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Preoperatively predicting non-home discharge after surgery for gynecologic malignancy☆

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HIGHLIGHTS

- Home discharge after surgery is a desirable, patient-centered outcome.
- This study shows that non-home discharge after hysterectomy for gynecologic malignancy can be predicted with high accuracy.
- We developed a nomogram that could be used as a tool to anticipate non-home discharge during routine preoperative evaluation.
- This tool could ultimately reduce wasted days and resource use, and increase patient satisfaction.

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ABSTRACT

Objective. Returning home after surgery is a desirable patient-centered outcome associated with decreased costs compared to non-home discharge. Our objective was to develop a preoperative risk-scoring model predicting non-home discharge after surgery for gynecologic malignancy.

Methods. Women who underwent surgery involving hysterectomy for gynecologic malignancy from 2013 to 2015 were identified from the Michigan Surgical Quality Collaborative database. Patients were divided by discharge destination, and a multivariable logistic regression model was developed to create a nomogram to assign case-specific risk scores. The model was validated using the National Surgical Quality Improvement Program (NSQIP) database.

Results. Non-home discharge occurred in 3.1% of 2134 women. The proportion of non-home discharges did not differ by cancer diagnosis (uterine 3.5%, ovarian 2.5%, and cervical 1.6%, $p = 0.2$). Skilled nursing facilities were the most common non-home destination (68.2%). Among patients with comorbidities (hypertension, diabetes, coronary artery disease, chronic obstructive pulmonary disease /dyspnea, arrhythmia, and history of deep vein thrombosis/pulmonary embolism), non-home discharge was more common in women with 1 (adjusted OR [aOR] 3.4; $p = 0.03$) or ≥2 of these comorbidities (aOR 5.1; $p = 0.003$) compared to none. Non-home discharge was more common after laparotomy (aOR 6.7; $p < 0.0001$) than laparoscopy, and in those aged ≥70 years (aOR 3.4; $p < 0.0001$) with American Society of Anesthesiologists class ≥ 3 (aOR 4.5; $p = 0.0004$) and dependent functional status (aOR 8.7; $p < 0.0001$). The model C-statistic was 0.89. When the model was applied to 4248 eligible patients from the NSQIP dataset, the C-statistic was 0.84 (95% CI: 0.79–0.89).

Conclusions. Non-home discharge after surgery for gynecologic malignancy was predicted with high accuracy in this retrospective analysis.

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1. Introduction

Returning home after surgery has been identified as a nationally recognized patient-centered outcome [1–3]. This is because discharge to a facility (e.g., a skilled nursing facility, long-term care facility, inpatient rehabilitation, etc.) rather than to home is associated with substantially increased costs, adverse outcomes including mortality, and stress to patients, family members, and caretakers [1,4]. In particular, among patients undergoing gynecologic oncology procedures, non-home discharge adds significant economic burden [5].

As such, accurately identifying patients prior to surgery who have a high likelihood of non-home discharge could potentially facilitate candid preoperative discussion about recovery expectations, early discharge planning, and hospital resource allocation. In the general surgery literature, models to predict non-home discharge based on preoperative patient factors have been developed, including one—the American College of Surgeons National Surgical Quality Improvement Project (ACS NSQIP) surgical risk calculator—that includes data from all surgical specialties except transplant and trauma [6]. Although this model includes gynecologic surgeries, such procedures account for a small percentage of the entire cohort, nor is procedure indication factored into the model [7]. Consequently, this calculator has been shown to be less accurate in predicting common complications after gynecologic oncology surgery [8]. Work that has been done in gynecologic oncology with regards to non-home discharge has focused on patients undergoing surgery for epithelial ovarian cancer, but not on those with other gynecologic malignancies [9].

In this context, the objective of our study was to determine preoperative predictors of non-home discharge after surgery for gynecologic malignancy and to develop a preoperative risk-scoring model to predict non-home discharge.

2. Materials and methods

2.1. Study setting

We performed a retrospective cohort study using collected data from the Michigan Surgical Quality Collaborative (MSQC). The MSQC is a statewide group of hospitals with quality and safety initiatives that are funded by Blue Cross and Blue Shield of Michigan. Details regarding nurse abstraction of clinical data and quality assurance of the database have been described in detail elsewhere [10,11]. At the time our analysis was conducted, there were 63 academic and community hospitals participating in the MSQC. This study was deemed exempt by the University of Michigan Institutional Review Board (HUM00073978).

2.2. Patient population

Patients ≥ 18 years old undergoing hysterectomy for malignant indications between January 1, 2013 to May 15, 2015 were included in the analysis. Having an indication for malignancy was based on the presence of one of the following criteria: 1) explicit indication recorded as uterine, cervical, or ovarian malignancy; 2) any of the *International Classification of Diseases, Ninth Revision* (ICD-9) principal diagnosis codes for gynecologic malignancy (179, 180, 180.0, 180.1, 180.8, 180.9, 182, 182.0, 182.1, 182.8, 183.0, 183.2, 183.4, 183.8, 183.9, 184.0, and 184.1); or 3) the presence of a gynecologic cancer diagnosis as verified using pathology reports at the time of abstraction. Any patient who died prior to discharge from the hospital ($n = 4$) or who left against medical advice was excluded from our analysis.

2.3. Outcomes

The primary outcome of interest was discharge destination. Patients were classified as having either a "home discharge" or a "non-home discharge." A "home discharge" was defined as discharge to home with self-care or with home health services. Home hospice was also included in this category. A "non-home discharge" was defined as discharge to a skilled nursing facility, inpatient rehabilitation, long-term care hospital, inpatient hospice, or "other" (short-term hospital for inpatient care, psychiatric hospital or psychiatric unit of a hospital, or another type of health care institution not defined elsewhere).

2.4. Statistical analyses

Bivariate analysis was initially performed between discharge destination and several patient and operative characteristics to determine statistically significant variables associated with non-home discharge. Patient characteristics collected included age, race, body mass index (BMI), American Society of Anesthesiologists (ASA) class, functional status, smoking history (defined as tobacco use within one year), medical comorbidities (hypertension, diabetes, coronary artery disease, history of deep vein thrombosis (DVT) or pulmonary embolism (PE), chronic obstructive pulmonary disease (COPD), dyspnea, or cardiac arrhythmia), >10% weight loss within six months prior to surgery, preoperative hematocrit and platelet count, and gynecologic cancer type (uterine, ovarian, or cervical). Operative characteristics collected included surgical approach (open, laparoscopic, or vaginal), complications within 30 days after hysterectomy (including intraoperative and postoperative), surgical time in minutes, and length of stay in days; however, only surgical approach was factored into the final nomogram as it was the only operative variable that could be considered modifiable. Complications within 30 days after hysterectomy were defined as surgical site infection, pneumonia, unplanned intubation, pulmonary embolism, acute renal insufficiency, urinary tract infection, stroke, cardiac arrest requiring cardiopulmonary resuscitation, myocardial infarction, cardiac arrhythmia, need for transfusion, deep vein thrombosis, sepsis, *Clostridium difficile* infection, central line-associated bloodstream infection, and hysterectomy-specific postoperative complications (cuff infection, pelvic abscess, vaginal cuff dehiscence, ureteral obstruction, vesicovaginal fistula, uterovaginal fistula, rectovaginal fistula, anastomotic leak, intestinal obstruction, and nerve injury). Bivariate associations for categorical variables were examined using Chi-Square tests, or Fisher exact tests in the case of small cell sizes. Independent sample parametric *t*-tests were conducted for continuous variables that satisfied normality assumptions by Shapiro-Wilk tests; otherwise, nonparametric Wilcoxon Rank-Sum tests were performed.

Covariates were selected by either clinical significance or statistical significance ($p < 0.05$) after bivariate analysis. They were then entered into a stepwise logistic regression model for further variable selection. Remaining statistically and clinically relevant variables were retained in a final multivariable logistic regression. Collinearity was examined by reviewing correlation matrices between all candidate covariates and assessing model parameter estimates before and after variable inclusion. Variables that were not eliminated were included in the final logistic regression model that was used for creation of the nomogram. C-statistic, Hosmer-Lemeshow Goodness-of-Fit test, deciles of risk, Received Operator Characteristic (ROC) calibration curves, and external validation were used to examine performance of the final model. The reduced model was used to develop a Kattan-style nomogram that could be used to graphically assess individual patient likelihood of non-home discharge from preoperative characteristics. Each statistically significant patient-level or operative characteristic was retained in the final model.

We externally validated our model with a reference cohort—the ACS NSQIP hysterectomy participant user files from 2014. We utilized the variables identified in our model development cohort to fit a multivariable logistic regression model with identical covariates from the NSQIP dataset, including the coding of categorical variables. Predictive potential and overall calibration of this regression model was examined using the C-statistic. We validated our nomogram findings in this cohort

by assigning the scores to each patient as predicted by our development cohort.

Statistical analyses were performed with SAS Version 9.4 (SAS Institute, Cary, NC) for Windows and Stata Version 14/SE (Stata, College Station, TX).

3. Results

3.1. Patient characteristics

Of the 24,206 women in the MSQC database who underwent hysterectomy, we identified 2134 women with a mean age of 59.7 years (SD = 12.6) who had hysterectomy for gynecologic malignancy and met inclusion criteria. Within this cohort of patients, 73.7% had uterine cancer, 11.2% had ovarian cancer, and 15.1% had cervical cancer. Home discharge occurred in 2068 patients (96.9%). Of those patients not discharged home ($n = 66$, 3.1%), skilled nursing facilities were the most common non-home destination (68.2%), followed by inpatient rehabilitation (19.8%). Two patients (3.0%) were discharged to a hospice facility. Table 1 shows the characteristics of patients discharged home compared with those discharged to a facility, and Table 2 specifies the various discharge destinations of the entire cohort.

As expected, patients not discharged home were older and more likely to have more comorbidities, an ASA class ≥ 3, and non-independent functional status. They were also more likely to have a longer hospital length of stay (10 vs. 3 days, $p < 0.0001$) and a surgical complication (50.0% vs. 14.2%, $p < 0.0001$). Notably, race and BMI were not significantly different between the home and non-home discharge destination groups ($p = 0.09$ and 0.25, respectively). Additionally, the proportion of non-home discharges did not differ significantly by cancer diagnosis; the rate of non-home discharge among patients with uterine cancer was 3.5%, compared to 2.5% among ovarian cancer patients, and 1.6% among cervical cancer patients ($p = 0.2$).

3.2. Non-home discharge risk prediction based on preoperative factors

The factors most clinically and statistically associated with non-home discharge in our development cohort after risk adjustment included age ≥ 70 years, dependent functional status, ASA class ≥ 3, open surgical approach, and the presence of comorbidities (Table 3). The model had a strong fit with a C-statistic of 0.89 and Hosmer-Lemeshow test of 9.81 ($p = 0.20$). Fig. 1 shows the ROC curve for the derived model.

3.3. Nomogram for predicting non-home discharge

Based on the above analyses, a nomogram was created for clinical use. The predicted risk of non-home discharge is based on a score, as shown in Fig. 2. Each patient receives points based on the presence of comorbidities, ASA class, functional status, surgical approach, and age. The sum of these points ("total points") is converted to a probability of non-home discharge ("total score").

3.4. External validation of prediction model

We utilized the ACS NSQIP participant user files as a reference validation cohort to assess our model's clinical applicability as a risk assessment tool. Among 4248 cases meeting identical eligibility criteria for analysis, we found the ACS NSQIP cohort non-home discharge rate to be 4.7% (95% confidence interval [CI]: 4.0–5.3%). Model fitting with identical covariates yielded a C-statistic of 0.84 (95% CI: 0.79–0.89).

4. Discussion

In a large cohort of women undergoing hysterectomy for gynecologic malignancy, we demonstrated the ability to preoperatively predict non-home discharge with high accuracy after model development and validation. We created a nomogram tailored to gynecologic oncology patients based on preoperative factors that clinicians can use to determine the likelihood of a patient's discharge to a facility rather than home.

In concordance with published literature in general surgery and other surgical specialties (including orthopedic surgery and urology), we found that patients who were not able to be discharged home were older and less healthy—with a higher comorbidity burden and ASA class—and were functionally dependent [4,6,12–15]. A prior study also found this to be true in the epithelial ovarian cancer population

Table 1
Patient factors according to discharge destination.

Patient characteristics	Home discharge ($n = 2068$[a])	Non-home discharge ($n = 66$[a])	p-Value
Age in years, mean (SD)	59.3 (12.5)	70.2 (11.0)	<0.0001
Race, n (%)			0.090
White	1778/1991 (89.3)	52/63 (82.5)	
Non-White	213/1991 (10.7)	11/63 (17.5)	
BMI, kg/m^2, n (%)			0.253
Underweight/normal (<24.9)	383 (18.5)	16 (24.2)	
Overweight (25.0–29.9)	468 (22.6)	10 (15.2)	
Obese (≥30)	1217 (58.9)	40 (60.6)	
ASA class, n (%)			<0.0001
1–2	1169 (56.5)	7 (10.6)	
≥3	899 (43.5)	59 (89.4)	
Functional status, n (%)			<0.0001
Independent	2038 (98.5)	52 (78.8)	
Partially or fully dependent	30 (1.5)	14 (21.2)	
Smoking history, n (%)[b]			0.526
No	1759 (85.1)	58 (87.9)	
Yes	309 (14.9)	8 (12.1)	
Medical comorbidities, n (%)			
Hypertension	1112 (53.8)	54 (81.8)	<0.0001
Diabetes	441 (21.3)	30 (45.5)	<0.0001
Coronary artery disease	116 (5.6)	9 (13.6)	0.006
History of DVT/PE	113 (5.5)	8 (12.1)	0.021
Chronic obstructive pulmonary disease	85 (4.1)	8 (12.1)	0.002
Dyspnea	170 (8.2)	15 (22.7)	<0.0001
Arrhythmia	117 (5.7)	10 (15.2)	0.001
Number of comorbidities, n (%)			<0.0001
0	795 (38.4)	4 (6.1)	
1	659 (31.9)	19 (28.8)	
≥2	614 (29.7)	43 (65.1)	
Preoperative transfusion, n (%)	22 (1.1)	6 (9.1)	<0.0001
>10% weight loss, n (%)[c]	20 (1.0)	3 (4.6)	0.032
Surgical approach, n (%)			<0.0001
Open	749 (36.2)	53 (80.3)	
Laparoscopic	1212 (58.6)	12 (18.2)	
Vaginal	107 (5.2)	1 (1.5)	
Any complication, n (%)	294 (14.2)	33 (50.0)	<0.0001
Surgical time in minutes, mean (SD)	154.9 (69.8)	182. 5 (98.0)	0.027
Length of stay in days, mean (SD)	3 (3)	10 (8)	<0.0001
Platelet count, platelets/μl (SD)	268 (83)	244 (79)	0.020
Hematocrit, volume % (SD)	39.3 (4.2)	37.4 (5.2)	0.0052
Cancer type, n (%)[d]			
Uterine	1491/1545[e] (96.5)	54/1545 (3.5)	0.08
Ovarian	238/244 (97.5)	6/244 (2.5)	0.54
Cervical	307/312 (98.4)	5/312 (1.6)	0.09

BMI=Body Mass Index; ASA = American Society of Anesthesiologists; COPD = chronic obstructive pulmonary disease; DVT = deep vein thrombosis; PE = pulmonary embolism.
[a] Denominator is equal to this except where otherwise indicated.
[b] Smoker defined as tobacco use within one year.
[c] >10% loss of body weight within six months prior to surgery.
[d] 14 patients had unknown or other cancer type.
[e] 19 patients were classified as having both uterine and endometrial cancer. If this is taken into account, there are 1564 uterine cancer patients. These patients were omitted to avoid possible duplication error.

Table 2
Discharge destination after hysterectomy for gynecologic malignancy.

Discharge destination	N (%)
Home	2068 (96.9)
Home with self-care	1949 (94.2)
Home with visiting health services	117 (5.7)
Home with hospice	2 (0.1)
Non-home	66 (3.1)
Skilled nursing facility	45 (68.2)
Inpatient rehabilitation	13 (19.8)
Long-term care hospital	2 (3.0)
Short-term care hospital	2 (3.0)
Hospice facility	2 (3.0)
Psychiatric hospital	1 (1.5)
Facility not otherwise specified	1 (1.5)

[9]. Our work adds to existing knowledge by examining discharge patterns of patients across the entire surgical subspecialty of gynecologic oncology, rather than a specific subgroup within the field. Knowing the relative contributions of various baseline patient factors that influence discharge destination specific to the field may be important, as universal surgical risk calculators may not perform well in the gynecologic oncology population. Such discordance has been demonstrated when the ACS NSQIP calculator has been applied to gynecologic oncology patients [8].

Improved understanding of the risk for non-home discharge can help surgeons decide whether surgery is indicated, manage patient expectations about discharge destination, coordinate postacute care, and potentially influence inpatient postoperative care to avoid a non-home discharge [13,16]. In the orthopedic population, one study showed that implementation of a preoperative risk assessment calculator for non-home discharge could reduce the length of stay following surgery—likely due to more efficient decision-making about discharge destination and early referral to postacute care facilities and thereby preventing unnecessary extended hospital stays while awaiting eligibility evaluation for a rehabilitation facility, as an example [16]. Additionally, the same study showed that the home discharge rate increased if patients with an intermediate risk for non-home discharge were targeted for physical therapy during their hospital stay. In other words, preoperatively predicting discharge destination—and changing management accordingly—can influence the actual discharge destination in certain patients. Beyond the quality and economic benefits to having a less arbitrary basis for discharge planning, anticipating discharge destination could allow for more educated decision-making between patients and providers prior to surgery. Fulfillment of expectations, in turn, is often correlated with increased patient satisfaction after surgery [17].

Our study is subject to several limitations. One is that our model incorporates only preoperative factors. This was done to make the model more practical for clinicians; however, there are intra- and postoperative factors (e.g., surgical complications) that undoubtedly impact the decision to discharge a patient to postacute care. Moreover, there are limitations inherent to retrospective cohort studies; in particular, they are subject to unmeasured confounders. We tested and controlled for known confounders, but our datasets lack sufficient granularity to capture every factor that influences an outcome like discharge destination. For example, the dataset does not characterize social support of patients at home, which may influence decisions about whether to send patients home or to postacute care. Also, due to the constraints of the MSQC database in particular, our study population was limited to gynecologic oncology cases involving hysterectomy. This could influence outcomes as well. For example, one notable finding in our study is the relatively low rate (2.5%) of non-home discharge among ovarian cancer patients. This differs from a previous publication that found a 12.8% rate of non-home discharge in this population [9]. Part of the discrepancy could be due to the omission of ovarian cancer patients undergoing primary cytoreductions with a history of prior hysterectomy or the omission of patients undergoing secondary cytoreductions (most of whom have had a hysterectomy). Such patients might be sicker, with an increased risk of non-home discharge. That being said, these data also reflect statewide practices, and there may be a higher neoadjuvant chemotherapy rate in Michigan relative to other regions, resulting in less extensive debulking procedures and lower rates of non-home discharge. Additionally, only including cases involving hysterectomy could also explain why there were more cervical cancer ($n = 312$) than ovarian cancer cases ($n = 244$) in this population, since ovarian cancer patients tend to be older and more likely to have had a prior hysterectomy. Finally, outcomes could potentially be underreported, as the MSQC database relies on provider documentation that may be incomplete.

In conclusion, this study developed and validated a nomogram that may be useful in planning patient disposition pre-admission by identifying patient-level factors that drive discharge destination. Additionally, this tool could be helpful in preoperative counseling to determine the best treatment options for patients. Further work could be done to incorporate these patient-driven factors with the physician- and hospital-level factors that influence discharge destination to refine the predictive model. Moreover, a prospective study examining outcomes such as healthcare costs and patient satisfaction after implementation of such a nomogram would be useful in evaluating its non-theoretical clinical utility.

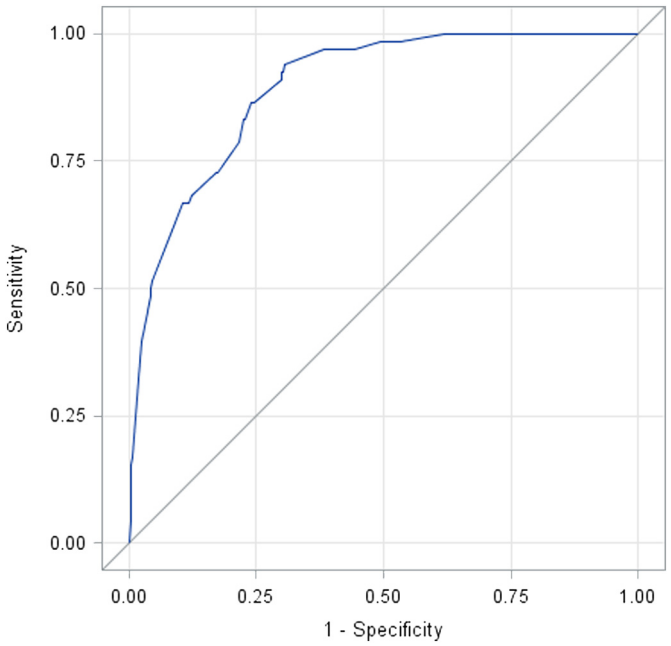

Fig. 1. Receiver operating characteristic (ROC) curve for the derived model for non-home discharge. Area under the curve (AUC) = 0.895.

Table 3
Logistic regression model of non-home discharge based on preoperative variables.

Patient factor	Referral	Adjusted OR	95% CI
Age ≥ 70, years	<70	3.42	1.99, 5.88
Dependent functional status	Independent	8.71	3.90, 19.42
ASA Class ≥ 3	1 or 2	4.53	1.98, 10.38
Open surgical approach	Laparoscopic	6.71	3.44, 13.12
1 Comorbidity[a]	0	3.37	1.11, 10.26
≥2 Comorbidities[a]	0	5.14	1.75, 15.10

ASA = American Society of Anesthesiologists; COPD = chronic obstructive pulmonary disease; DVT = deep vein thrombosis.
PE = pulmonary embolism.
[a] Comorbidities included: hypertension, diabetes, coronary artery disease, arrhythmia, COPD/dyspnea, history of DVT/PE.

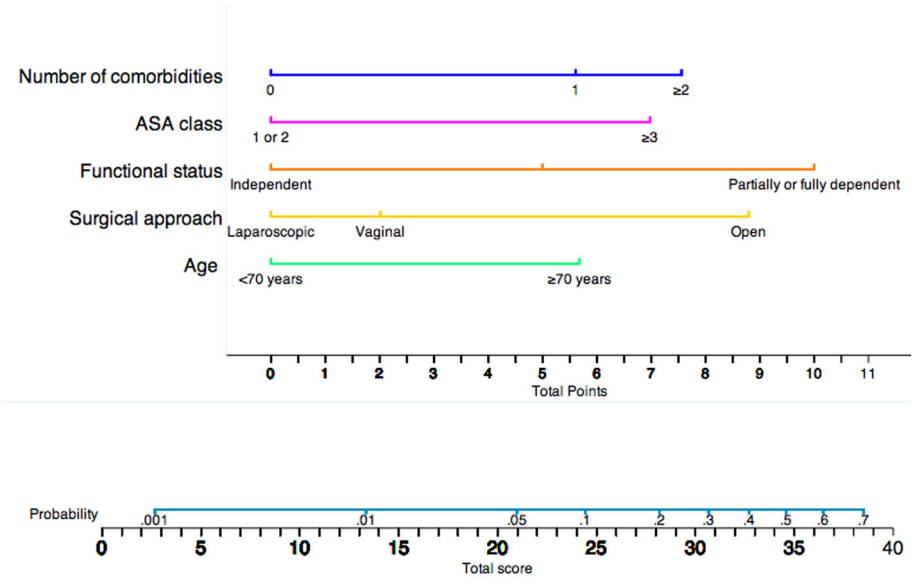

Fig. 2. Nomogram for non-home discharge after surgery for gynecologic malignancy. ASA = American Society of Anesthesiologists.

Conflict of interest disclosures

Daniel M. Morgan receives salary support for his role as a Director within the Michigan Value Collaborative (MVC) from the Value Partnerships program of Blue Cross and Blue Shield of Michigan (BCBSM) and Blue Care Network. Although BCBSM works collaboratively with the MVC, the opinions, beliefs, and viewpoints expressed do not necessarily reflect those of BCBSM or any of its employees. The remaining authors have no conflicts of interest to report.

Author contributions

CP: Study conception and design; analysis and interpretation of data; drafting of manuscript; critical revision.

NK: Acquisition of data; analysis and interpretation of data; drafting of manuscript; critical revision.

DM: Critical revision.

RS: Critical revision.

SU: Acquisition of data; analysis and interpretation of data; critical revision.

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