Original Study

Barriers to Completing Low Dose Computed Tomography Scan for Lung Cancer Screening

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Abstract

Among those referred for lung cancer screening (LCS), studies show that 15-30% of patients do not complete low-dose computed tomography (LDCT) and therefore lose out on the survival advantage that LCS offers. In our study, we found that the 13% of patients who did not complete LDCT were less likely to be married and more likely to be current smokers.

Introduction: Annual low-dose computed tomography (LDCT) screening has been shown to reduce lung cancer mortality in high-risk individuals by detecting the disease at an earlier stage. This study aims to assess the barriers to completing LDCT in a cohort of patients who were determined eligible for lung cancer screening (LCS). **Methods:** We performed a single institution, mixed methods, cross-sectional study of patients who had a LDCT ordered from July to December 2022. We then completed phone surveys with patients who did not complete LDCT to assess knowledge, attitude, and perceptions toward LCS. **Results:** We identified 380 patients who met inclusion criteria, including 331 (87%) who completed LDCT and 49 (13%) who did not. Patients who completed a LDCT and those who did not were similar regarding age, sex, race, primary language, household income, body mass index, median pack years, and quit time. Positive predictors of LDCT completion were: meeting USPSTF guidelines (97.9% vs 81.6%), being married (58.3% vs 44.9%), former versus current smokers (55% vs 41.7%), personal history of emphysema (60.4% vs 42.9%), and family history of lung cancer (13.9% vs 4.1%) (all $P < .05$). Of the patients who participated in the phone survey, only 7% of respondents thought they were high risk for developing lung cancer despite attending a shared decision-making visit and only 10% wanted to re-schedule their LDCT. **Conclusion:** There exist barriers to completing LDCT even after patients are identified as eligible and complete a shared decision-making visit secondary to knowledge barriers, misperceptions, and patient disinterest.

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Keywords: Screening scan, Shared decision-making, Barriers to screening

Introduction

Lung cancer is the leading cause of cancer-related death worldwide, with a high mortality rate due to late diagnosis.[1,2] Annual low-dose computed tomography (LDCT) screening has been shown to reduce lung cancer and global mortality in high-risk individuals by detecting the disease at an earlier stage.[3-6] However, the LCS rate among eligible individuals is estimated to be only 5.8% nationally,[7] and rates vary widely across states, from 1.0% in California to 16.3% in Massachusetts.[7]

Many factors contribute to the underutilization of LCS, including patient-related and healthcare system-related barriers[8] April 4, 2024 2:42:00 PM. Disparities in screening rates by race and ethnicity, education level, and insurance status are among various contributing factors that highlight the need for targeted interventions specific to each geographic location to increase screening uptake.[9] Most prior interventions aimed at increasing LCS rates have focused on the first steps of the screening process: identifying eligible patients and performing the shared decision-making visit.[10,11] However, there are few studies describing the subgroup of patients who begin the LCS process but never complete a

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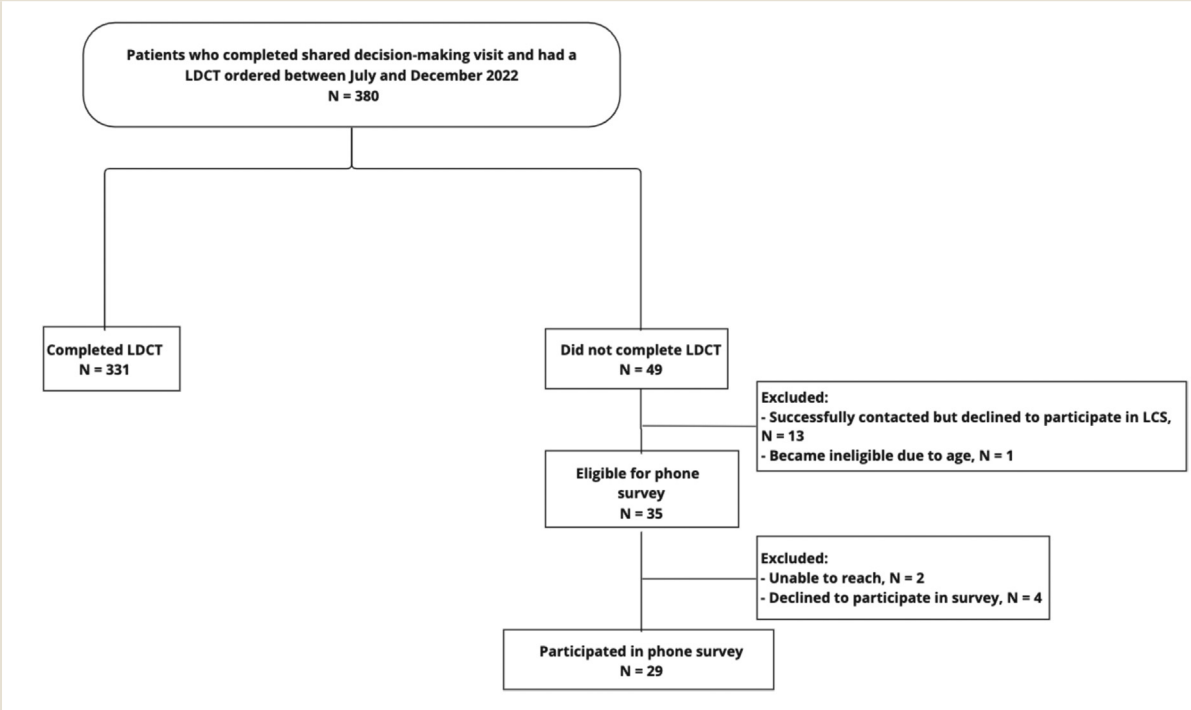
Figure 1 Patients included in the study and phone survey.



LDCT which presents a unique clinical question because barriers to follow-through are different than barriers to initial LCS enrollment.[12-14] This study aims to assess the barriers to completing LDCT in a cohort of patients who were determined eligible for LCS and had a LDCT ordered.

Methods

Patients

This is a mixed-methods, cross-sectional study using retrospective chart reviews and prospective surveys performed at a tertiary care, academic center in Northern California. Patients who had a LDCT ordered from July to December 2022 were included in the study and followed up for 1 year to assess completion of LDCT (Figure 1). Patients included in the study were de-identified prior to data analysis so informed consent was only obtained from those who participated in the phone survey. The Stanford Institutional Review Board approved this study (protocol number 67327).

The cohort was divided into patients who completed screening LDCT and those who had not. Retrospective chart review was performed to collect demographic and baseline characteristics. Household income was estimated using median income in the patient's zip code. Patients were noted as eligible for LCS based on either the expanded criteria from the United States Preventive Services Task Force (USPSTF) (age 50-80 years, at least a 20 pack-year smoking history, and either current smokers or those who have quit within the last 15 years)[2] or other risk factors such as occupational exposure or family history of lung cancer in a first-degree relative as noted by the provider who performed the shared decision-making visit.[15] Clinicians who ordered LDCT included primary care providers, pulmonology specialists, and thoracic surgeons. For patients who did not complete LDCT, a phone survey was conducted to assess knowledge, attitude, and perceptions toward LCS. Reasons for not completing LDCT was the only free-text question in the survey and is reported as recurring themes.

Statistical analysis

Baseline demographic and clinical characteristics between the groups were compared with Wilcoxon rank-sum test for continuous variables that were not normally distributed and Pearson's chi-square test for discrete variables. The Fisher's exact test was used for discrete variables with fewer than 5 outcomes. The quantitative and qualitative results from the surveys were shown using descriptive analysis. A P-value of $<.05$ was considered statistically significant. The data was analyzed using R version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

Results

Patients

There were 380 patients who had a LDCT ordered from July to December 2022. Of these, 331 (87%) patients completed a LDCT, and the remaining 49 (13%) patients did not complete a LDCT (Table 1). Patients who completed a LDCT and those who did not were similar regarding age, sex, race, primary language, household income, BMI, median pack years, and quit time. Patients who completed LDCT were more likely to have met USPSTF guidelines

Table 1 Patient Characteristics of Entire Cohort

Characteristic	Completed LDCT N = 331	Did Not Complete LDCT N = 49	*P-Value*
Age (y)	68.0 (61.0, 73.0)	69.0 (63.0, 74.0)	.426[a]
Sex			.721[b]
Male	218 (65.9%)	31 (63.3%)	
Female	113 (34.1%)	18 (36.7%)	
Race			.877[c]
White	204 (61.6%)	29 (59.2%)	
Asian	54 (16.3%)	10 (20.4%)	
Other	53 (16%)	8 (16.3%)	
Black	18 (5.4%)	2 (4.1%)	
Primary language			.332[c]
English	296 (89.4%)	41 (83.7%)	
Other	27 (8.2%)	6 (12.2%)	
Spanish	8 (2.4%)	2 (4.1%)	
Marital status			**.026**[c]
Married	193 (58.3%)	22 (44.9%)	
Single	131 (39.6%)	23 (46.9%)	
Other	7 (2.1%)	4 (8.2%)	
Household income			.391
<$46,277	16 (4.8%)	3 (6.1%)	
$46,277-$57,856	38 (11.5%)	2 (4.1%)	
$57,857-$74,062	56 (16.9%)	10 (20.4%)	
$74,063+	211 (63.8%)	34 (69.4%)	
Insurance status			.401[c]
Medicare	199 (60.1%)	26 (53.1%)	
Private	122 (36.9%)	23 (46.9%)	
None	9 (2.7%)	0 (0.0%)	
USPSTF criteria met	324 (97.9%)	40 (81.6%)	**<.001**[b]
Smoking status			**.025**[c]
Current	138 (41.7%)	24 (49.0%)	
Former	182 (55.0%)	20 (40.8%)	
Never	11 (3.3%)	5 (10.2%)	
BMI (kg/m^2)	27.0 (23.0, 30.0)	27.4 (24.2, 31.1)	.396[a]
Pack years	30.0 (15.6, 40.5)	30.0 (20.0, 45.0)	.540[a]
Quit time (years)	10.0 (5.0, 16.5)	9.0 (6.0, 11.0)	.332[a]
History of COPD	118 (35.7%)	19 (38.8%)	.671[b]
History of asthma	88 (26.6%)	10 (20.4%)	.356[b]
History of emphysema	200 (60.4%)	21 (42.9%)	**.020**[b]
History of lung cancer	1 (0.3%)	0 (0.0%)	.871[c]
History of smoke exposure	11 (3.3%)	1 (2.0%)	.527[c]
Family history of lung cancer	46 (13.9%)	2 (4.1%)	**.002**[c]

Values are n (%) for categorical variables and median (IQR) for continuous variables.
COPD, chronic obstructive pulmonary disease; IQR, inter-quartile range.
[a] Wilcoxon rank sum test.
[b] Pearson's chi-squared test.
[c] Fisher's exact test.

(97.9% vs 81.6%) for LCS rather than identified for LCS due to occupational exposure or family history of lung cancer in a first-degree relative. There were no significant differences in past medical history, such as a history of chronic obstructive pulmonary disease (COPD), asthma, lung cancer, and smoke exposure. However, patients who did not complete LDCT were less likely to be married (44.9% vs 58.3%, *P*=.026), have a history of emphysema (42.9% vs 60.4%, *P*=.02), and a family history of lung cancer (4.1% vs 13.9%, *P*=.002) compared to patients who completed LDCT. Moreover, these patients were more likely to be current smokers (49% vs 41.7%, *P*=.025). Patients who declined to participate were

Table 2 Patient Characteristics of Patients Who did not Complete LDCT

Characteristic	Overall, N = 49	Incomplete, N = 36	Declined to Participate, N = 13	*P-Value*
Age (years)	69.0 (63.0, 74.0)	68.0 (59.0, 73.5)	73.0 (68.0, 75.0)	**.040**[a]
Sex				.510[c]
Male	31 (63.3%)	24 (66.7%)	7 (53.9%)	
Female	18 (36.7%)	12 (33.3%)	6 (46.2%)	
Race				.153[c]
White	29 (59.2%)	19 (52.8%)	10 (76.9%)	
Other	18 (36.7%)	16 (44.4%)	2 (15.4%)	
Black	2 (4.1%)	1 (2.8%)	1 (7.7%)	
Language				.214[c]
English	41 (83.7%)	29 (80.6%)	12 (92.3%)	
Other	6 (12.2%)	6 (16.7%)	0 (0.0%)	
Spanish	2 (4.1%)	1 (2.8%)	1 (7.7%)	
Marital status				.564[c]
Married	22 (44.9%)	17 (47.2%)	5 (38.5%)	
Single	23 (46.9%)	17 (47.2%)	6 (46.2%)	
Other	4 (8.2%)	2 (5.6%)	2 (15.4%)	
Household income				.928[c]
< $46,277	3 (6.1%)	2 (5.6%)	1 (7.7%)	
$46,277 - $57,856	2 (4.1%)	2 (5.6%)	0 (0.0%)	
$57,857 - $74,062	10 (20.4%)	8 (22.2%)	2 (15.4%)	
$74,063+	34 (69.4%)	24 (66.7%)	10 (76.9%)	
Insurance status				.532[c]
Medicare	26 (53.1%)	18 (50.0%)	8 (61.5%)	
Private	23 (46.9%)	18 (50.0%)	5 (38.5%)	
USPSTF criteria met	40 (81.6%)	28 (77.8%)	12 (92.3%)	.246[b]
Smoking status				.445[c]
Current	24 (49.0%)	17 (47.2%)	7 (53.9%)	
Former	20 (40.8%)	16 (44.4%)	4 (30.8%)	
Never	1 (2.0%)	0 (0.0%)	1 (7.7%)	
Unknown	4 (8.2%)	3 (8.3%)	1 (7.7%)	
BMI (kg/m2)	27.0 (23.0, 30.0)	27.0 (24.0, 31.0)	24.0 (22.5, 27.5)	.139[a]
Pack years	30.0 (20.0, 45.0)	30.0 (17.5, 40.0)	30.0 (20.0, 50.0)	.427[a]
Quit time (y)	9.0 (6.0, 11.0)	9.0 (8.0, 11.0)	8.5 (4.0, 13.5)	.933[a]
History of COPD	19 (38.8%)	13 (36.1%)	6 (46.2%)	.530[c]
History of asthma	10 (20.4%)	8 (22.2%)	2 (15.4%)	.709[c]
History of emphysema	21 (42.9%)	15 (41.7%)	6 (46.2%)	1.000[c]
History of lung cancer	0	0	0	–
History of smoke exposure	1 (2.0%)	0	1 (7.7%)	.265[c]
Family history of lung cancer	2 (4.1%)	2 (5.6%)	0	.129[c]

Values are n (%) for categorical variables and median (IQR) for continuous variables.
COPD, chronic obstructive pulmonary disease; IQR, inter-quartile range.
[a] Wilcoxon rank sum test.
[b] Pearson's Chi-squared test.
[c] Fisher's exact test.

more likely to be older (median 73 vs. 68 years; P=.04) but were otherwise comparable to the cohort (Table 2).

Phone survey

Of the 49 patients eligible to participate in the phone survey, 13 people declined to participate in LCS and 1 person became ineligible according to USPSTF criteria due to age; thus there were 35 remaining patients. An additional 2 people were unreachable by phone and text messaging and 4 people declined to participate, leaving a total of 29 patients who completed the phone survey. The 29 remaining patients had a median age of 65.8 years and were predominantly male and white (Table 3). They all had completed at least some

Table 3 Phone Survey Results

Characteristic	Overall, N = 29
Age (years)	65.8 (48.0, 73.6)
Sex	
Male	23 (79%)
Female	6 (21%)
Race	
White	24 (83%)
Other	5 (17%)
Educational Level	
Some college	6 (21%)
Bachelor's	18 (62%)
Post-graduate	5 (17%)
Distance from radiology capabilities	
<10 miles	26 (90%)
<25 miles	3 (10%)
Smoking status	
Current	18 (62%)
Former	11 (38%)
Do you know anyone with lung cancer?	
Yes	5 (17%)
No	24 (83%)
Do you know there is a way to screen for lung cancer?	
Yes	11 (38%)
No	18 (62%)
Do you know the risks and benefits of getting a LDCT?	
Yes	25 (86%)
No	4 (14%)
Did you attend a shared-decision making visit as part of LCS?	
Yes	23 (79%)
No	6 (21%)
If yes, did you attend the shared-decision making visit alone?	
Yes	16 (55%)
No	13 (45%)
Specialty that ordered LDCT	
Primary care	27 (93%)
Pulmonology	2 (7%)
Has a healthcare professional told you that you are at increased risk for lung cancer?	
Yes	16 (55%)
No	13 (45%)
Do you think you are at high risk for developing lung cancer?	
Yes	2 (7%)
No	27 (93%)
Do you want to re-schedule your CT scan?	
Yes	3 (10%)
No	26 (90%)
Why did you not complete your screening CT?	
"I forgot"	12 (41%)
"I don't think I'm at risk for lung cancer"	12 (41%)
"I've already been screened before"	5 (18%)

college education and lived within 25 miles of a facility with radiology capabilities. About 62% of the group were current smokers and 38% were former smokers. Most of the group (83%) did not know anyone diagnosed with lung cancer. Only 38% of the group indicated that they knew there is a way to screen for lung cancer, and only 79% indicated they attended a shared decision-making visit, despite all patients having a documented shared decision-making visit. However, when asked about the risks and benefits of completing LDCT, 86% of the group indicated that they understood it clearly.

Regarding the shared decision-making visit, 55% stated attending the appointment alone, while the other 45% had accompaniment from family or friends. Primary care was the overwhelming specialty performing LCS and ordering LDCTs for this subgroup. About 55% of patients stated that a healthcare professional had told them they are at increased risk for lung cancer. Nevertheless, only 7% believed that they are at high risk for developing lung cancer and wanted to re-schedule and complete their LDCT. The reasons for not competing LDCT were split between: 'I forgot,' 'I don't think I'm at risk for lung cancer,' and 'I've already been screened before.'

Discussion

Current efforts to increase LCS focus mostly on identifying eligible people and performing a shared decision-making visit. However, among those referred for LCS, studies have shown that approximately 15%-30% of patients do not complete LDCT and therefore lose out on the survival advantage that LCS offers.[12-14] In our cohort of 380 patients who completed a shared decision-making visit and had a LDCT ordered, 49 (13%) patients did not complete LDCT. Our results show that being married, meeting USPSTF criteria, being a former smoker, history of emphysema, and positive family history of lung cancer are all predictors of completing LDCT. In a meta-analysis by Lopez et al, smoking status, age, race, and educational status were statistically associated with adherence rates.[16] While our data aligned on the association of smoking status and LCS completion with former smokers being more likely than current smokers to complete LDCT, our demographic data did show any statistically significant correlations but was limited by sample size. We did not collect educational status, but we did collect household income, and no differences were found between different income groups who completed and did not complete LDCT. More subtle predictors of participation which our study did not focus on, but that have been borne out in the literature include the fear of false positive scans, distrust of the healthcare system, negative stigmas related to smoking, and potential financial costs.[17]

For patients who did not complete the LDCT, the phone survey demonstrated that many of them attended the shared decision-making visit alone. Published studies have shown that health maintenance for chronic non-communicable diseases is greatly improved with strong social support and that positive relationships are associated with health promoting behavior.[18-20] The importance of social support has also been tied to smoking cessation success rates, with studies showing better abstinence rates with programs that intimately involve an element of partner or family support.[19,21] Our results highlight that we might increase LCS screening rates by sharing these results with primary care providers who may be able to focus on patients without strong support systems. Another finding from the phone survey was that patients who did not complete LDCT were less likely to have a family history of lung cancer, and most patients in the phone survey did not know anyone with lung cancer. The lack of personal experience with lung cancer as a deadly disease may contribute toward the drop-off of patients enrolled in LCS and the disinterest in completing LDCT. Lastly, a common misperception that we discovered during the phone survey is that many patients believe that LCS is a one-time process, rather than an annual screening until age 80. Public education programs might be warranted to inform the population at large about the process of LCS, as annual cancer screening is not an uncommon practice and is already reflected in many other screening guidelines such as breast cancer. A systematic review published in 2018 showed that educational model-based interventions that increase health belief and health promotion were shown to be the most effective at increasing cancer screening rates.[22]

One of the most striking aspects of this study was the inconsistency in responses given by patients who did not complete LDCT, which reflects major knowledge gaps and the large variation in depth of understanding between patients and providers about LCS. Importantly, only 7% of patients from the phone survey ultimately believed that they are at high risk for developing lung cancer and wanted to re-schedule and complete their LDCT. This disappointing number begs for an innovative solution to increase participation buy-in from LCS-eligible patients themselves. From the clinician side, a systematic approach with templated pertinent topics to cover during shared decision-making sessions would be an interesting intervention to ensure the uniformity of the LCS process regardless of healthcare provider or healthcare in which a patient seeks screening. Our results show that primary care providers are often the first and only point of contact for patients eligible for LCS. Thus, there should be continual cross-collaborations between outpatient general practitioners, specialized pulmonologists, radiologists, and thoracic surgeons to improve the patient experience and enhance screening behavior.[23,24]

We acknowledge several limitations in our study, particularly the single center nature of the results which may not be generalizable across the country. In addition, the limited sample sizes are not powered to make definite conclusions and patients who completed the survey may have demonstrated recall bias which is unmeasurable. Nevertheless, we believe that this mixed methods study provides a unique approach to investigating current barriers in lung cancer screening and offers a targetable intervention within a larger and more complex problem. The integration of tobacco cessation efforts with the promotion of screening programs will only serve to increase awareness and motivate patients to diminish their risk of developing lung cancer by seeking early intervention.

Cancer screening has been a long agreed upon tenet in the modern medical world. Nevertheless, the uptake and benefits from cancer screening have produced variable results.[24] For lung cancer, national guidelines and recommendations have only generated a screening adherence rate of approximately 5% nationally, which highlights the need for better communication with populations and health professionals about the effectiveness of LCS.[1,25] The

novelty in our study is in examining the gap between ordering and completing LDCT. We investigated why patients do not complete LDCT even after they are correctly identified as eligible and found that barriers are associated with misperceptions leading to patient disinterest and loss to follow up. We also found that less social support is a negative prognosticator for LCS completion and adherence which highlights the need for individualized assistance for higher-risk individuals during the LCS process.[26] A combination of population-based education and targeted interventions to ensure that LDCTs are successfully completed are crucial and our study sheds light on one potential implementation strategy in the overall aim to increase national LCS uptake.

Clinical Practice Points

- While studies mainly investigate barriers to entry for LCS, there are few studies that study the impact of poor follow-through for screening-eligible and identified patients. Thus, there is an important clinical question that exists regarding the ability to capture this high-risk group of patients and follow-up with them annually for their recommended screening scan.
- We performed a study at our institution characterizing people who had been identified by their healthcare providers for LCS and who had begun the process but failed to complete their CT scan. The data showed that there are large knowledge gaps even after patients undergo the shared decision-making visit that leads to misperceptions about LCS and disinterest in following through with the CT scan. These findings highlight common concerns and misunderstandings that patients may have toward LCS that physicians can proactively address in the clinic visit while discussing the risks and benefits of LCS.
- Due to current low rates of LCS, collaborative efforts are needed to address region-specific barriers to improving LCS uptake. We believe that single institution studies, such as this manuscript, are an important stepping stones toward shedding more light on ways to increase screening rates such that they are comparable to other cancers such as breast and colorectal cancer.

Disclosure

The authors have no conflicts of interest or funding sources related to this manuscript.

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Lye-Yeng Wong: Writing – review & editing, Writing – original draft, Resources, Investigation, Formal analysis, Data curation, Conceptualization. **Sania Choudhary:** Writing – review & editing, Resources, Methodology, Data curation. **Ntemena Kapula:** Resources, Methodology, Investigation, Formal analysis. **Margaret Lin:** Validation, Supervision, Software, Resources. **Irmina A. Elliott:** Visualization, Validation, Supervision, Software. **Brandon A. Guenthart:** Visualization, Supervision, Methodology, Investigation. **Douglas Z. Liou:** Validation, Supervision, Project administration, Investigation. **Leah M. Backhus:** Writing – review & editing, Supervision, Software, Project administration. **Mark F. Berry:** Software, Resources, Methodology, Conceptualization. **Joseph B. Shrager:** Visualization, Supervision, Software, Project administration. **Natalie S. Lui:** Writing – review & editing, Visualization, Validation, Resources, Project administration, Methodology, Investigation, Funding acquisition, Data curation, Conceptualization.

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