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ARTICLE

Optimizing participant and community engagement in cancer genomic sequencing research

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ABSTRACT

Purpose: We describe strategies implemented across research centers of the Participant Engagement and Cancer Genome Sequencing (PE-CGS) Network to optimize engagement of participants and communities in cancer genomics research. We also present consensus definitions of engagement and engagement optimization, informed by our shared experiences in the Network.
Methods: Key informant interviews and a document review identified engagement and optimization strategies across PE-CGS research centers. Findings were synthesized using qualitative content analysis. Consensus on definitions of engagement and optimization were developed through iterative review by PE-CGS members.
Results: PE-CGS research centers adopted tailored strategies based on community needs and scientific gaps. Engagement strategies included community-based efforts (eg, advisory boards and newsletters) and participant-focused approaches (eg, enhanced informed consent and decision support tools). Optimization strategies leveraged scientific methods (eg, randomized controlled trials and surveys) to evaluate engagement. Engagement was described as the sustained and meaningful interactions between researchers, participants, and communities. Optimization was described as the application of scientific methods to refine and improve engagement and research processes and outcomes.
Conclusion: Engagement and optimization strategies have informed research planning, conduct, and dissemination across PE-CGS. These approaches and definitions provide a foundation for developing evidence-based practices to strengthen participant and community involvement in cancer genomics research.

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The names of the PE-CGS Network members will appear at the end of the article.

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Introduction

Patient engagement in research refers to the inclusion of people experiencing a given health state in the design, conduct, and dissemination of research in ways that extend beyond their traditional role as study participants.[1-3] Engagement is based on the principle that patients have the right to be involved in science that is meaningful to them.[4,5] Engaging patients may help prevent or resolve study challenges, improve transparency, build trust or address mistrust, enhance understanding of context, and increase the relevance and uptake of research findings.[4,6-8] Emerging evidence suggests that engaging patients with cancer in research can help reduce cancer disparities and improve survival.[9-12]

The Cancer Moonshot was launched in 2016 by the National Cancer Institute (NCI) with a goal to "end cancer as we know it."[13] A key initiative was establishing a network for direct engagement that would expand access to genomic research by overcoming barriers to participation[14] (eg, participants' competing demands for time, structural issues, such as geographically dispersed academic facilities, distrust stemming from injustice). As a part of this effort, the NCI established the Participant Engagement and Cancer Genome Sequencing (PE-CGS) Network to bridge knowledge gaps in cancer genomics. PE-CGS focused on understudied populations, defined by the Network as groups for which there are scientific and evidence gaps that hinder the development of evidence-based cancer control, prevention, and intervention strategies. PE-CGS consists of 5 research centers focused on various cancer types and distinct populations, including rare cancers and cancers with incidence and outcome disparities. The Network builds upon previous genome sequencing programs[15-18] by directly engaging study participants and their communities in the design, conduct, and dissemination of research and by returning clinical-grade genomic sequencing results to research participants, which may be of direct value to their medical care.

PE-CGS was founded with an objective to develop evidence-based best practices for engaging understudied populations in genomics research.[19] The initial funding announcement introduced 2 concepts in genomics research: participant engagement and engagement optimization. Participant engagement was defined as an ongoing, mutually beneficial interaction between study participants and researchers throughout the research process.[20] However, this definition outlined activities typically associated with patient engagement rather than specifically speaking to the engagement of research participants. Engagement optimization was described as incorporating rigorous behavioral research to identify optimal approaches to participant engagement. This concept was interpreted in vastly different ways across research centers. To develop evidence-based best practices, the network needed to establish a shared understanding of engagement and optimization, which required understanding how the included research centers defined and operationalized these concepts.

This article characterizes how the PE-CGS Network defines, measures, and optimizes engagement and presents our shared understanding of engagement and optimization. It summarizes the early impacts of engagement on PE-CGS as a whole and across its 5 research centers. In doing so, it establishes a model of engagement that can accrue value for individuals, the communities they represent, and the research teams with which they collaborate. Through these efforts, PE-CGS not only supports the Cancer Moonshot's goal of ending cancer as we know it but also provides a foundation for identifying evidence-based practices to guide researchers and clinicians in advancing the science of engagement in cancer genomics.

Materials and Methods

The PE-CGS's Participant Engagement Subcommittee was established at the formation of the network to generate tools and resources to facilitate participant engagement across research centers. It endorsed the use of socially and culturally sensitive approaches to meaningfully engage the participant and research communities of PE-CGS. The Participant Engagement Subcommittee comprised members from each of the research centers, the coordinating center, and the NCI. The members represented a range of professional perspectives based on their roles as physicians, researchers, genetic counselors, program officers, and research coordinators.

The first initiative of the Participant Engagement Subcommittee was to characterize engagement and optimization strategies used early in the network's formation. This was done through a document review and key informant interviews with representatives from each research center. The subcommittee also sought to establish harmonized definitions of engagement and optimization. Because the focus was on exploring early network undertakings, the document review and interviews did not evaluate the impact of engagement activities on longer-term study outcomes. All activities were designated as nonhuman subjects research by the Ohio State University Institutional Review Board (2023E0471). This designation reflected that key informant interviews did not collect personal information about informants but rather collected information about the network as reported by informants in their professional capacity.

Document review

Document review is a process of identifying, comprehending, and synthesizing data contained in documents.[21] It is often used in combination with other methods, such as

interviews. A document review was used to gather information regarding how engagement and optimization were defined and operationalized across PE-CGS research centers during the first 3 years of network activities (September 2020-August 2023). Documents reviewed included research protocols, specific aims pages, slides of presentations at Network-wide meetings, and public-facing materials (eg, websites and social media).

Data abstracted (by N.L.C. and A.L.R.S.) from documents included: (1) description of the research center, (2) study population(s) characteristics, (3) cancer type(s), (4) definitions of engagement and optimization, (5) strategies for engagement and optimization, and (6) partner types engaged (eg, people living with cancer, care partners, clinicians, advocates, and subject matter experts).

In addition to the document review, 1 representative of each PE-CGS research center completed a structured documenting detailing the center's engagement and optimization. The document queried information about each center's approaches for engagement and optimization across different stages of the study conduct process (ie, outreach and recruitment, consent, data collection, return of genomic results, and retention).

Key informant interviews

Key informant interviews were conducted to clarify and enhance the descriptions of engagement and optimization gathered from document review and assess the contextual factors underpinning engagement at each center. Key informants were nominated by either principal investigators at each research center or by leaders in the areas of participant engagement and engagement optimization. Two to 5 interviews were conducted per research center, including at least 1 with an individual who oversaw participant engagement and another with a separate individual who oversaw optimization.

Key informant interviews provided information about each center's engagement and optimization strategies, definitions, and any preliminary evidence of engagement impacts. Interviews also confirmed or clarified information collected during the document review. Interviews (conducted by N.L.C.) followed a semistructured interview guide based on the Health Equity Implementation Framework[8] to assess multilevel contextual factors that informed the selection and adaptation of engagement and optimization approaches. Domains assessed included the context in which participant engagement (1) occurred (eg, the setting in which research was done), (2) was facilitated (eg, how and by whom participants were supported to enroll in research), and (3) considered cultural factors (eg, language and community trust in research), research team-participant interactions (eg, participant lived experience), and societal factors (eg, physical and sociopolitical forces and social norms related to research participation).

Data analysis

Qualitative content analysis was used to systematically organize and analyze the information gathered. Data from document reviews and interviews were summarized in tables. Strategies for engagement and optimization were sorted and grouped, and example engagement and optimization strategies were selected to highlight unique approaches across centers.

Definitions of engagement and optimization posed by each center were collated. Using these as a basis, new definitions of engagement and engagement optimization were drafted by the Participant Engagement Subcommittee and refined through multiple rounds of feedback with members of the Subcommittee and the PE-CGS Steering Committee. The process culminated in a meeting open to all Network members in which definitions were further refined based on shared understanding.

Results

We identified that PE-CGS centers approach engagement in terms of participant engagement in research, community engagement in research, and engagement optimization of both participant and community activities.

Harmonized definitions of engagement and optimization and how these vary when considering community or participant perspectives are included in Figure 1. A conceptual model portraying a process to achieve positive research outcomes (eg, study end points) and engagement outcomes (eg, relevance of research and participants and community members feeling valued) in cancer genomics research is included in Figure 2. In this model, research is driven by addressing scientific gaps and aligning with community priorities. Participant engagement activities occur during study conduct, whereas community engagement spans study planning, conduct, and dissemination. Optimization of engagement activities can occur at any point during participant or community engagement.

Engagement definitions, constructs, and instruments across PE-CGS

Engagement describes the sustained and beneficial interaction between research teams and diverse individuals to inform research processes and improve research and engagement outcomes (Figure 1). Initially, the 5 research centers described engagement in various ways. Some definitions focused on improvement of engagement at the participant-level, whereas others focused on engagement of broader community groups, community governing bodies, or councils to inform research. These descriptions of

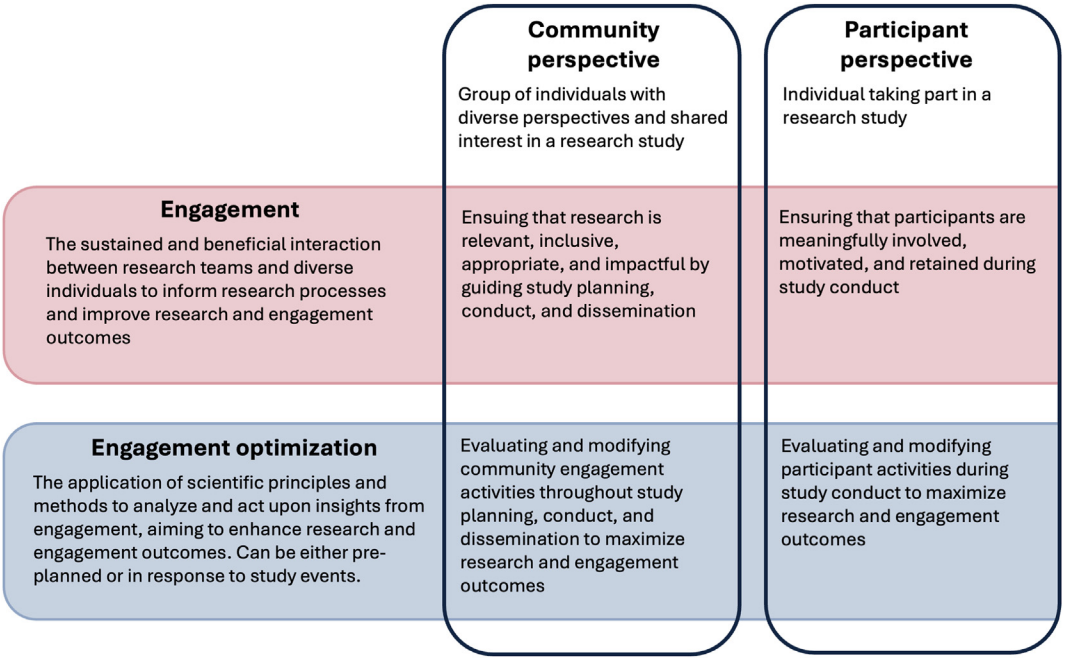

Figure 1 Definitions of engagement and engagement optimization in PE-CGS. Descriptions of how engagement and engagement optimization vary from the community and participant perspectives within PE-CGS. PE-CGS, Participant Engagement and Cancer Genome Sequencing.

engagement, along with the cancer type(s) and population of focus for each center, are included in Table 1.[22-30] Some descriptions of engagement, such as those posed by Center for Optimization of Participant Engagement for Cancer Characterization (COPECC) and Optimizing Engagement in Discovery of Molecular Evolution of Low-Grade Glioma (OPTIMUM), took an outcomes-based approach to define engagement, describing that engagement was something maximized through enhancement of knowledge and research participant trust. Other centers, such as Journey to Understanding Peoples Engagement in cancer Research University of New Mexico (JUNIPER) and Partnering with patients to define the clinical and genomic landscape of rare aggressive sarcomas in children and adults (Count Me In), described engagement as more strongly related to structure and process features. All centers considered the use of participant engagement as an approach to facilitate broader representation. Definitions of engagement across research centers placed similar emphasis on the importance of having a bidirectional relationship between research participants and the research team, as well as the importance of engagement being an ongoing process.

Engagement was measured using various constructs and instruments across research centers (Table 1[22-30]). Participant experience/satisfaction was the only engagement construct assessed across all centers. However, this construct was not uniformly measured because most centers used bespoke survey items or qualitative interviews to assess satisfaction. Other constructs assessed by multiple centers included knowledge, trust, communication, enrollment, and reasons for declining participation. These were collected using a mix of surveys, interviews, focus groups, and through researcher's evaluation of study records. Only 2 constructs were assessed across multiple centers using the same instrument: decisional regret[26] and feelings about genomic testing results.[28]

Participant engagement strategies

Centers applied participant engagement strategies across stages of study conduct, including outreach and recruitment, consent, data collection, return of results, and retention (Table 2). Centers reported that their selection and adaptation of participant engagement approaches were informed by literature reviews and assessments of appropriateness for their communities. Factors influencing selection included the language and culture of the participant population, the availability of validated measures for those populations, the timing of interactions with participants, and the participants' experiences with cancer. Participant engagement strategies used across different stages of study conduct are described in more detail below.

Participant engagement during the outreach and recruitment phase of study conduct focused on increasing study awareness and enrollment through multiple channels. All research centers had either already launched or were finalizing the launch of branded websites featuring educational content about their study and information on how to enroll. Centers used a mix of digital strategies (eg, social media, videos, and webinars) and traditional approaches (eg,

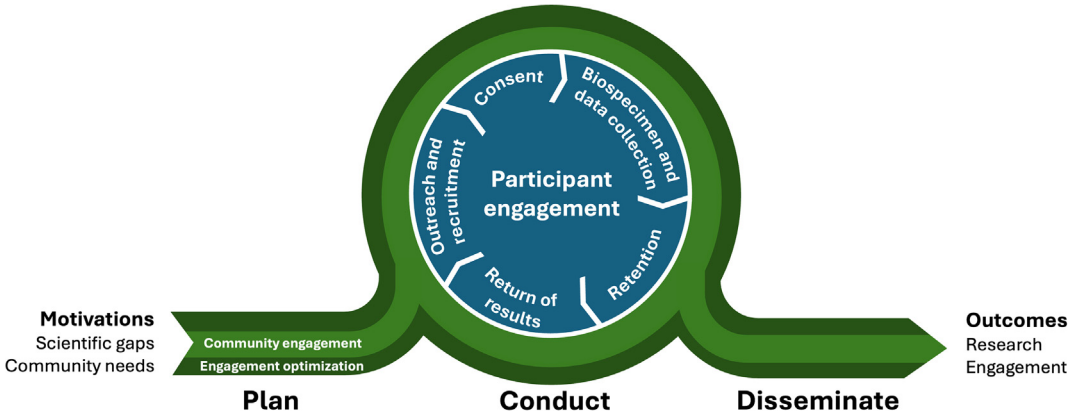

Figure 2 Conceptual model of engagement in PE-CGS. A conceptual model portraying a process to achieve positive research outcomes and engagement outcomes in cancer genomics research. Here, research is driven by addressing scientific gaps and aligning with community priorities. Participant engagement activities occur during study conduct, whereas community engagement spans study planning, conduct, and dissemination. Optimization of engagement activities can occur at any point during participant or community engagement. PE-CGS, Participant Engagement and Cancer Genome Sequencing.

brochures and informational materials) to reach potential participants. Recruitment efforts were strengthened through partnerships with patient groups, research/clinical groups, and physician networks. Centers also engaged participants through community events and conferences, with materials often being provided in multiple languages to increase accessibility. For example, OPTIMUM hosted quarterly webinars in both English and Spanish on topics relevant to their participant communities, such as disability services, quality of life, and how to discuss genomic testing with health care providers. These webinars aimed to promote participation in genomic research through participant testimonials. They were promoted through social media and were recorded and posted to OPTIMUM's study websites, ensuring that all informational materials were accessible to the entire brain tumor community, regardless of whether individuals chose to participate in the study.

During the consent phase, 2 centers incorporated additional materials to enhance participant comprehension and build trust. Centers used a combination of videos, educational aids, and visual artwork to enhance the consent process. JUNIPER provided a notable example of culturally tailored consent materials, in which they used American Indian visual artwork, created by an Indigenous artist, to anchor the consent document to the culture and improve comprehension. Their materials featured meaningful symbols such as an eagle feather intertwined with a DNA stem, in which the eagle feather represents strength and wisdom and is a commonly valued item among many American Indian peoples. Additional visual artwork included dragonflies and floral patterns, which were chosen because they symbolize hope, healing, and luck and could resonate well with patients diagnosed with cancer. JUNIPER's Tribal Advisory Committee, comprising tribal leaders and tribal cancer patients and survivors, reviewed and approved all the artwork design elements.

PE-CGS centers implemented participant-centered approaches to data collection that prioritized both accessibility and relevance. For example, Count Me In described providing multiple submission modalities through apps and other digital platforms. Research centers also recognized that comprehensive participant data extends beyond clinical information and centers have gathered survey-based data on quality of life, participant preferences, medical mistrust, socioeconomic factors, and environmental and occupation exposures. To enhance participant engagement and understanding, centers offered flexible survey data collection methods, including in-person surveys in participants' native languages and digital surveys that allowed participants to take breaks and resume later. These participant-centered approaches aimed to make data collection more convenient while ensuring the collected information remained meaningful to participants.

During the return of genetic/genomic results ("return of results") stage, centers focused on different goals, including improving the personal relevance of genomic testing results, enhancing participants' understanding of their genomic results, delivering information according to participant preferences, and providing psychosocial support. To achieve these goals, centers developed comprehensive support systems that included patient-centered decision support tools, multiple result delivery formats (both digital and paper), and access to genetic counselors. Centers also encouraged participants to review their results with their clinicians if they were not already automatically released to them. The genetic/genomic result reports were often tailored to the specific patient populations and followed good practices in health communication, such as maintaining 8th-grade reading level. For many centers, these reports went beyond presenting the results and offered interpretations that highlighted the medical relevance of the results for each participant.

Finally, centers across PE-CGS typically described that participant engagement during the retention stage of study conduct was aimed at maintaining connection and sustaining relationships. Centers used tools including newsletters,

Table 1 Engagement definitions, constructs, and instruments

Center, Cancer and Population of Focus	Engagement Definitions How is Engagement Described?	Measurement Constructs What Aspects of Engagement Are Being Measured?	Instruments What Tools Are Being Used to Evaluate the Constructs?	Instrument Description Description of These Tools
COPECC, Colorectal cancer in Hispanic or Latino adults (18+)	Engagement means fostering improved outcomes including: Knowledge Trust Self-Efficacy Adherence Family Communication Process Satisfaction Feeling Valued Feeling Heard	Knowledge and literacy Uncertainty Trust Self-efficacy Adherence Family communication Process satisfaction Feeling valued Feeling heard	Surveys	Genomics knowledge and literacy: GLAC, KnowGENE,[22] Uncertainty: PUGS[23] Trust: Health care System Distrust scale[24] Self-efficacy: General Self-Efficacy Scale[25] Process satisfaction: developed by study team Decisional regret: Decisional Regret Scale[26] Feeling Valued: PEIRS,[27] The Feelings About Genomic Testing Results (FACToR) Questionnaire[28]
Count Me In, Osteosarcoma or leiomyosarcoma	Engagement means continuously sharing about our work, our mission, and vision, and partaking in the community as an active member (eg, attending events, supporting others' efforts, taking the time to address concerns or questions, as well as holding conversations that foster trust and transparency and generate new collaborations).	Participant motivation Participant experience Study website evaluation Enrollment Participant experience Recruitment in special populations (Hispanic/Latino)	Interviews Study records Surveys Focus groups	Interview guides developed by study team Number of participants enrolled Intake Survey, conducted post return of results and developed by study team Explore topics such as culturally tailored enrollment strategies and native language materials
JUNIPER, Various cancers in American Indian adults (18+)	Participant engagement is defined in response to social determinants and participatory framework that values multi-stakeholder interaction across multilevels. Four values: inclusivity, equitability, and bidirectionality.	Communication Knowledge Information Participant experience and satisfaction Trust Reasons for declining participation	Survey	Interview guides developed by study team Decision Regret Scale[26] The Feelings About Genomic Testing Results (FACToR) Questionnaire[28]
OPTIMUM, Lower grade glioma in adults (21-79)	Enhancing the reach, representativeness, trust and experience of LGG Registry participants in the context of recruitment, data sharing, and return of results. Participant engagement in activities associated with the clinical study such as registry recruitment, data sharing, return of results.	Trust Participant experience	Survey Interviews	Survey developed by study team to capture participant's trust in research and preferences for communication Qualitative interviews with Registry participants to assess experience with enrollment, data sharing, communication, and return of results

(continued)

Table 1 Continued

Center, Cancer and Population of Focus	Engagement Definitions How is Engagement Described?	Measurement Constructs What Aspects of Engagement Are Being Measured?	Instruments What Tools Are Being Used to Evaluate the Constructs?	Instrument Description Description of These Tools
WU-PE-CGS, Cholangio-carcinoma in adults (18+), multiple myeloma in Black/AA adults (18+), colorectal cancer in Black/AA adults (18-65)	Broad representation and inclusion of all stakeholders across the spectrum of diagnosis, treatment, and follow-up (including survivorship). Patients and caregivers. A "moving target."	Patients and caregivers approached, consented, declined	Study records	Number of patients/caregivers approached, percent consented, percent declined
		Participant engagement experience	Engagement surveys and interview protocols	Surveys include validated scales such as: The Feelings About Genomic Testing Results (FACToR) Questionnaire[28] Expectations of Benefit,[29] Perceived Utility,[29] The Group-Based Medical Mistrust Scale.[30] Interview guides developed by study team.

COPECC, Center for Optimization of Participant Engagement for Cancer Characterization; *Count Me In*, Count Me In: Partnering with patients to define the clinical and genomic landscape of rare aggressive sarcomas in children and adults; *JUNIPER*, Journey to Understanding Peoples Engagement in cancer Research University of New Mexico; *LGG*, Lower-grade glioma; *OPTIMUM*, Optimizing Engagement in Discovery of Molecular Evolution of Low-Grade Glioma; *WU-PE-CGS*, Washington University Participant Engagement in Cancer Genome Sequencing Center.

websites, virtual meetings, social media postings, and in-person events to support retention. The information shared through these channels included updates on study activities and lay summaries of research findings.

Community engagement strategies

An array of community engagement approaches were applied to improve the planning, conduct, and dissemination of research across PE-CGS centers (Table 3). Community advisory boards served as a cornerstone of community engagement within the research centers. These boards informed research priorities, guided research activities, and helped develop and refine critical materials, such as informed consent documents and interview guides. All centers established multidisciplinary community advisory boards, which brought together perspectives including those of patients, ethicists, lawyers, community members, family and care partners, community leaders with governance authority, health care and research professionals, and institutional review board specialists. Four centers supplemented these multidisciplinary boards with population-specific advisory boards. For example, JUNIPER convened a Tribal Advisory Committee comprising tribal governors, leaders, and health care leaders, along with cancer patients and survivors. Their focus encompassed the full scope of study activities from protocol review to community engagement and establishment of data sovereignty conditions.

Centers implemented various strategies to facilitate bidirectional communication between study teams and their broader communities. These included listening sessions, discussions at patient community events, town halls with patients and caregivers, and roundtable events with community health educators. These were primarily conducted in person. They often served multiple purposes, including gathering community insights on study design and implementation, sharing research progress and findings, and providing informational resources to community members.

The PE-CGS Annual Network Meetings represented another vital channel for community engagement. The goal of these meetings was to bring together PE-CGS researchers, patient partners, participants, and community representatives to "inspire, collaborate, discover, and engage." The flexibility of a hybrid in-person/virtual format enhanced accessibility and increased participation. Beyond the formal agenda, these meetings created opportunities to strengthen relationships and foster collaboration both within centers and across the broader PE-CGS Network.

Engagement optimization definitions and impacts

Engagement optimization describes the use of scientific principles and methods to analyze and act upon insights from engagement, aiming to enhance research and engagement outcomes (Figure 1). The research centers approached

Table 2 Strategies for participant engagement

	Research Center				
Stage of Research Conduct (Engagement Strategy)	COPECC	Count Me In	JUNIPER	OPTIMUM	WU-PE-CGS
Outreach and recruitment					
Branded website	X	X	X	X	X
Partnerships with patient groups		X		X	X
Partnerships with research/clinical groups	X	X		X	X
Social media	X	X		X	
Brochures/cards/graphics	X	X	X	X	X
Videos/webinars		X	X	X	
Physician outreach	X	X	X	X	X
Events and conferences		X		X	
Consent					
Visually enhanced informed consent			X		
Videos	X		X		
Educational aids	X				
Data collection					
Health technology apps		X		X	
Participant-centered measures	X	X	X	X	X
Return of results					
Decision support tools					X
Participant portal		X			X
Written report		X	X	X	
Genetic counseling	X	X	X	X	X
Email to patient and provider				X	
Retention					
In person and virtual activities	X	X		X	
Newsletters	X	X	X	X	X

COPECC, Center for Optimization of Participant Engagement for Cancer Characterization; *Count Me In*, Count Me In: Partnering with patients to define the clinical and genomic landscape of rare aggressive sarcomas in children and adults; *JUNIPER*, Journey to Understanding Peoples Engagement in cancer Research University of New Mexico; *OPTIMUM*, Optimizing Engagement in Discovery of Molecular Evolution of Low-Grade Glioma; *WU-PE-CGS*, Washington University Participant Engagement in Cancer Genome Sequencing Center.

engagement optimization using proactive, planned activities, as well as through reactive, ongoing, and iterative adjustments throughout the funding period (Table 4). The primary goals of engagement optimization included developing and evaluating interventions to identify effective participant engagement strategies for recruiting and retaining participants, gathering reliable data, determining appropriate genetic information to share with participants, and communicating research results effectively. The effectiveness of engagement optimization activities was evaluated using the engagement measurement constructs and instruments outlined in Table 1.[22-30] The optimization activities integrated methods from multiple scientific disciplines, including behavioral science, implementation science, clinical trials, and quality improvement.

Engagement optimization influenced the strategies for data collection and sharing. For example, JUNIPER established a framework for conducting genomic research that respects tribal sovereignty and shared ownership. Count Me In revised its "return of somatic result" language to "shared learnings about your tumor" based on focus group feedback, whereas OPTIMUM updated its return-of-results templates to protect privacy while enhancing understanding of genomic test results. Washington University Participant Engagement in Cancer Genome Sequencing Center worked with Black/African American adults with multiple myeloma and colorectal cancer to improve participant experiences by addressing issues in real-time and refining strategies based on feedback. Collectively, these iterative processes led to optimized strategies for returning results that better engaged patients and their support networks.

Engagement optimization activities

PE-CGS centers applied optimization to support both participant and community engagement activities (Table 5, Supplemental Table 1). These optimization activities have had preliminary impacts on outreach, recruitment, and retention strategies (Table 4).

Optimization of the recruitment process was consistently implemented across all centers, with each center engaging in at least 1 related activity. Centers used randomized experiments, interviews, and surveys to evaluate aspects of recruitment including effectiveness of recruitment messaging and study accrual rates. Several centers gathered qualitative and survey data to understand reasons why some eligible individuals declined participation and to develop strategies to address these. OPTIMUM, for instance, improved its website with guidance on how to easily enroll,

Table 3 Strategies for community engagement

Community Engagement Strategies	Research Center				
	COPECC	Count Me In	JUNIPER	OPTIMUM	WU-PE-CGS
Advisory board (participant population specific): Advise on design, conduct, and evaluation of research	X	X	X	X	
Listening sessions: Facilitate planning and improve conduct of research	X	X	X		
Discussion and survey at patient group event: Facilitate planning and improve conduct of research; Foster communication between research team and community	X	X			
Town Hall with patients and caregivers: Facilitate planning and improve conduct of research; Foster communication between research team and community		X			X
Newsletters and digital/social media communications: Awareness of research process	X	X	X	X	
Roundtable and panel event: Foster communication between research team and community; Update community on research progress; Facilitate planning and improve conduct of research	X				
Annual network meeting: Team building and planning research	X	X	X	X	X
Advisory board (multidisciplinary): Advise on design, conduct, and evaluation of research	X	X	X	X	X

COPECC, Center for Optimization of Participant Engagement for Cancer Characterization; *Count Me In*, Partnering with patients to define the clinical and genomic landscape of rare aggressive sarcomas in children and adults; *JUNIPER*, Journey to Understanding Peoples Engagement in cancer Research University of New Mexico; *OPTIMUM*, Optimizing Engagement in Discovery of Molecular Evolution of Low-Grade Glioma; *WU-PE-CGS*, Washington University Participant Engagement in Cancer Genome Sequencing Center.

as well as refined its quarterly newsletter to better serve lower-grade glioma registry participants interested in research opportunities and findings.

During the consent phase, centers focused on improving both consent documents and processes. They did so using surveys, interviews, focus groups, randomized interventions, and collaboration with population-specific advisory boards. An example of this was JUNIPER's development of consent documents that incorporated Indigenous art and integrated Indigenous Ways of Knowing and Traditional Ecological Knowledge through collaboration with a Tribal Advisory Committee and American Indian adults.

Data collection optimization was less common across centers. JUNIPER notably sought to optimize biospecimen collection and data sharing protocols through interviews and rapid-cycle research approaches. Rapid-cycle research is a process used to identify and address less-than-optimized processes using analytical methods that are incremental, contextually defined, and scalable. It focuses on quick, small-scale studies to gather data rapidly.[31,32] Applying these methods identified a need for data collection processes to address cultural attitudes regarding genetic samples in American Indian communities.

Return of genomic sequencing results emerged as a key area for optimization, with centers working to improve communication effectiveness and participant experience and knowledge. Centers used various assessment methods, including participant interviews, validated survey measures, randomized studies, and tracking of return-of-results visit outcomes. More specialized approaches included COPECC's and JUNIPER's molecular tumor boards for integrating somatic and germline results and Washington University Participant Engagement in Cancer Genome Sequencing Center's evaluation of a novel decision support tool through a randomized controlled trial.

Approaches to optimize participant retention were explored by several centers. Count Me In used interviews, focus groups, and communication tools, including newsletters and emails to improve retention rates, and OPTIMUM focused on enhancing participant trust and experience through surveys and interviews. Other centers created protocols wherein they would implement optimization activities based on triggers, such as if a specific engagement metric fell below a prespecified benchmark.

Beyond individual participant engagement, centers also pursued optimization of community engagement activities. OPTIMUM conducted a comparative effectiveness study testing advisory board vs social media-based approaches for engaging community members in research planning, implementation, and dissemination. COPECC developed and evaluated community health educator training

Table 4 Definitions of engagement optimization and impacts on research

Center	Engagement Optimization	Impacts on Research
COPECC	Continuously improving participant engagement by assessing benchmarks and collaborating with the Engagement Optimization Unit to enhance informed consent, communication of results, and follow-up, considering both patient and provider perspectives. This process includes identifying key timepoints in the patient journey for optimization and using specific triggers, such as consent rates and survey completion, to guide improvements.	• Modification of educational materials to address participant desire for more information • Modification of retention and education video
Count Me In	Involves enhancing participant engagement across recruitment, retention, communication of results, and engagement quality. Key values include inclusivity, streamlined enrollment processes, understandable results, and collaborative design. Based on the Strategy for Patient-Oriented Research (SPOR) framework.	• Modifying "return of somatic results" to "shared learnings about your tumor" based on focus group findings • Creating Physician Engagement Materials for education and recruiting • Creating specific adolescent and young adult messaging via a social media content creator and creating project focused update newsletters
JUNIPER	The iterative development and testing of culturally relevant and innovative approaches to optimize participant engagement in genomic research through bidirectional communication, education, and recruitment across engagement events such as consent (document and process); biospecimen collection communication, process, and storage; return of results (both germline and somatic) communication and process; and data protection, privacy, confidentiality, and sharing. These engagement events are optimized on four constructs (subconstructs): communication (comprehension, cultural acceptability, satisfaction), education (knowledge), engagement (empowerment, motivation, trust, respect), recruitment (reach, accrual, attrition).	• Modified consent documents incorporating indigenous art and integration of Indigenous Ways of Knowing and Traditional Ecologic Knowledge • Development of a framework for the conduct of genomic research in collaboration with indigenous communities and participants (respect for Tribal sovereignty, respectful handling of biospecimens, acknowledgement of shared Tribal ownership, input and decision-making regarding data privacy, sharing, and development of interpretive data narratives) • Development of extensive culturally appropriate Indigenous participant educational materials
OPTIMUM	Involves enhancing participant engagement through theory-based communication and user-centered design. This approach ensures each engagement strategy component is refined, with a focus on qualitative and quantitative data collection and participatory codesign and rapid prototyping to address challenges in recruitment messaging.	• Website redesign and content enhancements including research enrollment guidance and links to online registration, research results, links to recorded webinars and explainer videos • Revised return-of-results templates and procedures to protect privacy and enhance knowledge and understanding of genomic test results • Refined quarterly newsletter formatting and content preferences for Registry participants and others interested in keeping up to date on Registry research opportunities and findings • Broadened in-person recruitment sites
WU-PE-CGS	Continuously improving participant experiences by addressing issues in real-time and refining strategies based on feedback. This includes enhancing recruitment, return of results, and overall engagement quality through methods like randomized controlled trials and qualitative interviews to understand participant needs and preferences. The goal is to create the best possible participant experience by being constantly informed and adaptable.	• Informing best practices for approaching patients for recruitment and retention in the study • Optimizing patient return-of-results processes to engage patients and their support network • Deeper understanding of barriers to participation as perceived by patients to best address and improve the clinical research process

COPECC, Center for Optimization of Participant Engagement for Cancer Characterization; *Count Me In*, Partnering with patients to define the clinical and genomic landscape of rare aggressive sarcomas in children and adults; *JUNIPER*, Journey to Understanding Peoples Engagement in cancer Research University of New Mexico; *OPTIMUM*, Optimizing Engagement in Discovery of Molecular Evolution of Low-Grade Glioma; *WU-PE-CGS*, Washington University Participant Engagement in Cancer Genome Sequencing Center.

Table 5 Engagement optimization strategies

What is Being Optimized/Studied	Strategies for Optimization	Center
Participant engagement		
Outreach and recruitment		
Recruitment messages	Randomized experiment	OPT
Reason for decline	Interviews with research decliners	JUN, WU, COP, CMI
Accrual	Survey, interviews	CMI, OPT
Recruitment process	Provider survey	COP
Consent		
Informed consent documents	Interviews, Tribal Advisory Committee	JUN
Consenting processes	Focus groups, interviews, randomized intervention	COP, JUN, OPT
Patient knowledge and experience	Focus groups, interviews, surveys	COP, JUN, OPT
Data collection		
Biospecimen collection	Interviews	JUN, OPT
Data storage and sharing	Interviews	JUN
Return-of-results		
Return of results process	Interviews	CMI, JUN
Decision support tools	Randomized controlled trial	WU
Molecular tumor board	Multidisciplinary review and integration of somatic and germline results	COP, JUN
Participant experience	Informal tracking sheet	WU
Patient knowledge and experience	Surveys, interviews	COP, CMI, JUN
Communication of results	Randomized controlled trial, interviews, rapid prototyping	COP, JUN, OPT
Cascade genetic testing	Surveys, interviews	CMI, COP, OPT, WU
Retention		
Rate of retention	Interviews, focus groups, newsletters, and emails	CMI
Participant trust and experience	Surveys, interviews	OPT
Community engagement		
Approaches to community engagement	Comparative engagement study	OPT
Genetics and genomics training of community health educators	Focus groups, training program, toolkit development, randomized controlled trial	COP

CMI, Count Me In: Partnering with patients to define the clinical and genomic landscape of rare aggressive sarcomas in children and adults; *COP*, Center for Optimization of Participant Engagement for Cancer Characterization; *JUN*, Journey to Understanding Peoples Engagement in cancer Research University of New Mexico; *OPT*, Optimizing Engagement in Discovery of Molecular Evolution of Low-Grade Glioma; *WU*, Washington University Participant Engagement in Cancer Genome Sequencing Center.

through focus groups and toolkit development and has plans to further evaluate these through a randomized controlled trial. Count Me In developed targeted messaging for adolescents and young adults with sarcomas through social media content creators and project-focused newsletters.

Discussion

The work of the PE-CGS Network represents a significant effort to explore and define the role of engagement and its optimization in cancer genomics research. This article provides a view of activities during the first 3 years of the network's formation, culminating in a shared understanding of how these concepts can be conceptualized and applied to community and participant engagement and optimization. Although it is too early to draw definitive conclusions about the overall impact of these efforts on research outcomes, this work establishes a foundation for identifying evidence-based and community- and data-informed practices for participant engagement in cancer genomics research.

A novel contribution of PE-CGS is its focus on engagement optimization, a new concept in cancer genomics research. Many iterative and microoptimizations occurred across PE-CGS in response to feedback gained through participant and community engagement. In some instances, engagement optimization has been conducted using traditional scientific methods, such as experimental studies. Although these approaches allow for rigorous evaluation of engagement activities, they can be constraining, time consuming, and poorly suited for iterative optimization. Other approaches to engagement optimization, such as those following quality improvement and rapid-cycle research frameworks, were found to be useful for making tweaks to research practices. There is a need for further work documenting the range of engagement optimization methods applied across health research broadly. The efforts underway in PE-CGS contribute to

important and ongoing discussions about the value of engagement.[8,33-35]

Engagement optimization has had demonstrable impact on study design for research centers within PE-CGS. Modifications to research strategies from engagement optimization have resulted in meaningful changes to how research activities are conducted (Table 4). Engagement optimization may also play a role in the PE-CGS Network's efforts to diversify the pool of participants included in cancer genomics research. Specifically, the demographics of PE-CGS participants include a higher proportion of racial and ethnic minorities compared with those in previous initiatives, such as The Cancer Genome Atlas Program.[36,37] Although these findings suggest progress in addressing the underrepresentation of these groups in cancer genomics research, further evaluation is needed to confirm the impact of engagement optimization on participant diversity.

A key contribution of PE-CGS is its emphasis on improving the experiences of research participants.[38] Engagement of individual research participants is distinct from patient engagement; it focuses on maximizing the quality and quantity of participation so as to improve both engagement and research outcomes.[38] This approach aligns with an identified trend among cancer genomics programs, such as the Cancer Moonshot Biobank,[39,40] which defined participant engagement as interpersonal, ongoing, and reciprocal.[41] The definitions of participant and community engagement posed by the network are consistent with the principles outlined by the Patient-Centered Outcomes Research Institution (PCORI).[42] Specifically, PE-CGS's definition of community engagement reflects the PCORI Engagement Rubric, which emphasizes the importance of community engagement across 3 main phases of research: planning, conduct, and dissemination.[43] Notably, the network preferred the term "community" over "stakeholder" because of the negative connotations associated with the latter, particularly its ties to colonialism and the appropriation of tribal lands.[44] By making these distinctions, PE-CGS can tailor its strategies and evaluate their effects more precisely, ensuring that both community-wide initiatives and individual study participant interactions are effectively evaluated. The systematic study of participant and community engagement for the purposes of "optimization" is new, and there is work to be done to operationalize these concepts across the research enterprise. The PE-CGS Network is an early adopter of such efforts. PCORI's Science of Engagement initiative represents another entity's prioritization of the need to define, measure, and study engagement strategies and outcomes.[45]

PE-CGS research centers' strategies for participant engagement mirror those applied in other genomics programs, such as My Pediatric and Adult Rare Tumor Network Network,[46] Comprehensive Oncology Network Evaluating Rare Central Nervous System Tumors,[47] Connect for Cancer Prevention Study,[48] All of Us,[49] and the Clinical Sequence Evidence-Generating Research Consortium.[50] Similar engagement strategies span broad categories that include the use of digital and nondigital communications and forming collaborative partnerships.[41] Similar to these other programs, PE-CGS research centers tailored their engagement strategies to align with specific study goals and unique contextual factors, and they included a concerted effort to overcome logistical, structural, and historical barriers to research participation among underserved populations. This includes an emphasis on using plain language and culturally tailored communications in multiple languages, as well as personalizing the return of genomic results to participants[19] in timely enough manner to potentially inform treatment decisions. The chosen participant engagement strategies reflect each center's focus on enhancing participant experience throughout research conduct. They also demonstrated how the centers considered the relevance and effectiveness of these strategies for the communities involved.

Based on the experiences of PE-CGS, we propose several recommendations for cancer genomics researchers and clinicians as they develop engagement and optimization strategies. First, we recommend establishing a robust infrastructure for engagement within research initiatives. The success of the PE-CGS center-specific advisory boards highlights the importance of this approach. Engaging participants and communities should extend beyond individual research projects and be meaningfully integrated into all aspects of genomics research and relevant clinical activities. This engagement can take various forms, such as creating community advisory boards or intentionally including participant, patient, and community representatives in research teams, working groups, and decision-making processes. Additionally, patients/participants could serve as formal consultants or funded community scientists, fostering deeper collaboration with the research team.

Our second recommendation is for cancer genomic research projects to develop a plan for measuring engagement and assessing its impact on study activities and outcomes from the outset. It is essential to involve community members in creating these plans, building on existing approaches to integrate community engagement into genomic research.[51] By incorporating the perspectives and insights of community members, researchers are better assured that the engagement strategies are relevant, culturally appropriate, and more likely to foster meaningful participation.

Finally, we suggest that cancer genomic researchers and clinicians actively engage community members in the selection of harmonized constructs and measures related to engagement. As shown in Table 1,[22-30] we identified overlap in the engagement measurement constructs used across PE-CGS centers. Although it may be challenging to harmonize data collection after study activities have already begun across PE-CGS, we see increased harmonization of measures as a goal for future collaborative efforts. Working with community members to identify key engagement measures that can be uniformly collected across various setting can enhance the value of engagement data generated by these initiatives. These data could then support the

inclusion of patient-centered data elements, alongside sequencing data in genomic data commons.

Our recommendations support the PE-CGS commitment to addressing scientific gaps resulting from underrepresentation of populations in cancer genomics research. The early impacts of engagement optimization suggest that meaningful improvements have been made, potentially enhancing participation and collaboration in this field of research. We are also dedicated to advancing the scientific study of engagement, and this article contributes to that goal by offering definitions, strategies, and methods for engagement and engagement optimization.

Data Availability

All data are reported directly in the manuscript.

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Ethics Declaration

These activities were designated as nonhuman subjects research by the Ohio State University Institutional Review Board (IRB) (2023E0471). Participation in activities implied consent.

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See Supplemental PE-CGS Banner Authorship List for additional author information.

Conflict of Interest

Norah L. Crossnohere reports grants from Pfizer outside of the submitted work and personal fees from Boehringer Ingelheim. Anne L.R. Schuster reports grants from Pfizer outside of the submitted work; John F.P. Bridges reports personal fees from Boehringer Ingelheim. Eliezer Van Allen reports personal fees from Enara Bio, Manifold Bio, Monte Rosa, Novartis Institute for Biomedical Research, Serinus Bio, and TracerDx and research support from Novartis, BMS, Sanofi, and NextPoint and equity in Tango Therapeutics, Genome Medical, Genomic Life, Enara Bio, Manifold Bio, Microsoft, Monte Rosa, Riva Therapeutics, Serinus Bio, Syapse, and TracerDx. Roel Verhaak reports equity in Boundless Bio. Elizabeth B. Claus is an advisory research board member to Servier Pharmaceuticals. John D. Carpten reports personal fees from Stand Up to Cancer Scientific Advisory Committee, BreakThrough Cancer Scientific Advisory Board; and personal fees from Roche/Genentech Advancing Inclusive Research External Advisory Board outside the submitted work. All other authors declare no conflicts of interest.

Additional Information

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