Understanding Patient and Clinical Stakeholder Perspectives to Improve Adherence to Lung Cancer Screening

Karen J Wernli, PhD1; Leah Tuzzio, MPH2; Sarah Brush, BA1; Kelly Ehrlich, MS3; Hongyuan Gao, MS1; Melissa L Anderson, MS1; Lorella Palazzo, PhD1

INTRODUCTION
Lung cancer is the leading cause of cancer death in the US, and until 2015, no recommended screening tests existed for lung cancer detection. Low-dose computed tomography (LDCT) is a population-based, secondary prevention screening tool to detect lung cancer at early stage, based on mortality reductions observed in multiple clinical trials. The US Preventive Services Task Force currently recommends annual LDCT screening scans for adults age 55 to 80 years with at least a 30-pack-year smoking history (eg, smoking 1 pack/day for 30 years), and who currently smoke or who quit in the past 15 years. Adherence to annual LDCT screening has the potential to impact profoundly the health of older US adults with significant smoking history.

METHODS
We conducted a concurrent mixed-methods study to measure adherence to repeat screening with low-dose computed tomography (LDCT); to interview KPWA stakeholders to understand the Lung Cancer Screening Program; and to conduct codesign workshops with KPWA members and researchers. We used descriptive statistics to describe adherence, and rapid qualitative data analysis for stakeholder interviews and workshops.

RESULTS: Between 2015 and 2019, 2089 KPWA members had initial LDCT scans with negative, benign or short-interval follow-up results. Among those with sufficient follow-up, the proportion with on-time repeat screening after a negative LDCT was 26.4% after the initial scan, and increased to 43.1% on subsequent scans. Opportunities for health-care system improvement included clarification of clinical roles and responsibilities, care coordination across providers, ongoing training in lung cancer screening, and revising electronic health record tools. From patient perspectives, facilitators to repeat screening were making screening personalized and convenient; offering consistent messages and reminders in different modes; increasing patient knowledge about benefits, harms, and expectations of LDCT; and providing non-financial and financial incentives for adherence. From a story-board exercise, we identified 10 design features for lung cancer screening interventions, including versatility of communication, social support, and knowledge.

CONCLUSION: We identified clear gaps in adherence to lung cancer screenings, organizational and clinical barriers to care, and design features for patient-centered interventions to improve lung cancer screening in US settings.
700,000 members. In 2015, a new KPWA Lung Cancer Screening Program was developed with a multidisciplinary team and institutional guidelines, based primarily on US Preventive Services Task Force recommendations.5 Rollout activities included continuing medical education on lung cancer screening across all clinics, clinicians, and staff. Integral components of the program were electronic health record (EHR) modules to guide and document shared decision-making conversations and decisions about whether to screen, and a clinician–EHR note template (ie, SmartSet), which prompts an LDCT order. Primary care physicians (PCPs) order the majority of LDCT scans for lung cancer screening. The radiology department schedules LDCT appointments with patients, reads scans, and reports results based on the Lung–CT Screening Reporting and Data System (Lung-RADS).12 Scans with negative (Lung-RADS 1), benign (Lung-RADS 2), and probably benign (Lung-RADS 3) results are mailed directly to patients, and the radiology report is available in the KPWA patient portal. Ordering providers might also discuss negative or benign results via secure messaging using the patient portal. A pulmonary nurse is responsible for direct follow-up of KPWA members with more significant LDCT finding for more immediate health-care needs (Lung-RADS 4a/4b). To support adherence, EHR alerts notify PCPs when patients are due for their next LDCT when the EHR is open, but the alert does not prompt direct patient outreach to order or schedule subsequent LDCT.

The study was reviewed by the Kaiser Permanente Washington Institutional Review Board. All study activities were approved (ie, measures of LDCT adherence), found to be exempt (ie, key informant interviews), or determined not research (ie, codesign workshops).

Data Collection

Identification of LDCT Scans and Subsequent Health-care Utilization
We identified KPWA members age 55 to 78 years meeting smoking eligibility criteria who received LDCT scans between January 2015 and December 2019 using KPWA’s Virtual Data Warehouse. The Virtual Data Warehouse is the Health Care System Research Network’s common data model with standard codes for health-care utilization and procedures.13 We included all observed LDCT scans, including the index LDCT (the first observed in the time period) and all subsequent LDCT scans observed. In addition to LDCT imaging, we also collected data on imaging with diagnostic chest CT.

Key Informant Interviews with KPWA Stakeholders
To understand the process and current state of screening in the Lung Cancer Screening Program at KPWA, we conducted 15 key informant interviews with KPWA stakeholders sampled purposively based on their organizational role, such as membership in the KPWA guideline committee responsible for lung cancer screening, and clinical leadership or practice in primary care, pulmonology, and radiology. We identified additional informants via snowball sampling.14 Identified informants were contacted via email up to 3 times by the research team and were invited to participate in phone interviews. Interviews lasted between 30 and 60 minutes.

The interviews were guided by a semistructured guide that focused on participants’ knowledge of and experience with lung cancer screening; perceptions of patients’ experience, strengths and challenges of the current program; and opportunities for improvement, particularly to improve screening adherence. Interviews were conducted by 2 team members (LP, SB) and were captured by real-time note-taking and audio recording after oral consent was acquired. Participants received no incentive for participation; however, participants were invited to an in-person meeting to share study findings at the end of the study period.

Codesign Workshops
KPWA members who were eligible for lung cancer screening were invited to participate in codesign workshops to help identify barriers to screening, and patient-centered intervention components to overcome these barriers. We invited members who received health care at a clinic based in a suburban area of Washington state, outside of the urban core. Participants were invited to a series of 4 2-hour workshops attended in-person near their KPWA clinic. Participants were provided with lunch and a $20 incentive to participate in each workshop (a total of $80 if they participated in all 4).

Two facilitators (KJW, LT) conducted the codesign workshops that followed a Futures Workshop format,15,16 which enables a group of people to share ideas and develop solutions. We aimed to elicit barriers, facilitators, and ideal future states of repeat lung cancer screening. Each workshop included introductions, an ice breaker, and brainstorming and semistructured discussions. The goal of the first workshop was to engage the group in a shared understanding of the problem (ie, high lung cancer rates are bad, lung cancer screening is new, low rates of repeat screening are insufficient for effective prevention) to elicit barriers and facilitators to screening adherence, and to brainstorm solutions to support adherence. The goal of the second workshop was to use hypothetical scenarios to elaborate the participants’ “blue-sky thinking” ideas generated during the first session and to sketch out ways in which these ideas could be made concrete. During this second workshop, participants sketched a storyboard, a comic strip-like format consisting of 6 tiles or scenes, using
.words and hand-drawings to describe steps in the patients’ journey to receive their next LDCT scan. For each session, the facilitators documented the participants’ input on a flip chart and invited participants to amend or clarify what was written. In addition, detailed meeting notes were captured by a research team member (SB) and were used to validate analysis of data after each session.

Analysis

Statistical Analysis

To assess on-time adherence lung cancer screening, we restricted the observed study population to those with negative (Lung-RADS 1), benign (Lung-RADS 2), and probably benign (Lung-RADS 3) findings. We described the demographic characteristics and smoking history for this study population. Furthermore, we calculated the adherence rate as the proportion of the study population with on-time adherence to repeat LDCT, with recommended screening intervals based on Lung-RADS results. For index LDCT scans with Lung-RADS 1 and 2, we assessed adherence within 9 to 15 months and restricted to LDCT scans with sufficient follow-up (ie, scans completed January 2015 and September 2018). For index LDCT scans with Lung-RADS 3, we assessed adherence within 4.5 to 7.5 months and restricted to LDCT scans with sufficient follow-up (ie, scans completed January 2015 through May 15, 2019). We allowed for 20% variation in on-time adherence, similar to measures in annual mammography.17 We summarize adherence by Lung-RADS as on-time LDCT scan and, among those without an observed LDCT, we summarized other imaging with diagnostic chest CT. To assess whether screening adherence differs by past screening history, analyses were stratified by index LDCT (first observed) and subsequent LDCT (next LDCT observed).

Qualitative Analysis of Key Informant Interviews

We followed a multistep process to analyze and summarize key informant interview data. Research team members (LP, SB, LT) reviewed interview notes individually to identify broad barriers and facilitators to repeat lung cancer screening. After the initial review, the study team met for a second, group-level review of raw interview data and broad initial analyses. The goal was to reach a preliminary shared understanding of how the KPWA Lung Cancer Screening Program functioned at the health-care system, clinician, and patient levels. Interview data were then coded formally according to 5 thematic domains derived inductively18 from reading interview notes (LP, SB). Themes and subthemes were summarized into a coding memo following in-depth content analysis (LP, SB).19 Last, the research team met once again and used an iterative process to integrate this coding memo with our preliminary assessment of barriers and facilitators. This final synthesis provided a comprehensive view of current gaps as well as possible improvements suggested by diverse stakeholders.

Qualitative Analysis of Codesign Workshops

A team member (LT) analyzed the output from the first codesign workshop to identify the main themes that emerged from the ideation exercise. The research team refined the list of themes through a consensus discussion. The analysis of the second workshop identified design features from the participants’ perspectives for interventions to improve screening adherence. LT reviewed the storyboards and drafted a list of features (including a brief definition and illustrative examples) that emerged from the storyboards. To refine the descriptions of the design features, each research team member reviewed the storyboards individually in aggregate and referred to the list that LT generated to confirm whether they agreed or had modifications to suggest. The study team met to discuss patterns, any changes to the list, and similarities and differences among the storyboards. LT updated the list, which was used for triangulation with clinical stakeholder qualitative data.

To triangulate findings, we sought to align and integrate the patient perspective surfaced by the codesign sessions with organizational and operational stakeholder perspectives on the lung cancer screening process. We expanded the interview coding memo using the features of future interventions that emerged from the codesign sessions to verify degree of congruence between organizational and clinical stakeholders’ perspectives and patient-level insights gathered through codesign sessions.

RESULTS

Adherence to Repeat LDCT

From January 2015 to December 2019, 2722 KPWA members had initial LDCT scans with Lung-RADS 1 through 3 for inclusion in the study population and 2089 initial LDCT scans with sufficient follow-up time.

Among the study population screened, the majority were men (average age, 64.5 years) and white (Table 1). Prior smoking history was evenly split between current and former tobacco users, reporting an average of 45.7 pack-years (Table 1). About one-quarter of the study population had a medical history of chronic obstructive pulmonary disease.

On-time adherence to the next LDCT scan after initial negative findings (Lung-RADS 1) was 26.4% (Table 2). Among those without an on-time LDCT, less than 2% had a chest CT. More than 70% had no observed follow-up. After a subsequent negative LDCT, on-time adherence to repeat LDCT improved to 43.1%. However, 54.4% had no observed additional follow-up.

On-time adherence to the next LDCT scan after initial benign–appearing findings (Lung-RADS 2) was 31.9% (Table 2), and another 4.3% received a chest CT. More
than 60% had no observed follow-up. After a subsequent benign findings LDCT, on-time adherence to repeat LDCT improved to 47.3%. However, 48.3% had no observed additional follow-up.

On-time adherence to the next LDCT scan after initial probably benign findings (Lung-RADS 3) was 34.5%, and another 16.8% received a chest CT only. About 49% had no observed follow-up. After a subsequent probably benign LDCT scan, on-time adherence to repeat LDCT improved slightly to 38.0%. However, 46.0% had no observed additional follow-up.

Perspectives of KPWA Organizational and Clinical Leaders
We interviewed organizational leaders (n = 6), PCPs (n = 4), and specialty providers (n = 5). Five major themes emerged from the interviews described next (Table 3).

### Clarifying Roles and Responsibilities Regarding LDCT
Stakeholders mentioned clarifying standard roles and responsibilities for ordering and following-up on LDCT scans as a systemic challenge. Stakeholders expressed that a lack of clarity created tension in an integrated care delivery system, where primary care is responsible for the process from initiating shared decision-making conversation to follow-up and tracking, although radiology and pulmonology also might have a role. One clinical leader noted a risk that some patients could “fall through the cracks” as a result of a case-by-case rather than a systematic approach, whereas another leader acknowledged that “fragmented care” can result from uncertain follow-up after the first scan.

### Enhancing Care Coordination across Primary Care, Specialty Care, and Ancillary Services
Stakeholders mentioned enhancing care coordination across all clinician types would improve care
continuity for patients and communication across teams. One clinician stressed that good care coordination would benefit preventive services beyond lung cancer screening: “We need to not think of all screenings as just primary care/specialty responsibilities. There should be understanding that preventive care is unified across primary and specialty care.”

**Improving Training of Clinicians and Care Teams in Lung Cancer Screening**

Since LDCT screening was adopted as a standard of practice at KPWA, stakeholders had mixed views on how well most clinicians had been informed about lung cancer screening and whether sufficient training was offered regularly and consistently. Some clinicians praised early efforts of the delivery system to make clinicians aware of new screening guidelines, but recognized recent educational outreach was lacking across the entire clinical team. While illustrating the current state, one stakeholder said staff and providers are not trained routinely to use LDCT to screen for lung cancer. Furthermore, training is directed to providers only and does not include other support staff (ie, medical assistants).

**Automating EHR Tools to Ease Clinician Burden and Simplify Processes**

Many clinicians mentioned an inadequate or cumbersome EHR system as a barrier to ordering a screening LDCT. Currently, EHR tools identify and flag patients eligible for screening. One stakeholder noted, “We really depend on PCPs to broach the conversation about LDCT screening [with individual patients].” However, initiating and continuing conversations about lung cancer screening can be challenging, if other medical concerns take priority during clinical care visits. Deprioritization of lung cancer screening could contribute to lower visibility and awareness compared with other cancer screening. Several stakeholders suggested that including lung cancer screening in the health maintenance reminders routinely seen by physicians could increase familiarity, could improve the likelihood that eligible patients are offered an LDCT appointment, and could ease provider burden in initiating the screening process.

**Creating Data Metrics to Support Benchmarking**

To date, few quantifiable measures are available to evaluate the Lung Cancer Screening Program, based on either internal KPWA goals or national measures, such as Healthcare Effectiveness Data and Information Set (HEDIS) measures. Stakeholders explained that several clinical metrics are generated based on a clinician’s patient panel, but currently these metrics do not include lung cancer screening. The absence of measures for lung cancer screening undermines the perceived value of screening with LDCT in the delivery of high-quality care and prevents an accurate assessment of the system’s capacity to perform the test. One clinical leader noted that data metrics would provide useful feedback on the effectiveness of the screening program, whereas a specialty clinician said that performance measures are critical to system improvement.

**Codesign Workshops with Patients and Researchers**

In the first codesign workshop, we identified 4 facilitators that would improve adherence to repeat lung cancer screening: 1) offer reminders for scheduling and appointments, 2) increase patients’ knowledge about LDCT and follow-up, 3) improve convenience in location and scheduling, and 4) provide financial and nonfinancial

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**Table 3. Themes from key informant interviews with organizational and clinical leaders**

<table>
<thead>
<tr>
<th>Theme</th>
<th>Description</th>
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<tbody>
<tr>
<td>1. Clarifying roles and responsibilities regarding LDCT</td>
<td>There is uncertainty about the boundary of responsibility for primary care provider vs others (radiologists, pulmonologists, etc). The lack of a clear boundary of roles and responsibilities creates an opportunity for patients to “fall through the cracks.”</td>
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<tr>
<td>2. Enhancing care coordination across primary care, specialty care, and ancillary services</td>
<td>Preventive care should be unified in mission and values across primary and specialty care. Adherence to lung cancer screening needs to be a shared responsibility, with clear handoffs and leveraging of the strengths of all health-care systems partners.</td>
</tr>
<tr>
<td>3. Improving training of clinicians and care teams in lung cancer screening</td>
<td>Clinicians have limited opportunities to learn about lung cancer screening and normalize the process in routine care. Ongoing training needs to include all team members, including medical assistants.</td>
</tr>
<tr>
<td>4. Automating EHR tools to ease clinician burden and simplify processes</td>
<td>Current EHR tools are inadequate to meet clinicians needs to remind them when patients are due for screening and to facilitate ordering of next LDCT. Clinicians lack a health maintenance reminder.</td>
</tr>
<tr>
<td>5. Creating data metrics to support benchmarking</td>
<td>Metrics from clinical leadership are based on the provider’s panel (eg, how many Pap smears the provider needs to do from their panel), and lung cancer screening is not included in these panels.</td>
</tr>
</tbody>
</table>

EHR = electronic health record; LDCT = low-dose computed tomography.
incentives for completing follow-up LDCT (Table 4). Examples of patient ideas from the brainstorming exercise are summarized in Table 4. Personas to develop storyboards focused on 2 of these domains: reminders and knowledge.

<table>
<thead>
<tr>
<th>Themes</th>
<th>Example solutions</th>
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| 1. Offer reminders for scheduling and appointments | • Send text message reminders  
• Offer reminder phone calls; person calling should also be able to schedule |
| 2. Increase patients' knowledge about tests and follow-up | • Make follow-up scheduling easy—for example, return every x months (when due), instead of telling people different time periods  
• Information on screening and recommended rescreen intervals  
• Screening risks and benefits  
• Expectations of what screening tests involve and how to interpret what results mean |
| 3. Improve convenience in location and scheduling | • Have LDCT available at all KP care centers  
• Make LDCT available in the doctor's office at time of yearly checkup  
• Make LDCT available in mobile vans like they do for blood banks  
• Offer scanning machine at the mall/grocery store  
• Reimburse patients for gas to travel to get the LDCT  
• Offer a discount on insurance if LDCT is completed  
• Offer a reasonable/no-cost option to have follow-up testing  
• Give a gift or present if patients do the test (“I gave blood” sticker)  
• Make getting test fun  
• Make follow-up scheduling easy |
| 4. Provide financial and nonfinancial incentives for completing follow-up LDCT | • Expectations of what screening tests involve and how to interpret what results mean  
• Make follow-up scheduling easy |

KP = Kaiser Permanente; LDCT = low-dose computed tomography.

DISCUSSION
Through mixed-methods research, our findings demonstrate that adherence to lung cancer screening remains low, at about one-third of eligible patients, even among an already activated and insured screening population. Significant barriers to screening adherence exist across multiple levels of the health-care system, clinicians, and patients. Patient-centered interventions developed to mitigate these barriers should consider multiple design features to improve effectiveness. Lung cancer screening is a complex process that includes several components, from eligibility identification, shared decision making, receipt of LDCT, possible follow-up, and then a repeat of this process. Our study evaluated barriers to repeat screening, which ideally could be addressed through normalizing the screening process for patients, clinicians, and health-care systems. Successful implementation of lung cancer screening requires interventions that make it possible to overcome identified barriers to each component of the screening process.

Adherence to repeat lung cancer screening reported from other academic centers for LDCT with Lung-RADS 1 or 2 is 28% to 38%. Our results were similar for follow-up after the first LDCT; however, adherence improved markedly for subsequent LDCT, suggesting that multiple rounds of LDCT led to improvements but still low levels of adherence. Our study results combined with other studies indicate that adherence to lung cancer screening is lagging other cancer screening tests. Adherence to guideline-recommended screening for breast and colorectal cancer screening is 76% to 81% and 59% to 65%, respectively, which suggests an opportunity gap to understand how to improve adherence for quality in lung cancer screening. Prior reports of LDCT adherence among those with probably benign findings and recommended for short-interval follow-up is at 54%. Our results were similar, if we include adherence to both LDCT or imaging with chest CT. Previous studies did not report the use of chest CT over LDCT directly, which might have contributed to improved adherence rates. A few patient factors are associated with
improved adherence, including older age, former smoker status, and current diagnosis of chronic obstructive pulmonary disease. These factors suggest that regular health-care system contact (eg, with specialty care resulting from chronic disease such as chronic obstructive pulmonary disease) may increase adherence. However, interventions to improve adherence should not focus only on patients with active clinical engagement, but also should be relevant to all eligible patients and feasible to implement regardless of context (eg, during a pandemic and switching to virtual visits).

The observed low adherence rates in lung cancer screening reflect a breakdown in the cancer care continuum that can exacerbate disparities if not identified and remedied. As outlined in the American Cancer Society Blueprint Series in 2019, high-quality health-care systems have the potential to minimize disparities by adopting several key goals, including timely access to evidence-based care, patient-centeredness, and enhanced coordination and communication among providers, including primary care and specialty care providers. Results from our key informant interviews with organizational and operational stakeholders and from the codesign workshops are aligned with the American Cancer Society Blueprint Series. As the US Preventive Services Task Force expands eligibility to lung cancer

### Table 5. Design features of interventions that emerged from storyboards

<table>
<thead>
<tr>
<th>Dimension (description)</th>
<th>Examples from storyboards</th>
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| Versatility: variation in communication modes and messages/information vary | • Modes: in-person, letter, email, phone call, magnet, video, etc  
• Messages: informational, encouraging, acknowledging, etc |
| Social support: Others (eg, spouse, children, peers) are engaged and aware in patient’s health | • Family aware when patient receives results  
• Spouse encourages patient to make follow-up appointment  
• Family participates and engages in discussing and learning about pros and cons, pathways, and expectations  
• Peer support group or educational seminar |
| Individualized: Information/communication is personalized and how responsive it is to a patient’s emotions, fears, concerns, values, and emotional state to build empathy and compassion | • Doctor talks one-to-one with patient/family by phone, in-person, or by email about questions, concerns, and results based on their preference  
• One’s personal doctor signs email or letter reminder |
| Feelings: Emotions or sentiments (eg, relief one doesn’t have cancer, fear of unknown, stigma) are recognized and validated | • Patients are relieved when they receive normal results (no cancer)  
• Doctor sends a “good job” letter for getting screened (validating feelings) |
| Knowledge: Information made available, including information on harms/benefits, pros/cons, expectations about LDCT and timing intervals | • Balanced information on potential harms (eg, biopsy with benign results) vs benefits (eg, cancer detected early)  
• Communication regarding future expectations of LDCT screening |
| Responsibility: Balance between whether a person (patient, staff, clinician) vs an automated system takes responsibility | • Patient needs to remember and know how and when to schedule LDCT  
• System needs to remember the frequency at which a patient is due for LDCT and to schedule the patient  
• If patients forget to schedule after their first reminder, doctor’s office contacts them |
| Continuity: Information and activities are shared repeatedly and continuously to gain continuous engagement | • Reminder letter mailed automatically at time of patient’s birthday including due dates for LDCT  
• Reminder is received at time of due date  
• Reminders sent multiple times and in multiple ways so one can expect to receive them |
| Consistency: The same messaging is delivered at each opportunity to avoid confusion, and create clarity and understanding. | • Messaging from different departments (eg, radiology, primary care) are stated in the same way  
• The directions and messaging about expectations for a repeat screening are described the same way each time |
| Cadence: Rhythm and timing sequence of providing information, doing reminders, and doing LDCT that is timely and respectful | • Having time to reflect after reviewing information, preparing for a conversation, and asking questions |
| Acknowledgment: Acknowledgment, appreciation, and/or celebration (eg, adherence, completing LDCT) is given internally (by self) vs given externally (by clinician, family, etc) to encourage the patient to be adherent | • Patient knows results, is told “good job for getting screened”  
• Shorter timescale of when information is delivered to patients so they can process and decide to enroll (or not) in the program  
• Longer timescale of when the patient needs to go in for follow-up screening and when to be reminded of appointments |

LDCT = low-dose computed tomography.
screening by lowering age and tobacco use criteria\textsuperscript{25,26} robust lung cancer screening programs need to address measured and documented barriers to high-quality care. Implementation strategies should account for clinical responsibility through clarification in roles, accountability through data metrics, and patient-centeredness by creating processes that ease burden on both patient and clinician. Lung cancer screening interventions should be adaptable to the multilevel impact, recognizing that system- and clinician-focused intervention are as important as patient-focused intervention.

Lung cancer screening interventions could rely on and adapt effective intervention strategies from breast, cervical, and colorectal cancer screening. Aligned with our identified patient-level barriers and facilitators, reminders and multimedia education (eg, video, pamphlet) that reflect the 10 design features we identified during the codesign workshops are the most impactful to improve cancer screening rates across other cancer screening tests, according to a recent systematic review.\textsuperscript{27} Patient-directed reminders can be timed appropriately to a health-care need and be delivered through mail, telephone, or EHR.\textsuperscript{27} Reminders can be “stepped” in intensity, from mailed/electronic communication to automated voice-call reminders to appointment scheduling assistance by a staff person. Furthermore, video interventions remain untested within lung cancer screening but offer the potential to address knowledge gaps. In a 2019 systematic review of video interventions along the cancer care continuum, 69\% of included studies were effective for key outcomes, including knowledge, self-efficacy, and receipt of cancer screening.\textsuperscript{28} The study authors mention directly that few studies had yet to evaluate video-based interventions in lung cancer screening. Furthermore, incorporating human-centered design offers a methodology that puts patient needs at the forefront to design patient-centered interventions.\textsuperscript{29} Although directed at patient barriers, these types of interventions require multilevel impacts on the system and clinician for improved implementation and effectiveness.

Our mixed-methods study provides a comprehensive overview of the current state of lung cancer screening adherence within one US-based health-care system. By using a mixed-methods approach, we evaluated the complexity of implementation of the KPWA Lung Cancer Screening Program across levels and contexts. However, our study had limitations. First, as an insured population with access to health care, KPWA might not reflect all health-care settings, particularly those with people who are uninsured. Further research within federally qualified health-care settings or among patients who are uninsured or insured through Medicaid might identify additional barriers and facilitators. Second, we summarized adherence to repeat screening in the study population as a proportion of those who received screening but did not account for censoring resulting from health plan disenrollment or diagnosis of lung cancer. Although our estimated adherence rates likely underestimate the true adherence rates, because some patients who disenroll from the health plan may receive screening elsewhere, we believe the underestimation to be minor, because disenrollment rates are low over the short follow-up time. Also, our estimates were comparable to rates reported by other studies.

In summary, we identified clear gaps in adherence to lung cancer screening, organizational and clinical barriers to care, and potential design features for intervention to improve lung cancer screening in US settings. Future studies should evaluate multilevel interventions to improve lung cancer screening nationally to achieve the population-level benefit as promised in randomized clinical trials.

\section*{Disclosure Statement}

The author(s) have no conflicts of interest to disclose.

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\section*{Author Contributions}

Karen J Wernli, PhD, and Lorella Palazzo, PhD, acquired funding. Substantial contributions to the conception or design of the work were provided by Karen J Wernli, PhD, Leah Tuzzio, MPH, and Lorella Palazzo, PhD. The acquisition, analysis, or interpretation of data for the work was accomplished by Karen J Wernli, PhD, Leah Tuzzio, MPH, Sarah Brush, BA, Kelly Ehrlich, MS, Hongyuan Gao, MS, Melissa L Anderson, MS, and Lorella Palazzo, PhD. In addition all authors drafted the work or revised it critically for important intellectual content, and provided final approval of the version to be published.

\section*{Ethics Approval}

All study activities were reviewed by the Kaiser Washington State Institutional Review Board and were approved, or were determined to be exempt or not research.

\section*{Availability of Data}

The data sets generated and/or analyzed during our study are not publicly available as they are still undergoing additional analysis. Please contact the corresponding author for any reasonable data request.

\section*{References}


