Care-paradigm shift promoting smoking cessation treatment among cancer center patients via a low-burden strategy, Electronic Health Record-Enabled Evidence-Based Smoking Cessation Treatment

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Abstract

Tobacco smoking is an important risk factor for cancer incidence, an effect modifier for cancer treatment, and a negative prognostic factor for disease outcomes. Inadequate implementation of evidence-based smoking cessation treatment in cancer centers, a consequence of numerous patient-, provider-, and system-level barriers, contributes to tobacco-related morbidity and mortality. This study provides data for a paradigm shift from a frequently used specialist referral model to a point-of-care treatment model for tobacco use assessment and cessation treatment for outpatients at a large cancer center. The point-of-care model is enabled by a low-burden strategy, the Electronic Health Record-Enabled Evidence-Based Smoking Cessation Treatment program, which was implemented in the cancer center clinics on June 2, 2018. Five-month pre- and post-implementation data from the electronic health record (EHR) were analyzed. The percentage of cancer patients assessed for tobacco use significantly increased from 48% to 90% ($z = 126.57, p < .001$), the percentage of smokers referred for cessation counseling increased from 0.72% to 1.91% ($z = 3.81, p < .001$), and the percentage of smokers with cessation medication significantly increased from 3% to 17% ($z = 17.20, p < .001$). EHR functionalities may significantly address barriers to point-of-care treatment delivery, improving its consistent implementation and thereby increasing access to and quality of smoking cessation care for cancer center patients.

Keywords

Smoking cessation, Referral and consultation, Point-of-care systems, Electronic health record, Cancer care facilities, Quality improvement

INTRODUCTION

Smoking remains the leading preventable cause of premature death in the USA due to its demonstrated role in increasing the risk of cancer alongside cardiovascular and respiratory diseases [1]. Smoking also causes adverse health outcomes in cancer patients and survivors [1]. In addition to the strong causal link between smoking and all-cause and cancer-specific mortality and risk for second primary cancers, there is evidence for causal relationships between smoking and poorer response to

Implications

Practice: Electronic health record systems offer a low-burden approach to delivering effective point-of-care smoking cessation treatment and support to patients in cancer centers who smoke.

Policy: Electronic health record-enabled point-of-care strategies offer a high-value investment for cessation treatment as they are highly scalable to health care systems in which tobacco-use treatment specialists are not available or accessible and have strong potential to be sustainable once built into the health care system electronic health record.

Research: The transition from a conventional specialist referral model to a point-of-care treatment model for tobacco use assessment and cessation treatment reflects a care-paradigm shift in cancer care that could be evaluated across health care systems.

treatment, increased treatment-related toxicity, and risk of cancer recurrence [1]. The evidence is clear that quitting smoking prevents cancer and improves the prognosis of cancer patients.

Although most oncologists routinely ask patients about tobacco use and advise patients to stop using tobacco, few routinely discuss medication options or provide cessation support [2,3]. Health care systems thus have an unrivaled opportunity to promote smoking cessation [4]. Despite key recommendations for treating tobacco use disorder in health care settings [5], there exists little guidance regarding the relative advantage of employing a dedicated cessation specialist model to provide tobacco-use treatment services (a “centralized” model), compared to a point-of-care model where a broader array of providers extend low-burden support (a “decentralized” model) to patients with cancer who smoke. The

advent of electronic health record (EHR) systems is shaping the landscape of health care, offering new opportunities to implement system-wide approaches in cancer care. As such, the field requires further examination of specialist and nonspecialist models of tobacco-use treatment to identify cost-effective, scalable, and sustainable support for cancer patients.

The specialist model of smoking cessation treatment

Tobacco-use treatment specialists—professionals skilled and trained to provide evidence-based interventions for tobacco use disorder—constitute an established approach to smoking cessation programming in health care settings. In outpatient cancer care, patients are often referred to a tobacco-use treatment specialist for a separate visit or may connect with a specialist available onsite. In primary care, patients are often referred to specialists outside the health care system (e.g., to quitlines) [6,7]. When sustainably funded, specialist referral approaches can be efficacious in addressing tobacco use disorder, often among patients most highly motivated to quit smoking [8]. This approach is generally viewed favorably by health care providers who may prefer to refer patients to an expert rather than deliver tobacco-use treatment themselves [9].

However, such a “centralized” treatment approach may have significant drawbacks. Chief among these is the low reach often attained. In cancer-care settings, where the proportion of patients who smoke may be as high as 33%–75% depending on cancer type and site [10–13], it is impractical for one or more tobacco-use treatment specialists to reach even a sizable fraction of these patients. To the extent that use of a centralized specialist requires travel, this approach may impose added barriers to poor and rural patients’ access to care.

Further system-, provider-, and patient-level barriers can contribute to the low reach and, ultimately, poor sustainability of the centralized specialist model. At the system level, inadequate billing options present a significant challenge to the financial sustainability of tobacco-use treatment specialists. Health care providers may not refer patients to the specialist due to provider oversight, difficulty coordinating care with the specialist, and the assumption that patients will not use the service [9]. Moreover, specialist referral models typically require that patients make or accept referral contacts (e.g., patients must accept a call from a quitline once referred). However, there is abundant evidence that the majority of patients referred to a quitline never accept a quitline call, comprising a key weakness in the specialist referral strategy [14–16].

There is increased interest in an opt-out approach to tobacco-use treatment in which providers refer patients to treatment unless they explicitly decline it [17]. The specialist model may not accommodate the influx of patients generated by an opt-out

approach, especially if specialists attempt to deliver the intensive treatment for which they are particularly well suited (e.g., treatment of nicotine withdrawal for inpatients, providing 4–6 sessions of counseling) [4]. Of course, specialists could merely serve as conduits to low-intensity external resources (e.g., evidence-based web resources and smartphone apps, quitline counseling), but such resources could be used via other less-expensive routes such as EHR-based e-referral mechanisms [6]. In sum, centralized specialist-based tobacco-use treatment may be unsustainable due to its relatively low reach and high costs.

Paradigm shift to a more sustainable alternative

Decentralized approaches that allow for team-based tobacco-use treatment at the point of care, facilitated by EHRs, constitute a highly promising alternative practice to specialist referral models [9]. This may involve a team of medical assistants, staff nurses, and nurse practitioners conducting the tobacco use assessment, providing brief advice to quit smoking, queuing the cessation medication order for the clinician to prescribe, and referring to a bidirectional “closed-loop” quitline that both links patients to the quitline and transmits feedback to providers about subsequent patient engagement outcomes. The clinician may also reinforce this cessation support with further advice and encouragement. Research indicates that multiple brief (1–2 min) interactions have a cumulative benefit for patients [4]. This team-based approach with multiple touchpoints at the point of care potentially capitalizes on (a) the rapport that patients often have with nurses and medical assistants, (b) the high credibility of physicians and other front-line clinicians, and (c) the fact that care can be delivered while the patient is physically present in the clinic (i.e., it eliminates the attrition that occurs when patients must accept later specialist outreach).

As supported in systematic reviews and meta-analyses, health care systems may benefit from these types of standardized, lighter-touch yet higher-reach approaches to tobacco-use treatment [18,19]. This constitutes a comparatively low-burden approach across stakeholders—patients do not need to seek cessation care through a separate visit or contact, providers receive decision support and guidance in offering low-intensity support, and institutions avoid the high costs of employing specialists and the risk of defunding a potentially unsustainable program. Adopting a systematic, decentralized approach, in which the responsibility to provide effective and sustainable behavioral health support is shared broadly, communicates to both patients and providers that treating tobacco use is a prioritized medical concern.

Importantly, point-of-care was once the preferred approach to tobacco-use treatment—one in which every clinician was urged to intervene consistently

with their patients who smoked. Specialist models became more frequently used and endorsed because of evidence that point-of-care techniques could not be consistently implemented. That is, clinicians were unlikely to assess and intervene in tobacco use [20–23] because they were too pressed with competing clinical obligations, felt inadequately trained, or did not believe that patients would be receptive to or aided by smoking intervention [24–26]. As these potential barriers may still be present, proactive strategies are needed to optimize the capability, opportunity, and motivation of clinicians to offer point-of-care cessation support [27]. EHR-based approaches that are compatible with clinician workflow may address these goals via timely prompts and scripts and by automating previously time-consuming tasks [28–31]. Further, adequate training combined with data-driven feedback can promote clinician self-efficacy, highlight patient receptivity to point-of-care support, and instill healthy competition among clinicians within and between departments to drive high-quality, evidence-based practice as part of a learning health system [32]. To be consistently effective, point-of-care strategies thus need to be complemented with health care systems and resources that enhance sustained implementation [33,34].

Current study: point-of-care smoking cessation treatment among cancer patients

Fig. 1 describes the care-paradigm shift from the conventional specialist referral model (in which patients are referred to a tobacco-use treatment specialist) to the point-of-care treatment model (in which patients are treated for tobacco use during regular clinical care). Comprehensive EHR-facilitated point-of-care treatment for smoking (i.e., with both cessation counseling referral and medication prescribing) has demonstrated effectiveness in inpatient [28,35] and primary care settings [29,30,36,37]. Far less research has focused on point-of-care treatment of smoking among cancer patients. Previously, cancer programs have used EHR-based methods to support automated tobacco use assessment and referral to a tobacco-use treatment specialist for counseling and discussion of pharmacotherapy in coordination with the treating clinician [31]. No known studies have evaluated the effectiveness of an EHR-based program integrated with a comprehensive point-of-care model of assessment, cessation advice, medication support, and automated referral to low-burden counseling options within outpatient cancer care. This study describes a newly developed low-burden point-of-care cessation treatment program for cancer patients, driven in part by two key contextual factors:

Fig 1 | Conventional tobacco-use treatment specialist referral versus point-of-care treatment models. The conventional model relies on successful referrals by the clinical care team to a tobacco-use treatment specialist. Electronic health record (EHR) functionality enables the point-of-care model to efficiently deliver treatment.

(a) a prior institutional history of implementing a low-value and unsustainable tobacco-use treatment specialist-based program and (b) an impending transition to a new EHR system. This study also reports on tobacco-use treatment rates associated with the recent implementation of this EHR-facilitated point-of-care cessation program for outpatient oncology patients at a large cancer center.

METHODS

This pre- and post-intervention study was undertaken as part of the National Cancer Institute (NCI) Cancer Center Cessation Initiative within the NCI Cancer Moonshot program [38]. The Alvin J. Siteman Cancer Center (Siteman) at Barnes-Jewish Hospital and Washington University School of Medicine in St. Louis (Washington University) was funded by NCI to “build and implement sustainable tobacco cessation treatment programs to routinely address tobacco cessation with cancer patients” [39]. This study reports on the intervention components and 5-month outcomes of the Electronic Health Record-Enabled Evidence-Based Smoking Cessation Treatment (ELEVATE) program, a low-burden point-of-care model of smoking cessation treatment capitalizing on an EHR transition from Allscripts TouchWorks (Allscripts Healthcare Solutions, Inc., Chicago, IL) to Epic (Epic Systems Corporation, Verona, WI).

Intervention: ELEVATE

ELEVATE facilitates systematic implementation of the “5 A’s” tobacco cessation intervention framework (*Ask, Advise, Assess, Assist, Arrange*) [4] by leveraging Epic EHR functionality to ensure consistent tobacco use assessment and cessation treatment support for Siteman patients. Notably, ELEVATE represents a paradigm shift from a cessation specialist referral model of care to a low-burden point-of-care treatment model. ELEVATE uses a two-pronged implementation approach that focuses on optimizing the EHR-enabled workflow and evaluating practice data for feedback. This approach is mediated by an internally developed Epic module specifically designed to facilitate end-to-end delivery of the “5 A’s,” guide provider workflow for each clinical encounter, and harness staff workflow training and formative process feedback to optimize implementation of the program (Fig. 1).

Epic module

The ELEVATE Epic module was designed to systematically facilitate the timely provision and documentation of tobacco use assessment and point-of-care treatment with counseling and cessation medication. Development of the module began in September 2017 by the ELEVATE team, a transdisciplinary group that included smoking cessation and cancer clinician-researchers, administrators

of informational systems and cancer center operations, implementation science experts, institutional EHR staff, and representative clinical staff and patient stakeholders. The new module was integrated into the Epic Beacon oncology information system and activated alongside the system-wide Epic EHR transition on June 2, 2018. Since its activation, the module has been continually evaluated with ongoing optimizations made to improve workflow efficiency and efficacy.

EHR-assisted point-of-care “5 A’s” workflow

Fig. 2 describes the comprehensive ELEVATE point-of-care “5 A’s” workflow ensuring that all patients are assessed for smoking and that all current smokers are offered cessation support. This workflow begins when a clinical care provider (e.g., a nurse or medical assistant) enters the module when taking patient vital signs. The module first prompts the provider to *Ask* about tobacco use and *Advise* cessation, including a brief script: “The best thing you can do for your health is quit smoking.” If the patient is documented as a current tobacco user and counseling options have not been offered in the last 90 days, a Tobacco Intervention Assessment Best Practice Advisory (BPA, [Supplementary Fig. S1](#)) prompts the provider to *Assess* readiness to quit and treatment needs by determining whether the patient is interested in phone-based, SMS text-based, or smartphone app-based counseling.

The Tobacco Intervention Assessment BPA then offers providers decision support to *Assist* the patient with tobacco cessation interventions. If phone-based counseling is selected, an order automatically generates and prints a completed referral form that the provider manually faxes to the Missouri or Illinois Tobacco Quitline. If SMS text-based or smartphone app-based counseling is selected, directions for enrollment in the NCI Smokefree.gov program or for downloading the NCI Smokefree.gov QuitGuide and quitSTART apps are automatically added to the patient’s After Visit Summary, which is provided to the patient at the conclusion of their clinic encounter. This point-of-care workflow thus bypasses the conventional steps of (a) referring to the specialist, who then (b) more thoroughly assesses interest in counseling and (c) provides and/or makes further referrals to phone-based, text-based, or smartphone app-based counseling.

If the patient is a current tobacco user without current documented use or prescription of tobacco cessation medication, the module also activates the Tobacco Cessation BPA for the prescribing clinician (e.g., an oncologist) to further *Assist* with cessation by using an Epic SmartSet to prescribe tobacco cessation medication (nicotine replacement therapy, bupropion, and/or varenicline) per evidence-based guidelines. Finally, ELEVATE facilitates workflow as providers *Arrange* to include tobacco use

EHR-Enabled Evidence-Based Cessation Treatment (ELEVATE)

Fig 2 | ELEVATE patient care workflow: A point-of-care treatment model for smoking cessation via the “5 A’s.” ELEVATE facilitates “5 A’s” patient care by harnessing Epic’s Best Practice Advisory (BPA) functionality to prompt and integrate intervention actions by clinical care providers (e.g., nurses or medical assistants) and prescribing clinicians within the electronic health record (EHR).

disorder in the problem list for ongoing tracking and follow-up point-of-care treatment. In addition to assessing tobacco use at every in-person clinical encounter, ELEVATE ensures that patients continually receive renewed opportunities for cessation support as counseling options are re-offered every 90 days and cessation medication may be prescribed once current medication documentation or prescriptions expire. [Supplementary Text S1](#) provides a detailed description of the ELEVATE workflow.

ELEVATE clinical training and feedback

To introduce and prepare clinics for the new point-of-care tobacco-intervention workflow, a half-day smoking-cessation Continuing Medical Education seminar entitled “Treating Smokers in the Health Care Setting” was provided to physicians, nurses, and other allied health professionals in May 2018. Since the June 2018 Epic transition, the ELEVATE team has offered various empirically supported [4,7,32] ad hoc training resources to prescribing

clinicians and clinical care providers (e.g., training sessions during clinical staff meetings and clinical tool cards). Formal training exercises have included in-person and video-based demonstrations of ELEVATE module use and simulated patient scenarios with clinical care providers using test patients in Epic. Informal training features oversight of live patient encounters and recommendations on providing effective and compassionate cessation support. The ELEVATE team also routinely solicits formative process feedback during clinical staff meetings and from representative stakeholders to enhance ELEVATE implementation. This feedback has informed ELEVATE module and workflow modifications, including additional patient response options, modes of resource delivery, and conditional suppression of selected module components.

Samples

Pre- and post-intervention samples comprised patients who completed outpatient encounters at 21 major

Siteman oncology clinics staffed by Washington University Physicians. The pre-intervention sample included all oncology outpatients seen between January 1, 2018 and June 1, 2018 (the 5-month pre-ELEVATE Allscripts TouchWorks EHR timeframe). The post-intervention sample included all oncology outpatients seen between June 2, 2018 and October 31, 2018 (the 5-month post-ELEVATE Epic EHR timeframe).

EHR data extraction

Pre-ELEVATE EHR data were extracted from Allscripts TouchWorks for oncology patients completing outpatient encounters from January 1, 2018 to June 1, 2018. As Allscripts TouchWorks lacked structured tobacco use and treatment data, patients were considered smokers if tobacco use or nicotine dependence were ever specified in their problem lists; cessation counseling was likewise considered provided (directly or by referral) if it was ever documented in the patient's problem list. Post-ELEVATE EHR data were extracted from Epic for oncology patients completing outpatient encounters from June 2, 2018 to October 31, 2018. Washington University Physicians billing information was used to optimize Epic data extraction ([Supplementary Text S2](#) and [Supplementary Fig. S2](#) provide a detailed description of the Epic data extraction process).

Measures

From the extracted EHR data, measures of tobacco use and cessation treatment rates characterized by the “5 A's” were defined and calculated from the number of *unique* patients who met specific criteria *over the duration of the respective pre- and post-ELEVATE timeframes*—instead of by encounter—in order to reflect the overall patient exposure to ELEVATE (see [Table 1](#)). Smoking status was validated by consistent documentation across multiple clinical encounters when available. Accuracy of calculated measures from extracted EHR data was internally validated through manual and automated calculation processes.

Data analysis

Data analysis entailed comparisons between pre- and post-ELEVATE proportions of patients receiving a tobacco use assessment, patients identified as smokers who were referred to cessation counseling, and patients identified as smokers who were prescribed or documented as using cessation medication. Statistical analysis included computation of the proportional measures and comparison of differences using two-sided z tests ($\alpha = .05$). All analyses were conducted using SAS, version 9.3 for Microsoft Windows (SAS Institute, Inc. Cary, NC).

RESULTS

[Table 2](#) provides data on smoking assessment and intervention delivery rates for the pre-ELEVATE ($N = 34,223$) and post-ELEVATE ($N = 24,485$)

samples of unique Siteman outpatients. Patient demographic factors were similar between the pre- and post-ELEVATE samples except for a significantly higher proportion of White patients (82.35% vs. 80.16%, $z = 6.74$, $p < .001$) and a significantly lower proportion of Black or African American patients (14.18% vs. 16.43%, $z = -7.51$, $p < .001$) in the post-ELEVATE sample ([Supplementary Table S1](#)).

More patients were assessed for tobacco use

[Fig. 3](#) illustrates the implementation outcomes of the “5 A's,” as facilitated by ELEVATE's EHR functionalities. Documented assessment of patient tobacco use status significantly increased from the 48% pre-ELEVATE to 90% post-ELEVATE timeframe ($z = 126.57$, $p < .001$). There was no accurate estimate of pre-ELEVATE smoking prevalence given the limitations of the Allscripts TouchWorks tobacco use assessment data.

More smokers were provided evidence-based treatment

Over the duration of the post-ELEVATE timeframe, the provision of brief smoking cessation counseling was documented for 18% of current smokers; no comparative pre-ELEVATE Allscripts TouchWorks data were available. During the post-ELEVATE timeframe, the proportion of current smokers offered cessation-counseling resources was 21%; again, no comparative pre-ELEVATE Allscripts TouchWorks data were available. The proportion of smokers directly provided (pre-ELEVATE only) or referred to cessation counseling increased from the pre-ELEVATE (0.72%) to post-ELEVATE timeframe (1.91%; $z = 3.81$, $p < .001$). Although 91% of offers for counseling resources were refused ([Supplementary Table S1](#)), of the documented post-ELEVATE referrals, the greatest number were ordered for counseling via the patient's state quitline (47%, [Supplementary Table S1](#)). The proportion of smokers with prescribed and/or documented tobacco cessation medication significantly increased from the pre-ELEVATE (3%) to post-ELEVATE timeframe (17%; $z = 17.20$, $p < .001$).

DISCUSSION

First, this study's pre-intervention data analysis confirms that patients in the cancer center infrequently received tobacco use assessment and cessation treatment. Second, post-intervention analysis supports both the feasibility and potential of a care-paradigm shift from a conventional specialist referral model to a point-of-care treatment model to increase the delivery of smoking cessation treatment during cancer center patients' regular clinical appointments. Specifically, rates of tobacco use assessment, referral to cessation counseling, and pharmacological cessation treatment were significantly higher in the point-of-care treatment model supported by ELEVATE implementation. These increases were

Table 1 | Measure definitions of tobacco intervention rates, pre- and post-ELEVATE

Measure	Numerator patient criteria		Denominator patient criteria
	Pre-ELEVATE (Allscripts TouchWorks)	Post-ELEVATE (Epic)	
Tobacco use assessment	Any tobacco use or nicotine dependence status (i.e., current-, former-, or never-use or dependence) ever documented in the problem list	Tobacco use status ever documented as value besides NULL, never assessed, or unknown if ever smoked	Completed at least one outpatient oncology clinic encounter
Current smokers	Current tobacco use or nicotine dependence ever documented in the problem list	Ever documented as a current smoker, was ever offered counseling, or was prescribed or documented as using tobacco cessation medication	Assessed for tobacco use
Brief counseling provided	Not available	Ever documented as receiving brief cessation counseling	Current smoker
Cessation counseling offered	Not available	Ever had a documented non-NULL response to an assessment of interest in counseling <i>without regard for documented tobacco use status</i>	Current smoker
Cessation counseling provided or referred	Smoking cessation counseling ever documented in the problem list	Ever had a documented referral to phone-based, SMS text-based, and/or smartphone app-based counseling	Current smoker
Cessation medication prescribed and/or documented	Ever had active smoking cessation medication documented in the EHR in the outpatient setting	Ever had active smoking cessation medication prescribed or documented in the EHR in the outpatient setting (excluding medications without an end date that were prescribed more than 6 months prior to the start of the timeframe)	Current smoker

EHR electronic health record.

Table 2 | Pre- and post-ELEVATE comparisons of tobacco use assessment and treatment among Siteman Cancer Center outpatients. ELEVATE is associated with significantly increased tobacco use assessment and documented treatment

Timeframe of data collection (EHR)	Pre-ELEVATE (January 1, 2018–June 1, 2018, Allscripts TouchWorks)	Post-ELEVATE (June 2, 2018–October 31, 2018, Epic)	<i>z</i>	<i>p</i>
Patients seen, <i>N</i>	34,223	24,485		
Tobacco use assessed, <i>n</i> (% of patients seen)	16,382 (47.87%) ^a	22,004 (89.87%)	126.57	<.001
Current smokers, <i>n</i> (% of patients assessed)	2,917 ^a	2,567 (11.67%)		
Brief counseling provided, <i>n</i> (% of current smokers)	NA	467 (18.19%)		
Cessation counseling offered, <i>n</i> (% of current smokers)	NA	527 (20.53%)		
Cessation counseling provided or referred, <i>n</i> (% of current smokers)	21 (0.72%)	49 (1.91%)	3.81	<.001
Cessation medication prescribed and/or documented, <i>n</i> (% of current smokers)	89 (3.05%)	434 (16.91%) ^b	17.20	<.001

EHR electronic health record; NA not available.

^aThere was no accurate estimate of pre-ELEVATE smoking prevalence due to low assessment rates.^b125 (4.87%) smokers were prescribed and 280 (10.91%) smokers were documented as using cessation medication, with 29 (1.13%) smokers having both prescribed and documented medication.

twofold for assessment and counseling and fivefold for medication treatment, indicating highly promising outcomes for this low-burden point-of-care cessation treatment program. In general, preliminary

post-ELEVATE outcomes compare favorably to related studies of tobacco use assessment (<80%) and medication delivery (<10%) [36,37]. Despite a significant increase in counseling provided or referred

“5 A’s” Implementation with ELEVATE

Fig 3 | “5 A’s” implementation with ELEVATE. The patient flow diagram demonstrates the electronic health record (EHR)-facilitated implementation of the “5 A’s” tobacco intervention through the outpatient oncology clinic workflow alongside rates of completion for each of the “5 A’s.”

from pre- to post-ELEVATE, which may be a function of the large sample sizes involved, the comparison with similar studies is equivocal (~1%–4%) [32,37]. Although these initial post-ELEVATE treatment rates remain fairly low overall, the program’s broad point-of-care reach demonstrates that even a “light touch” approach with a modest effect size may translate into major patient impacts on a population scale. In addition, these results are based on an initial system-level change, and further implementation efforts are likely to boost this effect size moving forward.

ELEVATE’s point-of-care model is supported by EHR functionality, an approach shown to enhance the scalability and sustainability of implementation strategies in other health care settings [28,40,41]. EHR-assisted strategies such as ELEVATE are highly scalable to health care systems in which tobacco-use treatment specialists are not available or accessible. The incorporation of ELEVATE into the health care system’s EHR should promote the sustainability or maintenance of tobacco intervention since it should both cue intervention delivery and reduce intervention burden. Furthermore, EHR-based programs such as ELEVATE are not only designed to facilitate

clinic workflow but also yield accessible queries for ongoing program evaluation. Systematic implementation of the “5 A’s” through ELEVATE provides nearly real-time access to accurate tobacco use and intervention data across Siteman Cancer Center clinics. This ongoing capability to assess variation in the usage of particular EHR modules can identify provider workflow barriers and training and data feedback needs. ELEVATE thus offers opportunities to use a learning health system to use—in real-time—the best possible information to drive high-quality clinical practice and high-impact research.

As an example of the evaluative and adaptive strengths of the EHR within a learning health system, this preliminary analysis of ELEVATE demonstrates a possible workflow barrier to documenting cessation advice to current smokers, a barrier that might be addressed through training or further EHR enhancements. Although 21% of current smokers were offered cessation-counseling resources, only 18% of these same smokers were documented as receiving brief advice to quit. In ELEVATE, documenting the provision of brief advice occurs before counseling resources are even offered. As successful documentation entails selecting a checkbox within the initial

tobacco use assessment module, which contains numerous other checkboxes and data entry fields (e.g., types of tobacco used, years of use), it is possible that many clinical staff do not fully review and/or complete this section of the module interface despite later offering counseling resources (and, at minimum, implicitly providing brief cessation advice) within the separate Tobacco Intervention Assessment BPA. This discrepancy in *Advise* and *Assist* rates identified by this preliminary analysis characterizes a potential workflow barrier and provides supportive evidence for targeted module, workflow, and training optimizations.

The results of this study should be interpreted in the context of several limitations. First, the design comprised a pre- and post-intervention comparison without randomization; a concurrent control condition, for example, would have enhanced internal validity. As an evaluation of the effect of an institution-wide EHR change, it is possible that a Hawthorne effect [42] enhanced the impact of ELEVATE features. Moreover, efforts should be made to determine the maintenance of ELEVATE, as maintenance of health care changes is difficult even in EHR-based systems due to a possible decrease in staff engagement over time [6]. Second, although delivery of evidence-based treatment was the primary outcome, this study was unable to establish accurate pre-ELEVATE smoking prevalence as smoking assessment rates were low and the Allscripts TouchWorks smoking status data were neither discrete nor easily queried. Finally, the point-of-care model may only prove feasible when EHR functionalities fully support evidence-based care and relay ongoing practice data, potentially limiting generalizability to other sites. Therefore, it is possible that a hybrid model that augments cost-effective, decentralized point-of-care treatment with a dedicated specialist may be a useful approach when resources are available yet EHR functionality is limited.

This study has yielded many insights, even in its relatively nascent stage. An early lesson learned was the importance of seizing on a concurrent system-wide change by timing the ELEVATE program development and implementation with the EHR transition from Allscripts TouchWorks to Epic, as this required providers to learn and adjust to a new system, constituting a natural opportunity to change smoking-related practices. Second, there are significant benefits to program sustainability in committing to the full learning health system cycle of *data-to-knowledge*, *knowledge-to-practice*, and *practice-to-data*. For example, comprehensive training within a health system that expects, supports, and rewards provider engagement and performance cultivates provider buy-in via increased *knowledge* of intervention value, increased *practice* competence in intervention execution, and increased *data* feedback on effectiveness. Relatedly, high-level administrative

and leadership support promotes provider investment in and commitment to improvement, and in turn, data-supported improvement promotes increased administrative and leadership support.

These lessons learned accordingly translate into recommendations to integrate the core elements of the ELEVATE program into other EHR systems, Epic or otherwise. The ELEVATE program module is highly scalable to any Epic system and able to be disseminated via Epic User Web. Similarly, the components of this module are transportable to other EHR systems with the appropriate functionalities. Importantly, it is not the Epic-specific tools, but rather commitment to a learning health system, that drives program success. Therefore, successful implementation efforts will likely require a convergence of administrative and leadership support, clinician team engagement to provide training and inform workflow-specific modifications, and EHR analyst availability and commitment to implement workflow-specific modifications, as needed. In addition, state-specific prescription policies may apply regarding the Medicaid coverage of cessation medications and quitline capabilities available across states. Nevertheless, ELEVATE serves as an EHR-enabled resource for other cancer centers, Epic users, and other entities intending to implement point-of-care cessation support. Of note, clinical staff and administrative buy-in is critical for the successful scalability and sustainability of SUCH point-of-care treatment models. Informal feedback on ELEVATE implementation has been overwhelmingly positive across all levels of Siteman Cancer Center care and administration. Institutional administration and clinicians appreciate that ELEVATE promotes patient-centered cancer care with minimal costs in time and resources. Perhaps both a cause and consequence of ELEVATE's success has been the high engagement of the clinical care providers who carry much of the point-of-care workload. Although providing constructive feedback informing module and workflow implementation and optimization, these providers report high levels of satisfaction with the intervention, feeling as though they can now directly contribute to an improved quality of patient care. They agree that patients benefit from repeated reminders and report that patients greatly appreciate receiving this immediate, detailed, comprehensive level of care for a significant aspect of their broader health.

Future directions to enhance progress toward a learning health system include systematic (e.g., monthly) performance data feedback at the individual provider level, in comparison to department- and/or clinic-level data and clinical benchmarks. Randomizing this provider feedback may also determine whether the positive initial outcomes of ELEVATE can be further enhanced by such feedback. In response to ongoing process data, ELEVATE will continue to undergo interface modifications (e.g.,

module alerts and suppressions) and development of additional module elements, including “closed-loop” quitline referrals [6] that eliminate manual faxing; assess patient engagement in counseling; and provide more robust reach, maintenance, and effectiveness data. With promising outcomes and a shared EHR platform across the health care system, the core components of ELEVATE can be scaled up across all oncology departments and then more broadly to other outpatient and inpatient settings.

Study findings demonstrate the potential of ELEVATE as an EHR-enabled point-of-care treatment strategy to increase cessation treatment and support as part of routine cancer center care for patients who smoke. The conventional specialist referral model without any point-of-care treatment support runs the risk of incurring non-sustainable costs and unacceptably low reach. In contrast, the point-of-care treatment model exemplified by ELEVATE activates a decentralized approach that can serve as a blueprint for maximizing reach across patients. This model benefits from timely and consistent access to providers with high potential for penetration (i.e., a large proportion of providers are able to deliver the intervention). Furthermore, an EHR-enabled point-of-care approach enables assessment of outcomes across all patients. Importantly, to the extent that ELEVATE enhances reach, it should also benefit population-based effects. ELEVATE thus offers an effective, population health-focused solution to maximize the reach of evidence-based smoking cessation care to cancer center patients who smoke.

Supplementary Material

Supplementary material is available at *Translational Behavioral Medicine* online.

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Compliance with Ethical Standards

Conflict of Interest: L.J. Bierut is listed as an inventor on Issued U.S. Patent 8,080,371 “Markers for Addiction” covering the use of certain SNPs in determining the diagnosis, prognosis, and treatment of addiction, and served as a consultant for the pharmaceutical company Pfizer Inc. (New York City, New York, USA) in 2008. The remaining authors declare no conflict of interest.

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thereof and takes overall responsibility for its conduct. All authors contributed to drafting the manuscript.

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