

# Glove and instrument changing to prevent tumour seeding in cancer surgery: a survey of surgeons' beliefs and practices

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## ABSTRACT

**Background** Some surgeons change gloves and instruments after the extirpative phase of cancer surgery with the intent of reducing the risk of local and wound recurrence. Although this practice is conceptually appealing, the evidence that gloves or instruments act as vectors of cancer-cell seeding in the clinical setting is weak. To determine the potential effect of further investigation of this question, we surveyed the practices and beliefs of a broad spectrum of surgeons who operate on cancer patients.

**Methods** Using a modified Dillman approach, a survey was mailed to all 945 general surgeons listed in the College of Physicians and Surgeons of Ontario public registry. The survey consisted of multiple-choice and free-text response questions. Responses were tabulated and grouped into themes, including specific intraoperative events and surgeon training. Predictive variables were analyzed by chi-square test.

**Results** Of 459 surveys returned (adjusted response rate: 46%), 351 met the inclusion criteria for retention. Of those respondents, 52% reported that they change gloves during cancer resections with the intent of decreasing the risk of tumour seeding, and 40%, that they change instruments for that purpose. The proportion of respondents indicating that they take measures to protect the wound was 73% for laparoscopic cancer resections and 31% for open resections. Training and years in practice predicted some of the foregoing behaviours. The most commonly cited basis for adopting specific strategies to prevent tumour seeding was "gut feeling," followed by clinical training. Most respondents believe that it is possible or probable that surgical gloves or instruments harbour malignant cells, but that a cancer recurrence proceeding from that situation is unlikely.

**Conclusions** There is no consensus on how gloves and instruments should be handled in cancer operations. Further investigation is warranted.

**Key Words** Tumour seeding, cancer recurrence, wound protection, surgical gloves, surgical instruments

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## INTRODUCTION

Tumour cell implantation at a site remote from the primary tumour can occur during cancer surgery<sup>1-3</sup>. Tumour cells circulating through the blood or lymph system represent one potential source of metastasis<sup>4-6</sup>. Surgical gloves and instruments have also been implicated as vectors that can directly transplant malignant cells to the tumour bed and surgical wound, potentially predisposing the patient to recurrence at those sites. Significant interest in the mechanisms of wound recurrence arose in the 1990s when

laparoscopic techniques in cancer surgery were associated with cases of port-site metastases. For some cancer types, the incidence of port-site metastases was estimated to be 14%–30%<sup>7</sup>. Authors have, in the past, recommended that surgeons change gloves and instruments when changing anatomic fields to prevent such implantation, a recommendation that is based on limited and indirect evidence<sup>8,9</sup>. For example, in porcine models, cancer cells have been identified on surgical instruments used during visceral manipulation after prior intraperitoneal injection of malignant cells<sup>10,11</sup>. Furthermore, malignant cells have been

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identified in washings from gloves and instruments used during resection of upper aerodigestive squamous cell and basal cell cancers in human patients<sup>9,12</sup>. At present, no available literature indicates whether cancer cells are present on the gloves or instruments used during margin-negative resection of other cancer types. In addition, no published evidence has indicated that cells retained on gloves and instruments can cause tumour seeding and recurrence.

Despite the lack of an evidentiary basis for changing gloves and instruments, empiric observation suggests that some surgeons change gloves or instruments, or both, as a routine component of extirpative cancer surgery; others do not. To date, there has been no published examination of the practices and beliefs held by surgeons about glove and instrument handling and wound protection as they relate to the prevention of cancer-cell seeding. The objective of the present study was to investigate how surgeons handle gloves and instruments in cancer resections, the strategies they use to prevent tumour seeding, and whether they believe that gloves and instruments are potential vectors that contribute to tumour seeding. We also aimed to identify potential opportunities for, and barriers to, guideline development and implementation.

## METHODS

A survey was developed and pilot-tested on 8 individual surgeons. After a process of iterative modification, the final survey consisted of 18 questions (some with multiple sub-questions). Including the sub-questions, there were 16 multiple-choice questions and 6 free-text response questions (supplemental Figure 1). Free-text response questions were used to elicit responses that the study team had not considered *a priori*, to lessen the risk of social desirability bias, and to expand on responses to the multiple-choice questions.

Using a modified Dillman approach<sup>13</sup>, the survey was mailed to all general surgeons listed in the public registry provided by the College of Physicians and Surgeons of Ontario. Surgeons in Ontario are required to be registered with the College to have a hospital-based practice. Ontario, which is Canada's most populous province<sup>14</sup>, has a population of 13 million (38.5% of Canadians). The decision for a single mailing or multiple mailings was based on whether thematic saturation was reached.

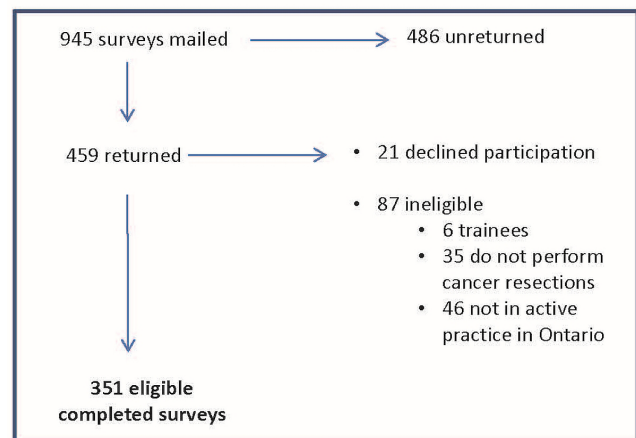
Survey packages consisted of a signed cover letter explaining the purpose of the study and consent to participate, the survey, and a pre-stamped return envelope with our office address for survey responses. Respondents also had the option to return the survey by fax.

The responses were used to assess respondents for inclusion criteria, which were these:

- Is a staff surgeon
- Carries out oncologic resections
- Is in active practice
- Has a practice address in Ontario

The study was approved by the Research Ethics Board of Sinai Health System, Toronto, Ontario, and all participants provided informed consent.

## Survey response among CPSO members



**FIGURE 1** Flowchart of survey distribution and response rate. American Association for Public Opinion Research response rate: 46%. CPSO = College of Physicians and Surgeons of Ontario.

Responses from multiple-choice questions were tabulated and reported. Responses from free-text questions were grouped into themes. Where respondents reported more than one circumstance in which they change gloves or instruments to minimize the chance of wound seeding, a score was recorded for each of the indicated three categories. Descriptive statistics are presented as percentages and frequencies. Chi-square tests of association were used to compare categorical variables and the paired t-test was used for continuous variables in the IBM SPSS Statistics software application (version 23; IBM, Armonk, NY, U.S.A.).

*A priori*, we hypothesized that number of years in practice, type of practice (academic vs. community), volume of cancer cases, surgeon sex, and cancer-specific fellowship training would be predictors of surgeon behaviours with respect to glove changing, instrument changing, and use of wound protectors. Cancer-specific fellowship training was categorized into three groups:

- General surgical oncology or breast, or both
- Site-specific surgical oncology—one or more of colorectal, thoracic, hepatopancreatobiliary, or endocrine, with or without other additional fellowships—not including general surgical oncology or breast
- No oncology-related fellowship training (vascular surgery, minimally invasive surgery, acute-care surgery, trauma, pediatrics, or none)

These potential predictors of surgeon behaviour were compared using Pearson chi-square analysis and *post hoc* pairwise comparisons with adjusted residual in the IBM SPSS Statistics software application (version 23). Statistical significance was set at  $p < 0.05$  for chi-square and adjusted residual greater than 2.

## RESULTS

The survey was mailed to 945 surgeons on 1 May 2015, and no further responses were received after 31 August 2015.

Of the 459 surveys returned, 351 had been completed by surgeons who met the eligibility criteria, 21 declined participation, and 87 were returned by surgeons who were ineligible based on our predetermined exclusion criteria (6 were trainees, 35 didn't perform cancer resections, and 46 were not in active practice in Ontario; Figure 1). The American Association for Public Opinion Research method was used to estimate ineligible nonrespondents, yielding an adjusted response rate of 46%<sup>15</sup>.

### Surgeon Demographics and Clinical Practice

Only the responses of the 351 eligible respondents were included in the analysis. The study cohort was 76% male, and median time since graduation from general surgery residency training was 14 years (range: 1–56 years; Table 1). In terms of practice, 208 (60%) had been practising general surgery for more than 10 years, and 76 (22%) had been in practice for fewer than 5 years. Primary practice site was described as an academic health sciences centre by 118 respondents (34%), a community centre with university affiliation by 156 (45%), and a community hospital by 74 (21%).

Of the 344 respondents who replied to a query about training after general surgery residency, 120 (34%) said that they had not completed any fellowship, and 224 indicated completing a total of 320 fellowships (range per surgeon: 1–7 fellowships). The most common fellowships were surgical oncology ( $n = 51$ , 15%), minimally invasive surgery ( $n = 49$ , 14%), colorectal ( $n = 32$ , 9%), hepatopancreatobiliary ( $n = 30$ , 9%), thoracic ( $n = 28$ , 8%), critical care ( $n = 26$ , 7%), and trauma ( $n = 23$ , 7%). Fellowships in breast surgery, pediatric surgery, transplantation, acute-care surgery, vascular surgery, community general surgery, and endocrine surgery were each reported by fewer than 3% of respondents.

About half the respondents reported that cancer cases constituted less than 30% of their practice volume, and about one fifth indicated dedicating more than 70% of their clinical activity to cancer care. A broad range of solid tumour types were managed by the surgeons in the study cohort, most notably colorectal cancer (80% of respondents), breast cancer (55%), and gastric cancer (30%). Esophageal, adrenal, and lung cancers, as well as sarcoma, were each treated by fewer than 10% of respondents (Table 1).

We compared eligible respondents with ineligible respondents and nonrespondents with respect to the two demographic characteristics that were publicly available for the latter two groups (Table 1). The proportion of women was higher (24% vs. 18%, chi-square  $p = 0.02$ ) and the period since graduation from general surgery training was shorter (median: 14 years vs. 18 years,  $p < 0.0001$ ) in the eligible respondent group than in the other two groups taken together.

### Protective Behaviours to Reduce the Risk of Tumour Seeding

#### *Prevalence and Indications for Glove and Instrument Changing to Reduce the Risk of Tumour Seeding (Self-Reported)*

Of 349 respondents, 181 (52%) reported that they have changed gloves and 139 (40%), that they have changed

**TABLE 1** Respondent characteristics

Characteristic	Responders	Response
Sex [ $n$ (%)]	351	
Men		267 (76)
Women		84 (24)
Time since completion of general surgery training (years)	338	
Median		14
Range		1–56
Time in practice [ $n$ (%)]	348	
≤5 Years		76 (22)
6–10 Years		64 (18)
11–15 Years		60 (17)
>15 Years		148 (43)
Type of practice [ $n$ (%)]	348	
Academic health sciences centre		118 (34)
University-affiliated community centre		156 (45)
Community hospital		74 (21)
Clinical fellowship type [ $n$ (%)]	344	
None		120 (34)
Surgical oncology		51 (15)
Minimally invasive surgery		49 (14)
Colorectal		32 (9)
Hepatopancreatobiliary		30 (9)
Thoracic		28 (8)
Critical care		26 (7)
Trauma		23 (7)
Community general surgery		12 (3)
Transplant		11 (3)
Acute care surgery		11 (3)
Breast		10 (3)
Vascular		10 (3)
Pediatric		9 (3)
Endocrine		5 (1)
Other		13 (4)
Proportion of practice [ $n$ (%)] represented by cancer cases	344	
≤30%		180 (52)
31%–70%		102 (30)
>70%		62 (18)
Cancer sites treated in practice [ $n$ (%)]	351	
Colorectal		282 (80)
Breast		193 (55)
Gastric		107 (30)
Non-melanoma skin cancer		84 (24)
Melanoma		79 (23)
Neuroendocrine		78 (22)
Lymphoma		68 (19)

**TABLE I** Continued

Characteristic	Responders	Response
Cancer sites treated in practice [ <i>n</i> (%)]	351	
Continued		
Thyroid		44 (13)
Liver		37 (11)
Pancreatic		35 (10)
Esophageal		30 (9)
Lung		28 (8)
Sarcoma		26 (7)
Adrenal		17 (5)
Other		18 (5)

instruments intraoperatively with the intent of reducing the risk of tumour seeding (chi-square  $p \leq 0.01$  gloves vs. instruments; Table III).

When asked, in a free-text answer format without prompts, to describe the circumstance or circumstances for making glove changes, 178 respondents provided 222 reasons that could be grouped into 3 general categories: routine practice; suspected gross contamination by tumour; and discontinuous sites of operation. Routine glove changing was inferred from any response referring to glove changing that was not related to case-specific risk of tumour cell contamination or the presence of multiple incisions. Examples were before abdominal wall closure, after specimen extraction, and at prescribed time intervals during long cases. Contamination of gloves was felt to occur when tumour tissue had been directly handled, or when the tumour pseudocapsule was suspected to have been disrupted during dissection. Glove-changing in cases of locally advanced disease, perforated tumours, or threatened margins, and in cases in which the specimen was manipulated *ex vivo* on the back table after resection were also categorized as motivated by the occurrence of contamination. The third category, discontinuous sites of operation, refers to changing gloves when moving between surgical sites. Examples of discontinuous sites included moving from the breast cancer lumpectomy site to the axilla for sentinel node excision and raising a flap or harvesting a vessel for reconstruction from a remote site. Reasons that fit under each of the 3 categories (routine, contamination, and discontinuous sites) were cited by 49% ( $n = 87$ ), 46% ( $n = 82$ ), and 28% ( $n = 49$ ) of surgeons respectively; 2% of responses were not classifiable into any category (for example, specific tumour histology). With respect to instrument changes for the purpose of decreasing the risk for tumour seeding, 136 respondents provided 161 reasons that could be grouped into the same 3 categories: 16% ( $n = 22$ ) reported instrument changing as routine, 40% ( $n = 54$ ) make the change for contamination, and 58% ( $n = 79$ ) make the change for discontinuous sites; 4% of responses were unclassifiable.

### **Basis of the Decision to Change Gloves or Instruments**

Respondents who change gloves or instruments (or both) with the intent of decreasing the risk of tumour seeding

**TABLE II** Comparison of eligible respondents to nonrespondents or ineligible respondents

Variable	Respondent type		<i>p</i> Value
	Eligible	Others <sup>a</sup>	
Contactees ( <i>n</i> )	351	594	—
Sex [ <i>n</i> (%)]			0.02
Men	267 (76)	489 (82)	
Women	84 (24)	105 (18)	
Time since GS training (years)			<0.0001
Median	14	18	
Range	1–56	1–60	
Contactees ( <i>n</i> )	338	549	

<sup>a</sup> Nonrespondents ( $n = 507$ ) and ineligible respondents ( $n = 87$ ) grouped together.  
GS = general surgery residency training.

were queried about the basis of their decision to adopt the practice. This multiple choice question was answered by 199 surgeons who provided 273 responses overall (1–4 responses per respondent). The most commonly cited basis was “gut feeling” (58%), followed by clinical training (55%), and clinical observation (17%). Experimental evidence was cited as the basis for their practice by 4% and “other” by 3% (for example, “scrub nurse decision”; Table III).

### **Other Measures to Protect Wounds from Tumour Seeding**

We asked if measures other than glove and instrument changing were used specifically to protect surgical wounds from tumour seeding during cancer surgery. For laparoscopic procedures, 73% of respondents reported taking additional precautions; for open procedures, 31% reported such precautions ( $p \leq 0.01$ ).

Surgeons who take measures to protect wounds in laparoscopic surgery were asked to describe their practice in a free-text answer format. The 248 responses from 221 respondents were grouped into 6 broad categories: wound protector; barrier other than commercially available wound protector; irrigation; specific surgical technique; specimen retrieval bag; and use of trocars (for example, pulling the specimen into the trocar before removal, desufflating with trocars in place). Use of a wound protector to minimize wound seeding was described by 84%, and use of a retrieval bag, by 17%. Other wound protection strategies were used by fewer than 5% of respondents each.

Measures used to protect open wounds were grouped into 4 categories: wound protector; barrier other than commercially available wound protector; irrigation; and specific surgical technique. The most common among the 123 responses provided by 101 respondents were wound protectors (43%) and use of an alternative barrier (sterile towels, sponges, adhesive polyurethane film, and so on—44%). Use of irrigation (for example, saline, povidone iodine) and elements of surgical technique (for example, minimal tumour handling) were each cited by 15% of respondents (Table III).



**TABLE III** Self-reported use of protective behaviours to reduce the risk of tumour seeding

Behaviour	Responders	Response [n (%)]	
Strategies to prevent tumour seeding	349		
Change gloves		181 (52)	
Change instruments		139 (40)	
Circumstances for glove and instrument changing	178, 136	Gloves	Instruments
Routine		87 (49)	22 (16)
Contamination by tumour		82 (46)	54 (40)
Discontiguous sites of operation		49 (28)	79 (58)
Other		4 (2)	6 (4)
Basis of decision to adopt protective strategies	199		
Gut feeling		116 (58)	
Clinical training		110 (55)	
Clinical observation		33 (17)	
Experimental evidence		8 (4)	
Other		6 (3)	
Take additional precautions <sup>a</sup>	334, 315	Open	Laparoscopic
		105 (31)	229 (73)
		<i>p</i> <0.01 (laparoscopic vs. open)	
Strategies to protect wound <sup>a</sup>	101, 221	Open	Laparoscopic
Wound protector		43 (43)	186 (84)
Other barrier		44 (44)	2 (1)
Irrigation		17 (17)	1 (<1)
Surgical technique		17 (17)	0 (0)
Specimen retrieval bag		0 (0)	37 (17)
Specific manipulation of trocars		NA	6 (3)
Other		2 (2)	0 (0)

<sup>a</sup> To protect the wound from seeding, excluding glove or instrument changing.  
NA = not applicable.

### Surgeon Beliefs About the Role of Gloves and Instruments in Tumour Seeding

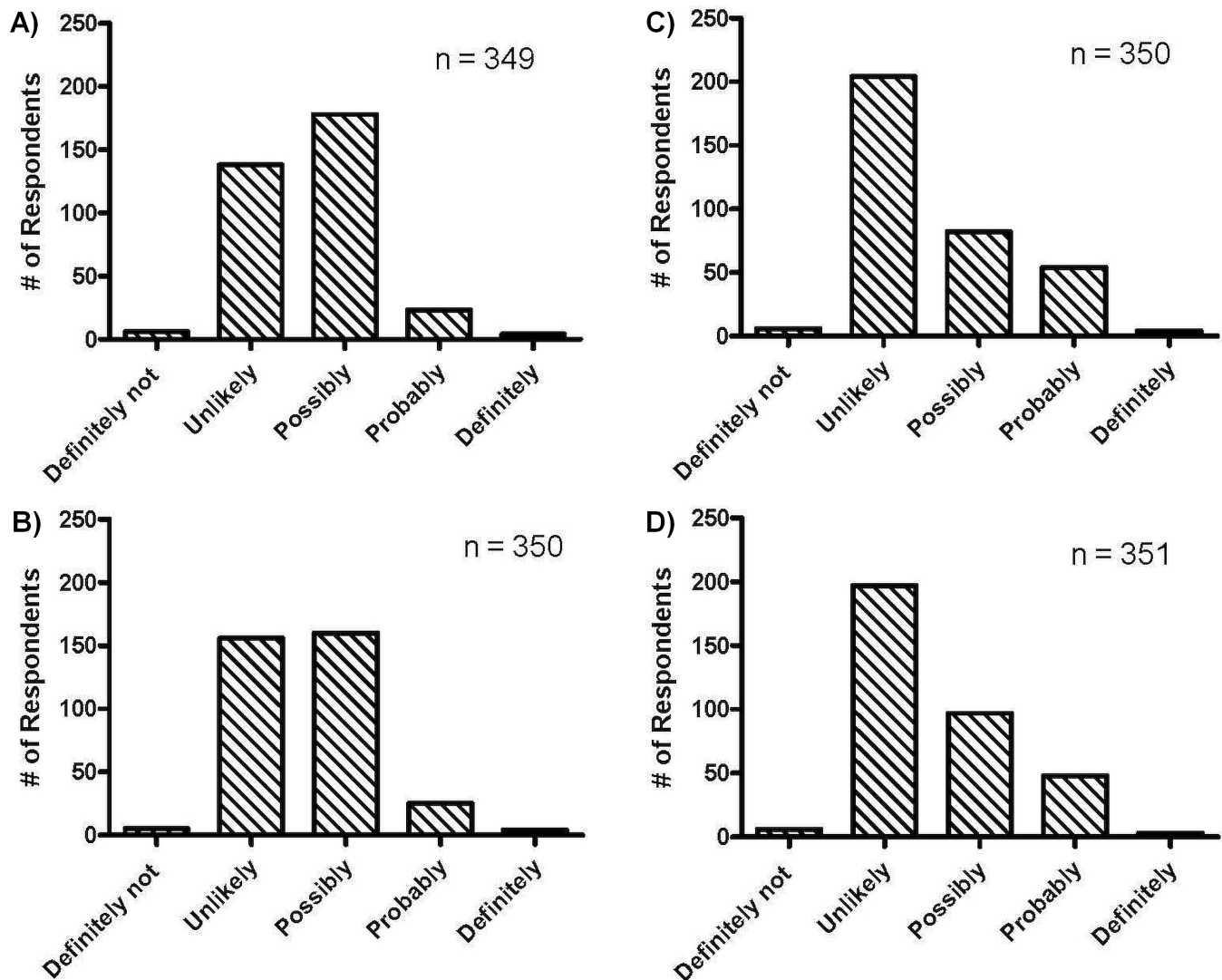
More than half the respondents (58%) believe that it is possible or probable that surgical gloves harbour malignant cells capable of seeding the tumour bed and surgical wound, and 53% believe the same of instruments [Figure 2(A,B)]. However, most felt it unlikely that cells seeded from gloves or instruments actually lead to locoregional or wound recurrence [Figure 2(C,D)]. Of responding surgeons, 94% said they would be willing to change their behaviours with respect to glove and instrument handling in cancer surgery if presented with evidence of potential benefit (Figure 3).

### Surgeon-Related Variables Associated with Glove or Instrument Changing

We examined potential predictors of glove, instrument, and wound-handling behaviours (Table IV). Sex, type of practice (academic vs. community), and proportion of practice dedicated to cancer were not significantly

associated with those behaviours. Surgeons in practice for fewer than 10 years were more likely than surgeons in practice for longer to protect laparoscopic wounds (81% of *n* = 140 vs. 61% of *n* = 209, *p* = 0.009). Surgeons with fellowship training in general surgical oncology or breast were more likely than those with site-specific surgical oncology training or no oncology-related fellowship training to change instruments to prevent tumour seeding (60% of *n* = 55 vs. 28% of *n* = 80 and vs. 38% of *n* = 208 respectively, *p* = 0.023). Surgeons who protect wounds (laparoscopic or open, or both, *n* = 205) were slightly more likely than those who do not protect wounds to change gloves with the purpose of preventing tumour cell seeding (*n* = 146, 56% vs. 45%, *p* = 0.04); the same case did not hold for instrument changing.

Surgeons whose cancer practice focuses largely on colorectal cancer (*n* = 130) were no more likely than surgeons who do not treat colorectal cancer to change gloves or instruments with the explicit purpose of preventing tumour seeding.



**FIGURE 2** Surgeons' self-reported beliefs about whether surgical gloves or instruments harbour malignant cells capable of leading to a recurrence. (A) Response to the question "Do you think that surgical GLOVES may harbour malignant cells capable of seeding the tumour bed and/or surgical wound?" (B) Response to the question "Do you think that surgical INSTRUMENTS may harbour malignant cells capable of seeding the tumour bed and/or surgical wound?" (C) Response to the question "If surgical GLOVES harbour malignant cells, what do you think the likelihood is that these cells can lead to locoregional recurrence or wound recurrence?" (D) Response to the question "If surgical INSTRUMENTS harbour malignant cells, what do you think the likelihood is that these cells can lead to locoregional recurrence or wound recurrence?"

After a single mail-out, thematic saturation was achieved for all survey questions.

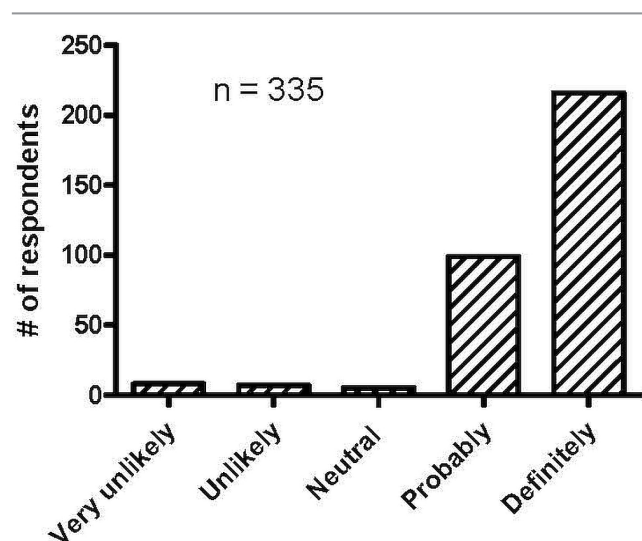
## DISCUSSION

Our survey revealed that the potential for iatrogenic tumour seeding is a concept that general surgeons in Ontario are familiar with, although there is no consensus on implementing protective strategies. About half the surgeons reported that they change gloves with the express purpose of preventing tumour seeding, and 40% said that they change instruments for that purpose. Gloves are most commonly changed by routine or when there are concerns of contamination by tumour; instruments are most commonly changed for discontinuous sites of operation. It is

conceivable that glove changing occurs more frequently than instrument changing because it is an easier strategy to implement. Changing instruments requires greater use of resources such that a second set is available for the reconstructive phase. Another barrier to glove and instrument changing is the frequency with which a change would have to be made if it followed every intraoperative episode of potential contamination by tumour cells. Innumerable events during surgery can potentially lead to tumour cells being exfoliated onto gloves or instruments, and then subsequently into the wound or tumour bed. Interestingly, surgeons with fellowship training in general surgical oncology or breast are more likely than surgeons with site-specific oncology fellowship training (hepatopancreatobiliary, endocrine, and so on) or no oncology-specific

fellowship training to change instruments. Respondents acknowledge that their behaviours are guided primarily by gut feeling and clinical training, not scientific evidence, and therefore it is not surprising that behaviours vary between groups of surgeons with different training paths.

Surgeons are more likely to take additional precautions to prevent tumour seeding in laparoscopic surgery than in



**FIGURE 3** Surgeon likelihood to adopt practices and protective strategies based on evidence. Response to the question “Willingness to change technique based on evidence.”

open surgery, and those precautions consist primarily in the use of wound protectors. Protection of open wounds with commercially available wound protectors or other mechanical means was not readily predicted by any of the surgeon-related variables we examined. However, laparoscopic wound protectors are more commonly used by surgeons who have been in practice for fewer than 10 years. We note that surgeons within the same division and subspecialty at the same hospital can have very different practices and beliefs with respect to wound protection and to glove and instrument handling in general.

The apparent variation in the adoption of protective strategies reflects inconsistent beliefs with respect to the role of gloves and instruments in tumour seeding. More than half the respondents believe that it is possible or probable that malignant cells are harboured on gloves and instruments, but most think it unlikely that those cells contribute to tumour seeding and eventual recurrence. Almost all respondents are aware that their beliefs and practices are not guided by evidence and would be willing to follow clinical practice guidelines if presented with evidence. The current lack of evidence is perhaps the greatest barrier to the rational implementation of a change in practice.

Our survey method was successful in obtaining responses from the desired population of surgeons. The full spectrum of general surgeons in Ontario was represented, as judged by practice setting, fellowship training, years in practice, surgeon sex, and proportion of practice consisting of cancer cases. Although minor differences in terms of sex and time since completion of general surgery training were observed between the group of surgeons who responded

**TABLE IV** Surgeon-related variables associated with glove or instrument changing

Variable	Respondents	Change (%)		Protect wounds (%)	
		Gloves	Instruments	In open surgery	In laparoscopic procedures
Sex					
Men	267	51	39	32	73
Women	84	55	42	28	71
Time in practice					
≤10 Years	140	56	35	30	81 <sup>a</sup>
>10 Years	209	48	42	30	61 <sup>a</sup>
Practice location					
Academic	118	43	33	34	62
Community	230	55	43	28	74
Proportion of practice consisting of cancer patients					
≤30%	179	48	38	28	70
>70%	62	53	45	32	73
Fellowship training					
General surgical oncology or breast	55	58	60 <sup>a</sup>	38	67
Site-specific surgical oncology	80	46	28 <sup>a</sup>	29	72
No oncology fellowship	208	51	38	28	70
<i>p</i> Value		0.37	0.023	0.93	0.0090

<sup>a</sup> Statistical significance: adjusted residual > 2.

to the survey and those who did not, those variables did not appear to have strongly biased the reported behaviours, except for the increased use of wound protectors for laparoscopic surgery among the more recent graduates. The overall response rate of 46% was sufficient to reach saturation of themes in the free-text response questions. Given that we did not expect to gain more information by re-contacting nonrespondents, we therefore conducted only a single mail-out. Among respondents, each individual applicable question achieved a response rate in excess of 95%, and the missing data rate ranged from 0% to 4% for each question.

Wound recurrence and port-site metastases are patterns of recurrence that might in part be attributable to exfoliation of malignant cells from gloves and instruments. After the widespread adoption of the laparoscopic approach to cholecystectomy in the 1990s, a wave of case reports and series noted port-site metastasis after removal of incidental gallbladder cancer<sup>7,16</sup>. The incidence was initially estimated to be very high (approximately 18%–20%), resulting in calls for the routine use of specimen retrieval bags, minimization of spillage of gallbladder contents, and better preoperative investigation. Perhaps partly because of those efforts, the incidence of port-site metastasis appears to have declined recently, and yet the rate remains high (approximately 10%) relative to that reported for laparoscopic colectomy (<1%)<sup>17,18</sup>. However, the latter incidence might well be underappreciated because of a lack of specific surveillance of surgical wounds during long-term follow-up in colorectal cancer patients. In patients with recurrent colorectal cancer as a cause of death, autopsy studies have shown wound recurrence rates as high as 17%<sup>19</sup>.

Although the development of wound recurrence is likely multifactorial, some studies have suggested that surgical gloves and instruments harbour malignant cells and can be a mechanical vector contributing to these events<sup>9,12</sup>, implicating an iatrogenic and potentially preventable mechanism. A similar clinical event that demonstrates a potential iatrogenic mechanism of tumour seeding is needle-tract seeding after tumour biopsy. Although the risk of that pattern of recurrence is histology-dependent, routine use of a coaxial sheathed biopsy needle is currently recommended<sup>20</sup>. During complex cancer operations at our institution that involve reconstruction by plastic or vascular surgical teams, new instrument sets are opened, light handles are changed, and drapes might also be changed when the reconstructive team scrubs in. The rationale is to prevent seeding of the flap or graft harvest site. Although cases of harvest-site implantation have been reported, those reports do not necessarily imply an iatrogenic event at the time of surgery<sup>1</sup>.

A limitation of our survey is that some protective practices are potentially multipurpose. Glove or instrument changing before wound closure or reconstruction might be intended to lower the incidence of surgical site infections, as well as to simultaneously protect against cancer cell seeding. The authors of a systematic review and meta-analysis of the surgical site infection literature<sup>21</sup> found that, of 16 intervention bundles used in colorectal surgery, 2 included the use of a wound protector, 2 required glove changing, and 3 included use of a closing tray of clean instruments for fascial and superficial wound

closures. Our survey respondents could in fact have been following protective strategies based on the belief that they prevent wound infection and instead attributed them to an intention to minimize cancer cell seeding. We did attempt to mitigate against that elision by explicitly stating that surgeons should report practices that were expressly performed to prevent tumour seeding (see supplemental Figure 1). Interestingly, our results reveal that surgeons whose practice focuses on colorectal cancer resections were no more likely than surgeons who performed no colorectal cancer resections to change gloves or instruments. That observation suggests that respondents appropriately reported practices intended to prevent tumour seeding rather than wound infection.

An additional potential limitation of our study is that, for some of the questions, the responses were intentionally in free-text format, such that some respondents might have inadvertently failed to mention some of their practices, leading to an underestimation of protective strategies. However, the free-text-response questions were primarily used to elaborate on responses to multiple-choice stem questions, and overall reported use of protective strategies should therefore not have been affected.

Finally, it is impossible to know how consistently the self-reported behaviours described here are actually translated into practice. Although the survey was anonymous, it carried a risk of social desirability bias leading to the reporting of behaviours that would be more favourably regarded by study investigators and readers. However, the large discrepancy in the reported use of protective strategies in laparoscopic compared with open surgery demonstrates that respondents were likely to have been responding truthfully and not overstating their practices; otherwise, we would anticipate a higher proportion of surgeons claiming to protect open wounds.

In the absence of evidence that surgical gloves and instruments harbour viable malignant cells that maintain proliferative potential, the financial and environmental burden of protective practices that surgeons are currently using might not be justified. Such practices could potentially be modified to minimize cost and environmental impact—for example, by reserving some instruments from the primary tray for simple reconstructive procedures, rather than opening a whole new tray of sterile instruments at the time of closure. Hospitals are the second most energy-intensive source of activity in the Canadian commercial and institutional sector, and 20%–33% of hospital total waste comes from operating rooms<sup>22–25</sup>. Surgeons have a duty to try to minimize waste. By clearly showing the heterogeneity in beliefs and practices concerning glove and instrument changing in cancer surgery, our results demonstrate to the individual practitioner the lack of consensus among their peers. That lack should prompt self-reflection and greater consideration of the resource implications of current practices.

## CONCLUSIONS

For many decades, surgeons have used strategies to mitigate the unconfirmed potential risks of mechanical tumour seeding of the wound and local tumour bed during cancer surgery. Such practices are inconsistently used, and no



consensus of beliefs or behaviours has been reached among practising surgeons. An evidentiary base for the practices would require experiments to determine whether viable and transferable malignant cells are in fact detectable on gloves and instruments in a spectrum of cancer resections. Because surgeons expressed a willingness to change practice if provided with scientific evidence, the potential effect of future work in this area includes development and implementation of evidence-based strategies to either decrease seeding and recurrence, or alternatively, to eliminate certain practices that carry financial and environmental burdens without benefit.

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#### CONFLICT OF INTEREST DISCLOSURES

We have read and understood *Current Oncology's* policy on disclosing conflicts of interest, and we declare that we have none. This study was supported by intramural funding from the Department of Surgery at the University of Toronto.

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