Using a Matrixed Multiple Case Study Approach to Identify Factors Impacting Successful Hereditary Cancer Risk Assessment Implementation in Primary Care

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Abstract

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Genetic testing can be used to identify those at risk for hereditary cancers for which lifesaving preventative interventions may be available. Despite the potential benefit that can come from this type of genetic testing, it is not often conducted in a primary care setting. Therefore, there is interest in implementing genetic testing for hereditary cancer risk more broadly. The EDGE trial previously studied implementing hereditary cancer risk assessment and genetic testing in a primary care setting. However, this prior research focused mainly on individual factors that may impact implementation success. The present study expands on EDGE by examining what multi-level factors may have impacted uptake of hereditary cancer risk assessment and genetic testing in this trial. For analysis, we used a matrixed multiple case study approach and found 7 factors that had clear impacts on implementation success. These findings provide important context on what is most important to the success of hereditary cancer screening implementation programs.

Background

Genetic testing is recommended for individuals with notable personal and/or family cancer history profiles, e.g., multiple relatives who were diagnosed with cancer at a young age [1]. Genetic testing can identify individuals with conditions such as Lynch syndrome or hereditary breast and ovarian cancer syndrome, for which surgery and other lifesaving preventative measures are available [1].

Around 5-10% of cancers are believed to be hereditary [2], meaning inherited risk can be identified through genetic testing and be used to guide preventative treatment, lowering morbidity and mortality. This highlights the utility of genetic testing for risk of hereditary cancer and the public health benefit that can come with broader implementation of this technology.

While genetic testing for hereditary cancer risk could have a population health impact, this technology is only beneficial if individuals who qualify for testing are routinely identified, offered, and choose to undergo testing. Unfortunately, systematic risk assessment for hereditary cancer is rarely conducted outside of oncology settings, meaning few individuals who are eligible for genetic testing based on clinical guidelines are ever offered it before they develop cancer [3]. Given the significant missed opportunity for prevention, there is a growing interest in implementing hereditary cancer risk assessment in primary care.

The Early Detection of Genetic Risk (EGDE) cluster-randomized trial studied two approaches to engage an entire primary care clinic population in hereditary cancer risk assessment and genetic testing [4]. These approaches were a point of care (POC) approach and a direct patient engagement (DPE) approach. The POC approach involved engaging patients during primary care visits to complete a hereditary cancer risk assessment while the DPE approach involved contacting patients by email or mail and asking them to complete the risk assessment online.

The EDGE trial was done in 12 clinics from two healthcare systems across Washington, Montana, and Wyoming and found that there were substantial differences in the proportion of the clinic population who completed risk assessment and genetic testing both across all clinics and between the clinics in the same study arm. The substantial variation observed here provides an opportunity to identify clinic-level factors that may have led to these differences.

There is previous literature on what factors impact uptake of hereditary cancer risk assessment and genetic testing uptake in clinical settings. This research has been heavily focused on factors at the individual level. For example, various provider and patient barriers that impact the successful implementation of risk assessment and genetic testing in clinical settings have been identified. One barrier providers face to ordering genetic testing is that their knowledge about genetic testing is often incomplete [5]. There is also evidence that implementation of genetic testing may be hindered if clinicians believe this testing is low priority [6]. One other finding from an implementation study was that the primary care climate is generally supportive of change but is less supportive of implementing genomic medicine partially due to its specialized and information-intensive nature [7].

Patient attitudes and knowledge about genetic testing may also impact engagement with hereditary cancer risk assessment and subsequent testing. For example, patient concerns about affordability, convenience, privacy, and ability to cope with results may lower engagement [8]. It has also been found that beliefs about how useful hereditary cancer screening is may impact whether patients engage with these services, if available [6].

Barriers to genetic testing uptake were also identified in the EDGE trial. For example, primary care providers reported in a baseline survey that a lack of knowledge about genetic testing contributes to them not ordering genetic testing much in their general practice [9]. Additionally, it was found for patients that having one or no first-degree relatives with a personal history of cancer and having a personal history of cancer were both factors associated with lower uptake of genetic testing [4].

One current gap in knowledge is what multilevel factors impact implementation of hereditary cancer risk assessment and genetic testing in primary care, as the previous literature described here has heavily focused on factors at the individual level. This present study expands upon prior literature and addresses this knowledge gap by using a matrixed multiple case study (MMCS) approach to identify contextual factors beyond the individual level that impact implementation of hereditary cancer risk assessment and genetic testing in primary care [10]. There are several benefits to using the MMCS approach for this analysis. One benefit of using this approach is that it is designed to be used for small sample sizes. Previous papers have reported using this approach for implementation studies with fewer than 10 sites and as few as 3 sites [11-13]. There are only 12 clinics that participated in EDGE, so using the MMCS approach here makes sense as opposed to focusing on statistical tests that would have low power.

The MMCS approach was also created specifically to use in studies where there is heterogeneity between sites. There is significant heterogeneity between the clinics in EDGE in terms of subjects, setting, and delivery of the intervention. An approach such as MMCS can utilize these heterogeneities to better understand what factors are most related with implementation success [10]. A mixed methods approach is also beneficial in that it allows us to triangulate observations across data type, providing stronger evidence of potentially causal relationships between implementation determinants and success in a smaller sample.

The matrixed multiple case study approach compares site-specific matrices containing qualitative and quantitative data sources, enabling the emergence of generalizable knowledge from common and heterogeneous local factors beyond the individual level that influence the success of implementation across sites. Overall, this will allow for an analysis of multilevel factors contributing to implementation success, providing new insights from the EDGE trial data.

Theoretical Framework

The EDGE study used the Consolidated Framework for Implementation Research (CFIR) to conceptualize the impact of clinic context on successful implementation of hereditary cancer risk assessment and genetic testing. CFIR consists of five main domains: Innovation, Inner Setting, Outer Setting, Individuals, and Process [14]. The first domain, innovation, refers to the

characteristics of the intervention being implemented [15]. The next two domains, inner setting and outer setting, refer to internal and external organizational influences that impact program implementation [16]. The fourth domain, individuals, refers to all individuals involved with the intervention and/or implementation process [15]. The final domain, process, pertains to activities such as planning, engaging, executing, and evaluating that are relevant to implementation success [17]. In the present study, CFIR was used to guide the selection of influencing factors for within and across clinic analyses.

Methods

The present study uses quantitative and qualitative data generated by the Early Detection of Genetic Risk (EDGE) cluster-randomized trial and a matrixed multiple case study approach to identify contextual factors that impacted successful implementation of hereditary cancer risk assessment and genetic testing in primary care clinics. A list of all data sources used for the current paper is included in Table 3.

Setting

The EDGE trial was conducted within 12 clinics across two healthcare systems: Billings Clinic, with primary care clinics located in Montana and Wyoming, and MultiCare Health System, with primary care clinics located in Washington State. Clinics from each healthcare system were matched by size and then randomized into the POC (n=6) or DPE (n=6) intervention arm to achieve balance by health care system and clinic size as determined by number of patients served annually.

Data collection

Clinic demographics

Information on clinic demographics was gathered as part of data collection. The demographic metrics we focused on for the present study were the rurality of each clinic setting and the relative size of each clinic.

Patient survey

Surveys were used to collect data from a subset of patients from each of the 12 clinic populations following the launch of the EDGE trial. Surveys were not limited to those who participated in risk assessment. These surveys were emailed to patients and included questions on socioeconomic status, education, race, sex, views, and previous experience with genetic testing. These patient surveys used in the present study were all baseline surveys conducted prior to any participation in the trial.

Provider survey

Providers at the clinics in EDGE were given the opportunity to complete baseline surveys that included a variety of questions related to opinions and experience with genetic testing. These

surveys also included some questions on how providers felt about the EDGE trial being implemented in general.

Clinic leader survey

The final stakeholder group that participated in baseline surveys were clinic leaders. The survey questions for this group focused on leaders' perspectives of contextual factors at the clinics that could potentially impact implementation success, such as culture and availability of resources.

Provider interview

Providers who completed the baseline surveys were encouraged to participate in interviews that took place before the EDGE trial started. These semi-structured interviews were conducted over the phone and focused on providers' experience with conducting hereditary cancer risk assessment and ordering genetic testing. Providers were also asked specifically about EDGE, including questions on their opinion of the program, and what facilitators/barriers to implementation success they envisioned would be encountered.

Clinic leader interview

Clinic leaders who completed the baseline surveys were also asked to participate in interviews that took place before the EDGE trial started. These semi-structured interviews were conducted over the phone and focused on current genetic testing practices at the clinic, opinions about EDGE, and factors they perceived could impact the success of the program.

Data Analysis

We used the matrixed multiple case study (MMCS) approach to analyze our data, which involves nine steps in the data analysis process as described by Kim et al. 2020 [10]. A visualization of all the steps of MMCS as applied to this project is available in figure 1. For the present study, the steps in MMCS were rearranged the into three main parts, which were related to implementation success, domains and factors, and finally data organization and analysis. One step was also separated into two to give us a total of ten distinct steps.

The data analysis began with step 1 of the MMCS approach, which involved describing the research goal. For this study, the goal was to determine what factors are associated with successful implementation of hereditary cancer risk assessment and genetic testing in primary care settings. After this step, we moved to the first main part of the MMCS approach focused on implementation success.

Implementation success

The first main part of MMCS is related to implementation success, and this included steps 2-4 of the overall MMCS approach. Step 2 is to define implementation success by site, and we used two variables to do this. These two variables were 1) the proportion of primary care patients with a clinic visit who underwent hereditary cancer screening and 2) the proportion of primary care

patients who underwent at-home genetic testing. Intervention arm was not considered as a variable in determining implementation success.

Step 3 of MMCS involves gathering data on both implementation success and potentially relevant domains. Data on hereditary cancer screening and genetic testing uptake by clinic had already been collected as part of EDGE and these were used as the data for determining implementation success.

For step 4 of the MMCS approach, we had to assess the extent of implementation success for each site. To do this, we categorized both risk assessment completion and genetic testing proportions for each clinic into high, moderate, and low success groups. Then, the classifications of these two variables within each clinic were used to classify clinics into groups of high, moderate, or low overall implementation success. Clinics with different levels of risk assessment and testing success were put into the moderate overall implementation success category.

Domains and factors

The next part of the MMCS approach is related to domains and factors and this comprises steps 5-7. Step 5 of the MMCS approach is to select relevant domains of factors influencing implementation success. As mentioned previously, the Consolidated Framework for Implementation Research (CFIR) is an important theoretical framework to EDGE, with certain parts of the surveys based on CFIR. Because of the relevance of CFIR to our work, we decided to use its domains here.

For step 6, we had to gather data on potentially relevant domains. This study used secondary data from the EDGE trial, so all data had been collected beforehand. These data on potentially relevant domains included results from the surveys and interviews for the three stakeholder groups.

Step 7 of MMCS is to identify a list of influencing factors per data source per site. To do this, we first analyzed the survey questions, then created a list of influencing factors based on these and finally categorized them into the different CFIR domains. The interview data was also important here, as it informed us about which factors were talked about at which sites. This culminated with a list of factors for each site being identified, with information about data sources also included here.

Data organization and analysis

The final part of the MMCS approach is related to data organization and analysis, which includes steps 8-10. As part of step 8 of the MMCS approach, the examined data was organized into a sortable matrix. Previous approaches have described using spreadsheet software for this organization, where each column is a data source and each row is an influencing factor [10, 12]. We decided to use a word processing software to organize the data into tables rather than spreadsheets for analysis due to some influencing factors having multiple data points coming from the same data source. All data inputted into the data matrix were clinic-level summaries,

and information about what these summaries were and how they were generated is included below.

The quantitative data summaries were made using the baseline survey results and clinic demographic data. Some survey questions used a Likert scoring system with scores from 1 (strongly disagree) to 5 (strongly agree), and the data summaries for these questions were the mean score for all participants who answered that question. The survey also included some yes/no questions, and the summaries for these questions were the percentage of individuals who answered yes to a particular question.

For clinic demographic data summaries, one metric looked at was rurality, which was based on the setting where the clinic was located. Rural-Urban Continuum Codes (RUCC) were used to determine how rural the settings for the clinics were. Three distinct RUCC scores assigned to clinics in EDGE and these scores were 1, 3, and 7. The RUCC scores of 1 and 3 correspond to metro counties with populations of over 1 million and over 250,000, respectively, while 7 corresponds to a nonmetro county with a population of 5,000 to 20,000 that is not adjacent to a metro area [18]. Clinic demographic data also included data on clinic size defined by how many primary care patients the clinic saw in the past year.

For the qualitative data, we had 27 total interviews from clinic leaders and providers across the clinics. To create data summaries from the interviews, we used a content analysis. This involved first creating a list of codes to use on the transcripts based on the quantitative data. Coding was conducted using Dedoose version 10.0.59 with a deductive codebook. The data summaries here were all the excerpts related to a potential influencing factor that were talked about by people who worked at a specific clinic.

Step 9 is on within-site analysis, which involved determining whether each factor was 1) present, somewhat present, or minimally present at the site and 2) enabling, neutral, or hindering towards implementation success. This categorization allowed for the impact each factor had on implementation to be ascertained for each clinic separately. Data from the within-site analysis was entered into a sortable matrix spreadsheet to be used for the analysis in the final step. A representation of the final spreadsheet we generated from the within-site analysis is displayed in Appendix 2.

The final step (step 10) of the MMCS approach involves cross-site analysis, and there were several ways that a factor's overall impact on implementation was assessed here. One thing was to look at factors that were universally enabling or hindering across the clinics, while noting factors that had different effects by clinic as well, such as being enabling in one setting and hindering in another. We also looked for factors that were consistently associated with high or low implementation success as these could explain differences in success seen between the clinics. It should be noted that for this analysis, we focused on implementation success in terms of risk assessment completion rather than the metrics of genetic testing success or overall implementation success. Cross-site analysis ultimately gave insights on what influencing factors are associated with implementation success among the 12 clinics in EDGE.

Results

Participant characteristics

In total, there were 2,317 patients who completed the baseline patient survey across the 12 sites. The median number of patients completing the survey was 191 and sample size per clinic ranged from 140 to 256 individuals.

There were 60 providers who completed the baseline provider survey and a median of 4 providers completed the survey per clinic. Provider survey representation per clinic ranged from 2 to 11 individuals. For the provider interviews, a total of 16 individuals participated across the clinics. However, there were 4 clinics where no providers participated in interviews.

One leader from each clinic completed the baseline leader survey, while a total of 11 clinic leaders participated in the interviews. This corresponded to all the sites having one clinic leader participate in interviews except for one site which conducted no leader interviews.

Clinic characteristics

The classifications of all the clinics and the cutoffs used for the high, moderate, or low categories for each variable can be viewed in Table 1 along with the size, intervention arm, and rurality classification of each clinic. Summaries of within-clinic analyses can be viewed in Appendix 1.

Overview of influencing factors

We identified 7 factors affecting hereditary cancer risk assessment program implementation success across the clinics. In terms of the CFIR domains, there were 2 factors related to innovation, 1 factor related to outer setting, 1 factor related to inner setting, and 3 factors related to individuals. Additionally, there were 3 factors (2 in the inner setting and 1 in the process domain) for which it was unclear whether or how they impacted implementation success.

Based on their impact on implementation, factors were grouped into the following categories: factors with enabling influence at all clinics, factors with hindering influence at all clinics, factors deemed important to implementation success, and factors that distinguished clinics with high or moderate versus low success (Table 2).

Factors with enabling influence at all clinics

Three factors were present across all clinics regardless of implementation success status and consistently enabled population-based hereditary risk screening program implementation.

The first factor was *relative advantage*, which is defined as whether population screening is viewed as an improvement over current approaches to assessing hereditary cancer risk. This factor is in the innovation domain. Providers and leader at all clinics thought that a systematic approach to screening all their patients for hereditary cancer risk and offering them genetic testing would be better than their current approach to offering genetic testing, which was almost universally ad hoc.

For example, when asked about why the EDGE program would be beneficial, one participant mentioned why opportunities to conduct genetic testing may be missed in their current environment:

"I suspect I miss opportunities to refer genetic testing all the time... It's just so many other competing things. This is one of our greatest challenges. If somebody's having a heart attack right in front of you or falling off the cliff, we're really good at taking care of them. Looking down the line and saying, 'Well, we need to treat your high cholesterol for the next 20 years,' is harder for us and the same with this genetic testing" (Participant BC-108)

Another participant had this to say regarding current risk assessment practices in their clinic and whether they believed the program would be better:

"Yeah, because we suck at it currently" (Participant BC-602)

The other two factors were in the individuals domain. The first was *patients are interested in genetic testing for hereditary cancer risk*. Specifically, over three quarters of patients who took the survey at each clinic reported being at least moderately interested in genetic testing for hereditary cancer risk. Providers also mentioned in the interviews that they thought in general, patients would be interested in the program.

One clinic leader describes why they believed their patients would be interested in genetic testing:

"I think that people now in today's society want to know. People want more education... And so it will give all of us that information to just be able to share with our patients and let them make informed decisions" (Participant MC-401)

The final influencing factor in the individuals domain was *providers are confident in their ability to implement populations screening for hereditary cancer risk*. Though providers who responded to the survey rated their knowledge of cancer genetics as low, they rated their implementation capability highly and spoke about their confidence with rolling out new programs when provided with appropriate guidance and resources during interviews.

One provider had this to say when asked how they felt the program was going to go:

"I think it be a little bit of a learning curve in the beginning, but once educated on it, it seems like it would be pretty self-explanatory and work smoothly" (Participant BC-503)

Factors with hindering influence across all clinics

There was one factor which was consistently absent or minimally present across all clinics, regardless of implementation status, which hindered population based hereditary risk screening program implementation.

This factor in the inner setting domain was *staff have enough time to integrate population screening for hereditary cancer risk into clinical practice*. Provider survey results indicated that in general, providers did not feel that they would have enough time to implement the program. This sentiment was also evident in the provider interviews, as providers often brought up time as a barrier to implementation success.

One provider mentioned time constraints when asked what potential barriers to implementation may be:

> *"Lack of time is always a barrier"* (MC-405)

Additionally, a clinic leader said this about time constraints as a potential issue that could impact implementation of the risk assessment:

> *"I don't want us to roll this out and then 'Oh, I don't have time today to talk to any patients.' Even though they have high risk of certain things, I want it to be able to be something that is built into every single visit"* (Participant BC-301)

Factors deemed important to implementation success

There was one factor that enabled implementation success when present and hindered implementation when absent or minimally present. However, this factor's presence showed no clear trend with implementation success. In other words, this factor could be both present and enabling at both high and low success clinics.

This factor was *providers have experience ordering genetic testing for hereditary cancer risk*, which is in the individuals domain. There was generally not much experience with genetic testing across clinics.

Here is a quote from a clinic leader regarding whether their clinic has experience with conducting genetic testing for hereditary cancer risk:

> *"As far as I'm aware, we have not had much experience with the cancer genetic testing"* (Participant BC-501)

However, clinics that had experience with genetic testing spoke to its enabling influence. Clinics with more experience with genetic testing were not consistently those with great implementation success. This is highlighted by the fact that clinics in both high and low implementation success groups generally had minimal experience with genetic testing, but each group also had one clinic that was more experienced.

One provider at a clinic with more experience mentioned this about some of the physicians there:

> *"I think that there are a few physicians that do order genetic tests. Some of the more experienced physicians that have been here for a number of years, I think do order that. I think the majority of the other APPs, so the other nurse practitioners like myself tend to refer"* (Participant MC-102)

Factors that distinguish clinics with high or moderate versus low success

Two factors showed clear trends with clinic-level implementation success.

The first factor was the *intervention*, which is in the innovation domain. In terms of risk assessment completion, there was a clear trend of POC clinics being more successful than DPE clinics. This is demonstrated by our data matrix, where all three high implementation success clinics were in the POC arm, while three of four low success clinics were in the DPE arm. However, not all clinics in the POC arm had successful implementation, as clinic 12 was in the POC arm but still had low implementation success.

The other factor was *rurality*, which is in the outer setting domain. For this factor, there was a trend that metropolitan clinics were more successful in implementing hereditary cancer risk assessment than rural clinics. All but one of the high and moderate success clinics were in urban settings, while all low success clinics were in rural or somewhat rural settings. This trend was supported by the interviews, with staff at rural clinics emphasizing that being rural could make implementation more difficult. One exception to this trend was clinic 11, which had a high level of risk assessment completion despite being a rural clinic.

Here are two quotes from interviewees who work at rural clinics regarding why implementing the program in a rural setting may be more difficult:

> *"it's harder for people, when you have a really rural and underserved community, it's harder for people to get their annual exams, et cetera. Let's just talk about colonoscopy. We have a very low rate of screening for colon cancer"* (Participant BC-108)

> *"these people are a lot different. I mean, they don't come into the clinic unless they're very ill or injured for two or three days and then figure out, 'Well, yeah, I think we probably better go in because I can't breathe now.' So, they're tough, and, I think, they don't always come in and ask for help very easily. And, I think, that would be just to break that barrier down that we're here to help you and it's okay to ask for help"* (Participant BC-401)

Factors with unclear relationships with implementation success

Three factors had unclear relationships with implementation success.

The first factor was clinic size, which was based on whether the clinic sees over or under 10,000 patients in a year. This factor is in the inner setting domain.

There was some belief here that implementation would be easier in a smaller clinic:

> *"we only have seven providers that we would need to communicate with and they all have a specific nurse and the nurse works with the provider very closely. So I think as far as that would ease implementation as far as communication and getting everybody on the same page"* (Participant BC-201)

> *"It is quite a large clinic, so that might make it a little bit harder. In my mind, I feel like if it's a smaller clinic, that's more not as spread out as we are, would be easier to manage"* (Participant MC-301)

However, despite some belief that implementation would be easier in a smaller clinic, there was also some uncertainty expressed about the potential effect of clinic size. A sentiment that implementation may be easier in a larger clinic was also expressed in some cases. The data matrix showed no clear relationship between clinic size and implementation success, as most of both high and low success clinics were classified as small.

The second factor was *clinic leadership has openly supported implementation*. This factor is in the process domain.

In the interviews, clinic leadership seemed generally supportive of the program. Here are two quotes from clinic leaders to illustrate this point:

> *"I am excited for this. I think it is such a great thing that you guys are doing and how beneficial for everybody. So I'm fully on board here"* (Participant MC-201)

> *"We're very excited about it. I think it'll just be one more preventative type service that we can offer to help potentially catch some early on diagnosis. And so we're looking forward to it. Yeah, it'll be good"* (Participant BC-601)

While leaders expressed support for EDGE in the interviews, we did not see a clear trend between leadership support and implementation success in the data matrix. Leadership support was generally at least somewhat present at clinics in both the high and low implementation success groups. There was also some discordance between clinic leaders and providers, with provider survey results indicating they did not feel leadership supported the program even when the clinic leaders felt support was sufficient. This made it difficult to classify the overall level of leadership support at certain clinics.

The final factor was *clinic has sufficient staff, financial, and other resources to undertake practice change*. This factor is in the inner setting domain.

We did not see a clear trend between this factor and implementation success. Clinics across all success groups generally thought they had sufficient resources for implementation, but there were some notable cases where staff indicated that their clinic had insufficient resources. This included clinic 6, which had the highest risk assessment completion percentage, yet provider survey results indicated providers at this clinic disagreed or strongly disagreed that they had sufficient resources for practice change.

Discussion

In our study, we found 7 factors that impacted implementation success in various ways. *Intervention* and *rurality* distinguished clinics by implementation success. *Relative advantage*, *patients are interested in genetic testing for hereditary cancer risk*, and *providers are confident in their ability to implement populations screening for hereditary cancer risk* had an enabling influence across all clinics. *Staff have enough time to integrate population screening for hereditary cancer risk into clinical practice* had a hindering influence across all clinics. Lastly, *providers have experience ordering genetic testing for hereditary cancer risk* was a factor that was deemed important to implementation success.

There were also 3 factors that we looked at that had unclear relationships with implementation success. These factors included *clinic size*, *clinic leadership has openly supported implementation*, and *clinic has sufficient staff, financial, and other resources to undertake practice change*.

The matrixed multiple case study approach enabled us to identify contextual factors that are common across primary care clinics, acting to enable and hinder implementation of population-based hereditary cancer risk assessment and genetic testing. Specifically, it appears that in most primary care clinics, patients are at least moderately interested in genetic testing, while providers know they could be doing better at identifying eligible patients and are confident they could implement population screening. Clinic stakeholders are, however, worried about time pressures that could accompany screening workflows. Potential implementers should be aware of these widespread barriers and facilitators, which have been found in prior research, when developing implementation strategies. For example, both the POC and DPE interventions were designed to occur outside dedicated patient appointments to address concerns that risk assessment would take up already limited time.

Our study identified contextual factors in the innovation and outer setting domains that may drive implementation success and are important foci for future research. First, in the innovation domain, the point of care intervention was clearly better than direct patient engagement at achieving high levels of risk assessment completion. This was evident in our analysis matrix where all clinics with high screening implementation success were in the POC arm, while 3 of the 4 clinics with low screening success were in the DPE arm. One important note here is that our study design does not allow us to clearly determine if this is because POC is more efficacious than DPE, easier to implement, or both. However, we hypothesized that POC would be more challenging to implement given the need for in person interactions and aligning

screening with patient appointments. Given this hypothesis and the trends seen in risk assessment completion across the clinics, we believe that the POC intervention is substantially more efficacious than the DPE intervention, but more susceptible to inconsistent implementation. To this point, screening rates in POC clinics differed by 33% (from 42% to 9%), but only by 7% in DPE clinics (from 12% to 5%).

Second, our data matrix showed that in the moderate and high success groups, rurality was generally minimally present and neutral, while the low implementation success clinics were all rural or somewhat rural, and this was generally viewed as a detriment to implementation. This raises the question of why rural clinics may face challenges with implementing population-based screening for hereditary cancer risk. One way to potentially try and find answers to this question is to look at outliers, such as clinic 11, which was in the POC arm and was the only rural clinic to have high implementation success (23%). Another outlier to look at is clinic 12, which is rural and was the only clinic in the POC arm to have low implementation success (9%).

There is some evidence in the literature that rurality may impact uptake of preventative medicine. For example, it has been shown that breast cancer screening may be less utilized in rural settings [19, 20]. Additionally, data have shown that uptake of colorectal cancer screening is lower for rural residents [19, 21]. It should be noted that this trend has not always been found to be true. For example, a study in a wealthier, more educated rural setting than average in Pennsylvania found that rural individuals had equal or higher uptake of preventative healthcare than urban individuals [22]. Overall, the literature does suggest that rurality is an important factor to consider when considering what could impact uptake of preventative medicine, such as hereditary cancer risk assessment.

Our study indicates that there is more work to be done to understand how clinic inner setting and the implementation process affect implementation of population screening for hereditary cancer risk. For example, while some interview subjects expressed the belief that implementation could be easier at smaller clinics, there was also much uncertainty about the impact clinic size would have on implementation. Despite some belief that small clinic size could be beneficial, it did not differentiate clinics with high and low success, as all clinics with high success were classified as small clinics, and 3 of the 4 clinics with low implementation success were also small.

There does not appear to be much previous research on the topic of how clinic size impacts the ease to which an intervention can be implemented. Given the paucity of information on this topic, more research here is needed to help explain the results we found. One point to note is that the high and low success clinics were in different settings, so that context may have been important to the impact clinic size had on implementation success.

Clinic leadership supporting implementation was another contextual factor where there was an inconsistent relationship with implementation success. In the data matrix, this factor of leader support for implementation was somewhat present in several high and low implementation success clinics. It was also notable that in the survey data, leaders generally agreed that they openly supported implementation, while providers at the same clinics often disagreed about this.

It was found in a systematic review that organizational leadership and the presence of intervention champions to be essential to implementation success [23]. The fact that leadership is thought to be very important to successful implementation makes it surprising that we did not see such a trend in our data. Part of the issue could be that providers and clinic leaders were often not in agreement about whether leadership was sufficient and this made it difficult to determine how much leadership support there really was at certain clinics.

Perceived availability of resources was another contextual factor that had no clear relationship with implementation success. For example, across the success groups, clinic leaders generally felt that they had at least somewhat sufficient resources, while there were also clinics in the moderate and high success groups that indicated they lacked sufficient resources.

Previous research has described a lack of available resources to carry out a program as a key barrier to implementation success [24]. Furthermore, financial and educational resources are key resources that are common in settings where change is successfully implemented [23]. This makes it surprising that there was no clear relationship here between availability of resources and success.

It should be noted that the study provided extra resources to the clinics to help with certain things, such as hiring a staff member to assist with implementation. This could have addressed resource concerns in clinics and may have been a contributing factor to why we did not see a trend between resource availability and implementation success in our data. It would also be interesting to see how the clinics felt about resources after the study was no longer providing resources, since resources would become more limited at that point.

Finaly, one other important point is that characterization of implementation success can change depending on what metric is used. We had risk assessment completion and genetic testing as metrics of success. The clinics that are classified as high, moderate, or low success depends on which metric is used as a measurement of implementation success. This concept is demonstrated in Table 1. Because of the differences in success classification, clinics need to decide whether their main goal is risk assessment completion, genetic testing, or both when picking how to measure implementation success.

We chose risk assessment completion as our metric for implementation success in this study because the decision to have genetic testing after being identified as high risk through risk assessment is preference sensitive. Clinic staff were also not involved in intervention delivery after someone was identified as high risk through screening. The at home testing process was largely patient driven and monitored centrally by study staff, making clinic implementation context less important for driving success here. Moreover, the proportion of those offered testing who chose to undergo testing is not expected to be related to clinic factors, such as the intervention used.

Limitations

There are various limitations to this study. One potential issue is that rurality and health system are confounded, as all the rural clinics are in the Billings system. It is therefore possible that

rurality does not have a true causal relationship with implementation success and the differences we saw were just due to differences in the healthcare system.

It is also important to acknowledge that the surveys and interviews were baseline only. This means these data only reflect the climate at baseline and the perceptions about how implementation would go. It is certainly possible that unanticipated challenges arose during implementation and these would not be reflected in the data we have.

Another limitation is that leader and provider participation in the surveys and interviews was different depending on the clinic. For example, some of the clinics did not have any providers participate in interviews and there was one clinic where no one participated in an interview. This limited the ability to triangulate interview data with survey data in some clinics, and our conclusions about certain clinics may have been different if interviews on all relevant stakeholders had been conducted here.

The EDGE study also took place during the COVID pandemic, which created additional limitations. One way COVID impacted the study was that some clinics had to adapt the intervention to practice changes, such as a transition to telehealth in many clinics. Specifically, POC clinics in MultiCare switched to conducting risk assessment over the phone, while POC clinics in Billings Clinic continued to conduct risk assessment in person. This means that COVID impacted how the intervention was conducted, which likely had an impact on implementation success, but our analysis does not address this issue.

One final limitation was that this study used data that had already been generated as part of the EDGE trial. The surveys and interview guides were also not developed for the specific research explained in this paper, so there were some factors potentially of interest that could not be evaluated due to them not being discussed in the interviews.

Conclusions

Broader implementation of genetic testing for hereditary cancer risk could save lives. Our study utilized the matrixed multiple case study approach to identify what influencing factors are most important to the successful implementation of hereditary cancer risk assessment and genetic testing into a primary care setting. Overall, we identified key influencing factors and how they impact the implementation of programs to screen for hereditary cancer risk in a primary care setting. More specifically, the factors found most important to implementation success were the intervention used as well as the rurality of the clinic. Insights from the present study can be used to help inform the design of future programs to implement hereditary cancer risk assessment and genetic testing in primary care to ensure that these efforts are successful. This will hopefully lead to higher uptake of these services in the future, which will help provide valuable information to individuals and empower those at high risk of developing hereditary cancer to take lifesaving preventative measures.

Site #	Clinic Size (10,000)	Intervention	Rurality (RUCC)	Screening % {High: > 20%; Moderate: 10.1% - 20%; Low: ≤ 10%}	Testing % {High: > 2%; Moderate: 1.1% - 2%; Low: ≤ 1%}	Overall Success
1	Large	DPE	1	10.3% Moderate	2.0% Moderate	Moderate
2	Large	POC	1	17.9% Moderate	1.7% Moderate	Moderate
3	Small	POC	1	28.9% High	2.6% High	High
4	Small	DPE	1	12.4% Moderate	2.4% High	Moderate
5	Small	DPE	1	10.6% Moderate	1.9% Moderate	Moderate
6	Small	POC	1	41.8% High	4.2% High	High
7	Large	DPE	3	7.2% Low	1.4% Moderate	Moderate
8	Large	POC	3	12.8% Moderate	0.5% Low	Moderate
9	Small	DPE	3	5.4% Low	0.9% Low	Low
10	Small	DPE	7	4.8% Low	0.8% Low	Low
11	Small	POC	7	23.0% High	1.4% Moderate	Moderate
12	Small	POC	7	9.0% Low	1.0% Low	Low

Table 1. Classification of implementation success by clinic. Also included here are clinic size classifications based on whether the clinic saw over or under 10,000 patients in the past year, the intervention arm, and rurality based on RUCC codes.

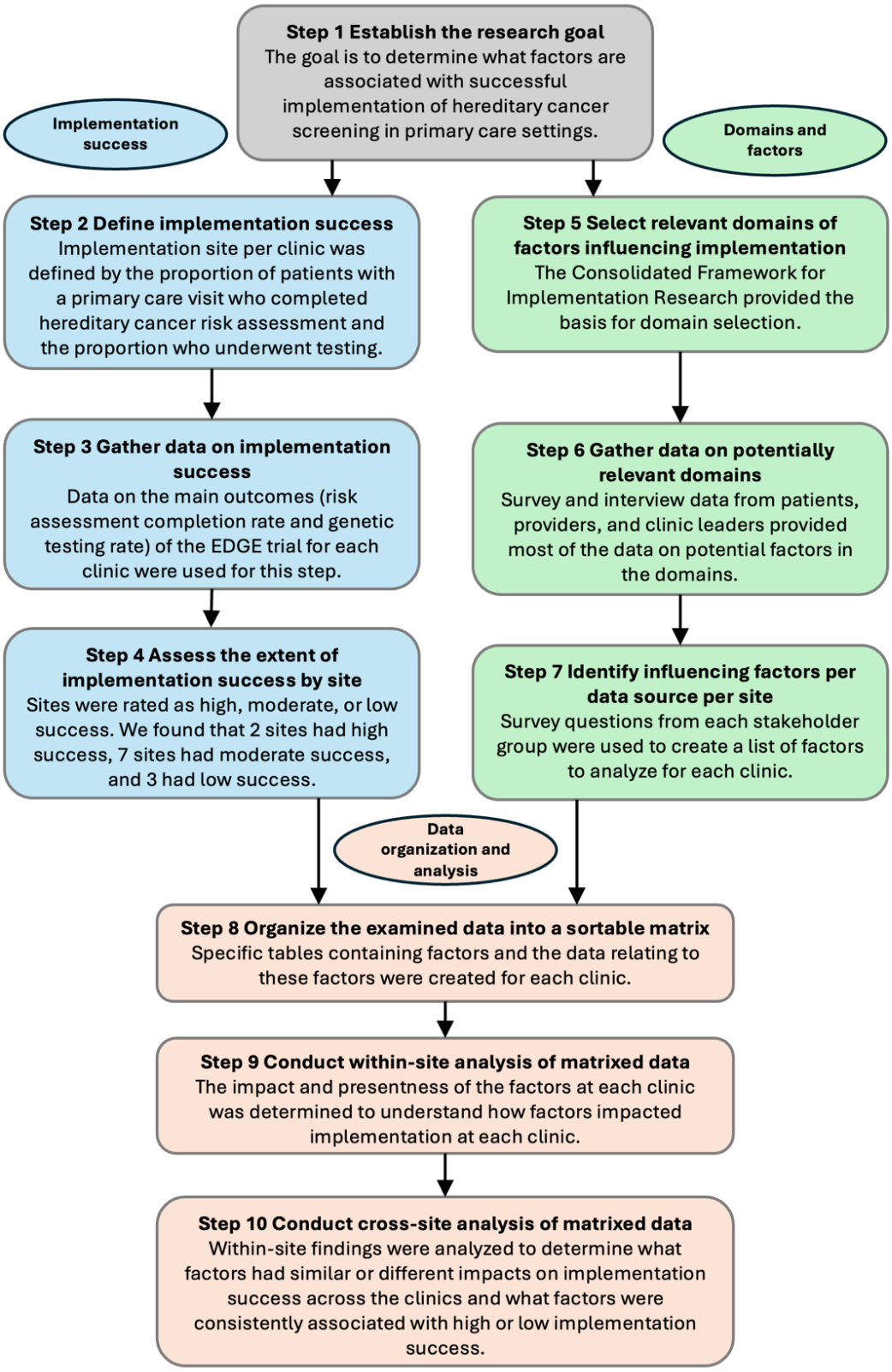

Figure 1. The matrixed multiple case study approach as conducted in this study.

CFIR domains	Factors with enabling influence at all clinics	Factors with hindering influence at all clinics	Factors deemed important to implementation success	Factors that distinguish clinics with high, moderate, and low implementation success	Factors with unclear relationships with implementation success
Innovation	Population screening would be an improvement over current approaches to assessing hereditary cancer risk			Point of care intervention	
Outer setting				Rurality	
Inner Setting		Staff have enough time to integrate population screening for hereditary cancer risk into clinical practice			Clinic size Clinic has sufficient staff, financial, and other resources to undertake practice change
Individuals	Patients are interested in genetic testing for hereditary cancer risk Providers are confident in their ability to implement populations screening for hereditary cancer risk		Providers have experience ordering genetic testing for hereditary cancer risk		
Process					Clinic leadership has openly supported implementation

Table 2. Influencing factors by CFIR domain.

Data source	Overview
Risk assessment and genetic testing completion	Data on hereditary cancer risk assessment and genetic testing completion at each of the clinics was used to classify clinics into high, moderate, and low implementation success groups. These data were collected throughout the duration of study.
Patient baseline survey	Surveys were used to collect data from patients at the participating clinics in the study. These online surveys were sent to patients throughout the duration of the study and included questions on their socioeconomic status, education, race, sex, and previous experience/interest in genetic testing.
Provider baseline survey	Providers at the clinics in EDGE completed baseline surveys. These surveys included a variety of questions related to opinions and experience with ordering genetic testing as well as questions regarding their thoughts about implementing the EDGE trial.
Clinic leader baseline survey	Clinic leaders participated in baseline surveys that focused on their perspectives of potential contextual factors at the clinics that may impact implementation success. This included questions about the clinic's readiness to change and leadership support for the program.
Clinic demographic data	Data on clinic demographics was gathered as part of data collection. This demographic information included metrics on the rurality of each clinic setting and on the relative size of each clinic. RUCC codes for the location of each clinic were used to assess rurality. RUCC scores ranged from 1 to 7, with 1 corresponding to an urban setting and 7 corresponding to a rural setting. Clinic size was determined by the number of patients that visited the clinic in the past year, with 10,000 patients used as the cutoff between small and large.
Provider interview	Providers who completed the surveys were encouraged to participate in interviews. These semi-structured interviews were conducted at baseline over the phone and focused on providers' experience with conducting hereditary cancer risk assessment and ordering genetic testing. Providers were also asked specifically about EDGE, including questions on their opinion of the program, and what facilitators/barriers to implementation success they envisioned would be encountered.
Clinic leader interview	Clinic leaders who completed the surveys were also asked to participate in interviews. These semi-structured interviews were conducted at baseline over the phone and focused on current genetic testing practices at the clinic, their opinions about EDGE, and potential factors that could impact the success of the program.

Table 3. Data sources.

References

1. Saam J, Moyes K, Landon M, et al. Hereditary Cancer-Associated Mutations in Women Diagnosed with Two Primary Cancers: An Opportunity to Identify Hereditary Cancer Syndromes after the First Cancer Diagnosis. *Oncology*. 2015;88(4):226-233. doi:10.1159/000368836

2. Nagy R, Sweet K, Eng C. Highly penetrant hereditary cancer syndromes. *Oncogene*. 2004;23(38):6445-6470. doi:10.1038/sj.onc.1207714

3. Guan Y, McBride CM, Rogers H, Zhao J, Allen CG, Escoffery C. Initiatives to Scale Up and Expand Reach of Cancer Genomic Services Outside of Specialty Clinical Settings: A Systematic Review. *Am J Prev Med*. 2021;60(2):e85-e94. doi:10.1016/j.amepre.2020.08.029

4. Swisher EM, Harris HM, Knerr S, et al. Strategies to Assess Risk for Hereditary Cancer in Primary Care Clinics: A Cluster Randomized Clinical Trial. *JAMA Netw Open*. 2025;8(3):e250185. doi:10.1001/jamanetworkopen.2025.0185

5. Hamilton JG, Abdiwahab E, Edwards HM, Fang ML, Jdayani A, Breslau ES. Primary care providers' cancer genetic testing-related knowledge, attitudes, and communication behaviors: A systematic review and research agenda. *J Gen Intern Med*. 2017;32(3):315-324. doi:10.1007/s11606-016-3943-4

6. McMullen C, Holup J, Davis JV, et al. Discordant Patient and Clinician Perspectives on the Potential Value of Genetic Services in Safety-Net Clinics. *J Health Care Poor Underserved*. 2020;31(3):1347-1363. doi:10.1353/hpu.2020.0099

7. Heffernan EW, Hearld KR, Moss IP, et al. Implementing Genomic Medicine in Primary Care: A Convergent Mixed Method Case Study. *J Eval Clin Pract*. 2026;32(2):e70397. doi:10.1111/jep.70397

8. Duenas DM, Shipman KJ, Porter KM, et al. Motivations and concerns of patients considering participation in an implementation study of a hereditary cancer risk assessment program in diverse primary care settings. *Genet Med*. 2022;24(3):610-621. doi:10.1016/j.gim.2021.11.017

9. Conner S, Theoryn T, Dusic E, et al. Primary care provider practices, attitudes, and confidence with hereditary cancer risk assessment and testing: A mixed methods study. *Genet Med*. 2025;27(4):101307. doi:10.1016/j.gim.2024.101307

10. Kim B, Sullivan JL, Ritchie MJ, et al. Comparing variations in implementation processes and influences across multiple sites: What works, for whom, and how? *Psychiatry Res*. 2020;283:112520. doi:10.1016/j.psychres.2019.112520

11. Adjognon OL, Brady JE, Iverson KM, et al. Using the Matrixed Multiple Case Study approach to identify factors affecting the uptake of IPV screening programs following the use of implementation facilitation. *Implement Sci Commun*. 2023;4(1):145. doi:10.1186/s43058-023-00528-x

12. Kim B, Sullivan JL, Brown ME, et al. Sustaining the collaborative chronic care model in outpatient mental health: a matrixed multiple case study. *Implement Sci*. 2024;19(1):16. doi:10.1186/s13012-024-01342-2

13. Tuda D, Bochicchio L, Stefancic A, et al. Using the matrixed multiple case study methodology to understand site differences in the outcomes of a Hybrid Type 1 trial of a peer-led healthy lifestyle intervention for people with serious mental illness. *Transl Behav Med*. 2023;13(12):919-927. doi:10.1093/tbm/ibad060

14. Damschroder LJ, Reardon CM, Widerquist MAO, Lowery J. The updated Consolidated Framework for Implementation Research based on user feedback. *Implement Sci*. 2022;17(1):75. doi:10.1186/s13012-022-01245-0

15. Damschroder LJ, Aron DC, Keith RE, Kirsh SR, Alexander JA, Lowery JC. Fostering implementation of health services research findings into practice: a consolidated framework for advancing implementation science. *Implement Sci*. 2009;4(1):50. doi:10.1186/1748-5908-4-50

16. Madrigal L, Haardörfer R, Kegler MC, et al. A structural equation model of CFIR inner and outer setting constructs, organization characteristics, and national DPP enrollment. *Implement Sci Commun*. 2023;4(1):142. doi:10.1186/s43058-023-00522-3

17. Schroeder D, Luig T, Finch TL, Beesoon S, Campbell-Scherer DL. Understanding implementation context and social processes through integrating Normalization Process Theory (NPT) and the Consolidated Framework for Implementation Research (CFIR). *Implement Sci Commun*. 2022;3(1):13. doi:10.1186/s43058-022-00264-8

18. U.S. Department of Agriculture, Economic Research Service. Rural-Urban Continuum Codes. January 2024. https://www.ers.usda.gov/data-products/rural-urban-continuum-codes/documentation

19. Moss JL, Ehrenkranz R, Perez LG, Hair BY, Julian AK. Geographic disparities in cancer screening and fatalism among a nationally representative sample of US adults. *J Epidemiol Community Health*. 2019;73(12):1128-1135. doi:10.1136/jech-2019-212425

20. Casey MM, Thiede Call K, Klingner JM. Are rural residents less likely to obtain recommended preventive healthcare services? *Am J Prev Med*. 2001;21(3):182-188. doi:10.1016/S0749-3797(01)00349-X

21. Anderson AE, Henry KA, Samadder NJ, Merrill RM, Kinney AY. Rural vs Urban Residence Affects Risk-Appropriate Colorectal Cancer Screening. *Clin Gastroenterol Hepatol*. 2013;11(5):526-533. doi:10.1016/j.cgh.2012.11.025

22. Calatayud BM, Moss JL. Rural/Urban differences in uptake of preventive healthcare services: Variability in observed relationships across measures of rurality. *J Public Health Res*. 2024;13(1):22799036241238670. doi:10.1177/22799036241238670

23. Clay-Williams R, Nosrati H, Cunningham FC, Hillman K, Braithwaite J. Do large-scale hospital- and system-wide interventions improve patient outcomes: a systematic review. *BMC Health Serv Res*. 2014;14:369. doi:10.1186/1472-6963-14-369

24. Rogers HL, Pablo Hernando S, Núñez-Fernández S, et al. Barriers and facilitators in the implementation of an evidence-based health promotion intervention in a primary care setting: a qualitative study. *J Health Organ Manag*. 2021;ahead-of-print(ahead-of-print):349-367. doi:10.1108/JHOM-12-2020-0512

Supplementary Material

Appendix 1. Individual clinic summaries

Clinic 1	
Intervention	Direct Patient Engagement
Health care system	MultiCare
Number of patients who completed the survey	156
Number of physicians who completed the survey	3
Number of leaders who completed the survey	1
Number of providers who participated in an interview	2
Number of leaders who participated in an interview	1
Level of implementation success	Moderate

Summary of clinic 1:

Providers and leaders at clinic 1 indicated support for the program and were not concerned about implementation despite seeming not to have a great understanding of the study or population screening in general. This larger clinic serves a more upper middle-class population, and this meant there weren't huge concerns related to cost or other related barriers. The size of the clinic could make it more difficult to manage everything. Providers at the clinic do not have much experience ordering genetic testing and generally just refer for counseling, testing, and follow up. The clinic has some helpful resources, such as genetic counselors, but staffing was still a concern, and the leader wanted a point person to do the work to limit the burden on staff who are somewhat stressed. Burnout was notably present at this clinic, with busy providers who stressed that it was important for the risk assessment not to be too time consuming. Providers also mentioned that genetic testing would not be useful to some patients who may not act on the results.

Interviewee	Selected quotes
MC-303 (Provider)	"INTERVIEWER: Do you ever interpret results with patients for genetic tests? physician: Rarely ever… basically if I have a patient come back to me to talk a little bit more about risks or potentially referrals elsewhere, my job as a primary care provider, my job is not to be the expert, but to help to be air traffic control. So I try to translate in a way that is understandable and applicable. And it helps them to know what the next steps are in terms of a referral so that they can make an informed decision with the expert"
MC-302 (Provider)	"INTERVIEWER: And then how do you think this program is going to go? MC302:

	I think it's going to go well. Like I said, I don't think it would take much time from the patients and for me and my staff. INTERVIEWER: Is that important to you, just not taking a lot of time from the patient visit? MC302: Yes. All of us know that we run very busy days and patients come in with multiple medical problems, so timing is very important"
MC-301 (Clinic leader)	"INTERVIEWER: Can you tell me a little bit about your location and the demographic that you serve? MC-301: Yes. So it's an up and coming city, I guess. And I want to say middle-class to higher upper class… There's not a lot of diversity... So I think it's something that they would understand and be welcomed to, without the worry of financial... INTERVIEWER: …Basically, they might already be familiar and interested in genetic testing and there might not be any financial barriers for them? MC-301: Yes"

Clinic 2	
Intervention	Point of Care
Health care system	MultiCare
Number of patients who completed the survey	195
Number of physicians who completed the survey	9
Number of leaders who completed the survey	1
Number of providers who participated in an interview	2
Number of leaders who participated in an interview	1
Level of implementation success	Moderate

Summary of clinic 2:

Clinic 2 is a large clinic and is they generally refer patients across the hall to hematology and oncology for genetic testing and management. Providers have minimal experience with ordering tests, as they just refer when needed. High risk patients are managed by specialists, such as radiology. The staff are excited about the program despite not really understanding it. They believe it will provide information and access to services for patients. They mention that many barriers here will be related to time, as providers indicate their time is limited. Despite the time issue, providers seem confident in their ability to implement the program. One new provider mentions some ethical and legal issues that may be a barrier. Leadership seems to be supportive of the program. Providers believe that in general, patients will be interested in the program.

Interviewee	Selected quotes
MC-405 (Provider)	"Interviewer: Can you elaborate a little bit on what your experience is with cancer genetic testing? MC-405: As a provider or...? Interviewer: Yeah. As a provider. If you had any training opportunities or what's your guys's testing processes? Anything like that. MC-405: I haven't had any training opportunities. Providers have asked about ordering genetic testing and I've seen a few messages here and there, and frankly it sounds so complicated... A kid has to be ordered, "And this has to be done, and this has to take place, and..." I just don't have time to do that. I also worry about insurance coverage, cost of genetic testing, ramifications for future insurance coverage, licensure or not, and I feel like, as a primary care provider who doesn't have a lot of training in ordering this genetic testing... I don't want to open Pandora's box, I would rather that they speak with a genetic counselor, or hematology/oncology to his training, and is a little bit more familiar with how the process works"
MC-404 (Provider)	"INTERVIEWER: Right. Do you anticipate any barriers or facilitators to getting your patients to participate in the EDGE program? physician: Facilitators, I think are going to be, patients want to know. A majority of patients again, they say, "I do want to know." They want to know that information. I do have one patient. I have a couple, I see not one, but a couple who refuse any type of cancer screening because they're like, "Why do I care about cancer? If I have cancer, I have cancer, who cares?" So there's going to be a few, but I think maybe our target population being a younger group with who most likely would decline any sort of cancer screenings more than 70 and above. I think our younger group who might be more of a benefit target would appreciate this a lot more. So I think it's going to be more facilitators because it's going to be another tool that they're going to want to do and to know"
MC-401 (Leader)	"I: Totally okay. Okay. What are you most worried about with the implementation of this program? MC-401: Providers time. I: Sure. MC-401: Making sure we have the time for the providers"

Clinic 3

Intervention	Point of Care
Health care system	MultiCare
Number of patients who completed the survey	140
Number of physicians who completed the survey	4
Number of leaders who completed the survey	1
Number of providers who participated in an interview	0
Number of leaders who participated in an interview	1
Level of implementation success	High

Summary of clinic 3:

Clinic 3 serves mainly elderly, White patients who are interested in prevention. The leader is positive about the program, but they are less certain of the details, as COVID has been a big distraction. There is minimal experience with genetic testing for hereditary cancer risk at this clinic. Implementation is not a concern as long as it does not take too much time from providers and does not have significant costs for patients. Leadership expressed support for the program, but providers expressed some disagreement that leadership supported the program. This clinic has many resources and they already do many labs and the leader felt this would make implementation easier.

Interviewee	Selected quotes
MC-201 (Leader)	"Interviewer: Sure. What are you most worried about with the implementation of this program? MC-201: If it's going to be any kind of inconvenience for my providers, I definitely don't want that. Like I said, I'm hoping it's as easy as a click of a button and handing someone a kit or sending them for blood work. So I want it as seamless as possible there. Besides that, I think that's it" "Interviewer: Is there anything about your clinic that you think would make it easier or more difficult to implement the EDGE program? MC-201: I don't think anything that would be more difficult. If anything, easier just incorporating with the lab work and all of the screenings that they already send out for and it's easier. It just goes with the flow of everything else"

Clinic 4	
Intervention	Direct Patient Engagement
Health care system	MultiCare

Number of patients who completed the survey	183
Number of physicians who completed the survey	3
Number of leaders who completed the survey	1
Number of providers who participated in an interview	0
Number of leaders who participated in an interview	1
Level of implementation success	Moderate

Summary of clinic 4:

The only interview for clinic 4 was conducted with a clinic leader who did not know the current processes around genetic testing, the evidence base, or the project in general. Positivity was expressed for the program and the ability of it to meet patient needs despite the leader not being too sure of the details. The leader is operational and did not see barriers, as they thought it would not be expensive or time consuming. The clinic is close to a city and many patients are of lower socioeconomic status than those in surrounding areas. It was expressed that some patients will definitely be interested in the program, while others will not. It was also mentioned that the time spent discussing positive results could be disruptive. The leader stressed the importance of educating providers and patients as part of implementation, but was not sure if any education had occurred. It was also mentioned that the program seemed simple and easy to implement.

Interviewee	Selected quotes
MC-601 (Leader)	"I: What about the setting that your clinic's situated in? Anything about the community or the policy environment that might affect implementation? MC601: … I guess if you really want to point something out, again, it goes back to the education piece. And for patients is that there's a lot of socioeconomic issues that can be a barrier for patients: homelessness, education, things like that, right? So you always got to think about that kind of stuff. And so we're not necessarily in an area that's in a high socioeconomic status. There's some areas around us, but for the majority it's a lower... You get where I'm going. It's just, there's some more socioeconomic barriers that we deal with and you may see in a place like [bigger city]" "I: if you've looked at the evidence for doing hereditary cancer risk assessment and genetic testing, just what is your perception of the quality and validity of that evidence? MC601: I wouldn't question it, but I'm also not... I guess I'm a trusting person in general. So I don't- I: Sure. Do you feel like any of that has been presented to you yet?

MC601:
No”

Clinic 5	
Intervention	Direct Patient Engagement
Health care system	MultiCare
Number of patients who completed the survey	156
Number of physicians who completed the survey	4
Number of leaders who completed the survey	1
Number of providers who participated in an interview	0
Number of leaders who participated in an interview	0
Level of implementation success	Moderate

Summary of clinic 5:

No interviews were conducted at clinic 5, so qualitative data analysis was not possible for this clinic.

Clinic 6	
Intervention	Point of Care
Health care system	MultiCare
Number of patients who completed the survey	187
Number of physicians who completed the survey	2
Number of leaders who completed the survey	1
Number of providers who participated in an interview	2
Number of leaders who participated in an interview	1
Level of implementation success	High

Summary of clinic 6:

Clinic 6 is located in more of an urban setting, which is said to make implementation easier. The clinic has access to genetic counselors, and also an oncologist and referral coordinator but there are not standard protocols for referral. Clinic seems to have access to many resources, but this sentiment was not seen in the survey data. Most physicians refer to the GCs when they need genetic testing, which may have long wait times. One physician mentions they sometimes order genetic testing themselves using Color. There seems to already be some educational materials available at this clinic. Providers in general are supportive of the program and trust the evidence base. The only concern about implementation is making sure that there is a

clear workflow. There is a clinic champion here who is leading the project. The staff here are used to implementing research studies. One barrier raised is getting patients to consistently turn in samples.

Interviewee	Selected quotes
MC-103 (Physician)	"INTERVEIWER: Overall, how do you think this program is going to go? MC-103: I think it'll probably go well. INTERVEIWER: Yeah. What about the program or the clinic you're in, makes you say that? MC-103: I think most of the patients would probably be agreeable to it and I think staff are willing to work it. I already do a fair amount of research studies so they're kind of used to that"
MC-102 (Physician)	"Interviewer: Yeah. And are there any facilitators to this process? It sounds like the genetic counselor is a good resource for you. MC-102: Yeah. They've been a pretty good facilitator and then the referral coordinator in our office has helped a lot with that too. So they're both really good"
MC-101 (Leader)	"Interviewer: Great. And then do you think there's anything broader than your clinic, maybe about your community or the policy environment that might affect implementation? MC-101: Oh, yeah. So I think one thing that I've admired most in my transition out here is being in the Tacoma. It's a very close knit community and very welcoming to all, all various types. Right. And I feel like this base, this community, we have, we have all kinds of resources, all in one area. I don't know the radius exactly, but there's just a lot of options and a lot of resources. Interviewer: Okay. And you think that'll be helpful? MC-101: I think that plays a huge part. Very helpful. Yeah. When you have, when you have everything all in one pot, versus having to venture out far to go to one location for something, whether it's specialty or whether it's a treatment, I feel like we have everything right here in this ball"

Clinic 7	
Intervention	Direct Patient Engagement
Health care system	Billings
Number of patients who completed the survey	256
Number of physicians who completed the survey	10

Number of leaders who completed the survey	1
Number of providers who participated in an interview	4
Number of leaders who participated in an interview	1
Level of implementation success	Moderate

Summary of clinic 7:

At clinic 7, sometimes physicians will order genetic testing, and other times they will refer out. They have a genetics person and a counselor, but the providers do not work with them a lot. It is mentioned that the referral process is challenging and there are long wait times. Providers in general are excited about the program and trust the evidence base. The leader mentions that they like having a point person as they see them as a supplement to the genetic counselor. There were some concerns about fitting the risk assessment into care given time constraints. It is mentioned that some may not be interested, as there are some who don't believe in COVID. There is some prior experience with implementing other genetic testing at this clinic such as pharmacogenetic testing. Nurses are mentioned as important to the process. A COVID surge at this clinic is mentioned. The clinic is partnering with their research department for implementation. Despite having some helpful staff, it was mentioned that more resources would be helpful. Also, some providers may lag behind others who are early adopters of the innovation.

Interviewee	Selected quotes
BC-108 (Physician)	"108: I suspect I miss opportunities to refer genetic testing all the time and that's an area I'm interested in. It's just so many other competing things. This is one of our greatest challenges. If somebody's having a heart attack right in front of you or falling off the cliff, we're really good at taking care of them. Looking down the line and saying, "Well, we need to treat your high cholesterol for the next 20 years," is harder for us and the same with this genetic testing"
BC-107 (Physician)	"INTERVIEWER: And then, can you tell me what you usually recommend to the patients after they've received genetic test results? BC-107: I guess it depends on what the results show, if they're positive or not, and not so much for genetic testing for cancers, but some genetic testing for other diseases. I do give them a heads up that before we even ordered the testing that sometimes when you do genetic testing, some patients that are healthy, some patients would rather not know that in the future, they may develop a disease. So that way they always have the anxiety and the worry over the years is when that disease process is going to hit them. And so, that's an education or counseling tool that I use for patients also, just to let them know that there are genetic tests out there that we can complete if they're curious"
BC-105 (Physician)	"INTERVIEWER: And overall, how do you think this program is going to go?

	BC 105: I would guess, I could see it going either way really. If it's something that's not too complicated and people can keep it in the front of their mind then I think it could fly, but if it gets out of sight out of mind, then I think it could flop at this facility" "BC 105: A decent number of patients. And I don't know if they're, I don't know if it's a [rural state] thing, but they don't believe in COVID even if they have it, it's something else causing them some thumbs. Maybe that's true for every single region, but just makes you wonder if we are a more rural area. May have more suspect of this. I don't know. INTERVIEWER: Yeah. So just general hesitation about medical knowledge from that population will be a barrier. BC 105: Yes"
BC-103 (Physician)	"INTERVIEWER: Is there anything else that you'd like to share about your experience with familial cancer risk assessment or cancer genetic testing? 103: No. I think that there's a certain population that is very motivated to this. And so they're going to grasp onto this a lot, but for just the general public kind of a thing, you put it out there. You send them an informational sheet. I hope that they're going to take the time to read it because I think reaching out to them in the office or in person is probably more effective"
BC-101 (Leader)	"Interviewer: Your perception of the quality and validity of the evidence supporting this kind of program. BC-101: …I think the data shows that it's a valid study. My physicians... I have not had any pushback from physicians. It's not a good thing. That's usually my canary, right? Doctors don't say, 'This might be bogus.' But I haven't had any of that. We've had a lot of education surrounding notes. We've spent a lot of time with [researcher name], talking to her about the whole stuff. [Inaudible 00:11:09] and nurses [inaudible 00:11:12] educating them on what this is, and how it's helpful, and everyone was in agreement" "BC-101: Well, current situation is difficult with our... Because our clinic is in a COVID search currently [inaudible 00:15:43]. And I don't know what timeline is. So, it's hard to launch new programs. Seeing a percentage of our staff, where we've shifted staff from outpatient to inpatient to cover this, the surge. We're just continuing to move down the road"
Clinic 8	

Intervention	Point of Care
Health care system	Billings
Number of patients who completed the survey	198
Number of physicians who completed the survey	11
Number of leaders who completed the survey	1
Number of providers who participated in an interview	2
Number of leaders who participated in an interview	1
Level of implementation success	Moderate

Summary of clinic 8:

Clinic 8 has a good process in place for referring to known genetic counselors and a high-risk breast clinic. Providers refer to GCS because of their skill in getting tests paid for and in interpretation and don't have much experience themselves in ordering genetic testing. There is not too much concern about implementation other than issue of time and this being a COVID hot spot resulting in people not wanting to come in. The leader mentions that a point person will be important but hiring for the role and other roles in general is difficult. The leader also thinks the implementation team is strong and sees the program as another good service to offer patients. Providers feel some excitement about implementation and trust the evidence base. It was also mentioned that there are individuals acting as leaders for the program.

Interviewee	Selected quotes
BC-305 (Physician)	"BC_305: Well I definitely have had patients who've asked and I don't feel that I'm knowledgeable enough, so having expanded knowledge and then just that ability for patients who I do think have the potential for a high risk or high risk for some cancer that there'd be more willing to do testing or to do something if I can just order it right there. And then just the fact that they have to go to take the time to a genetic counselor and talk with them and have another appointment does keep people from doing it or I've had patients who do the online test kits and they're like, "Well that test kit said that I'm fine," and I just don't know that I trust that they are, that that's the right thing for that patient to be doing and that they falsely feel reassured. So that would be a big benefit if I can just order something right there that can be done without having to have another appointment"
BC-303 (Physician)	"INTERVIEWER: Yeah. It's just generally easier. Are there any facilitators to collecting family history or performing genetic testing? Physician: Sometimes patients just don't want to talk about it or they don't want to... Yeah. I've had patients straight up say, "I don't really want to know." INTERVIEWER:

	Yeah. Physician: I want to know, or I don't want to talk to them about it or I don't want to address it” “INTERVIEWER: Yeah. Then, to what degree do you think that the EDGE program could be adapted to meet your local needs? Physician: I think if it was something that I could do... If it takes 20 minutes to assess a patient, realistically, I can't. It has to be able to be done in a probably five-minute span of time. INTERVIEWER: Yeah. Physician: Time is a barrier. I get maybe 40 minutes to do the history and physical and talk about all the patients' issues that they want to talk about, and so it just needs to be something that's done in an efficient way”
BC-301 (Leader)	“Interviewer: What are you most worried about with the implementation of this program? BC-301: Probably what I'm most worried about is hiring somebody. Interviewer: Okay. BC-301: Our situation right now, I have positions that are open for months and months and months” “BC-301: But I've got some physician champions that are like, "Yeah, we definitely need to hop on this." And then when the rest of them see that it doesn't disrupt the flow of your clinic and that we've got someone that can help us with this. And I see it taking off relatively quickly”

Clinic 9	
Intervention	Direct Patient Engagement
Health care system	Billings
Number of patients who completed the survey	214
Number of physicians who completed the survey	2
Number of leaders who completed the survey	1
Number of providers who participated in an interview	0
Number of leaders who participated in an interview	1
Level of implementation success	Low

Summary of clinic 9:

Clinic 9 is a small clinic and serves many people from rural areas who may not prioritize prevention. The small size is seen as goo because it may make it easier to get physicians on the same page. The staff have many obligations, so fitting the risk assessment into their schedules may be difficult. Therefore, it may not be possible to do something for every patient visit. There also is some physician burnout here. Providers have only referred out genetic testing but have the option to order it themselves. The clinic has some experience implementing a pharmacogenetic testing study. The staff trust the evidence base for the program but are not completely sold on the usefulness of the program at their clinic.

Interviewee	Selected quotes
BC-201 (Leader)	"BC-201: I think that we see a lot of more rural patients because of our location and I think traditionally in like rural [state] health care and going to the doctor and kind of preventative medicine is, I think traditionally maybe not utilized from the patient perspective as well as it could be. And a lot of times we see patients when they are sick and have already say, felt that lump in their breast, but haven't had a mammogram in the last 10 years or something like that. So I think that if we have any ability to be proactive and identify risks or any preventative measures before we hit crisis mode for the patient, that would be in my opinion, better care" "Interviewer: So as a small clinic, do you think that that will be to your benefit that that's kind of like more controllable? Or do you think as a small clinic it'll be more difficult to implement this kind of complex program? BC-201: I think it will be beneficial. Interviewer: Okay. Can you expand on that, just a little? BC-201: I think that we only will have, because we actually have two providers leaving, so we will only have [inaudible 00:17:47] seven, possibly eight, depending on we have another mid-level coming that was from Western. So I don't know if he will fit in under us or under Western. And I guess I didn't actually think of that until just now, but we only have seven providers that we would need to communicate with and they all have a specific nurse and the nurse works with the provider very closely. So I think as far as that would ease implementation as far as communication and getting everybody on the same page"

Clinic 10	
Intervention	Direct Patient Engagement
Health care system	Billings

Number of patients who completed the survey	225
Number of physicians who completed the survey	5
Number of leaders who completed the survey	1
Number of providers who participated in an interview	1
Number of leaders who participated in an interview	1
Level of implementation success	Low

Summary of clinic 10:

Clinic 10 was described as an extremely rural clinic. Providers did not do genetic testing and referred everything to an oncologist and GCs at a different site. The doctor and leader were excited about the program as they thought risk assessment was needed. Things that were unique about this clinic included factors related to it being so rural, meaning patients had to drive a long way to the clinic, they were often busy with work outside, may not have access to cell service or internet, and don't address health issues unless they are emergencies. It was mentioned that providers may be uncomfortable with the program before at first. The oncologist and GC are described as helpful resources, but they may not be able to help as much if testing was scaled up.

Interviewee	Selected quotes
BC-402 (Physician)	"INTERVIEWER: Yeah. So it seems like because you're like handed back and forth a little bit, it would be nice to have a streamlined process where you were just able to like, know what to order and be able to give them results. 402: It would be. And I, it would be useful particularly in rural [state], it's hard for patients to, you know, get to [clinic name] three, four hours away from them sometimes. And sometimes they don't have smartphones or internet at their houses where they can do like a television, those genetics. So, and actually it could be very beneficial"
BC-401 (Leader)	"Interviewer: Sure. And are there important aspects of being rural that you see as major things to consider? BC-401: Just the fact that these people are a lot different. I mean, they don't come into the clinic unless they're very ill or injured for two or three days and then figure out, "Well, yeah, I think we probably better go in because I can't breathe now." So, they're tough, and, I think, they don't always come in and ask for help very easily. And, I think, that would be just to break that barrier down that we're here to help you and it's okay to ask for help" "Interviewer: Thank you. That's great to hear. To what degree do you think the EDGE program is going to be able to be adapted to meet your specific needs? BC-401:

I think maybe the hardest part may be being able to get with some of the patients that you need to. I don't know how you're going to meet with them, if it's phone calls, Zoom, whatever. Because just like this, sometimes we don't always have, I mean, there's still areas in [rural part of state] that don't have internet, which is surprising, but it is. So that, I think will be the biggest obstacle"

Clinic 11	
Intervention	Point of Care
Health care system	Billings
Number of patients who completed the survey	243
Number of physicians who completed the survey	3
Number of leaders who completed the survey	1
Number of providers who participated in an interview	2
Number of leaders who participated in an interview	1
Level of implementation success	Moderate

Summary of clinic 11:

Clinic 11 is a small clinic in a rural setting. The rural setting could go either way in its impact on implementation, while the small size was viewed as a good thing, especially if people know who is asking them to participate. There is distance to services, but some telehealth options now exist. The clinic partners with GCs, but there is not a standard process for identifying those who might need genetic testing, and providers do not really have experience ordering genetic tests. Most feel there is not a huge need for genetic testing, but it could be beneficial to some. Lack of time and providers not remembering things or reading emails were considered barriers. The existing staff have a team environment and good organizational and workflow skills. The additional staff provided by the grant are viewed as essential to success of the program at this clinic. COVID has led to less time for providers, but they are not burnt out. Providers do not know a ton about the program but are supportive and trust the evidence base. The leader is more involved and supportive of the program. The clinic is partnering with their research department for implementation. The leader does not want the program to disrupt patient flow. Resources available at this clinic seem to be helpful here.

Interviewee	Selected quotes
BC-503 (Physician)	"physician: Well mostly it's just I don't know how long what kind of questions I need to ask with patients who would be identified as high risk. If that's something that could simply be added in, then I could probably do it but if it's something that took a five minute conversation. I don't know, it depends but I just don't know how

	much time it would take, I guess. My concern is that it would take a lot of extra time, however"
BC-502 (Physician)	"INTERVIEWER: Do you anticipate any barriers or facilitators to getting your patients to participate in the program? Just general knowledge of genetics? BC-502: I think general knowledge education and then some of them will be, 'Doc, hey. If I get it, I get it. That's the way it is.' But I'll definitely have the rancher type who are going to say that to me"
BC-501 (Leader)	"Interviewer: What barriers and facilitators do you foresee in trying to get your patient population to participate in the program? BC-501: Like I said earlier, we are a smaller community and we are [rural state] and sometimes I think people out here, it may take a little bit longer or more explanation and clarity for them to accept something new. So like I said, as it's all in how you approach them and how you explain and reassure" "Interviewer: Is there anything unique about your clinic otherwise or your larger healthcare system you think that might play a role in making this easier or harder? BC-501: I think that we have a wonderful research department and I think they are very excited and gung-ho to make sure that this is successful. So I think having them behind us and supporting us will make it very successful"

Clinic 12	
Intervention	Point of Care
Health care system	Billings
Number of patients who completed the survey	164
Number of physicians who completed the survey	4
Number of leaders who completed the survey	1
Number of providers who participated in an interview	1
Number of leaders who participated in an interview	1
Level of implementation success	Low

Summary of clinic 12:

Clinic 12 is a small clinic in a rural setting. They are very close knit, which is said to make communication easier. The clinic has not shut down due to COVID, but the provider thinks they will. They have access to some helpful resources, such as a genetic counselor, an oncologist, and a cancer navigator. They currently do not have processes in place to screen for hereditary

cancer risk, and the provider wants to do better since they can't be doing worse in their opinion. Providers do not have experience ordering genetic testing and refer to GCs when necessary. There is belief that the program will be helpful despite staff not being familiar with the evidence base. The leader thinks the program should be easy to implement, especially because they have the point person the grant is paying for. They already do some pre-appointment screenings, so this program could be done similarly. Providers were less sure that leadership would provide adequate support for implementation. Knowledge of family history could be difficult because of estrangement. Dealing with insurance companies about coverage is also seen as a pain.

Interviewee	Selected quotes
BC-602 (Physician)	"INTERVIEWER: Is this program something you see yourself supporting and trying to use with your patients? BC-602: Yeah, because we suck at it currently" "INTERVIEWER: Yeah. How do you see this program fitting into your existing workflow? BC-602: I don't know the details, but I'll make it happen" "I think if patients need to get somewhere to do anything. I have a sneaking suspicion that we'll be shutting down a lot of stuff and doing everything via telemedicine soon, and people are in survival mode. So they're not going to think about their cancer that could happen when they can barely make ends meet now"
BC-601 (Leader)	"Interviewer: what barriers and facilitators to getting your patients to participate in the program are you anticipating? BC-601: Oh, just taking a bit more time and I can see some of the patients not wanting to spend more time doing another assessment, so I can see that being a barrier, for sure" "Interviewer: Can you explain to me why it will be well received by the community? BC-601: It's just one more step forward to helping our patients in our community. And we're a small community, so very close knit"

Appendix 2. Data matrix

Presentness key		
Minimally present ↑	Somewhat present ↑↑	Present ↑↑↑

Impact on implementation key		
Hindering	Neutral	Enabling

***** Indicates there was disagreement between data sources; we are less confident about these classifications.

High implementation success clinics			
	Clinic 6 (42%)	Clinic 3 (29%)	Clinic 11 (23%)
Innovation			
Intervention arm	POC	POC	POC
Population screening would be an improvement over current approaches to assessing hereditary cancer risk	↑↑↑	↑↑↑	↑↑↑
Outer setting			
Clinic is located in a rural community	↑	↑	↑↑↑
Inner setting			
Clinic has sufficient staff, financial, and other resources to undertake practice changes	↑*	↑↑↑	↑↑↑
Clinic serves a small patient population	↑↑↑	↑↑	↑↑↑
Individuals			
Patients are interested in genetic testing for hereditary cancer risk	↑↑↑	↑↑	↑↑
Providers have experience ordering genetic testing for hereditary cancer risk	↑↑	↑	↑
Providers are confident in their ability to implement populations screening for hereditary cancer risk	↑↑↑	↑↑	↑↑
Process			
Staff have enough time to integrate population screening for hereditary cancer risk into clinical practice	↑	↑	↑
Clinic leadership has openly supported implementation	↑↑↑	↑↑*	↑↑*

Moderate implementation success clinics					
	Clinic 2 (18%)	Clinic 8 (13%)	Clinic 4 (12%)	Clinic 5 (11%)	Clinic 1 (10%)
Innovation					
Intervention arm	POC	POC	DPE	DPE	DPE
Population screening would be an improvement over current approaches to assessing hereditary cancer risk	↑↑↑	↑↑↑	↑↑↑	↑↑	↑↑↑
Outer setting					
Clinic is located in a rural community	↑	↑	↑	↑	↑
Inner setting					
Clinic has sufficient staff, financial, and other resources to undertake practice changes	↑↑↑	↑	↑↑	↑↑	↑↑*
Clinic serves a small patient population	↑	↑	↑↑↑	↑↑↑	↑
Individuals					
Patients are interested in genetic testing for hereditary cancer risk	↑↑↑	↑↑	↑↑↑	↑↑↑	↑↑↑
Providers have experience ordering genetic testing for hereditary cancer risk	↑*	↑	↑	↑↑	↑
Providers are confident in their ability to implement populations screening for hereditary cancer risk	↑↑	↑↑	↑↑	↑	↑↑↑
Process					
Staff have enough time to integrate population screening for hereditary cancer risk into clinical practice	↑	↑	↑↑	↑	↑↑
Clinic leadership has openly supported implementation	↑↑	↑	↑	↑	↑↑↑

Low implementation success clinics				
	Clinic 12 (9%)	Clinic 7 (7%)	Clinic 9 (5%)	Clinic 10 (5%)
Innovation				
Intervention arm	POC	DPE	DPE	DPE
Population screening would be an improvement over current approaches to assessing hereditary cancer risk	↑↑↑	↑↑↑	↑↑	↑↑↑
Outer setting				
Clinic is located in a rural community	↑↑↑	↑↑	↑↑	↑↑↑
Inner setting				
Clinic has sufficient staff, financial, and other resources to undertake practice changes	↑↑↑	↑↑	↑↑	↑↑
Clinic serves a small patient population	↑↑↑	↑	↑↑↑	↑↑↑
Individuals				
Patients are interested in genetic testing for hereditary cancer risk	↑↑	↑↑	↑↑	↑↑
Providers have experience ordering genetic testing for hereditary cancer risk	↑	↑↑	↑	↑
Providers are confident in their ability to implement populations screening for hereditary cancer risk	↑↑↑*	↑↑↑	↑↑	↑↑*
Process				
Staff have enough time to integrate population screening for hereditary cancer risk into clinical practice	↑	↑↑*	↑	↑
Clinic leadership has openly supported implementation	↑↑*	↑↑*	↑	↑↑