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Variability in Synoptic Reporting of Colorectal Cancer pT4a Category and Lymphovascular Invasion

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• Context.—Serosal involvement (pT4a category) and lymphovascular invasion have prognostic significance in colorectal carcinoma, but are subject to interobserver variation in assessment.

Objectives.—To provide the first large-scale assessment of interobserver variability in pT4a category and lymphovascular invasion reporting in real-world practice and to explore the impact of information from guidelines on variability in reporting these features.

Design.—Analysis of 1555 consecutive synoptic reports of colorectal carcinoma was performed using multivariate logistic regression. Interobserver variability before and after the presentation of guideline information was assessed using an image-based survey.

Results.—Significant differences in the odds of reporting pT4a versus pT3 category, detecting lymphovascular invasion of any type, and detecting large vessel invasion were identified among hospital sites and for individual pathologists compared with the median pathologist at the same site. Consistent with these results, interobserver agreement was only moderate in the image-based survey regarding T4a staging and lymphovascular invasion (all \( \kappa \leq 0.57 \)). The provision of information from guidelines did not tend to increase interobserver agreement in the survey, though responses in favor of using an elastic stain increased following recommendations for their use. However, when observers were provided with elastic-stained images, interobserver agreement remained only moderate (\( \kappa = 0.55 \)).

Conclusions.—Real-world reporting of pT4a category and lymphovascular invasion shows substantial variability at both local and regional levels. Our study underscores the need to address these features in quality initiatives, and provides a novel method through which existing synoptic data can be harnessed to monitor reporting patterns and provide individualized feedback.

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Accurate clinical prognostication relies on practices in pathology that are consistent with those used in prognostic marker studies. Improving consistency of interpretation and reporting in pathology is therefore a key component of quality initiatives. The widespread adoption of synoptic reporting has improved report completeness and produced more consistent use of terminology,1,2 but questions remain as to how synoptic reporting data can most effectively be used to monitor trends in reporting and provide feedback for individual pathologists. As synoptic reporting systems provide easily compiled, large sample sizes of real-world data with minimal response bias, developing robust statistical analyses for synoptic data has practical appeal. However, statistical analysis of synoptic data on the scale of individual pathologists or hospital sites has typically been limited to elements with well-defined thresholds for adequacy (eg, whether lymph node retrieval was adequate3,4).

Features of prognostic significance are of particular interest for quality initiatives, given their potential implications for patient management. Among the prognostic features identified for colorectal carcinoma are pT3 versus pT4a category (distinguished by invasion through the visceral peritoneum in pT4a)5,6 and lymphovascular invasion (LVI).7,8 Lymphovascular invasion can be subdivided into small vessel invasion, intramural large vessel invasion, and extramural large vessel invasion. Extramural large vessel invasion is an independent adverse prognostic factor associated with risk of visceral metastases,6,9,10 whereas lymphatic vessel invasion has been associated with increased risk of lymph node involvement.10

Surveys have identified substantial variability in the criteria used to define pT4a category disease and LVI.11-14 However, the impact of this disagreement on variability in daily practice remains unclear, as contentious cases comprise an unknown proportion of real-world cases. Although rates of pT4a category disease and LVI are expected to vary between sites, further work is needed to understand what proportion of this variability is attributable to differences in...
interpretation by pathologists rather than differences in case characteristics.

Through a novel approach to synoptic data analysis, we provide the first large-scale study of the variability of pT4a versus pT3 category reporting, LVI detection, and large vessel invasion detection in real-world practice. We used an image-based survey to validate the presence of substantial interobserver disagreement among pathologists in our region and assess whether information from guidelines could influence reporting variability.

**MATERIALS AND METHODS**

Anonymized data from synoptic reports was received from British Columbia’s Synoptic Reporting Central Data Repository, following approval by the Synoptic Reporting Advisory Committee. All colorectal cancer synoptic data from January 2018 to June 2019 were available for 3 of 5 health authorities in British Columbia, Canada. Odds ratios were calculated using univariate or multivariate logistic regression. Comparisons with case volume used 2-tailed unpaired t-tests, assuming unequal variance if an F test P < .05. Statistical significance was defined as P < .05.

For analysis of T4a versus pT3 staging, tumors entirely below the anterior peritoneal reflection or resected with transanal minimally invasive or microsurgery procedures were excluded, as pT4a would not be possible. In 5 cases reported by 5 different pathologists, the tumor was categorized as pT4a despite being reported as entirely below the anterior peritoneal reflection. Tumors with macroscopic tumor perforation were also excluded, as pT3 would be unlikely. For analysis of LVI reporting, we excluded cases in which LVI could not be determined, transanal minimally invasive or microsurgery cases, and pTx, pTis, and pT0 cases. Analysis of large vessel invasion used cases from the LVI analysis, but also excluded cases that had neither large nor small vessel invasion specified. This exclusion was intended to reduce the impact of nonreporting on the data. We analyzed data from pathologists who reported at least 5 cases fitting the above criteria and who worked at sites with at least 2 included pathologists.

Pathologists across British Columbia were invited to participate in an online survey containing images from the archives of the Vancouver General Hospital pathology department and colleagues’ teaching files. Excerpts from the College of American Pathologists’ Cancer Protocol Template for Colon and Rectum were included at the midpoint of the survey. These excerpts indicated that tumor cells continuous with the serosal surface through inflammation are categorized as pT4a, and that large and small vessel invasion are distinguished by the presence of a smooth muscle layer or elastic lamina only in the former. The guideline excerpts also noted that venous invasion is extramural if it extends beyond the muscularis propria, that a circumscribed tumor nodule surrounded by elastic lamina is reported as large vessel invasion, and that elastic staining could increase identification of large vessel invasion.

A standard diagnosis for each image in the survey was determined by the consensus of 2 subspecialty-trained gastrointestinal pathologists and supported by a third pathologist prior to survey release. The images were selected by the subspecialty pathologists with the intention of providing good examples of the diagnoses. The survey contained 5 pT3 or pT4a cases (2 before and 3 after guideline presentation) and 4 cases with a standard diagnosis of extramural large vessel invasion (2 before and 2 after guideline presentation). For the large vessel invasion cases, hematoxylin-eosin images (at ×20 and ×100) were classified by participants, who were then asked to classify either elastic- or Movat-stained images (at ×20 and ×100) of the same area. During the guideline information component, the standard diagnoses for images from the preceding questions were revealed. Fleiss κ statistics were used to assess interobserver variability, with values 0.21 to 0.4 considered fair, 0.41 to 0.60 considered moderate, 0.61 to 0.80 considered substantial, and 0.81 or higher considered excellent agreement. We calculated that 50 respondents per study would have a power of at least 0.94 to detect a 0.05 difference in κ (assuming SD of 0.1 and α of .05). Statistical analysis was performed using RStudio version 1.2.1335.

**RESULTS**

Synoptic reporting data from 93 pathologists at 14 hospital sites on 1555 consecutive cases of colorectal cancer in an 18-month period were available for analysis (tumor characteristics summarized in Table 1). A median of 15 cases per pathologist (range, 1–43 cases) were reported by a median of 6 pathologists per site (range, 1–18 cases). The synoptic reporting system allowed optional reporting of whether LVI involved large or small vessels. Neither large nor small vessel invasion was specified in 111 of the 541 LVI-positive cases (21%) (Figure 1, A). Only 47 of 85 pathologists (55%) specified large or small vessel invasion for all LVI-positive cases (Figure 1, B). Pathologists who never reported vessel size had a significantly lower number of colorectal cancer cases (mean, 3.1 cases/pathologist) than pathologists who reported vessel size in at least 1 case (mean, 6.8 cases/pathologist; P = .001).

We sought to analyze variability in the reporting of 3 prognostically significant elements: pT4a versus pT3 category, LVI (of any type), and large vessel invasion. Following the exclusion criteria detailed above (see Materials and Methods), the pT3 versus pT4a staging analysis included a total of 852 cases (620 pT3 and 232 pT4a), the LVI analysis included a total of 1458 cases (524 with LVI present and 934 without LVI), and the large vessel invasion analysis included 322 cases (184 with large vessel invasion identified and 138 without large vessel invasion). The proportion of cases reported as pT4 varied greatly among pathologists and sites (Figure 1, C), as did the proportion of cases reported to have LVI (Figure 1, D) or large vessel invasion (Figure 1, E).

Univariate logistic regression showed associations between pT4a category, LVI, large vessel invasion, and other tumor characteristics (Table 2). To assess whether differences in reporting between sites were independent of the variables in Table 2, we used multivariate logistic regression. Adjusted odds ratios for pT4a versus pT3 category relative to the site with the median odds ratio ranged from 0.40 to 2.00 (Figure 2, A). The same analysis produced odds ratios ranging from 0.38 to 6.60 for LVI being identified versus not identified (Figure 2, B), and ranging from 0.36 to 6.24 for large vessel invasion being identified versus not identified (Figure 2, C). For all 3 analyses there were statistically significant differences in the odds ratio for multiple sites compared with the median site (P as low as .004 for pT4a, <.001 for LVI, and .015 for large vessel invasion). Sites with an odds ratio significantly greater than the reference site for LVI or large vessel invasion had significantly more cases per site (P = .04 for LVI, P = .04 for large vessel invasion). Site A, which had the greatest number of cases and the third greatest number of pathologists, had odds ratios significantly different from the reference site in all 3 analyses.

When adjusted odds ratios were calculated for the reporting of pT1 versus pT2, pT2 versus pT3, and pT3 versus pT4b category cases at each site (excluding transanal minimally invasive or microsurgery cases and adjusting for the same variables as in the above pT4a analysis), there were no significant differences among sites (lowest P = .07). This result is consistent with the notion that pT3 versus pT4a staging is more variable than staging across other pT thresholds. Similarly, the odds of small vessel invasion being reported (using the same exclusions and adjusting for the same variables as in the above large vessel invasion analysis)
did not significantly differ among sites (lowest \( P = .54 \)), consistent with greater variability in large than small vessel invasion identification.

We then assessed whether significant differences in reporting were detectable among individual pathologists within the same site, using adjusted odds ratios relative to the pathologist at the same site who had the median odds ratio. An odds ratio was calculated for all pathologists with at least 1 positive and 1 negative case for the feature of interest. Odds ratios ranged from 0.058 to 7.69 for \( pT4a \) versus \( T3 \) (Figure 3, A), from 0.085 to 13.28 for LVI identification (Figure 3, B), and from 0.0077 to 35.60 for large vessel invasion identification (Figure 3, C). Significant differences (uncorrected for multiple testing) were detected among pathologists for all 3 analyses (\( P \) as low as .04 for \( pT4a \), .002 for LVI, and .008 for large vessel invasion). After multiple testing correction (Benjamini-Hochberg), only differences in odds ratios for LVI were significant, at a false discovery rate of 0.20. No associations were evident between the number of cases per pathologist and odds ratio (Figure 3).

We sought to validate our observations regarding variability in reporting by asking pathologists (\( n = 50 \) for \( pT \) staging, \( n = 48 \) for LVI assessment) to evaluate a set of images in an online survey. Information from guidelines was presented midway through the survey, allowing assessment of the variability that persisted after this intervention. For \( pT3 \) or \( pT4a \) classification, interobserver agreement was only moderate both before and after guidelines were presented (\( \kappa = 0.47 \) and 0.51, respectively; Table 3; Figure 4, A through C). For LVI identification, we included in the presented guidelines a recommendation that elastic staining may be of

### Table 1. Characteristics of Colorectal Carcinomas With Available Synoptic Reporting Data

| Characteristic                        | Reported As                                      | No. of Cases | % of All Cases |
|--------------------------------------|--------------------------------------------------|--------------|----------------|
| **pT category**                      |                                                  |              |                |
| \( pT0 \) or \( pTis \)              |                                                  | 19           | 1              |
| \( pT1 \)                            |                                                  | 127          | 8              |
| \( pT2 \)                            |                                                  | 271          | 17             |
| \( pT3 \)                            |                                                  | 766          | 49             |
| \( pT4a \)                           |                                                  | 289          | 19             |
| \( pT4b \)                           |                                                  | 72           | 5              |
| \( pTX \)                            |                                                  | 11           | 1              |
| **Lymphovascular invasion**          |                                                  |              |                |
| Present                              |                                                  | 541          | 35             |
| Not identified                       |                                                  | 986          | 63             |
| Cannot be determined                 |                                                  | 28           | 2              |
| **Grade**                            |                                                  |              |                |
| Low-grade (well to moderately differentiated) |                                              | 1330         | 85             |
| High-grade (poorly differentiated to undifferentiated) |                                  | 151          | 10             |
| Cannot be assessed, other or not applicable |                                          | 74           | 5              |
| **pN category**                      |                                                  |              |                |
| \( pN0 \)                            |                                                  | 858          | 55             |
| \( pN1 \)                            |                                                  | 443          | 28             |
| \( pN2 \)                            |                                                  | 230          | 15             |
| \( pNX \)                            |                                                  | 24           | 2              |
| **Tumor size, cm**                   |                                                  |              |                |
| \( \leq 4.0 \)                        |                                                  | 905          | 58             |
| \( >4.0 \)                           |                                                  | 623          | 40             |
| Cannot be determined/not reported    |                                                  | 27           | 2              |
| **Procedure**                        |                                                  |              |                |
| Right hemicolectomy                  |                                                  | 621          | 40             |
| Transverse colectomy                 |                                                  | 18           | 1              |
| Left hemicolectomy                   |                                                  | 62           | 4              |
| Sigmoidectomy                        |                                                  | 170          | 11             |
| Low anterior resection               |                                                  | 292          | 19             |
| Abdominoperineal resection           |                                                  | 97           | 6              |
| Total colectomy                      |                                                  | 16           | 1              |
| Transanal minimally invasive or microsurgery |                              | 26           | 2              |
| Other/not specified                  |                                                  | 253          | 16             |
| **Location**                         |                                                  |              |                |
| Entirely above anterior peritoneal reflection |                                | 92           | 6              |
| Straddles anterior peritoneal reflection |                                    | 63           | 4              |
| Entirely below anterior peritoneal reflection |                                | 151          | 10             |
| Not specified                        |                                                  | 1249         | 80             |
| **Macroscopic tumor perforation**    |                                                  |              |                |
| Present                              |                                                  | 80           | 5              |
| Not identified                       |                                                  | 1433         | 92             |
| Cannot be determined/not reported    |                                                  | 42           | 3              |
| **Histologic type**                  |                                                  |              |                |
| Adenocarcinoma not otherwise specified |                                        | 1375         | 88             |
| Mucinous adenocarcinoma              |                                                  | 109          | 7              |
| Signet ring cell carcinoma           |                                                  | 10           | 1              |
| Medullary carcinoma                  |                                                  | 8            | 1              |
| Other                                |                                                  | 31           | 2              |
| No residual tumor                    |                                                  | 22           | 1              |
use in confirming large vessel invasion. Prior to guideline presentation, only 32% of pathologists requested an elastic stain to confirm large vessel invasion when presented with a hematoxylin-eosin image that, according to expert consensus, included an area of large vessel invasion. The pathologists not requesting an elastic stain showed considerable variation in responses (Table 4; Figure 4, D through I). Following guideline presentation, 66% of pathologists requested an elastic stain and 90% of the remaining pathologists agreed that the image showed extramural large vessel invasion.

When provided with an elastic-stained image, interobserver agreement for the presence of LVI (of any kind) was substantial but not excellent, both before and after guideline presentation ($\kappa = 0.78$ and 0.75, respectively; Table 4; Figure 4, F and I). Interobserver agreement regarding the presence specifically of extramural large vessel invasion was only moderate before guideline presentation ($\kappa = 0.55$) and was
slightly improved after guideline presentation ($k = 0.65$; Table 4). Most respondents (63%) reported using an elastic stain in less than 20% of their own colorectal cancer cases prior to the survey, whereas only 8% had used an elastic stain in more than 80% of their colorectal cancer cases.

**DISCUSSION**

We demonstrate a novel method of harnessing preexisting synoptic reporting data to assess the extent of variability in clinical practice. We used this method to profile for the first time the degree of variability in pT4a and LVI reporting in a large-scale study of real-world practice. Significant variability in the odds of reporting these features was evident even after adjustment for differences in other tumor characteristics. Although comparisons between sites may be confounded by differences in case characteristics, variability persisted in analyses among pathologists within the same site. As cases are typically randomly divided among pathologists within a site, these data are likely reflective of individual differences in interpretation, though it is recognized that some sites may assign more complex cases to subspecialized pathologists. Consistent with the synoptic data, the survey results demonstrated substantial interobserver variability.

Variability in pT4a staging may relate to differences in the criteria used by different pathologists. In a prior survey, only 51% of pathologists agreed with the College of American Pathologists guidelines that tumor communicating with the serosa through inflammation constituted pT4a disease. Granulation tissue was considered equivalent to inflammation when assessing pT4a category by 42% of pathologists. In light of evidence that tumor less than 1 mm from the serosal surface may be associated with increased risk of peritoneal recurrence, tumor within 1 mm of serosa may be seen by some pathologists as sufficient for pT4a categorization. Indeed, 53% of surveyed pathologists would provide a comment about higher risk of peritoneal recurrence for tumor less than 1 mm from serosal surface that did not involve serosa.

To our knowledge, the impact of this disagreement on a large series of consecutive real-world cases has not previously been assessed. The variability we find in real-world detection rates may be contributed to by differences in the criteria used and differences in the number of tumor blocks and levels examined. The vast majority of sites in British Columbia do not have pathologists’ assistants to gross specimens, and therefore grossing is pathologist dependent. We also note that whereas the median reported

**Table 2. Association of Tumor Characteristics With Features of Interest**

| Feature                | pT4a Versus pT3 Analysis | Lymphovascular Invasion Present Versus Not Identified | Large Vessel Invasion Present Versus Not Reported Among Lymphovascular Invasion–Positive Cases |
|------------------------|--------------------------|------------------------------------------------------|------------------------------------------------------------------------------------------|
|                        | Odds Ratio (95% CI) P    | Odds Ratio (95% CI) P                                | Odds Ratio (95% CI) P                                                                      |
| pT category            | NA                       | 2.35 (2.06–2.71) <.001                               | 1.16 (.86–1.56) .32                                                                      |
| Lymphovascular invasion| 2.25 (1.64–3.08) <.001   | NA                                                   | NA                                                                                       |
| High grade             | 1.35 (.86–2.11) .20      | 3.87 (2.70–5.54) <.001                               | 0.45 (0.25–0.81) .008                                                                    |
| pN category            | 3.80 (2.71–5.33) <.001   | 2.00 (1.84–2.18) <.001                               | .98 (.87–1.11) .74                                                                       |
| Tumor size >4 cm       | 1.20 (0.88–1.63) .25     | 2.02 (1.62–2.52) <.001                               | 1.07 (0.68–1.67) .78                                                                     |

Abbreviation: NA, not applicable.

* Odds ratios were calculated using univariate logistic regression.

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**Figure 2.** Odds ratios for reporting of pT4a versus pT3 category (A), the presence of lymphovascular invasion (LVI) (B), and the presence of large vessel invasion (C) at each site compared with the median odds ratio. Odds ratios were calculated using multivariate logistic regression adjusted for the variables in Table 2. Error bars represent 95% CI. P was calculated compared with the reference site. Bar plots indicate the number of cases analyzed for each site.
Figure 3. Odds ratios for reporting of pT4a versus pT3 category (A), the presence of lymphovascular invasion (LVI) (B), and the presence of large vessel invasion (C) for each pathologist, compared with a reference pathologist with the median odds ratio at the same site. The reference pathologists are not shown, as their odds ratios were set to a value of 1. Odds ratios were calculated using multivariate logistic regression adjusted for the variables in Table 2. Error bars represent 95% CI. *P < .05

*false discovery rate ≤ .20

Bar plots indicate the number of cases analyzed for each site.
incidence may not be the most accurate reflection of the true incidence, comparison with the median may be useful to guide further investigation, such as an investigation of blocks submitted per case. The true incidence of pT4a category disease may tend to be greater than that reported, as tumor has been detected in serosal scraping cytology specimens from patients reported on histologic sections to have only pT3 disease.16–18

| Assessment                  | Proportion of Responses in Agreement With a Standard Diagnosis of T3, No./Total (%) | Proportion of Responses in Agreement With a Standard Diagnosis of T4a, No./Total (%) | Overall Proportion of Responses Agreeing With Standard Diagnosis, No./Total (%) | \( \kappa \) Statistic (95% CI) |
|-----------------------------|---------------------------------------------------------------------------------|-----------------------------------------------------------------------------------|---------------------------------------------------------------------------------|--------------------------------|
| Pretest                     | 49/50 (98)                                                                      | 34/50 (68)                                                                        | 83/100 (83)                                                                     | 0.47 (0.43–0.51)               |
| Posttest                    | 42/50 (84)                                                                      | 89/100 (89)                                                                       | 131/150 (87)                                                                    | 0.51 (0.48–0.54)               |
| Combined pretest and posttest| 91/100 (91)                                                                      | 123/150 (82)                                                                      | 214/250 (86)                                                                    | 0.54 (0.51–0.56)               |

* Each participant’s response to each question was counted as a separate response. The same 50 participants completed the pretest (before receiving information from guidelines) and the posttest (after receiving information from guidelines).

Figure 4. Representative images from the survey. A, For this image, 84% of survey respondents agreed with a standard interpretation of pT3. B and C, For these images, 86% and 92% of respondents agreed with a standard interpretation of pT4a. The images in A through C were presented after guideline information. D and E, When asked about lymphovascular invasion (LVI), 42% of respondents requested an elastic stain on the area, whereas 36% reported extramural large vessel, 14% considered the area negative for LVI, 6% reported intramural large vessel invasion, and 2% could not determine LVI. F, When given an elastic-stained image of the same area, 74% of respondents reported extramural large vessel invasion, 10% reported intramural large vessel invasion, 10% considered the area negative for LVI, and 6% could not determine if LVI was present. G and H, For a separate case, 22% of respondents requested an elastic stain on the area, whereas 47% reported extramural large vessel invasion, 22% reported small vessel invasion, 6% considered the area negative for LVI, and 2% reported intramural large vessel invasion. I, When given an elastic-stained image of the same area, 71% of respondents reported extramural large vessel invasion, 18% reported small vessel invasion, 8% considered the area negative for LVI, and 2% reported intramural large vessel invasion. The images in D through H had a standard interpretation of extramural large vessel invasion and were presented prior to guideline information (hematoxylin-eosin, original magnifications ×100 [A through C, E, and H] and ×20 [D and G]; elastic stain, original magnification ×100 [F and I]).
Widespread underreporting has also been postulated for venous invasion. European guidelines indicate that extramural large vessel invasion is expected in at least 25% of resections, a threshold reached by 7% of the pathologists for whom we assessed large vessel invasion. In prior studies, the incidence of large vessel invasion ranged from 9% to 25%, though the extent to which differences in detection rates were due to differences in tumor characteristics remained unclear. Our study includes multivariate analysis adjusting for other tumor characteristics, and supports the notion that variable detection rates are contributed to by differences in individual pathologists’ practices. The number of tumor sections examined, whether elastic stains are used, and whether stains are ordered upfront or at a later time may all contribute to variability. Interestingly, we found LVI and large vessel invasion to be more frequently reported at larger centers. We suspect this may be due in part to greater numbers of subspecialty-trained pathologists at larger centers, as in smaller studies gastrointestinal subspecialization has been correlated with more frequent reports of venous invasion.

Greater venous invasion detection has also been associated with the use of elastic stains, and therefore we anticipated greater agreement regarding the presence of venous invasion on elastic-stained images than on hematoxylin-eosin images. We present the novel finding that agreement with the standard diagnosis remained only moderate on elastic images, with no improvement in agreement compared with hematoxylin-eosin. The limited interpretation has been correlated with more frequent reports of venous invasion. European guidelines indicate that venous invasion. 1%4,21,22

Our novel approach to the analysis of staging and LVI variability in synoptic report data could be used to provide feedback to individual pathologists or to track changes in reporting patterns over time without requiring manual report auditing. This methodology may also be adapted to other tumor types. We note that odds ratio analysis may underestimate the extent of variability, as finite odds ratios cannot be calculated for pathologists who always or never report the feature of interest. Nonetheless, the use of multivariate logistic regression rather than raw incidence estimates may be due in part to difficulty recognizing the attenuated elastic lamina, as agreement increased slightly after example interpretations were provided. Sixty-three percent of the surveyed pathologists indicated that they rarely used elastic stains for LVI identification, such that limited familiarity with the interpretation of elastic-stained images may be a barrier to effective use. These findings regarding variability in interpreting elastic stains are likely widely generalizable, as the routine use of elastic stains appears uncommon across North America (eg, routinely used by only 7% of pathologists in one prior survey).

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types of LVI. As extramural large vessel invasion has unique prognostic significance but was inconsistently specified in reports, it may be advisable to change the specification of vessel size and location to mandatory fields. Automatic notifications when contradictory synoptic report elements are entered (eg, pT4a category for a tumor entirely below the anterior peritoneal reflection) may also improve consistency.

We note that comparisons of interobserver variability before versus after the educational component of our survey are limited by differences in the particular cases presented in each component. Nonetheless, our data demonstrate that for at least some cases considerable variability remained present after the educational intervention. We surveyed a large number of pathologists regarding a small number of images, such that our survey provides examples of the breadth of variability in pathologists’ interpretations, but not the extent of variation across a wide range of cases. Variation across many cases is instead captured in our synoptic data analysis.

We demonstrate for the first time the extent of variability in pT4a staging, LVI detection, and large vessel invasion detection in a large-scale study of real-world practice, with significant differences identified between individual pathologists and hospital sites. Our study highlights pT4a staging and large vessel invasion as features to target in future quality initiatives and presents a novel use of synoptic data for robust quality assessment.

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