An Electronic Health Record Tool Increases Genetic Counseling Referral of Individuals at Hereditary Cancer Risk: An Intervention Study

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Family history · Screening · Primary care providers · Genetic counseling

Abstract
Introduction: There is widespread under-identification of individuals at hereditary cancer risk despite national guidelines calling for screening. We evaluated the utilization of a tool embedded in the electronic health record (EHR) to assist primary care providers in screening patients for cancer genetic counseling referral. Methods: We designed BestPractice Advisories linked to a Genetic Cancer Screening Tool (GCST) in EpicCare Ambulatory. The GCST identifies individuals for evaluation for BRCA1/2, Lynch syndrome, and other risk mutations due to personal and family history. We tested the tool in a 7-week intervention in adult wellness visits at two clinics, one urban and one rural. Results: Out of 687 eligible patients, the screening survey was completed for 469 (67%), and of these, 150 (32%) screened positive for a personal and/or family history meeting genetic counseling referral criteria. Of individuals screening positive, a referral order was placed for 20 (13%). GCST screen-positive rate varied by patient gender but not race or age. Referral rate varied by provider and clinic but was not significantly affected by patient demographics. In the previous year over an equivalent date range, 0.1% of wellness visits (1 of 1,086) led to a referral, and this rate increased to 2.1% (22 of 1,062) during the intervention. The proportion of providers referring patients also increased, from 3.8% (1 of 26) to 42.3% (11 of 26). Discussion/Conclusion: Genetic counseling referral of individuals at hereditary cancer risk was increased by use of an EHR-integrated tool. These findings add evidence for the benefit of clinical decision support for cancer genetic risk screening in primary care.

Introduction

Identification of individuals at increased cancer risks from BRCA1/2, Lynch syndrome, or other hereditary cancer risk mutations presents an opportunity to reduce morbidity and mortality through increased cancer screening and/or prophylactic surgeries [1–5]. Nonetheless, most people who carry a cancer risk mutation are unaware of their gene status. For example, while BRCA1/2 mutation prevalence rates have been estimated at 1/400 to 1/180 in the USA, studies have observed over 70% of individuals with mutations to be unaware of their status [6–8].
National guidelines recommend screening for hereditary cancer risk syndromes. US Preventive Services Task Force (USPSTF) BRCA1/2 recommendations call for primary care providers (PCPs) to ask all women about personal and/or family history of cancer [9]. Then, for any women reporting a personal and/or family history of breast or ovarian-type cancer, the provider is to use a screening tool to assess the need for genetic counseling referral. The Centers for Disease Control and Prevention (CDC) consider cancer risk from BRCA1/2 mutations and Lynch syndrome to be Tier 1 genomic applications because of the evidence-based potential for significant impact on public health [10].

Primary care has been a focus of quality improvement interventions to increase implementation of these national recommendations because PCPs typically coordinate care for patients over time, including screening for a range of health conditions [11, 12]. There are some data to suggest that most patients expect their PCP to take the lead in recognizing a family history of cancer [13]. Indeed, the majority of individuals who have been seen for cancer genetic counseling did so on the recommendation of their doctor [14]. PCPs largely agree on the importance of their role in screening patients for hereditary cancer risk and facilitating access to genetic services [12, 15]. However, only 10% of women with a family history of BRCA-related cancers report discussing genetic testing with a provider [16]. Many providers report barriers to addressing risk assessment, including self-reported lack of knowledge, lack of confidence discussing genetic testing with patients, challenges gathering family history information from patients, and time constraints [12, 16–18].

While a large number of tools have been developed for collection and assessment of family histories [19], only a relatively small number of implementation studies have been published to address feasibility in primary care clinics [20–24]. Within the primary care setting, we sought to address under-identification of individuals at hereditary cancer risk. We developed a Genetic Cancer Screening Tool (GCST) to assist PCPs in asking targeted questions about personal and family history and then determining whether genetic counseling referral is indicated. In response to the time constraints of primary care as well as the established validity of other condensed family history questionnaires [25–27], the GCST’s patient questionnaire uses a simplified version of National Comprehensive Cancer Network (NCCN) genetic testing guidelines. To address the needs of PCPs for clinical decision support while maximizing provider efficiency, we embedded the tool in the EpicCare Ambulatory electronic health record (EHR). Here, we present a quality improvement study assessing utilization of the GCST during initial implementation.

Materials and Methods

Study Design
An interdisciplinary advisory committee including representatives from primary care, genetic counseling, and information services developed a clinical decision support tool integrated into the EpicCare Ambulatory EHR. A pre-post-implementation-effectiveness study design was used to evaluate the tool in routine primary care. The study protocol was approved by the Allina Health Institutional Review Board and carried out in accordance with relevant guidelines and regulations.

Setting and Participants
The study was conducted within the Allina Health system, which operates ~100 nonprofit clinics and hospitals within Minnesota. This study took place at two Allina Health primary care clinics: one in an urban setting and one in a rural setting. There were a total of 26 PCPs at the two clinics. PCPs at the urban clinic are board-certified in internal medicine (n = 6), family medicine (n = 1), or gerontology (n = 1). PCPs at the rural clinic are board-certified in family medicine (n = 18).

Individuals age 18 or older were eligible for the study if they were seen for a wellness visit at a participating clinic. For all analyses, individuals were only included if they had indicated a willingness to have their medical records included for research purposes as identified in the EHR. The study tool was implemented in visits from April 9, 2019, to May 28, 2019. Visits were also analyzed from April 10, 2018, to May 29, 2018, for pre-implementation metrics.

Intervention
Pre-screening of patients was used to reduce the clinical workload added by the GCST by identifying patients more likely to screen positive. Pre-screening occurred in two ways: (1) previous documentation in the EHR that a patient reported a family history of cancer and (2) a pre-visit EHR-linked online questionnaire. The online questionnaire asked whether the patient or a close blood relative (parent, sibling, child, aunt, uncle, niece, nephew, or grandparent) meets certain criteria (Table 1) based on the NCCN genetic testing guidelines. The online questionnaire can be found in online supplementary File 1 (for all online suppl. material, see www.karger.com/doi/10.1159/000525447). If a family history of cancer was reported via either of these methods, the PCP saw a BestPractice Advisory during the wellness visit prompting the provider to complete the GCST with the patient (Fig. 1). The GCST asked whether the patient or a close blood relative meets certain criteria (Table 1) based on the NCCN genetic testing guidelines. The GCST can be found in online supplementary File 2. If “none” was selected, the BestPractice Advisory was turned off for a year.

If any criterion was selected, a secondary BestPractice Advisory appeared for the provider to either place an order for referral to genetic counseling or select a reason for not placing the order (will schedule future reason to discuss, not appropriate for patient, done already, or patient declines). Images from the provider and patient interfaces of the screening tool can be found in online supplementary File 3.
Measures

The outcome measures were the rate of completion of the GCST screening survey, the proportion of eligible individuals screening positive for a personal and/or family history meeting genetic counseling referral criteria, and the rate of genetic counseling referrals in wellness visits pre- and post-implementation. Demographic data were collected on patients through the EHR. Provider characteristics were collected through publicly available clinic website listings and National Provider Identifier (NPI) records. Exploratory measures included associations between patient demographics or provider characteristics and survey completion, screening result, or genetic counseling referral rate.

Table 1. Personal/family history criteria used in the pre-visit EHR-linked online questionnaire and in the GCST

| Personal/family history criteria                                                                 |
|--------------------------------------------------------------------------------------------------|
| Breast cancer diagnosed before age 46                                                            |
| Breast cancer and Jewish ancestry                                                                |
| Ovarian cancer diagnosed at any age                                                               |
| Male breast cancer diagnosed at any age                                                            |
| Colorectal cancer diagnosed before age 50                                                          |
| Uterine cancer diagnosed before age 50                                                              |
| 3 or more relatives on same side of family with breast cancer and/or pancreatic cancer at any age  |
| 3 or more relatives on same side of family with colorectal and/or uterine cancer at any age        |

Patients were asked whether they or a close blood relative (parent, sibling, child, aunt, uncle, niece, nephew, or grandparent) meet any of the above criteria.

Table 2. Demographics of patients in the intervention cohort

| Characteristics | Frequency, n (%) (n = 687) |
|-----------------|----------------------------|
| Gender          |                            |
| Female          | 409 (59.5)                 |
| Male            | 278 (40.5)                 |
| Race            |                            |
| White           | 664 (96.7)                 |
| Others          | 23 (3.3)                   |
| Age             |                            |
| <65 years       | 437 (63.6)                 |
| ≥65 years       | 250 (36.4)                 |

Statistical Analyses

The data are presented as counts and proportions for categorical variables. Associations were assessed using the $\chi^2$ and or Fisher’s exact test as appropriate. The odds ratio (OR) with associated 95% confidence limits (CL) was used to quantify the magnitude and direction of association among the variables. All statistical analysis was performed using SAS version 9.4 and all tests done at a 5% level of significance.

Results

Participant Characteristics

In the intervention period, 1,876 individuals were seen for adult wellness visits at a participating clinic during the study period. Of these, 687 unique individuals were eligible for the study intervention based on a previous documentation in the EHR reporting a family history of cancer or based on a positive response to a pre-visit EHR-linked online family history questionnaire. These eligible individuals were majority female (60%), white (97%), and under 65 years old (64%) (Table 2).
An Electronic Health Record Tool Increases Cancer Genetic Counseling Referral

Table 3. GCST completion rates

| Characteristics | Overall, n (n = 687) | GCST completed, n (%) (n = 469) | GCST not completed, n (%) (n = 218) | OR (95% CL OR) | p value |
|-----------------|----------------------|---------------------------------|-------------------------------------|----------------|---------|
| Clinic          |                      |                                 |                                     |                |         |
| Urban           | 172                  | 109 (63.4)                      | 63 (36.6)                           | 0.74 (0.52–1.07) | 0.11    |
| Rural           | 515                  | 360 (69.9)                      | 155 (30.1)                          |                |         |
| Gender          |                      |                                 |                                     |                |         |
| Female          | 409                  | 289 (70.7)                      | 120 (29.3)                          | 1.31 (0.95–1.82) | 0.10    |
| Male            | 278                  | 180 (64.7)                      | 98 (35.3)                           |                |         |
| Race            |                      |                                 |                                     |                |         |
| White           | 664                  | 454 (68.4)                      | 220 (33.1)                          | 1.15 (0.48–2.76) | 0.75    |
| Others          | 23                   | 15 (65.2)                       | 8 (34.8)                            |                |         |
| Age             |                      |                                 |                                     |                |         |
| <65 years       | 437                  | 296 (67.7)                      | 141 (32.3)                          | 0.93 (0.67–1.31) | 0.69    |
| ≥65 years       | 250                  | 173 (69.2)                      | 77 (30.8)                           |                |         |
| Provider experience |            |                                 |                                     |                |         |
| ≤10 years       | 131                  | 83 (63.4)                       | 48 (36.6)                           | 0.32           |         |
| 10–20 years     | 248                  | 176 (71.0)                      | 72 (29.0)                           |                |         |
| >20 years       | 308                  | 210 (68.2)                      | 98 (31.8)                           |                |         |

GCST, Genetic Cancer Screening Tool; OR, odds ratio; CL, confidence limits.

Table 4. GCST outcomes

| Characteristics | Overall, n (n = 687) | Screened positive, n (%) (n = 150) | Screened negative, n (%) (n = 537) | OR (95% CL OR) | p value |
|-----------------|----------------------|------------------------------------|-------------------------------------|----------------|---------|
| Clinic          |                      |                                    |                                     |                |         |
| Urban           | 172                  | 41 (23.8)                          | 131 (76.2)                          | 1.17 (0.77–1.76) | 0.46    |
| Rural           | 515                  | 109 (21.2)                         | 406 (78.8)                          |                |         |
| Gender          |                      |                                    |                                     |                |         |
| Female          | 409                  | 110 (26.9)                         | 299 (73.1)                          | 2.19 (1.47–3.27) | <0.0001 |
| Male            | 278                  | 40 (14.4)                          | 238 (85.6)                          |                |         |
| Race            |                      |                                    |                                     |                |         |
| White           | 664                  | 145 (21.8)                         | 519 (78.2)                          | 1.01 (0.37–2.76) | 0.99    |
| Others          | 23                   | 5 (21.7)                           | 18 (78.3)                           |                |         |
| Age             |                      |                                    |                                     |                |         |
| <65 years       | 437                  | 100 (22.9)                         | 337 (77.1)                          | 1.01 (0.69–1.49) | 0.96    |
| ≥65 years       | 250                  | 50 (20.0)                          | 200 (80.0)                          |                |         |
| Provider experience |            |                                    |                                     |                |         |
| ≤10 years       | 131                  | 23 (17.6)                          | 108 (82.4)                          | 0.18           |         |
| 10–20 years     | 248                  | 63 (25.4)                          | 185 (74.6)                          |                |         |
| >20 years       | 308                  | 64 (20.8)                          | 244 (79.2)                          |                |         |

GCST, Genetic Cancer Screening Tool; OR, odds ratio; CL, confidence limits.

GCST Use

Out of 687 eligible patients, the GCST was completed by a provider in the visit for 469 (67%; Table 3). Female patients were associated with higher GCST completion rates, although the difference between female and male patients was not significant ($p > 0.05$). No significant differences in GCST completion rates were seen for patient race, age, and provider years of experience.

When the GCST was completed, 150 of 469 patients (32%) then screened positive for a personal and/or family history meeting genetic counseling referral criteria. This was 21.8% of the 687 patients eligible for the inter-
vention. GCST screen-positive rate was statistically significantly higher for female patients than for male patients (27% vs. 14%, p value <0.0001; Table 4). GCST screen-positive rate did not vary significantly by patient race or age.

**Referral Rate**

Of the 150 individuals screening positive on the GCST, a genetic counseling referral order was placed for 20 (13%), or 2.9% of the 687 patients eligible for the intervention. Referral rate varied by individual provider (data not shown) and clinic but not on the provider years of experience (Table 5). Referral rate was not significantly affected by patient demographics including gender, race, or age, although there was a nonsignificant trend toward a higher referral rate for female patients than male patients (3.9% vs. 1.4%, p value 0.06).

The EHR-based BestPractice Advisory referral tool collected responses from providers regarding the reason a referral was not placed. The most common outcome was no action taken by the provider (61%). Responses collected from providers also included that the patient declined (17%), referral was not appropriate for the patient (12%), the patient had already done genetic counseling (6%), or a separate appointment would be needed to discuss referral (5%).

Comparison of the pre- versus post-implementation referral rate was made. In the previous year over an equivalent date range, 0.1% of wellness visits led to a referral (1 of 1,086 visits), and this rate increased to 2.1% during the intervention phase (22 of 1,062 visits). This analysis considered all wellness visits for adults at the two clinics, regardless of family history-based eligibility for the study intervention. The proportion of providers making at least one referral also increased, from 3.8% in the previous year over an equivalent date range (1 of 26 providers) to 42.3% in the intervention phase (11 of 26 providers).

**Discussion/Conclusion**

In this implementation study of an EHR-based GCST, PCPs were found to use the GCST in the majority of encounters where it was indicated, more providers made genetic counseling referrals with the tool, and the year-over-year genetic counseling referral rate increased with the tool. Our work adds to growing evidence for the benefit of clinical decision support tools in primary care to assist with identification of individuals at hereditary cancer risk. In a previous study in one health center, EHR-based reminders to PCPs to ask about family history and assess the need for genetic referral led to increased documentation of cancer family history and increased referrals [22]. Use of web-based family cancer history assessment tools by PCPs also has been shown to increase genetic counseling referral rate [20, 21].

| Characteristics | Overall, n (n = 687) | Referral placed, n (%) (n = 20) | Referral not placed, n (%) (n = 667) | OR (95% CL OR) | p value |
|-----------------|---------------------|-------------------------------|-----------------------------------|--------------|---------|
| Clinic          |                     |                               |                                   |              |         |
| Urban           | 172                 | 9 (5.2)                       | 163 (94.8)                        | 2.53 (1.03–6.21) | 0.04    |
| Rural           | 515                 | 11 (2.1)                      | 504 (97.9)                        |              |         |
| Gender          |                     |                               |                                   |              |         |
| Female          | 409                 | 16 (3.9)                      | 393 (96.1)                        | 2.79 (0.92–8.43) | 0.06    |
| Male            | 278                 | 4 (1.4)                       | 274 (98.6)                        |              |         |
| Race            |                     |                               |                                   |              |         |
| White           | 664                 | 19 (2.9)                      | 645 (97.1)                        | 0.65 (0.08–5.06) | 0.50    |
| Others          | 23                  | 1 (4.3)                       | 22 (95.7)                         |              |         |
| Age             |                     |                               |                                   |              |         |
| <65 years       | 437                 | 16 (3.7)                      | 421 (96.3)                        | 2.34 (0.77–7.07) | 0.16    |
| ≥65 years       | 250                 | 4 (1.6)                       | 246 (98.4)                        |              |         |
| Provider experience |             |                               |                                   |              |         |
| ≤10 years       | 131                 | 7 (5.3)                       | 124 (94.7)                        |              |         |
| 10–20 years     | 248                 | 5 (2.0)                       | 243 (98.0)                        |              | 0.17    |
| >20 years       | 308                 | 8 (2.6)                       | 300 (97.4)                        |              |         |

GCST, Genetic Cancer Screening Tool; OR, odds ratio; CL, confidence limits.
Nonetheless, in our study, the GCST was not completed for 31% of eligible patients, and the majority of patients screening positive for a personal/family history on the GCST were not referred to genetic counseling. Reasons given by PCPs for nonreferral included that the patient declined or that referral was not appropriate. For some of these patients, it is possible that referral could occur in the future. For others, nonreferral may have reflected underlying patient preference and/or shared decision-making with the PCP to prioritize other health issues. One limitation of our study is incomplete information regarding reasons PCPs did not use the GCST or did not refer patients to genetic counseling who had screened positive. Other possibilities include the phenomenon of alert fatigue [28, 29] and provider identification of false-positive screens due to incorrect family history entries. Notably, not all prior studies have found benefit for analogous tools. In one study, patient responses to a family health questionnaire triggered EHR prompts to PCPs; however, a family history of cancer did not increase genetic counseling referral [23]. Future work to improve these tools may include surveys of providers and patients and/or workflow studies.

Our demographic findings point to a potential area for future equity work. The GCST screen-positive rate was lower for male patients; other patient demographics did not affect GCST use or referral rate. While the prevalence of cancer risk mutation is equal across genders, the observed gender difference in screening in our study is consistent with a national trend of higher rate of genetic counseling and testing for women [14, 30]. Testing disparities for men without personal history of cancer may be reduced by emphasis on family history screening.

We also observed that referral rate varied by provider and clinic but was not affected by patient demographics, suggesting that there are other patient, provider, and/or institutional factors beyond the factors measured. For example, Jbilou and colleagues propose a framework of factors that predict medical doctors’ practices around genetic breast cancer risk assessment and risk communication: demographic (e.g., age or gender), organizational (e.g., health care system management), experiential (e.g., personal experience), professional (e.g., model of practice, clinical skills), psychological (e.g., perceived roles), and cognitive (e.g., sources of information) [31].

The small number of clinics and the demographics of the study population lead to intrinsic limitations in study generalizability. Comparison between the two clinics is also limited because of a difference in the predominant board specialty at the two sites. Future directions could include use of a randomized trial to test effectiveness of the tool.

This implementation study demonstrated utilization of a clinical decision support tool for hereditary cancer risk screening and referral in one health system. Different implementation strategies may prove effective in different settings. Other health care systems may consider approaches to increasing identification of individuals with cancer risk mutations ranging from targeted education for providers [32, 33] to tools for collecting and assessing family cancer history [19] to population-based genetic testing [7, 34]. In order to give other institutions guidance in meeting local needs, future work should address the implementation factors that determine effectiveness of various strategies in different settings.

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Statement of Ethics

The study protocol was approved as exempt by the Allina Health Institutional Review Board, decision reference number 1444466-1. In the Allina Health system, patients have the option to provide a general approval to have their medical records included in research, and this is recorded in the EHR. Individuals were only included in this study if they had indicated a willingness to have their medical records included for research purposes as identified in the EHR. For this type of study, no additional consent was required.

Conflict of Interest Statement

The authors have no conflicts of interest to declare.

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Author Contributions

E.J.W., S.B., S.O., A.D., and K.K.S. designed the study and approved the final manuscript. E.J.W., S.O., and K.K.S. analyzed the data. E.J.W. drafted the manuscript. S.O. and K.K.S. critically revised the manuscript.

Data Availability Statement

The data are not available publicly on privacy grounds.
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