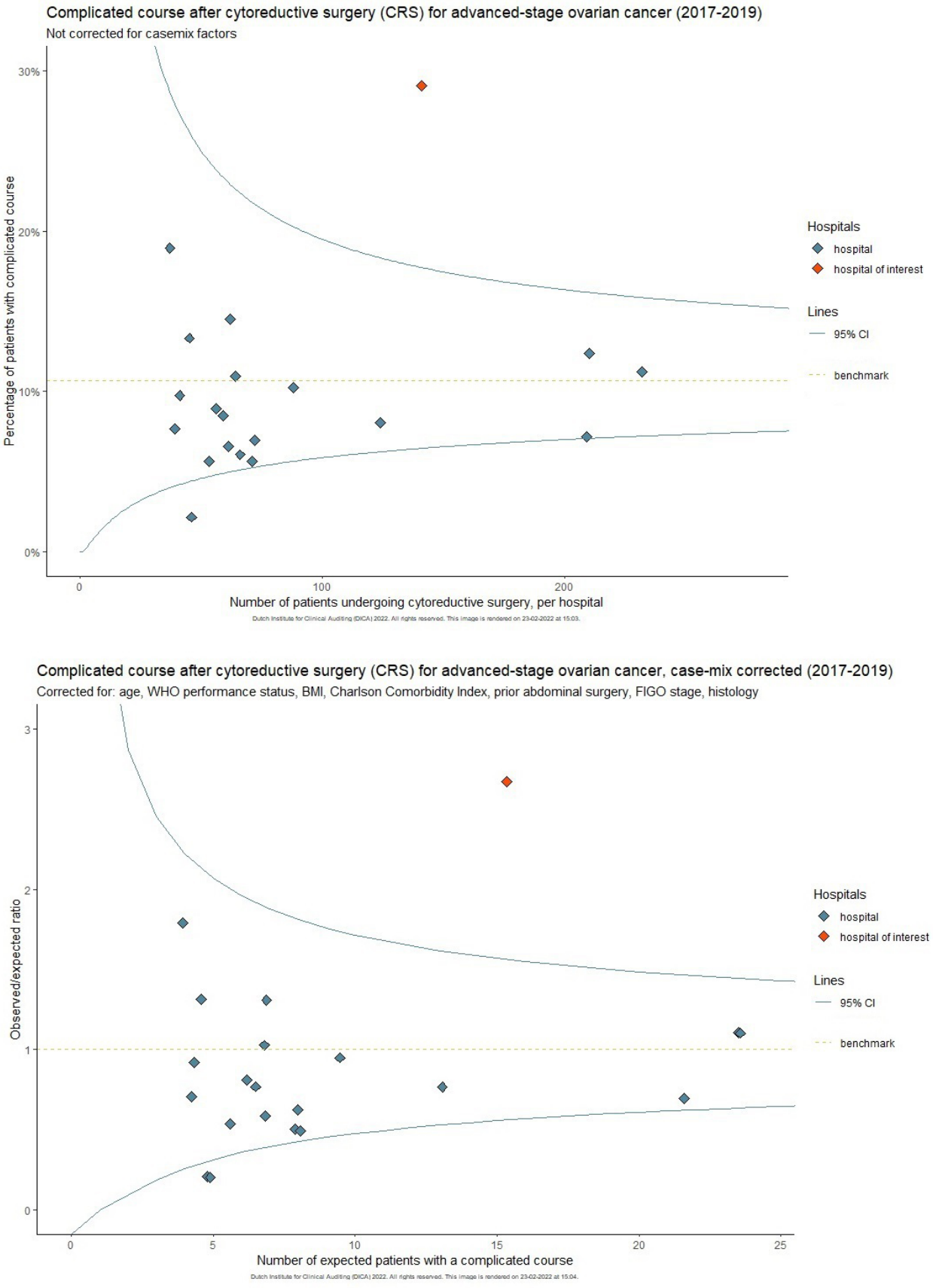

Figure 2 Funnel plot showing the hospital variation in complicated course after cytoreductive surgery for advanced-stage ovarian cancer in the Netherlands (2017–2019) not adjusted for case-mix factors (A) and adjusted for age, World Health Organization Performance Status, Charlson Comorbidity Index, prior abdominal surgery, International Federation of Gynecology and Obstetrics stage, and histology (B).

populations and provides a complete view of the quality of (surgical) care. Patients have a textbook outcome when multiple outcome requirements are met (radical surgery, no 30-day mortality, no prolonged length of hospital stay, and no severe complications).[18 19] The textbook outcome should be evaluated in the future for patients undergoing cytoreductive surgery for ovarian cancer.

When clinical auditing is performed and outliers are analyzed, it is also essential to include external factors such as the efficiency of healthcare. The definition of 'complicated course' includes patients with any complication combined with a prolonged length of hospital stay (>14 days). If a patient with a minor complication is ready for discharge but stays admitted for >14 days because of limited availability in nursing homes, this could have affected the complicated course rates. Assessment of the regional differences regarding external factors could identify these underlying mechanisms and provide opportunities to improve the quality of healthcare outside the hospital. Healthcare professionals of all hospitals treating ovarian cancer should discuss their outcomes yearly, thus enabling the (external) factors that could cause increased complicated course rates to be identified, after which the quality of healthcare could be improved.

Strengths and Weaknesses

One of the strengths of this study is that the population-based data available in the registry were used. Also, using the composite outcome measure 'complicated course' in the analyses prevented minor complications with minimal morbidity and normal hospital stay being assessed as complicated. Another strength is that the variables used in the case-mix model had limited missing values, resulting in robust analyses. However, there are certain limitations to the current study. First, variables not included in our model (such as race, ethnicity, socioeconomic factors) could have influenced the complicated course rates. Although these variables were unavailable, a careful selection of the available case-mix variables was made. Second, the additional analysis did not include intraoperative factors like bowel and upper abdominal surgery because of limited data availability. Third, under-reporting of complications could have caused bias. Last, overall survival was not analyzed in this study because of limited data availability.

Implications for Practice and Future Research

The case-mix adjustment model did not significantly impact individual hospital outcomes, probably because of the Dutch centralized healthcare model.[5 16] However, the case-mix model resulted in a more accurate comparison and showed that comorbidity and FIGO stage were significant factors that impacted complicated course rates. Careful analysis of the patterns of care provided by outliers could give insight into other factors that impact complicated course rates. Subsequently, this information could be used to gain insight into existing care and improve care for this group of patients. Possibly, the current case-mix adjustment model could significantly impact hospital outcomes when used in a different healthcare system with more heterogeneous hospital populations.

CONCLUSIONS

Hospital variation regarding post-operative complications after cytoreductive surgery for ovarian cancer exists in the Netherlands. While comorbidity and FIGO stage were case-mix factors that significantly affected complicated course, case-mix adjustment did not reveal any significant changes in hospital outcomes. The effect of adjustment could be limited because of the Dutch centralized healthcare model, resulting in a more evenly distributed pattern of patient and tumor characteristics. Nevertheless, the current adjustment model could significantly impact hospital outcomes in a different healthcare system with more heterogeneous hospital populations. The observed hospital variation should be further analyzed in order to learn from these differences and improve the quality of healthcare. At the same time, it is essential to consider a broader set of quality indicators when hospital outcomes are analyzed and compared.

Author affiliations
[1]Gynecologic Oncology, Maastricht University Medical Centre+, Maastricht, The Netherlands
[2]Scientific Bureau, Dutch Institute for Clinical Auditing, Leiden, The Netherlands
[3]GROW School for Oncology and Reproduction, Maastricht, The Netherlands
[4]Department of Obstetrics and Gynecology, Radboudumc, Nijmegen, The Netherlands
[5]Gynaecology, Netherlands Cancer Institute, Amsterdam, The Netherlands
[6]Department of Surgical Oncology, Netherlands Cancer Institute, Amsterdam, The Netherlands

Collaborators Participants of the Dutch Gynecological Oncology Audit Collaborator Group: A J Kruse, gynecologist, Isala Klinieken, Zwolle; R Yigit, gynecologist, University Medical Center Groningen, Groningen; M van der Aa, senior investigator, National Cancer Care Network (NCCN); J W M Mens, radiation oncologist, Erasmus Medical Center Cancer Institute, Rotterdam; T C Stam, radiation oncologist, Haaglanden Medical Center, The Hague; M J A Engelen, gynecologist, Zuyderland Medisch Centrum, Heerlen; L S Nooij, gynecologist, Leiden University Medical Center, Leiden; J Diepstraten, patient advocate, Stichting Olijf; A van der Kolk, patient advocate, Stichting Olijf; H P M Smedts, gynecologist, Amphia Ziekenhuis, Breda; N Reesink, gynecologist, Medisch Centrum Twente, Enschede; K N Gaarenstroom, gynecologist, Leiden University Medical Center, Leiden; P M L H Vencken, gynecologist, Bravis Ziekenhuis, Roosendaal; D Boll, gynecologist, Catharina Ziekenhuis, Eindhoven; G Fons, gynecologist, Amsterdam University Medical Center, Academic Medical Center, Amsterdam; A Baalbergen, gynecologist, Reinier de Graaf Groep, Delft; E B L van Dorst, gynecologist, University Medical Center Utrecht, Utrecht; M Y Tjiong, gynecologist, Amsterdam University Medical Center, Vrije Universiteit Medisch Centrum, Amsterdam; E M Roes, gynecologist, Erasmus Medical Center Cancer Institute, Rotterdam; C G Gerestein, gynecologist, Meander Medisch Centrum, Amersfoort and University Medical Center Utrecht, Utrecht; H T C Nagel, gynecologist, Haaglanden Medical Center, The Hague; A L Aalders, gynecologist, Rijnstate Ziekenhuis, Arnhem; I Ebisch, gynecologist, Cansius Wilhelmina Ziekenhuis, Nijmegen; J de Waard, gynecologist, Fransiscus Gasthuis & Vlietland, Rotterdam; M Huisman, gynecologist, Gelre Ziekenhuis, Apeldoorn.

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ORCID iDs
Marc Daniël Algera http://orcid.org/0000-0002-7530-9817
Roy F P M Kruitwagen http://orcid.org/0000-0002-1305-9541

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