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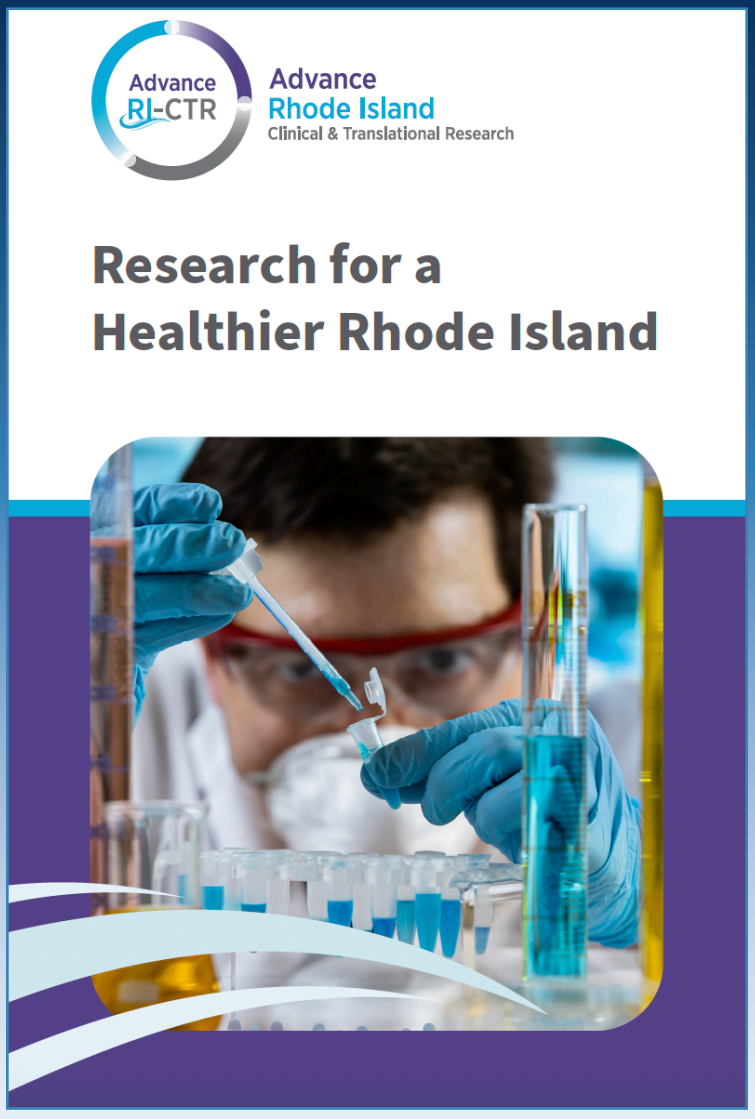
RHODE ISLAND MEDICAL JOURNAL



SPECIAL SECTION

ADVANCE RI-CTR

GUEST EDITOR: SHARON ROUNDS, MD

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In celebration of Advance RI-CTR's 10th-year anniversary, a mosaic showcasing portraits of its investigators emphasized the translational collaboration of all the researchers involved.

IDeASymposium poster session

SPECIAL SECTION
Advance RI-CTR

Advance RI-CTR: Advancing a Decade of Discovery for Clinical & Translational Research in Rhode Island

SHARON ROUNDS, MD; EDWARD HAWROT, PhD; METHODIUS TUULI, MD, MPH, MBA; KERRI CONNOLLY, MPH; STEPHEN KOGUT, PhD, MBA; JUDY KIMBERLY, PhD; NADIA TSADO, MPH; PATRICIA COULTER

ABSTRACT

Advance Rhode Island Clinical and Translational Research (Advance RI-CTR) is a statewide consortium funded by the Institutional Development Award (IDeA) Program of the National Institute of General Medical Sciences. Over the past decade, it has strengthened Rhode Island's clinical and translational research ecosystem. Led by Brown University in partnership with Brown University Health, Care New England, the Providence VA Medical Center, and the University of Rhode Island, the consortium provides infrastructure, pilot funding, workforce development, and community-engaged resources aligned with state health priorities.

Guided by environmental assessment and sustained community input, Advance RI-CTR prioritizes chronic disease and aging, behavioral and mental health, and maternal and child health, with crosscutting emphases on substance use disorder, social determinants of health, and healthcare delivery. Through five integrated cores, the program supports investigators statewide.

Major accomplishments include establishing a practice-based research network, expanding informatics capacity, strengthening implementation science, enhancing workforce training, and increasing competitiveness for extramural funding. The program demonstrates strong return on investment and measurable statewide impact.

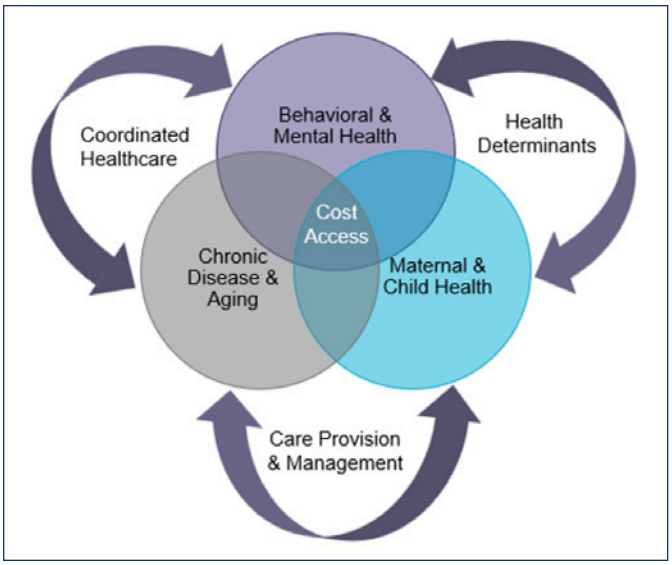
KEYWORDS: Clinical/translational research; research infrastructure; workforce development; community-engaged research; research funding

BACKGROUND

Advance Rhode Island Clinical and Translational Research (Advance RI-CTR) is in its 10th year of funding through the National Institute of General Medical Sciences (NIGMS) IDeA Program (U54GM115677). It has provided the resources, funding, and infrastructure to fuel a decade of discovery for clinical and translational research in Rhode Island. Advance RI-CTR is based at Brown University and is a consortium of research institutions in partnership with Brown University and the Warren Alpert Medical School, including Brown University Health (Brown Health), Care New England (CNE), the Providence VA Medical Center (PVAMC), and the University of Rhode Island (URI). Led by **JAMES PADBURY, MD**, and **EDWARD HAWROT, PhD**, initially, Advance RI-CTR was one of the first successful statewide partnerships of Rhode Island universities and health care institutions. The mission of Advance RI-CTR is to support Rhode Island investigators through funding, research resources and services, and professional development offerings, with the goal of fueling discoveries and collaborations that are responsive to the health priorities of the state's communities. Advance RI-CTR has submitted a renewal application that is currently under review at the National Institutes of Health (NIH) which would provide, if funded, another five years of support to expand our network of impact and increase services and opportunities for Rhode Island's clinical and translational research workforce.

Advance RI-CTR strategically prioritizes research projects that address Rhode Island's most pressing health needs. Identification of these priorities was informed by multiple inputs, including guidance from the Advance RI-CTR's Community Advisory and Action Board (a group convened to represent community perspectives across the state), along with Affordable Care Act-mandated Community Health Needs Assessments conducted by Advance RI-CTR's partner hospitals, and the Rhode Island Department of Health's strategic framework for reducing health disparities and achieving health equity.[1-8] Priority areas are also informed by the quality indicators reported in the Commonwealth Fund's Scorecard on State Health System Performance and the National Healthcare Quality and Disparities Reports from the Agency for Healthcare Research and Quality. Three distinct priority areas emerged: Chronic Disease & Aging (including cancer), Behavioral & Mental Health, and Maternal & Child Health.[9] Interdomain themes include addressing health determinants, healthcare coordination, and healthcare provision and management [**Figure 1**]. Important crosscutting areas not explicitly noted in the figure include disability and functional status, healthcare quality, infectious disease, palliative and end-of-life care, and substance use disorder. The services, resources, funding and professional development opportunities provided by Advance RI-CTR serve investigators to advance research that will directly improve health outcomes in these identified priority areas.

Figure 1. Advance RI-CTR Health Priority Areas



ORGANIZATIONAL STRUCTURE

Advance RI-CTR comprises five Cores responsible for the provision of services, training, seminars, consultations and funding awards, in addition to a centralized Administrative Core (AC). Each Core is led by distinguished faculty from each of Advance RI-CTR's partner institutions and staffed by a core manager reporting to the AC.

Community, Engagement and Outreach (CEO) Core

The CEO Core, led by **ALISON TOVAR, PhD**, and **JACLYN HUGHTO, PhD**, (Brown University School of Public Health); **JOSEPH DIAZ, MD**, (Care New England), and **MARGARET SALINGER, MD**, (Brown University Health), prepares investigators to launch research in community-based settings and implement best practices for community engaged research. The CEO Core offers expert faculty consultations and virtual and in-person training opportunities. In the past two years, the CEO Core has launched an innovative new offering for researchers: "Community Engaged Studios" (Studios). These Studios facilitate respectful conversation between a panel of community experts (e.g., people from the population that a researcher aims to serve or other stakeholders) and a research team planning, implementing, and/or disseminating information about a planned or in-progress study. The overall goal of the Studios is to facilitate the collaborative engagement of community experts and researchers to gather information that is meaningful to all stakeholders. Since its inception in 2024, the CEO Core has organized 10 Studios, and formal evaluative findings have shown a high degree of satisfaction and impact for both the researcher and for community participants [**Table 1**].

In addition to the Studio offerings, the CEO Core has established and provides administrative support for a Practice-Based Research Network (PBRN). The PBRN is a collaborative network of practicing clinicians who strive to formulate and answer clinical and organizational questions relevant to their practices and the communities they serve. By participation in the PBRN, practice organizations and providers can access resources from Advance RI-CTR, including vetted research proposals. These proposals align with the practices' and providers' goals and priorities, such as improving healthcare quality, fostering innovation, and achieving significant breakthroughs for patients, providers, and communities. Individual providers and practices have the flexibility to choose whether to participate in the proposed projects that have been proposed by external researchers or internally developed by the practices and/or providers. Currently, the PBRN includes 104 private, hospital-affiliated, or Federally Qualified Health Center practices. These practices represent over 400 providers and 300,000 patients, and eight studies are underway in this network [**Table 2**]. Moving forward, we aim to increase the number of research studies in the primary care practices of the PBRN.

Table 1. Community Engaged Studios

Investigator	Studio Title
Joanne Wilkinson	Patient Engagement for Diabetes Management in Latinx Communities
Gisela Jimenez-Colon	Transgenerational Trauma in Latinx Families: Impact on Parenting, Child Suicidality, and Access to Mental Health Services
Julia Shinnick	Intravesical Gentamicin to Prevent Recurrent UTIs
Ana Abrantes	Exercise as a Treatment for Depression
Liqi Shu	Efficacy of Portable EEG Systems in Identifying Large Vessel Occlusion Strokes in the Prehospital Setting
Michelle Wilson	Exploring the Lived Experience of Southeast Asians During the COVID-19 Pandemic
Joanne Wilkinson & Annmarie Moraitis	Transition Off Active Treatment
Alexis Gimovsky	Community Perceptions of a Shared Decision-Making Application for Labor and Delivery
Odinaka Anyanwu	Enhancing Birth Equity
Natalie Fenn	Novel Civic Engagement Intervention to Improve Mental Health Outcomes Among LGBTQ+ Adults

Biostatistics, Epidemiology and Research Design (BERD) Core

The Biostatistics, Epidemiology and Research Design (BERD) Core is led by **CHRISTOPHER SCHMID, PhD**; **MELISSA CLARK, PhD**, and **SHIRA DUNSIGER, PhD**, (Brown SPH), and **ROCHELLE ROSEN, PhD**, (Brown Health). This Core is responsible for providing easily accessible, multidisciplinary collaborative support for quantitative and qualitative research design, analysis, interpretation, and dissemination

Table 2. Practice-Based Research Network (PBRN) Studies

Investigator	Study Title	Clinic Name
Joanne Wilkinson	Patient Engagement in Diabetes Management in Urban Latinx Communities	CNEMG
Joseph Diaz & Charles Eaton	Association between Social Drivers and Cancer Screening Uptake	CNEMG & RICPCP
Linda E. Guzman & Hannah E. Frank	Enhancing Depression Screening for Spanish-Speaking Adults in Primary Care Settings: An Implementation Science Approach	IM – letter of intent with Clinica Esperanza
Charles B. Eaton	Diabetes Health Equity Data Pilot	Brown Physicians Incorporated, CNEMG, RIPCPC, PCHC
Louisa Thompson	Accelerating Digital Cognitive Screening for Alzheimer's Disease in the Primary Care Setting (Dig-Cog)	CNEMG
Jennifer Freeman	Team-Based Cognitive Behavioral Treatment (CBT) for Pediatric Anxiety in Primary Care	RIPCPC
Jamie Blalock	Contextual and Social Predictors of Perinatal Mental Health	Proposal in a RIPCPC
Joseph Diaz & Stacey Ranucci	CKD Screening and Monitoring	CNEMG

that can work seamlessly with and within existing health research structures. Expert faculty facilitate trainings in study design, epidemiology, biostatistics and qualitative and mixed methods to clinical and translational researchers and research staff, delivered in a variety of formats, both synchronous and asynchronous (both in-person and remote), using the latest educational methods and technologies. During the past five years, the BERD Core has completed over 900 consultations, contributing to over 80 reported research products (e.g., publications, presentations).

Biomedical Informatics, Bioinformatics, and Cyberinfrastructure Enhancement (BIBCE) Core

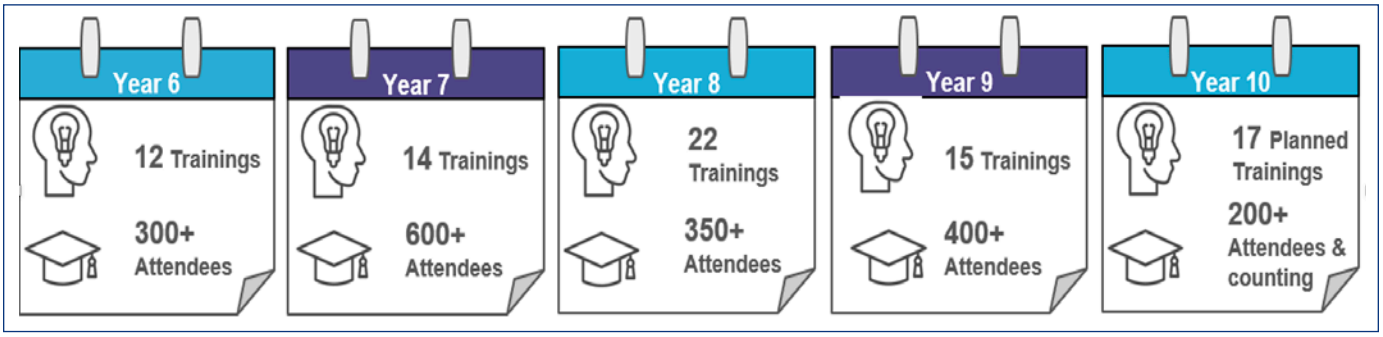
The Biomedical Informatics, Bioinformatics, and Cyberinfrastructure Enhancement (BIBCE) Core is led by **NEIL SARKAR, PhD**; **ELIZABETH CHEN, PhD**, and **RUBEN MARTINEZ, PhD**, of Brown University Division of Biology and Medicine (Brown BioMed). The BIBCE core is focused on the creation and maintenance of a sustainable and extensible informatics infrastructure to support: (1) expanded data sharing & analysis; (2) statewide cohort discovery; and (3) a more integrated and efficient approach to data collection and management. The BIBCE Core develops innovative data, software, and technology solutions in collaboration with clinical and translational researchers and provides state-of-the-art informatics training and engagement with clinical and translational research stakeholders. The BIBCE Core has operationalized a best-of-breed infrastructure, including Fast Healthcare Interoperability Resources (FHIR) and SMART-on-FHIR Apps, as well as Observational Health Data Sciences and Informatics (OHDSI) standards and tools (e.g., Observational Medical Outcomes Partnership (OMOP) Common Data Model) to maximize use of real-world electronic health records (EHR) data across institutions. The utilization and education in artificial intelligence (AI) approaches through enhanced literacy programs focused on responsible AI practices (including algorithmic bias assessment, model interpretability standards, and transparent reporting frameworks) has strengthened data governance protocols to enable secure, ethical sharing of EHR data across partner institutions while maintaining compliance with privacy regulations and institutional policies, all of which will help catalyze multi-institutional collaborative research across this rapidly evolving field.

The BIBCE Core also offers services in Implementation Science in collaboration with the Brown Research on Implementation and Dissemination to Guide Evidence Use (BRIDGE) Program. Implementation science aims to maximize the public health impact of interventions and reduce the research to practice gap by encouraging implementers and program creators to examine barriers and facilitators to a practice being used, pick strategies to work with facilitators and overcome barriers, and plan for sustainable implementation. The BIBCE Core provides consultations and trainings, including an annual Implementation Science (IS) Retreat focusing on the research-practice gap for physician scientists. The IS retreat featured a keynote speaker, panel discussion, four didactic breakout sessions, and a networking lunch. These events foster interinstitutional collaboration and a team science culture among the clinical and translational workforce.

Professional Development (PD) Core

The Professional Development (PD) Core, led by **METHODIUS TUULI, MD**, (CNE), and **AUDRA VAN WART, PhD**, (Brown BioMed), has provided funding mechanisms, cohort-based training, and programming to connect faculty, mentors, and teams across our network institutions. Key accomplishments during the last 10 years include 10 two-year Mentored Research Awards (MRAs), which led to 34 federal and non-federal research grant awards and six grant resubmission awards, resulting in five funded federal and non-federal awards. The PD Core also offers the year-long Advance-K scholar program to assist junior faculty in preparation of NIH K and VA Career Development Award applications. The Advance-K program has graduated 37 faculty

Figure 2. Phase II Trainings and Reach



scholars, 65% of whom submitted research, career-development grant applications (of which 46% were funded and 11% are currently in review) and >50 other research awards. Satisfaction with this program has been high, raising confidence among participants. The PD Core also offers a four-month Advance-R program for investigators planning to submit their first R type research awards. Advance-R has supported 11 scholars who submitted seven research grant applications (two funded to date). The PD Core provides research mentor training based on a nationally recognized program developed by the University of Wisconsin. About 300 Brown and URI faculty have completed this research mentor training and 40 also completed advanced training modules. Finally, the PD Core has provided a rich program of educational offerings, including a monthly CTR seminar series, good clinical practice training workshops, and entrepreneurship training [**Figure 2**].

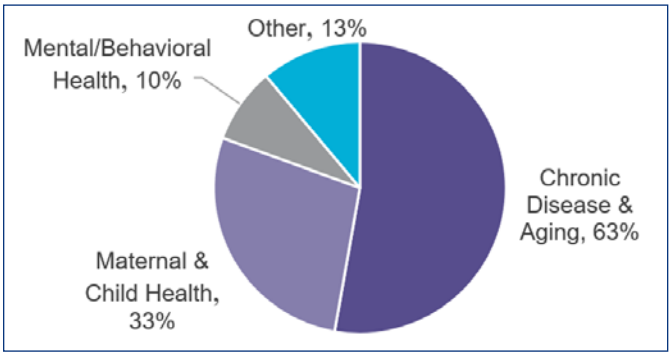
Pilot Projects Program (PPP) Core

The Pilot Projects Program (PPP) Core, led by **GAURAV CHOUDHARY, MD**, (PVAMC) and **TRACIE SHEA, PhD**, (Brown BioMed) has provided funding for junior investigators to perform clinical and translational research that addresses the major health needs of Rhode Island. These grants support the development of preliminary data required for extramural research funding. The need for this type of support was evident from a survey of Brown and URI investigators performed at the time of initial funding of Advance RI-CTR.[10] The PPP has fostered inter-institutional and interdisciplinary collaboration, mentoring by an established investigator, and support for project administration and professional development. Advance RI-CTR has awarded a total of 99 awards, approximately $10.5 million, in the last decade, bringing in over $132 million in subsequent research funding to Rhode Island.

The Advance RI-CTR Pilot Projects Program has supported a diverse portfolio of studies aligned with the state's top health priority areas. **Figure 3** presents funded pilot projects during Phase II of the CTR award (2021–2026) categorized by broad health priority areas. Although the Pilot Projects Core emphasizes research that addresses statewide health priorities, pilot awards are also made for scientifically meritorious research with high potential for impact outside these areas (grouped as "Other" in **Figure 3**).

Beyond supporting investigator development and generating preliminary data for larger interventional studies, these pilot projects have contributed to improved health and healthcare in Rhode Island. Their impact spans numerous domains, including the identification of novel biomarkers and screening modalities, advancements in neonatal and maternal care, cancer and chronic disease management, and improvements in mental health and population health. Collectively, research funded by Advance RI-CTR has served as a substantial catalyst for addressing the state's priority health needs, serving a role that has become even more important given the recent delays and decline in federal NIH support for early-stage research.

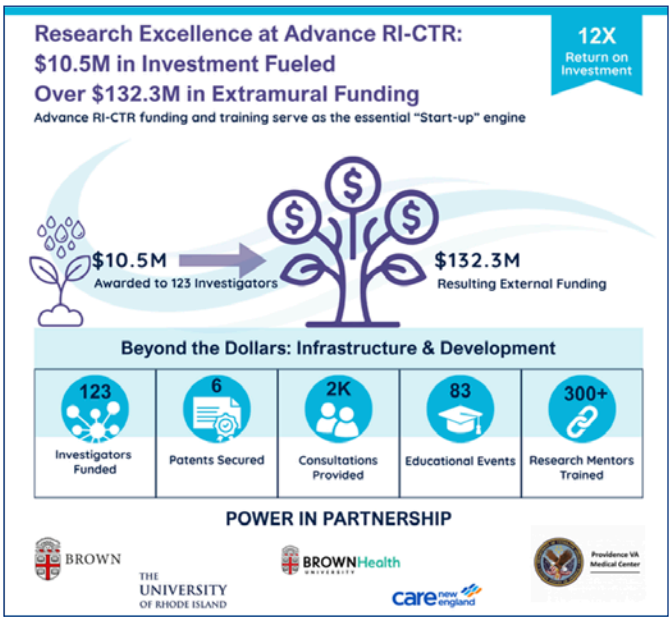
Figure 3. Advance RI-CTR Pilot Projects 2021–2026



RETURN ON INVESTMENT

Advance RI-CTR exemplifies the benefits of investing in clinical and translational research infrastructure and workforce development. One way of assessing this is by the monetary Return on Investment (ROI). In Phase I Advance RI-CTR was funded for five years in the amount of $19,513,469, and in Phase II for a total of $20,799,099, including supplemental research awards. Through this investment in the creation and expansion of Advance RI-CTR, over $10.5 million was awarded to RI investigators in start-up research funds, who

Figure 4. Advance RI-CTR Return on Investment



went on to generate $132,345,181 in extramural funding through government and private foundations. For every one dollar put into Advance RI-CTR, $12.00 has been generated as the return on investment, as shown in **Figure 4**.

Other important considerations with respect to Returns on Investment of research funding and infrastructure programs are the career development and self-efficacy of participating young scientists. The professional growth of researchers supported by Advance RI-CTR is periodically assessed through surveys and interviews, and is evaluated in terms of research outputs, such as subsequent grant funding, peer-reviewed publications, presentations at professional conferences, and patents awarded. Illustrative qualitative feedback from awardees includes comments such as:

> *"Seed funding really helped protect my time from having more clinical and administrative duties until I secured additional funding," and "I don't think I could have received IRB approval without their [Advance RI-CTR] help]".*[11]

The remaining articles in this edition of the *Rhode Island Medical Journal* further demonstrate these ROIs. The contributing authors were selected based on their success in using the data and experience obtained from Advance RI-CTR awards and services in obtaining extramural support for their subsequent research. It is noteworthy that the subjects of the research range from cell and small animal studies of osteoarthritis (**CHATHURAKA T. JAYASURIYA, PhD**), to implementation of best clinical practices (**DARIA SZKWARKO, DO**), to community-engaged research (**TAYLA VON ASH, ScD**, and **LAURA E. KORTHAUER, PhD**), to sophisticated statistical analytic techniques (**ASHLEY BUCHANAN, DrPH**).

The authors include a clinician (Dr. Szkwarko), psychologists (Drs. von Ash and Korthauer), a data scientist (Dr. Buchanan), and a bench scientist (Dr. Jayasuriya**).** They are employed by Brown University (Dr. von Ash), the University of Rhode Island (Dr. Buchanan), Care New England (Dr. Szkwarko), and Brown University Health (Dr. Korthauer). Thus, they illustrate the multi-institutional participation and contributions to Advance RI-CTR. The recipients of support from Advance RI-CTR have made major contributions towards elevating Rhode Island to the top tier of states receiving NIH research support in fiscal year 2024 when measured on a per capita (i.e., state population) basis.[12]

FUTURE DIRECTIONS

In the next phase of Advance RI-CTR, we propose to transition to a "Networked CTR" (CTR-N), as mandated by NIGMS. The purpose of the CTR-N program is to further enhance capacity to perform research on health challenges faced by the populations served by the CTR-N. It is increasingly evident that impactful and generalizable clinical and translational research requires larger populations than may be available in a single center. Furthermore, there is increasing interest in "real-world" data from deidentified electronic health records. Finally, the powerful tools provided by AI will be used to provide new insights and approaches. The Advance RI-CTR program will support statewide or multistate regional networks to expand existing infrastructure for clinical and translational research, and to coordinate clinical research activities across partnering IDeA states. To meet these objectives, Advance RI-CTR will restructure cores, tailor and enhance our consultations and training opportunities, and expand our research network. The leadership team has refined our Vision, Mission and Theme to address these goals. The vision is "To improve health outcomes for all RI communities" with the theme of "Collaborate to Innovate."

There will be several changes to the Core structure in Phase III**.** The BERD and BIBCE Cores will merge to create the Research Design, Compliance, and Data Management (RDCD) Core comprising four sub-cores: Health Informatics, Qualitative Data, Quantitative Data, and Implementation Science. Services and trainings will be expanded in this next phase to offer expert trainings and consultations to help investigators remain in compliance with all government, foundation, and industry regulations and produce high-quality clinical translational research.

The Professional Development Core will expand to include trainings for professional research coordinators to enhance Rhode Island's research workforce. At the present time Advance RI-CTR and Rhode Island Hospital participate in the NIH-funded IDeA State Consortium for a Clinical Research Resource Center (ISCORE-RC) with the goal to serve as a catalyst to increase the number of clinical studies in IDeA states. To achieve this mission, ISCORE-RC

leads a comprehensive training program for clinical research coordinators and a dedicated service core to build capacity for increased clinical study opportunities. In the next phase of funding, Advance RI-CTR will expand this program to other Rhode Island health system partners and to URI.

In the next phase of funding, the Health Research Core (formerly Pilot Projects Program) will significantly expand its award opportunities in both duration and funding amounts. These award types and amounts address current gaps identified in the funding landscape, specifically to: 1) offer protected time for clinician fellows and junior faculty to develop mentored research programs in conjunction with protected time for mentors to have dedicated time for mentoring activities; 2) longer funding periods for developmental projects to support the preparation of extramural applications; 3) support for community-engaged research using the PBRN; 4) support for multi-site collaborative research, with a milestone-driven award process; 5) engagement of community members and the Community Advisory and Action Board (CAAB) of the CEO Core in reviewing applications to maximize community impact, and; 6) use of an evaluation rubric that selects proposals in which merit and impact align with the health priorities of RI communities, the latter in collaboration with the Tracking and Evaluation (T&E) Team.

CONCLUSION

Advance RI-CTR has transformed clinical and translational research in Rhode Island through a wide-reaching network of partner institutions, community organizations, and institutional affiliates. Since initial NIH funding in 2016, Advance RI-CTR has developed innovative approaches to improve and strengthen clinical and translational research across the state. Building on these impactful achievements from Phases I and II, Advance RI-CTR is positioned to address newly identified barriers and launch Advance RI-CTR into a streamlined and even more connected CTR-N framework with increased capacity for collaborative and innovative research that effectively addresses current and future health needs within RI and beyond.

References

1. Rhode Island Executive Office of Health and Human Services. Statewide Community Needs Assessment. March 22, 2024. Retrieved from https://eohhs.ri.gov/sites/g/files/xkgbur226/files/2024-05/Statewide%20Community%20Needs%20Assessment_03.22.2024.pdf
2. Brown University Health. Brown University Health Rhode Island Hospital 2025 Community Health Needs Assessment. 2025. Retrieved from https://www.brownhealth.org/sites/default/files/2025-10/Brown-University-Health-Rhode-Island-Hospital-2025-CHNA-Final.pdf
3. Rhode Island Department of Behavioral Healthcare, Developmental Disabilities & Hospitals. Eleanor Slater Hospital 2025 Community Health Needs Assessment Final Report. 2025.Retrieved from https://bhddh.ri.gov/sites/g/files/xkgbur411/files/2025-10/Eleanor%20Slater%20Hospital%202025%20CHNA%20Final%20Report.pdf
4. Health Assessment Resource Inventory. HARI 2022 Community Health Needs Assessment Final Report. 2022. Retrieved from https://stdidhariprod.blob.core.windows.net/hari/documents/HARI-2022-CHNA-Final-Report.pdf
5. Care New England. Butler Hospital 2025 community health needs assessment final report. 2025. https://www.carenewengland.org/hubfs/-%20CNE/CNE%20Butler%20Hospital%202025%20CHNA%20Final%20Report.pdf
6. Care New England. Kent Hospital 2025 community health needs assessment final report. 2025. https://www.carenewengland.org/hubfs/-%20CNE/CNE%20Kent%20Hospital%202025%20CHNA%20Final%20Report.pdf
7. Care New England. Women & Infants Hospital 2025 Community Health Needs Assessment final report. 2025. https://www.carenewengland.org/hubfs/-%20CNE/CNE%20Women%20and%20Infants%20Hospital%202025%20CHNA%20Final%20Report.pdf
8. Rhode Island Department of Health. RIDOH Strategic Framework. 2025, January 14. https://health.ri.gov/about-us/ridoh-strategic-framework
9. Radley DC, Kolb K, Collins SR. 2025 Scorecard on State Health System Performance. The Commonwealth Fund. 2025, June 18. https://www.commonwealthfund.org/publications/scorecard/2025/jun/2025-scorecard-state-health-system-performance
10. Willey C, Fede J, Stevenson J, Hayward A, Kogut S, Fournier H, Padbury J. Clinical and Translational Research in Rhode Island: Results of a Needs Assessment Survey. R I Med J. 2018 Feb 2;101(1):21-25. PMID: 29393306; PMCID: PMC6053046.
11. Kimberly JA, Kogut S, Stevenson JF, Fede J, Hayward AR, Tenca ME. Researcher Views of Barriers to Clinical and Translational Research in a Statewide Program. Eval Health Prof. 2023 Dec;46(4):344-352. doi: 10.1177/01632787231167942. Epub 2023 Apr 8. PMID: 37029918; PMCID: PMC10560312
12. Axios. 2025. "Which States Get the Most Federal Health and Science Funding." Axios. January 29, 2025. https://www.axios.com/2025/01/29/federal-health-science-funding-states-map

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Disclosures

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Use of AI-assisted tools: Portions of this manuscript were edited and revised for clarity and style using AI-assisted writing tools, including ChatGPT (OpenAI; GPT-5.2). These tools were used solely for language editing and did not contribute to the substantive intellectual content. The authors take full responsibility for the content of the manuscript.

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Augmentation of Meniscus Surgery with Cartilage Progenitor Cell Treatment May Stimulate Healing and Improve Repair Efficacy

CHATHURAKA T. JAYASURIYA, PhD

ABSTRACT

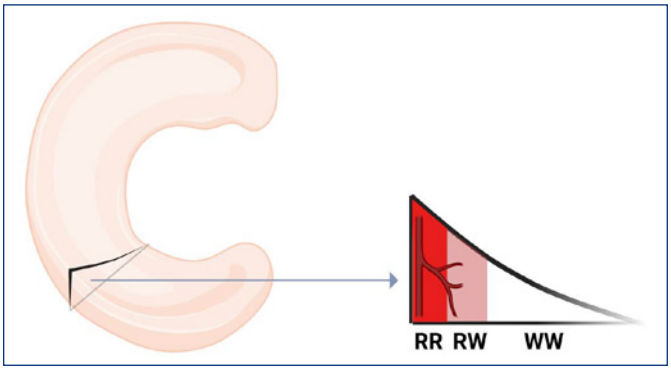
Meniscal tearing is one of the most common knee injuries. Meniscus tears seldom heal, making partial meniscectomy the primary surgical option for patients seeking quick relief. Unfortunately, removal of meniscal tissue impedes loadbearing in the knee, which can lead to accelerated post-traumatic osteoarthritis. It is hypothesized that implementing stem/progenitor cells in the treatment of orthopedic soft-tissue injuries may improve the rate of healing. This article discusses the progress made by our research group in the Department of Orthopedics at Brown University Health, with funding and logistical support from Advance RI-CTR, to develop a novel cell-based strategy for stimulating meniscal fibrocartilage healing. We detail the clinical need that fueled (and continues to fuel) our research efforts, our justification for cell selection, and our published studies that have tested the efficacy of this approach using both *in vitro* and *in vivo* models of meniscal injury.

KEYWORDS: meniscus; cartilage; osteoarthritis; stem cells

BACKGROUND

Tearing of the meniscus is one of the most common knee injuries seen by orthopedic surgeons today. It is also an injury that doesn't have an ideal clinical solution for long-term relief. The lateral and medial menisci are crescent-shaped fibrocartilage soft tissues that sit inside the knee joint, with the primary function being load absorption and displacement, which fundamentally protects the more rigid articular cartilage from being damaged during physical activity.[1,2] Meniscal tearing leads to about one million surgeries annually in the U.S. alone.[3] A 2025 study by Bergstein et al found that 94% of 2,053,884 million meniscus surgeries were meniscectomies—a procedure where entire portions of the torn meniscus is excised and removed to resolve chronic inflammation in an effort to stop further damage to the joint.[4] Unfortunately, even partial removal of meniscal tissue results in increased load placement on articular cartilage, thereby making it more vulnerable to injury and increasing the risk of post-traumatic osteoarthritis (PTOA).[5,6]

Figure 1. Illustrated diagram of the different zones of the knee meniscus. The cross-sectional diagram shows three different regions that constitute the meniscus, from left to right. The red-red (RR) zone is the thickest and most vascular region. The red-white (RW) zone has limited vascularity. The thinnest and most avascular region is the white-white (WW) zone, which does not heal on its own.



The loadbearing inner two-thirds of the meniscus consist of fibrochondrocytes that are well-dispersed and entrenched within a dense, collagen-rich extracellular matrix with little to no vasculature [**Figure 1**].[7] Meniscal tears in this region seldom heal, helping to explain why meniscectomy is the predominant intervention today. Finding ways to support meniscus healing stands to revolutionize the clinical landscape with respect to how meniscal tears are treated. For the past eight years, our group has been developing and optimizing a cell-based intervention to help stimulate meniscus healing following arthroscopic meniscal repair. Our central strategy is to repurpose mesenchymal progenitor cells originating from articular cartilage, which have a natural propensity for producing proteoglycans and type 2 collagen, to support matrix anabolism and reintegrative healing of the tear channel.

In 2017, we received pilot research support from the (then) newly formed and National Institutes of Health (NIH)-funded program, Rhode Island Clinical and Translational Research (Advance RI-CTR), to investigate whether (and how) cartilage progenitor cells (CPCs) can be used to stimulate meniscal healing. This article will detail the findings of the initial project and summarize the overall progress that our group at Brown University Health has made in translational, cell-based tissue engineering since its completion.

METHODS

CPC isolation and stabilization

Human CPC isolation and culture experiments are described in our original publications.[8,9] Briefly, human cartilage tissue was obtained with approval from the Rhode Island Hospital Institutional Review Board (IRB). Cells were separated from chondrocytes using differential adhesion to fibronectin. Cell lines were generated by introducing Large T-Antigen using pRetro-E2 SV40 infection.[8]

Explant culture meniscal injury model

Explant culture experiments are described in the original publication.[8] Briefly, menisci were collected from three-month-old Lewis rats, with approval from the Rhode Island Hospital Institutional Animal Care and Use Committee (IACUC). A radial tear was created in the anterior horn and treated with CPCs, bone marrow-derived stromal cells (BM-MSCs), or left untreated as a negative control. The menisci were cultured for four weeks. Menisci were imaged at different time points. Menisci were sectioned and stained with trichrome at the four-week mark.

In Vivo meniscal injury model

Studies in live rats are fully detailed in the original work.[9] Briefly, skeletally mature RNU athymic male rats were used in the study, with approval from the Rhode Island Hospital IRB. A 1.0 mm meniscal tear was surgically created using micro scissors, ensuring that the meniscus did not detach into two separate pieces. Cells were administered by intraarticular injection through the patellar tendon at Weeks 1 and 4, post-surgery. Repair efficacy was evaluated by sectioning the menisci, staining with Saf O/Fast green, and measuring the mean area of the open tear channels in each experimental group, seven weeks following treatment. Articular cartilage was also stained with Saf O/Fast green and Modified Mankin scoring was used to evaluate cartilage quality.

Statistical Analysis

Statistical analyses are detailed in our original publications.[8,9] To summarize, analysis was performed using a student's t-test, when comparing only two groups. When comparing more than two groups, a one-way analysis of variance (ANOVA) was used, followed by post-hoc analysis. For live rodent experiments, when examining the effects of the treatments on meniscus defects and Mankin scores, generalized linear models were used, as detailed in the original published work. P-values smaller or equal to 0.05 were considered statistically significant. Sample sizes were always greater than or equal to 3 and error bars represent ±1 standard deviation of the mean.

RESULTS

Progenitor cells native to articular cartilage exhibit phenotypic specificity for rebuilding inner meniscus tissue.

The tissue microenvironment of the inner meniscus is remarkably similar to that of articular cartilage. Much like the inner meniscus, articular cartilage has a dense tissue matrix that is rich in type II collagen and proteoglycans. These proteins form networks that contribute to the resilient mechanical properties of both tissues. Specifically, aggrecan is a proteoglycan that is abundant in both tissues and functionally important because it is negatively charged and attracts water molecules. Hyaluronic acid (HA) is another proteoglycan that aids in holding the Aggrecan core proteins together, while the type II collagen network prevents excessive expansion that comes with water retention, which helps to build the compressive tension within the extracellular matrix (ECM) that is the essential functional feature of these loadbearing tissues.

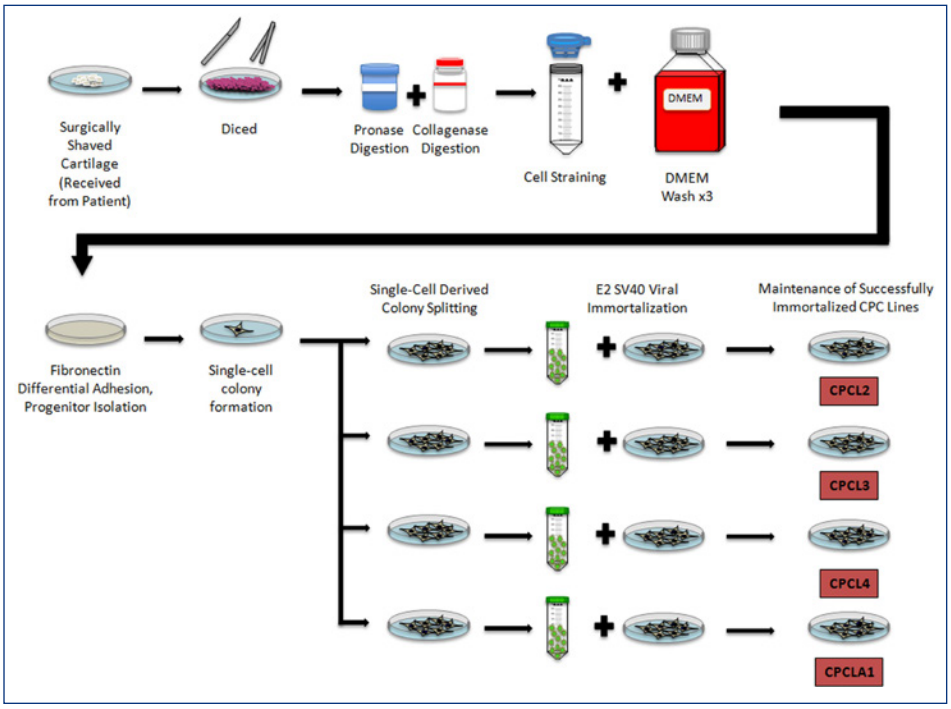
Another similarity is that unlike the elongated spindle-like fibrochondrocytes that are native to the outer third of the meniscus, cells in the inner meniscus are round and resemble chondrocytes—the resident adult cell population in articular cartilage. Hence, in our pursuit to identify a source of cells that are well-suited to help rebuild damaged inner meniscal tissue, we first considered utilizing chondrocytes. However, despite their well-reported capacity for producing an ideal ECM, rich in type II collagen and aggrecan, chondrocytes have several features that make them unideal for our needs. Chondrocytes are fully differentiated adult cells that, while immune-privileged compared to other mature cell populations,[10,11] no longer exhibit the extensive immunosuppressive capabilities characteristic of less committed cells like mesenchymal progenitor/stem cells.[12,13] This feature helps cells to evade a host recipient's immune system so that they can function properly while minimizing the chance of rejection and/or immune reaction. Fortunately, there is a satellite cell population within cartilage that fits this description. Cartilage-derived progenitor cells are a sparce population of mesenchymal progenitors that are native to articular cartilage.[14] They exhibit all the important key features we were looking for, including a high chondrogenic capacity for essential ECM protein synthesis, immunosuppressive capabilities, and high proliferative capacity (for *in vitro* expansion).[15,16]

Human cartilage progenitor cells stimulate mending of meniscal tears in *ex vivo* culture.

In our 2017 pilot study funded by Advance RI-CTR, the primary goal was to find a bioavailable source of CPCs and test their efficacy for stimulating meniscal healing, *ex vivo* and *in vivo*. We isolated these cells from cartilage using fibronectin adhesion. Compared to chondrocytes, CPCs exhibit high expression of CD49e (receptor for fibronectin), which makes enriching these cells relatively easy and cost effective, by

Figure 2. Illustrated diagram of procedure used to establish human cartilage progenitor cell lines. Healthy human cartilage was diced into small pieces and digested using pronase and collagenase. Released cells were washed and strained to remove clumps. Cells were seeded at low density and individual single-cell derived colonies were separated and stabilized using SV-40 mediated delivery of Large-T antigen.

[Figure 2 panels and legend are reprinted from *Jayasuriya et al. 2019. Human Cartilage-Derived Progenitors Resist Terminal Differentiation and Require CXCR4 Activation to Successfully Bridge Meniscus Tissue Tears. Stem Cells 37:102-114.* with permission from publisher.]



taking advantage of their high propensity for binding to fibronectin. Since CPCs are a rare, satellite cell population that make up less than 1% of cells within cartilage, we engineered stable CPC cell lines by introducing Large T Antigen [**Figure 2**].[8] We selected two of these engineered cell lines to validate that their differentiation potential, most importantly their chondrogenicity, was not impeded as a result of immortalization.[8]

Using an *ex vivo* meniscal injury model, we tested our hypothesis that CPC treatment can stimulate meniscal healing.[8] A radial tear was created in the white-white zone of rat menisci and treated with a fluorescently labeled CPC line in explant culture [**Supp. Figure 1**]. The control groups consisted of tears that were either left untreated or treated with fluorescently labeled bone marrow-derived stromal cells (BM-MSCs). Veritably, CPC treated meniscal tear channels exhibited complete filling by 20 days post treatment, whereas BM-MSC-treated menisci did not achieve this end. Histology analysis performed four weeks following CPC treatment demonstrated bridging at the tear channel [**Supp. Figure 2**]. [*Editor's note: Email author for supplementary figures 1,2*].

Human cartilage progenitor cells stimulate meniscal healing and delay onset of post-traumatic osteoarthritis in athymic rats.

Encouraged by these findings, we next tested whether CPC treatment could have the same effect in a live animal model of meniscus repair. We worked closely with Janine Molino, PhD, MS, of the Advance RI-CTR Biostatistics, Epidemiology, and Research Design (BERD) Core to design this study. We used a rat medial meniscus tear model to evaluate CPC-stimulated meniscus healing [**Figure 3**] in comparison to treatment with BM-MSCs [**Figure 4**] or treatment with saline/vehicle as a negative control [**Figure 5**]. A 1.5 mm longitudinal tear spanning the full thickness of the meniscus was created on the medial meniscus of 15-week-old skeletally mature rats. Fluorescently labeled human CPCs (1.6 million cells) were administered via intra-articular injection twice (at day 7 and at day 28 post-meniscal injury). There were two control groups: BM-MSC injected animals and vehicle (PBS) only injected animals. Rats were sacrificed and their medial menisci were evaluated using fluorescence imaging of the tear site seven weeks post-surgery. Localization and engraftment of injected cells (labeled fluorescent red) to the tear site was confirmed on tissue sections. Analyses showed that CPC-treated animals exhibited increased tear filling compared to the group treated with BM-MSCs [**Figure 6**].[9] These experiments suggested that CPC-treatment stimulates fibrocartilage healing in an animal model.

We also analyzed the articular surface of the medial knee compartment as a secondary outcome measure of success.[9] Animals treated with CPCs exhibited less cartilage damage in the medial compartment of the tibial plateau, which sits directly below the injured medial meniscus. The medial femoral condyles and medial tibial plateaus were sectioned and stained with Safranin-O/fast green. Mankin histopathology scores demonstrated that the CPC-treated group exhibited a significant improvement over the vehicle only treated saline control group, whereas the BM-MSC-treated group did not.

Figure 3. CPC-mediated healing of isolated medial meniscus tears in rats 46 days following treatment with CPCs. 3.2 million fluorescently labeled CPCs were injected into the joint capsule following meniscus injury. CPCs from the treatment are fluorescently labeled (red). Nuclei of all cells (both native meniscus cells and injected cells) are labeled with Dapi (blue). Yellow lines and arrows signify areas that remain open without healing, with yellow dotted lines inscribing the unfilled areas. Scale bar = 100μm

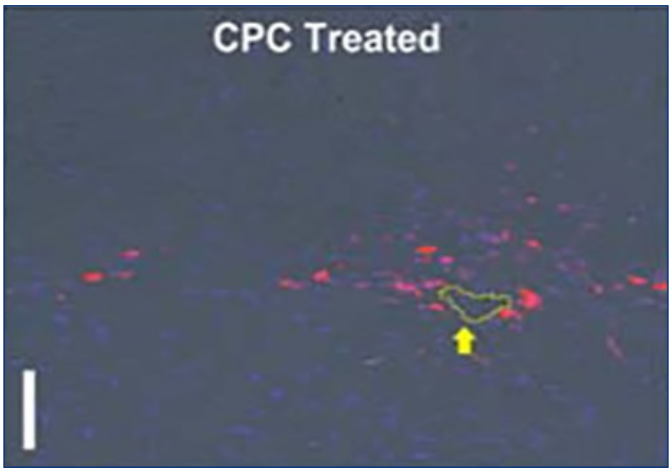


Figure 4. BM-MSC-mediated healing of isolated medial meniscus tears in rats 46 days following treatment with BM-MSCs. 3.2 million fluorescently labeled BM-MSCs were injected into the joint capsule following meniscus injury. This was used as a control group to compare against the CPC-treated group. BM-MSCs from the treatment are fluorescently labeled (red). Nuclei of all cells (both native meniscus cells and injected cells) are labeled with Dapi (blue). Yellow lines and arrows signify areas that remain open without healing, with yellow dotted lines inscribing the unfilled areas.

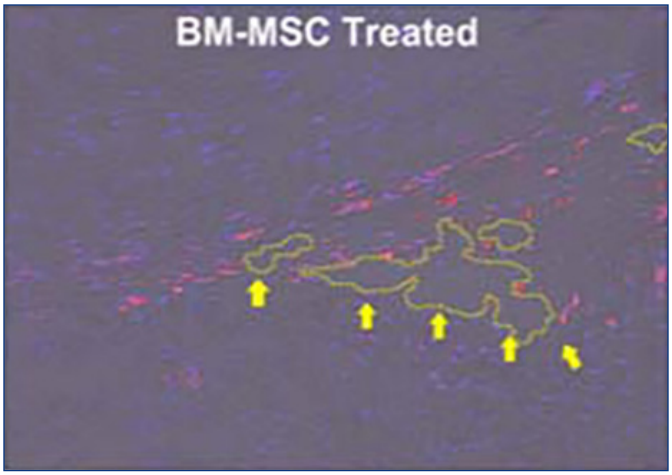


Figure 5. A medial meniscus tear in rats 46 days following treatment with no cells. This group was the negative control group. Nuclei of all native cells meniscus cells are labeled with Dapi (blue). Yellow lines and arrows signify areas that remain open without healing, with yellow dotted lines inscribing the unfilled areas.

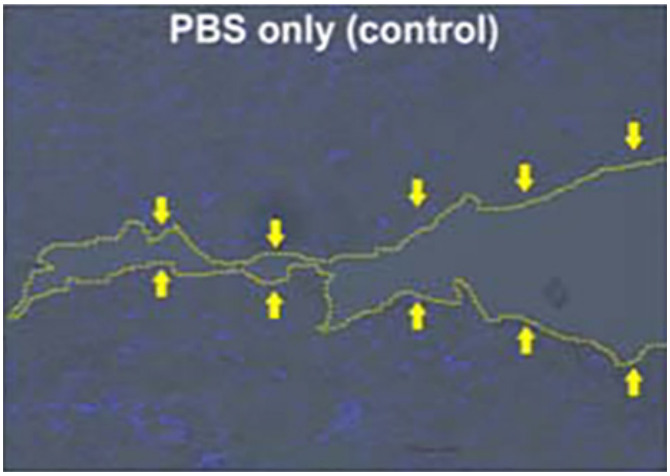
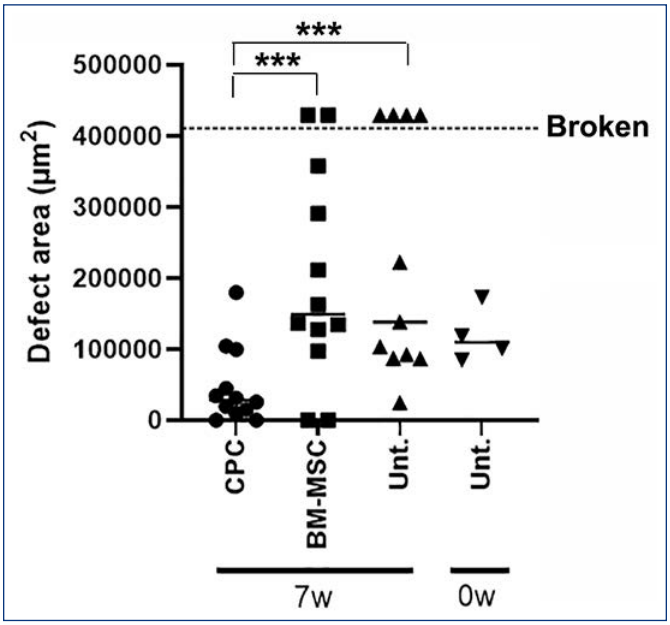


Figure 6. Open areas remaining within the meniscal tear channel was quantified by image analysis and compared across experimental groups. A 0-week control group was used to determine the open area of the meniscal tear before healing, or further tearing due to the *in vivo* environment, can take place. Data points above the dotted line indicates menisci that were broken in two at the time of harvest. N≥8 per group. ***, P≤0.005.

[Figure 5B and corresponding part of the legend are reprinted from *Desai et al. 2022. Stable human cartilage progenitor cell line stimulates healing of meniscal tears and attenuates post-traumatic osteoarthritis. Front Bioeng Biotechnol 10:970235.* with permission from publisher.]



DISCUSSION

Our goal is to develop a novel cell-based treatment to stimulate healing in the meniscus. The studies detailed in this article are the first to demonstrate the efficacy of administering CPCs as a means of accelerating meniscal healing. We have shown that CPCs can maintain a highly chondrogenic phenotype without the need for exogenous growth factors. We have shown that these cells can migrate to areas of fibrocartilage injury and accelerate the integration of tears, both in *ex vivo* culture and in live animals that have compromised immunity.

Since completing these studies, we have explored ways that CPC might be implemented to treat tears in fully immunocompetent live animals,[17] and to treat human meniscus tissue using an explant injury model.[18] We have also investigated the molecular mechanism(s) that constitute the anabolic and anti-catabolic effects of CPCs that may contribute to their propensity for musculoskeletal tissue repair,[19,20] as well as their potential to be further primed for chondrogenesis using commercially available small molecules.[21] Based on our findings, we expect that augmenting the standard clinical procedure of meniscus suture repair with adjuvant CPC therapy has practical potential for significantly improving repair efficacy in the near future.

References

1. Bilgen B, Jayasuriya CT, Owens BD. Current Concepts in Meniscus Tissue Engineering and Repair. Adv Healthc Mater. 2018;7:e1701407.
2. Twomey-Kozak J, Jayasuriya CT. Meniscus Repair and Regeneration: A Systematic Review from a Basic and Translational Science Perspective. Clin Sports Med. 2020;39:125-163.
3. Irwin RM, Brown M, Koff MF, et al. Generating New Meniscus Therapies via Recent Breakthroughs in Development, Model Systems, and Clinical Diagnostics. J Orthop Res. 2025;43:1073-1089.
4. Bergstein VE, Ahiarakwe U, Haft M, et al. Decreasing Incidence of Partial Meniscectomy and Increasing Incidence of Meniscus Preservation Surgery From 2010 to 2020 in the United States. Arthroscopy. 2025;41:1919-1927:e1911.
5. Andersson-Molina H, Karlsson H, Rockborn P. Arthroscopic partial and total meniscectomy: A long-term follow-up study with matched controls. Arthroscopy. 2002;18:183-189.
6. Trivedi J, Betensky D, Desai S, et al. Post-Traumatic Osteoarthritis Assessment in Emerging and Advanced Pre-Clinical Meniscus Repair Strategies: A Review. Front Bioeng Biotechnol. 2021;9:787330.
7. Trivedi J, Jayasuriya CT. 2022. Meniscus tissue engineering and repair. In: Chen Y editor. Musculoskeletal Tissue Engineering: Elsevier. 2022; Chapter 5:107-132.
8. Jayasuriya CT, Twomey-Kozak J, Newberry J, et al. Human Cartilage-Derived Progenitors Resist Terminal Differentiation and Require CXCR4 Activation to Successfully Bridge Meniscus Tissue Tears. Stem Cells. 2019;37:102-114.
9. Desai S, Dooner M, Newberry J, et al. Stable human cartilage progenitor cell line stimulates healing of meniscal tears and attenuates post-traumatic osteoarthritis. Front Bioeng Biotechnol. 2022;10:970235.
10. Garrity C, Arzi B, Haus B, et al. A Fresh Glimpse into Cartilage Immune Privilege. Cartilage. 2022;13:119-132.
11. Adkisson HD, Milliman C, Zhang X, et al. Immune evasion by neocartilage-derived chondrocytes: Implications for biologic repair of joint articular cartilage. Stem Cell Res. 2010;4:57-68.
12. Liu S, Liu F, Zhou Y, et al. Immunosuppressive Property of MSCs Mediated by Cell Surface Receptors. Front Immunol. 2020; 11:1076.
13. Kim J, Tran AN, Lee JY, et al. Human Fetal Cartilage-Derived Progenitor Cells Exhibit Anti-Inflammatory Effect on IL-1beta-Mediated Osteoarthritis Phenotypes In Vitro. Tissue Eng Regen Med. 2022;19:1237-1250.
14. Desai S, Jayasuriya CT. Implementation of Endogenous and Exogenous Mesenchymal Progenitor Cells for Skeletal Tissue Regeneration and Repair. Bioengineering (Basel). 2020 Aug 4;7(3):86. doi: 10.3390/bioengineering7030086. PMID: 32759659; PMCID: PMC7552784.
15. Dowthwaite GP, Bishop JC, Redman SN, et al. The surface of articular cartilage contains a progenitor cell population. J Cell Sci. 2004;117:889-897.
16. Hattori S, Oxford C, Reddi AH. Identification of superficial zone articular chondrocyte stem/progenitor cells. Biochem Biophys Res Commun. 2007;358:99-103.
17. Trivedi J, Desai S, Molino J, et al. Intra-articular Injections of CXCR4-Overexpressing Human Cartilage-Derived Progenitor Cells Improve Meniscus Healing and Protect Against Posttraumatic Osteoarthritis in Immunocompetent Rabbits. Am J Sports Med. 2025;53:396-405.
18. Newberry J, Desai S, Adler C, et al. SDF-1 preconditioned HPC scaffolds mobilize cartilage-derived progenitors and stimulate meniscal fibrocartilage repair in human explant tissue culture. Connect Tissue Res. 2020;61:338-348.
19. Twomey-Kozak J, Desai S, Liu W, et al. Distal-Less Homeobox 5 Is a Therapeutic Target for Attenuating Hypertrophy and Apoptosis of Mesenchymal Progenitor Cells. Int J Mol Sci. 2020;21.
20. Betensky DJ, Chen MD, Trivedi J, et al. Extracellular vesicles from cartilage progenitors stimulate type II collagen expression and wound healing in meniscal cells. J Orthop Res. 2024; Nov 7;43(3):682–691. doi: 10.1002/jor.26013
21. Yang DS, Trivedi J, Betensky D, et al. Kartogenin Induces Chondrogenesis in Cartilage Progenitor Cells and Attenuates Cell Hypertrophy in Marrow-Derived Stromal Cells. Curr Stem Cell Res Ther. 2025;20:577-583.

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Disclosures

Dr. Jayasuriya is a co-founder of EnkaBio Inc. and holds equity in the company.

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An Open Pilot Trial of a Physical Activity (PA) Intervention Designed to Address Barriers Experienced by Hispanic and Black Mothers

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ABSTRACT

INTRODUCTION: Mothers, especially those with marginalized identities, often struggle to meet physical activity (PA) guidelines. We examined feasibility, acceptability, and preliminary efficacy of Moms on the Move (MOMs), a community-based PA promotion intervention targeting Hispanic and Black mothers delivered in partnership with a youth sports organization in Providence, RI.

METHODS: Feasibility targets centered around enrollment (i.e., n≥30 participants), retention (i.e., ≥80% of participants through follow-up), and assessment (i.e., collection of PA data from ≥80% of participants at multiple timepoints), while acceptability targets centered around participant satisfaction (i.e., ≥80% of participants being satisfied with the intervention). For preliminary efficacy, we assessed weekly minutes of moderate-to- vigorous intensity PA (MVPA) via 7-Day PA Recall (PAR) at baseline, intervention end (8 weeks), and follow-up (12 weeks), and examined within-person changes in MVPA over time using paired T-tests. Stratified analysis was used to examine differences between participants who were already meeting the national guideline of ≥150 minutes of MVPA per week at baseline and those who were not.

RESULTS: We met recruitment (n=35) and retention (94%) targets but only collected PA data at multiple timepoints from 21 participants (64%). Most participants (94%) were satisfied with the intervention, all (100%) said they learned from the program, and all (100%) said they would recommend participation to a friend. Participants who were not meeting the MVPA guideline at baseline (n=12) reported an increase in MVPA at both intervention end (mean change: 110.27 minutes, Cohen's d: 0.89) and follow-up (mean change: 82.09 minutes, Cohen's d: 0.76).

CONCLUSIONS: Findings around recruitment, retention, and participant satisfaction were promising, though assessing MVPA via the PAR, which requires a semi-structured interview, proved challenging. Nonetheless, the findings, which also showed that insufficiently active mothers had significantly higher levels of MVPA at intervention end and follow-up, support testing MOMs in a fully powered, randomized controlled trial.

KEYWORDS: physical activity; youth sports; mothers; community-based; pilot

INTRODUCTION

It is unquestionable that mothers face unique health concerns. They experience health issues, including those specific to pregnancy and childbirth, even long after giving birth (e.g., dyspareunia and chronic postpartum pain[1]). In addition, mothers experience generalized health concerns that are contextualized by their social role. Mothers care for the needs of their families before caring for themselves.[2] By recognizing the complex nature of mothers' health within the context of their social role and environment, we can better understand how to implement interventions to improve health outcomes for mothers.

Physical activity (PA) is a modifiable lifestyle behavior that has numerous health benefits, including reducing the risk of obesity[3] and chronic disease.[4] In fact, meeting the national PA guidelines, which include ≥150 minutes of MVPA per week,[5] is associated with a 29% reduced risk of all-cause mortality.[6] However, mothers are less likely to engage in sufficient moderate-to-vigorous intensity PA (MVPA) to experience benefits compared to the general population,[5] and trends indicate PA among mothers is decreasing.[8,9] In response, research has focused on both understanding barriers and facilitators of PA among mothers, and developing interventions tailored to addressing these needs. Barriers to PA for mothers include lack of social support, lack of childcare, lack of time due to competing responsibilities, prioritization of children's needs, and guilt associated with exercise as an activity that takes away time from family obligations.[10-13] Successful PA interventions developed for mothers have focused on increasing social support (Juwono et al, 2020) by implementing group-based interventions.[14-16]

While such interventions hold promise for improving mother's PA, previous studies have had low representation of mothers from underserved and marginalized social groups. Increasing PA among mothers with multiple marginalized identities may benefit from an intersectional approach,[17] which acknowledges that individuals hold multiple social identities, embedded within interlocking systems of oppression and privilege, allowing for nuanced understanding of PA experiences and resources. Notably, Hispanic and Black women, and those with low socioeconomic status (SES) report especially low levels of PA,[18-21] contributing to increased risk for poor health outcomes.[22,23] In addition to PA barriers experienced by mothers generally, those with

marginalized identities often lack access to PA opportunities.[7,24,25] As PA interventions for marginalized populations tend to focus on women, without the specific tailoring to mothers, there is a significant need to address barriers experienced by low SES and/or Hispanic and Black mothers.

To date, few PA interventions have focused on addressing the needs of mothers with marginalized identities. In a systematic review of mothers' PA and related interventions,[7] merely three studies included samples with at least a fourth of the participants identifying as Hispanic and/or Black,[26-28] and only one of these included a focus on low-income mothers.[27] While all interventions included similar components (e.g., in person group PA sessions), only three of the interventions successfully increased PA among mothers.[27-29] Among these, just one study assessed PA maintenance post-intervention, reporting that PA increases were not maintained.[29] Notably, none of the studies used an intersectionality framework to address the multiple and intersecting identities of the mothers. Together, the interventions demonstrate modest and growing evidence in support for PA interventions addressing the unique needs of mothers with multiple marginalized identities.

The current study builds on our team's prior work demonstrating the feasibility and acceptability of partnering with youth sports organizations to deliver group-based PA sessions to mothers.[30] Specifically, we assess the feasibility, acceptability, and preliminary efficacy of the community-based Moms on the Move (MOMs) intervention, which was intentionally developed to address PA barriers experienced by Hispanic and Black mothers with low SES. To our knowledge, this is the first PA intervention for mothers that was designed using an intersectionality approach.[17] Our primary aim was to examine whether *a priori* targets for enrollment, retention, assessment completion, and participant satisfaction were met. We also examined changes in MVPA from baseline to intervention end, and one-month post-intervention to assess preliminary efficacy. In doing so, this study adds to a very limited literature of studies examining maintenance of PA intervention effects among mothers. It was funded by Advance Rhode Island Clinical and Translational Research (Advance RI-CTR), which is supported by Institutional Development Award Number U54GM115677 from the National Institute of General Medical Sciences of the National Institutes of Health. Advance RI-CTR also provided support through targeted consultations to strengthen the study design.

METHODS

Study Design

We conducted an eight-week, single-arm open pilot trial during the fall of 2023 football season to assess the preliminary efficacy of MOMs. We examined changes in self-reported MVPA from baseline to intervention end (at 8 weeks) and a month later (at 12 weeks) to assess maintenance. The intervention was delivered in partnership with a youth football and cheerleading organization in Providence, RI, that predominantly serves Hispanic and Black families. Procedures and materials for the study were approved by the Brown University Institutional Review Board, and the study was registered at www.clinicaltrials.gov (NCT05461742).

Participants

Participants were at least 18 years old, self-identified as female, were the mother or primary caregiver of a child who was on one of the partner organization's football teams or cheerleading squads, had email access, and spoke English. Eligibility was not restricted based on minutes of MVPA at baseline, but for safety reasons, participants were required to pass the Physical Activity Readiness Questionnaire.[31] Research assistants recruited participants by approaching parents and distributing flyers at the field where the organization was practicing. The president of the organization also shared the flyer with parents via social media and an app used to communicate with families. All participants provided written informed consent and received remuneration for completing assessments.

Intervention Description

The MOMs intervention consists of three components: in-person group PA sessions, goal setting with motivational interviewing, and tailored written materials. The theory-driven intervention was designed using the intersectionality framework,[32] social cognitive theory (SCT),[33] and the Transtheoretical Model (TTM).[34] The intersectionality framework[32] was used to ensure that PA barriers faced by Hispanic and Black mothers, due to their intersecting identities, were addressed by the intervention [**Table 1**]. For example, MOMs was administered during children's sports practices to address time and access barriers. By partnering with youth sports organizations whose mission is to promote exercise, and including a group PA component, the intervention also addressed social support barriers. Further, by holding the group PA sessions during practice, where children were supervised and mothers already traveled to and from, the intervention addressed childcare and transportation barriers, and alleviated guilt that mothers report when taking time away from family obligations. With respect to behavioral theory, MOMs targeted SCT and TTM constructs that influenced PA in our prior studies,[35-38] including PA social support, enjoyment, self-efficacy, outcome expectancies, and cognitive and behavioral strategies used to advance through the stages of change.

The previously published in-person component was designed using a staged approach with a community advisory board (CAB) of coaches and parents from the partner organization.[30,39] This ensured that the intervention was culturally relevant, feasible, and acceptable to the organization

Table 1. Intervention strategies to address physical activity barriers experienced by racial and ethnic minority mothers

Identity	Physical Activity Barrier	Strategy
Mother	Lack of time due to other responsibilities	Intervention occurs during children's sports practices; a time mothers have already blocked off
	Guilt from not prioritizing children	Participants can be active while present for their children's extracurriculars
	Lack of social support*	Group PA sessions create a community of mothers who are active together
	Lack of childcare*	Children under coach supervision; childcare available for additional children
Racial/ Ethnic Minority	Lack of culturally relevant interventions	Intervention is adapted for Hispanic & Black women; also offered in Spanish
	Lack of access to PA opportunities*	Intervention is provided free of charge in a safe and accessible space
	Lack of transportation*	Intervention is at a location where participants must already travel to and from

*Especially pronounced among individuals with low SES

and its families. One-hour group PA sessions, facilitated by an experienced personal trainer who was part of the partner organization, were scheduled three times per week during practice. Sessions were offered free of charge and participants could attend as desired. All PA equipment used was provided, including a yoga mat and workout bag with resistance bands, small weights, and a jump rope. Sessions included a five-minute warm-up, 50 minutes of circuit-style aerobic and strength-training activities with modifications to accommodate different fitness levels, and a five-minute cool down. Child supervision was available for participants who had additional children (e.g., five years and under) that were not practicing football or cheerleading.

The goal-setting and written materials' components, evidence-based approaches to teach behavioral skills, were especially included to promote PA maintenance. These components were adapted from prior successful women-targeted PA interventions conducted by our team.[35-37] Participants were invited to complete two, one-on-one goal-setting phone calls (~20 minutes) with a research assistant trained in motivational interviewing.[40] The first call was scheduled at baseline and the second midway through the intervention (four weeks). Participants learned about key behavior change techniques (such as goal-setting and self-monitoring) and established personal PA goals. The second call allowed participants to check their progress, set new goals, and discuss being active once the sessions end. For written materials, participants were emailed materials weekly throughout the intervention period. Materials included tip sheets on PA-related topics (e.g., useful facts about PA, health benefits, stretches) and motivation-matched PA manuals based on their responses to questionnaires at baseline and four weeks. Manuals emphasized behavioral strategies for increasing activity, including goal-setting, self-monitoring, problem-solving barriers, increasing social support, and planning rewards for meeting PA goals. These evidence-based materials have been shown to help Hispanic and Black women increase PA in our prior studies.[36-38, 41-43]

Measures

For feasibility, we examined whether *a priori* set targets for enrollment (i.e., n≥30 participants), retention (i.e., ≥80% of participants through 12 weeks), and assessment (i.e., collection of PA data from ≥80% of participants at multiple timepoints) were achieved. Thresholds were informed by existing literature on intervention pilot studies,[44,45] expected effect size in a fully powered randomized controlled trial given our team's prior studies promoting PA among racial and ethnic minority women,[38,41,46] and contextual factors specific to the study population and setting, including the number of families belonging to the organization.

For acceptability, we examined participants' responses to a consumer satisfaction questionnaire, also used by our team in prior studies.[38,47-49] This was completed at the end of the intervention via an online questionnaire. The intervention would be deemed acceptable if ≥80% of participants were satisfied with it, felt they learned something, and would recommend the program to a friend.

For preliminary efficacy, we assessed whether participants experienced changes in weekly minutes of MVPA. Weekly minutes of MVPA were self-reported using the 7-Day Physical Activity Recall (PAR)[50] at baseline, intervention end (8 weeks), and follow-up (12 weeks). The 7-Day PAR, conducted via a semi-structured interview, has been used across many PA studies and has consistently demonstrated acceptable reliability, internal consistency, and congruent validity with objective PA measures,[51-55] along with sensitivity to changes in MVPA.[56,57] Our team has extensive experience with administering the 7-Day PAR, which requires annual recertification. Participants were given the flexibility of completing 7-Day PARs in-person during practice or via phone. In assessing changes in MVPA during the study period, self-reported occupational PA was excluded.

Participant characteristics (i.e., age, number of children living at home, marital status, employment status, race/ethnicity, educational attainment, annual household income, and self-reported height and weight) were assessed via an online questionnaire at baseline.

Statistical Analysis

We descriptively analyzed feasibility targets, acceptability targets, and participant characteristics. Stratified analysis was used to examine differences in characteristics between participants who were already meeting the national MVPA guideline at baseline (i.e., self-reported ≥150 minutes per week) and those who were not. Fisher's exact tests were used to examine group differences for categorical variables, while T-tests were used to examine group differences for ordinal and continuous variables. To assess preliminary efficacy, we examined within-person changes in weekly minutes of MVPA over time. Specifically, we ran unadjusted paired T-tests to compare baseline MVPA to MVPA at intervention end (8 weeks) and follow-up (12 weeks), first for the full sample and then stratified by baseline MVPA (i.e., meeting the guideline vs. not). Change scores and effect sizes (i.e., Cohen's d) were calculated for significant findings. Analyses were run using StataSE statistical software and an alpha of 0.05 was used for significance.

RESULTS

We recruited 35 participants in less than a month, exceeding the target of ≥30 participants. Only two participants withdrew from the study, resulting in a retention rate of 94%, also exceeding the target of ≥80%. However, while 7-Day

Table 2. Participant characteristics

	Study sample (n=21)	Those already meeting MVPA guideline at baseline with multiple 7-Day PARs (n=9)	Those not meeting MVPA guideline at baseline with multiple 7-Day PARs (n=12)	P-value for group comparison
Age in years	37.18 (5.00)	35.00 (4.95)	39.00 (4.65)	0.201
Missing (n)	10	4	6	
Number of children living in home	1.93 (1.22)	1.50 (0.55)	2.22 (1.48)	0.278
Missing (n)	6	3	3	
Marital status				0.554
Married or living with partner	3 (20%)	1 (14%)	2 (25%)	
Single	12 (80%)	6 (86%)	6 (75%)	
Missing (n)	6	2	4	
Employment status				0.591
Unemployed	6 (38%)	2 (29%)	4 (44%)	
Part-time	4 (25%)	2 (29%)	2 (22%)	
Full-time	6 (38%)	3 (43%)	3 (33%)	
Missing (n)	5	2	3	
Race/ethnicity				1.000
Non-Hispanic White	1 (6%)	0 (0%)	1 (11%)	
Hispanic	6 (38%)	3 (43%)	3 (33%)	
Black	5 (31%)	2 (29%)	3 (33%)	
American Indian/Alaskan Native	1 (6%)	1 (14%)	0 (0%)	
Multiracial	3 (19%)	1 (14%)	2 (22%)	
Missing (n)	5	2	3	
Educational attainment				0.181
<12 years	1 (6%)	0 (0%)	1 (11%)	
High school	4 (25%)	3 (43%)	1 (11%)	
Vocational/technical school	1(6%)	1 (14%)	0 (0%)	
Some college	4 (25%)	2 (29%)	2 (22%)	
College graduate	4 (25%)	1 (14%)	3 (33%)	
Post-graduate studies	2 (13%)	0 (0%)	2 (22%)	
Missing (n)	5	2	3	
Annual household income				0.591
<$30k	6 (38%)	2 (29%)	4 (44%)	
$30k<50k	4 (25%)	2 (29%)	2 (22%)	
≥$50k	6 (38%)	3 (43%)	3 (33%)	
Missing (n)	5	2	3	
Body mass index				0.733
<18.5	0 (0%)	0 (0%)	0 (0%)	
18.5–24.9	0 (0%)	0 (0%)	0 (0%)	
25–29.9	3 (21%)	1 (17%)	2 (25%)	
≥30	11 (79%)	5 (83%)	6 (75%)	
Missing (n)	7	3	4	

P-value is for Fisher's exact test for categorical variables and T-tests for continuous and ordinal variables

PAR data was collected for all participants at baseline, MVPA data was only collected for 21 participants (64%) at multiple timepoints, which did not meet the target of >80% of the sample. Among participants in the analytical sample (n=21), 57% self-reported <150 minutes of weekly MVPA at baseline. On average, participants were 37.2 years old (SD: 5.0) and had 1.9 children (SD: 1.2). While not an inclusion criterion, all participants were classified as either overweight or obese (i.e., had a BMI ≥25); however, self-reported height or weight information was missing for seven participants. The racial/ethnic composition of the sample was 38% Hispanic, 31% non-Hispanic Black, 19% multiracial, 6% American Indian/Alaskan Native, and 6% non-Hispanic White. Most (80%) of the sample were single mothers, with 38% unemployed, 25% working part-time, and 38% working full-time. The sample was diverse with respect to socioeconomic status [**Table 2**]. No significant differences in participant characteristics were found between those meeting the MVPA guideline at baseline and those not.

Sixteen participants completed the consumer satisfaction survey [**Table 3**]. Most participants (94%) were satisfied with the intervention. Specifically, 75% of participants were very satisfied with the intervention and 19% were satisfied; 6% were a little satisfied and 0% were not satisfied. All participants (100%) reported that they learned something about exercising from participating in the program and that they would recommend the program to a friend; thus, acceptability targets were met. All participants also found the PA sessions pleasing (75% very pleasing) and most found them beneficial (56% very beneficial). When asked how motivated they felt to continue to exercise after the program, 75% felt motivated or very motivated.

Participants in the analytical sample reported engaging in an average of 106.5 (SD: 131.0) minutes of MVPA/week at baseline, 136.4 (SD: 120.9) minutes of MVPA at intervention end (8 weeks), and 103.4 (SD: 100.9) minutes of MVPA at follow-up (12 weeks); changes in MVPA over time for the full sample were not statistically significant [**Table 4**]. From stratified analyses, participants who were not meeting the guideline at baseline reported significantly more MVPA at both intervention end (mean change: 110.27 minutes, Cohen's d: 0.89) and follow-up (mean change: 82.09 minutes, Cohen's d: 0.76) compared to baseline. Conversely, participants who were meeting the guideline at baseline reported significantly less MVPA at follow-up compared to baseline (mean change: –116.75 minutes, Cohen's d: –1.26).

Table 3. Participant satisfaction with the intervention

	Study sample (n=16)	Those already meeting MVPA guideline at baseline (n=8)	Those not meeting MVPA guideline at baseline (n=8)	P-value for group comparison
How satisfied were you with the program overall?				0.693
I was not satisfied	0 (0%)	0 (0%)	0 (0%)	
I was a little satisfied	1 (6%)	0 (0%)	1 (13%)	
I was satisfied	3 (19%)	2 (25%)	1 (13%)	
I was very satisfied	12 (75%)	6 (75%)	6 (75%)	
How pleasing did you find the physical activity sessions?				0.278
They were not pleasing at all	0 (0%)	0 (0%)	0 (0%)	
A little pleasing	0 (0%)	0 (0%)	0 (0%)	
They were pleasing	4 (25%)	1 (13%)	3 (38%)	
They were very pleasing	12 (75%)	7 (88%)	5 (63%)	
How beneficial did you find the physical activity sessions?				0.273
Not beneficial at all	1 (6%)	0 (0%)	1 (13%)	
A little beneficial	1 (6%)	1 (13%)	0 (0%)	
They were beneficial	5 (31%)	1 (13%)	4 (50%)	
Very beneficial	9 (56%)	6 (75%)	3 (38%)	
Do you think that you learned something about exercising from participating in this program?				1.000
Yes	16 (100%)	8 (100%)	8 (100%)	
No	0 (0%)	0 (0%)	0 (0%)	
Would you recommend the program to a friend?				1.000
Yes	16 (100%)	8 (100%)	8 (100%)	
No	0 (0%)	0 (0%)	0 (0%)	
How motivated do you feel to continue exercising after the program?				0.646
I do not feel motivated	1 (6%)	0 (0%)	1 (12%)	
I feel a little motivated	3 (19%)	1 (13%)	2 (25%)	
I feel motivated	4 (25%)	3 (38%)	1 (13%)	
I feel very motivated	8 (50%)	4 (50%)	4 (50%)	

n (%); p-value is for Fisher's exact test for categorical variables and T-tests for continuous and ordinal variables

Table 4. Self-reported weekly minutes of MVPA at baseline, 8 weeks, and 12 weeks

	Baseline mean (SD) [95% CI]	8 weeks mean (SD) [95% CI]	P-value for baseline to 8 weeks comparison (n)	12 weeks mean (SD) [95% CI]	P-value for baseline to 12 weeks comparison (n)
Analytical sample	106.48 (131.01) [46.84, 166.11]	136.40 (120.94) [79.80, 193.00]	0.461 (n=20)	103.42 (100.91) [54.78, 152.06]	0.961 (n=19)
Those already meeting MVPA guideline at baseline	219.33 (127.11) [121.63, 317.04]	142.56 (133.52) [38.13, 246.99]	0.111 (n=9)	105.63 (91.24) [29.35, 181.90]	0.010* (n=7)
Those not meeting MVPA guideline at baseline	21.83 (34.89) [-0.34, 44.00]	131.36 (113.84) [54.88, 207.85]	0.014* (n=11)	101.82 (111.79) [26.72, 176.92]	0.031* (n=12)

SD: standard deviation; CI: confidence interval; *: $p < 0.05$

DISCUSSION

Feasibility and acceptability findings around recruitment, retention, and participant satisfaction were very promising. However, missing data for PA at intervention end and follow-up was abundant. Notably, we assessed PA via the 7-Day PAR, which requires a semi-structured interview. Given the relatively short study period (e.g., intervention end and follow-up being only four weeks apart), we limited the completion window for PARs to two weeks at each timepoint; in addition, getting in contact with participants to schedule and conduct PARs within such a limited timeframe was difficult. As such, we strongly recommend that future studies with similar constraints consider alternate measures of PA such as self-reported survey measures and accelerometry.

Preliminary efficacy findings, particularly for mothers who are not meeting PA guidelines, were also promising. These findings and the high participants' satisfaction are likely the result of MOMs being designed specifically to address PA barriers experienced by high-risk mothers. The growing use of the intersectionality framework in PA research is evident from a recent systematic scoping review[58]; however, it is worth noting that 41 of the 45 studies were qualitative, none were interventions, and only one study[59] included motherhood as a relevant identity. Findings from the latter, combined with the present study, underscore the importance of social and community support, and addressing access, affordability, childcare, and mom guilt when designing PA interventions for this population.

Our team previously pilot-tested the in-person component of MOMs and similarly observed increases in MVPA among participants not meeting the MVPA guideline at baseline.[30] However, in the previous six-week pilot, increases were significant midway through the intervention (three weeks), but not at intervention end (six weeks). A notable difference between the two pilots, aside from intervention length (6 weeks vs. 8 weeks), is that while all PA equipment was supplied for the initial pilot, aside from yoga mats (which were gifts to the participants), the equipment stayed on site at the practice field and was later donated to the sports organization. By providing participants with their own PA equipment to keep in the present pilot, we facilitated opportunities for participants to complete workouts outside of the scheduled PA sessions, which may have contributed to the significant increases in MVPA found among those who were insufficiently active at baseline, especially when assessing the maintenance of the intervention effect at 12 weeks, a month after the PA sessions has ended.

Expanding on the initial pilot, this pilot also included goal-setting with motivational interviewing and tailored written materials. Goal-setting and motivational interviewing are widely used strategies in successful PA interventions, supporting both the initiation and maintenance of MVPA over time.[60-62] Written materials offer a low-cost way to easily disseminate important PA-related information, with research demonstrating the positive effect tailored materials specifically can have.[35-38,63] These additional intervention components also likely contributed to the significant increases in MVPA found among those who were insufficiently active at baseline, though future, larger studies could examine the individual and potential synergistic effects of the different MOMs intervention components.

Taken together, findings from this pilot study support testing MOMs in a fully powered randomized controlled trial (RCT), though it is important to note this study has significant limitations. The single-arm open pilot trial design with no control group precludes causal claims. As we cannot attribute the observed changes in MVPA to the intervention, caution is warranted when interpreting the preliminary efficacy findings. Notably, that we observed a decrease in MVPA among sufficiently active participants, makes regression to the mean a possible explanation for the findings. That said, given that the baseline assessment occurred during August and the follow-up assessment occurred during November, the observed decreased in MVPA among sufficiently active participants is also consistent with well-documented PA seasonality effects.[64] A fully powered RCT would address this key limitation. That those who were already meeting the MVPA guideline at baseline did not experience an increase in MVPA is not perceived as a limitation, as sufficiently active individuals are generally excluded from PA promotion interventions. We did not exclude active individuals because

it was important to the CAB that the program was offered to the entire community and did not create an impression that it was only for mothers who were not physically fit. Also, that those who were active at baseline reported significantly less MVPA at follow-up supports their inclusion in future studies. A final limitation of the present study was the use of the 7-Day PAR. Not only did this measure likely contribute to the large amount of missing PA data at intervention end and follow-up, but the PAR is also subject to social desirability and recall bias. Thus, future studies should aim to also include alternate and more objective measures of MVPA (e.g., accelerometry).

Despite limitations, this study contributes to the nascent literature on PA interventions for mothers by demonstrating how an intersectionality approach helps more fully address PA barriers and through assessment of the maintenance of intervention effects.

References

1. Vogel JP, Jung J, Lavin T, Simpson G, Kluwgant D, Abalos E, et al. Neglected medium-term and long-term consequences of labour and childbirth: a systematic analysis of the burden, recommended practices, and a way forward. The Lancet Global Health. 2024;12(2):e317-e30.
2. Gilligan C. In a different voice: Psychological theory and women's development: Harvard university press; 1993.
3. Hruby A, Manson JE, Qi L, Malik VS, Rimm EB, Sun Q, et al. Determinants and consequences of obesity. American journal of public health. 2016;106(9):1656-62.
4. Anderson E, Durstine JL. Physical activity, exercise, and chronic diseases: A brief review. Sports medicine and health science. 2019;1(1):3-10.
5. Piercy KL, Troiano RP, Ballard RM, Carlson SA, Fulton JE, Galuska DA, et al. The Physical Activity Guidelines for Americans. JAMA. 2018;320(19):2020-8.
6. Zhao M, Veeranki SP, Magnussen CG, Xi B. Recommended physical activity and all cause and cause specific mortality in US adults: prospective cohort study. BMJ. 2020;370.
7. Juwono ID, Kun B, Demetrovics Z, Szabo A. Mothers' physical activity in the new millennium: a systematic review of the literature. Baltic Journal of Sport and Health Sciences. 2020;4(119):4-23.
8. Archer E, Lavie CJ, McDonald SM, Thomas DM, Hébert JR, Ross SET, et al., editors. Maternal inactivity: 45-year trends in mothers' use of time. Mayo Clinic Proceedings; 2013: Elsevier.
9. Bellows-Riecken KH, Rhodes RE. A birth of inactivity? A review of physical activity and parenthood. Preventive medicine. 2008;46(2):99-110.
10. McGannon KR, Schinke RJ. "My first choice is to work out at work; then I don't feel bad about my kids": a discursive psychological analysis of motherhood and physical activity participation. Psychology of sport and exercise. 2013;14(2):179-88.
11. Miller YD, Trost SG, Brown WJ. Mediators of physical activity behavior change among women with young children. American journal of preventive medicine. 2002;23(2):98-103.
12. Mailey EL, Huberty J, Dinkel D, McAuley E. Physical activity barriers and facilitators among working mothers and fathers. BMC public Health. 2014;14:1-9.
13. Rose J. "Never enough hours in the day": Employed mothers' perceptions of time pressure. Australian Journal of Social Issues. 2017;52(2):116-30.
14. Peralta LR, Yager Z, Prichard I. 'There's Just Something Really Peaceful About It': a Qualitative Exploration of Mothers with Young Children and Engagement in Group-Based Physical Activity Programs. International Journal of Behavioral Medicine. 2022;29(6):807-19.
15. Cramp AG, Brawley LR. Moms in motion: a group-mediated cognitive-behavioral physical activity intervention. International Journal of Behavioral Nutrition and Physical Activity. 2006;3:1-9.
16. Mailey EL, McAuley E. Impact of a brief intervention on physical activity and social cognitive determinants among working mothers: a randomized trial. Journal of behavioral medicine. 2014;37:343-55.
17. Crenshaw K, editor Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. University of Chicago Legal Forum; 1989.
18. Patel NA, Kianoush S, Jia X, Nambi V, Koh S, Patel J, et al. Racial/ethnic disparities and determinants of sufficient physical activity levels. Kansas Journal of Medicine. 2022;15:267.
19. Marshall SJ, Jones DA, Ainsworth BE, Reis JP, Levy SS, Macera CA. Race/ethnicity, social class, and leisure-time physical inactivity. Medicine & Science in Sports & Exercise. 2007;39(1):44-51.
20. Williams DR. Miles to go before we sleep: Racial inequities in health. Journal of health and social behavior. 2012;53(3):279-95.
21. Saffer H, Dave D, Grossman M, Leung LA. Racial, Ethnic, and Gender Differences in Physical Activity. J Hum Cap. 2013;7(4):378-410.
22. Flegal KM, Kruszon-Moran D, Carroll MD, Fryar CD, Ogden CL. Trends in obesity among adults in the United States, 2005 to 2014. Jama. 2016;315(21):2284-91.
23. Palmer T, Jaworski CA. Exercise prescription for underprivileged minorities. Current Sports Medicine Reports. 2004;3(6):344-8.
24. Cotter EW, Hamilton NS, Kelly NR, Harney MB, Greene L, White KA, Mazzeo SE. A qualitative examination of health barriers and facilitators among African American mothers in a subsidized housing community. Health promotion practice. 2016;17(5):682-92.
25. Mansfield ED, Ducharme N, Koski KG. Individual, social and environmental factors influencing physical activity levels and behaviors of multiethnic socio-economically disadvantaged urban mothers in Canada: a mixed methods approach. International Journal of Behavioral Nutrition and Physical Activity. 2012;9:1-15.
26. Alhassan S, Nwaokelemeh O, Greever CJ, Burkart S, Ahmadi M, St. Laurent CW, Barr-Anderson DJ. Effect of a culturally-tailored mother-daughter physical activity intervention on pre-adolescent African-American girls' physical activity levels. Preventive Medicine Reports. 2018;11:7-14.
27. Clarke KK, Freeland-Graves J, Klohe-Lehman DM, Milani TJ, Nuss HJ, Laffrey S. Promotion of Physical Activity in Low-Income Mothers Using Pedometers. Journal of the American Dietetic Association. 2007;107(6):962-7.
28. Keller C, Ainsworth B, Records K, Todd M, Belyea M, Vega-López S, et al. A comparison of a social support physical activity intervention in weight management among post-partum Latinas. BMC Public Health. 2014;14(1):971.
29. Dlugonski D, Das BM, Martin TR. Impact of a standard versus collective-efficacy enhanced intervention to increase physical activity among mothers. Psychology & Health. 2020;35(2):239-53.
30. von Ash T, Ohagan B, Gupta-Louis SK, Dunsiger S, Toure F, Connell Bohlen L, Benitez TJ, Murphy CM, Pindus DM, Brown CS, Marcus BH. Leveraging youth sports to deliver a physical activity intervention to mothers: feasibility, acceptability, and preliminary efficacy of a single-arm open pilot trial. AJPM Focus. 2025;100465.

31. Adams R. Revised Physical Activity Readiness Questionnaire. Can Fam Physician. 1999;45:992, 5, 1004-5.
32. K C. Demarginalizing the Intersection of Race and Sex: A Black Feminist Critique of Antidiscrimination Doctrine, Feminist Theory and Antiracist Politics. University of Chicago Legal Forum. 1989;1(8).
33. Bandura A. Social foundations of thoughts and action: A social cognitive framework. Englewood Cliffs, NJ: Prentice HHall; 1986.
34. Prochaska JO, Velicer WF. The transtheoretical model of health behavior change. Am J Health Promot. 1997;12(1):38-48.
35. Benitez TJ, Dunsiger SI, Pekmezi DJ, Larsen BA, Mendoza-Vasconez AS, Linke SE, et al. Design and rationale for a randomized trial of a theory- and technology- enhanced physical activity intervention for Latinas: The Seamos Activas II study. Contemp Clin Trials. 2020;96:106081.
36. Marcus BH, Dunsiger SI, Pekmezi DW, Larsen BA, Bock BC, Gans KM, et al. The Seamos Saludables study: A randomized controlled physical activity trial of Latinas. Am J Prev Med. 2013;45(5):598-605.
37. Pekmezi DW, Neighbors CJ, Lee CS, Gans KM, Bock BC, Morrow KM, et al. A culturally adapted physical activity intervention for Latinas: a randomized controlled trial. Am J Prev Med. 2009;37(6):495-500.
38. Marcus BH, Dunsiger SI, Pekmezi D, Larsen BA, Marquez B, Bock BC, et al. Twelve-month physical activity outcomes in Latinas in the Seamos Saludables trial. Am J Prev Med. 2015;48(2):179-82.
39. Onken LS, Carroll KM, Shoham V, Cuthbert BN, Riddle M. Reenvisioning Clinical Science: Unifying the Discipline to Improve the Public Health. Clin Psychol Sci. 2014;2(1):22-34.
40. Hettema J, Steele J, Miller WR. Motivational interviewing. Annu Rev Clin Psychol. 2005;1:91-111.
41. Marcus BH, Hartman SJ, Larsen BA, Pekmezi D, Dunsiger SI, Linke S, et al. Pasos Hacia La Salud: a randomized controlled trial of an internet-delivered physical activity intervention for Latinas. Int J Behav Nutr Phys Act. 2016;13:62.
42. Pekmezi D, Ainsworth C, Desmond R, Pisu M, Williams V, Wang K, et al. Physical Activity Maintenance Following Home-Based, Individually Tailored Print Interventions for African American Women. Health Promot Pract. 2020;21(2):268-76.
43. Pekmezi D, Ainsworth C, Joseph RP, Williams V, Desmond R, Meneses K, et al. Pilot Trial of a Home-based Physical Activity Program for African American Women. Med Sci Sports Exerc. 2017;49(12):2528-36.
44. Bell ML, Whitehead AL, Julious SA. Guidance for using pilot studies to inform the design of intervention trials with continuous outcomes. Clin Epidemiol. 2018;10:153-7.
45. Thabane L, Ma J, Chu R, Cheng J, Ismaila A, Rios L, Goldsmith CH. A tutorial on pilot studies: the what, why and how. BMC medical research methodology. 2010;10:1.
46. von Ash T, Dunsiger SI, Williams DM, Larsen BA, Bohlen LC, Pekmezi D, et al. Pasos Hacia La Salud II: A Superiority RCT Utilizing Technology to Promote Physical Activity in Latinas. Am J Prev Med. 2024;67(2):220-30.
47. Hartman SJ, Dunsiger SI, Bock BC, Larsen BA, Linke S, Pekmezi D, et al. Physical activity maintenance among Spanish-speaking Latinas in a randomized controlled trial of an Internet-based intervention. J Behav Med. 2017;40(3):392-402.
48. Larsen B, Benitez T, Cano M, Dunsiger SS, Marcus BH, Mendoza-Vasconez A, et al. Web-Based Physical Activity Intervention for Latina Adolescents: Feasibility, Acceptability, and Potential Efficacy of the Ninas Saludables Study. J Med Internet Res. 2018;20(5):e170.
49. Marcus BH, Napolitano MA, King AC, Lewis BA, Whiteley JA, Albrecht A, et al. Telephone versus print delivery of an individualized motivationally tailored physical activity intervention: Project STRIDE. Health Psychol. 2007;26(4):401-9.
50. Sallis JF, Haskell WL, Wood PD, Fortmann SP, Rogers T, Blair SN, Paffenbarger RS, Jr. Physical activity assessment methodology in the Five-City Project. Am J Epidemiol. 1985;121(1):91-106.
51. Hayden-Wade HA, Coleman KJ, Sallis JF, Armstrong C. Validation of the telephone and in-person interview versions of the 7-day PAR. Med Sci Sports Exerc. 2003;35(5):801-9.
52. Irwin ML, Ainsworth BE, Conway JM. Estimation of energy expenditure from physical activity measures: determinants of accuracy. Obes Res. 2001;9(9):517-25.
53. Leenders N, Sherman WM, Nagaraja HN. Comparisons of four methods of estimating physical activity in adult women. Med Sci Sports Exerc. 2000;32(7):1320-6.
54. Leenders NY, Sherman WM, Nagaraja HN, Kien CL. Evaluation of methods to assess physical activity in free-living conditions. Med Sci Sports Exerc. 2001;33(7):1233-40.
55. Prince SA, Adamo KB, Hamel ME, Hardt J, Connor Gorber S, Tremblay M. A comparison of direct versus self-report measures for assessing physical activity in adults: a systematic review. Int J Behav Nutr Phys Act. 2008;5:56.
56. Dunn AL, Andersen RE, Jakicic JM. Lifestyle physical activity interventions. History, short- and long-term effects, and recommendations. Am J Prev Med. 1998;15(4):398-412.
57. Dunn AL, Marcus BH, Kampert JB, Garcia ME, Kohl HW, 3rd, Blair SN. Comparison of lifestyle and structured interventions to increase physical activity and cardiorespiratory fitness: a randomized trial. JAMA. 1999;281(4):327-34.
58. Lim H, Jung E, Jodoin K, Du X, Airton L, Lee EY. Operationalization of intersectionality in physical activity and sport research: A systematic scoping review. SSM Popul Health. 2021;14:100808.
59. Dlugonski D, Martin TR, Mailey EL, Pineda E. Motives and barriers for physical activity among low-income black single mothers. Sex Roles. 2017;77(5):379-92.
60. Paxton RJ, Taylor WC, Hudnall GE, Christie J. Goal Setting to Promote a Healthy Lifestyle. Int Proc Chem Biol Environ Eng. 2012;39:101-5.
61. Zhu S, Sinha D, Kirk M, Michalopoulou M, Hajizadeh A, Wren G, et al. Effectiveness of behavioral interventions with motivational interviewing on physical activity outcomes in adults: systematic review and meta-analysis. BMJ. 2024;386:e078713.
62. Garstang KR, Jackman PC, Healy LC, Cooper SB, Magistro D. What Effect Do Goal Setting Interventions Have on Physical Activity and Psychological Outcomes in Insufficiently Active Adults?: A Systematic Review and Meta-Analysis. Journal of Physical Activity and Health. 2024;1-13.
63. Short CE, James EL, Plotnikoff RC, Girgis A. Efficacy of tailored-print interventions to promote physical activity: a systematic review of randomised trials. Int J Behav Nutr Phys Act. 2011;8:113.
64. Tucker P, Gilliland J. The effect of season and weather on physical activity: a systematic review. Public Health. 2007;121(12):909-22.

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Disclosures

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Adaptation of a Multidomain Behavioral Intervention for Dementia Prevention in Hispanic/Latino Adults: Protocol to Guide an Evidence-Based Cultural Adaptation

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ABSTRACT

OBJECTIVE: Alzheimer's disease and related dementias (ADRD) pose a growing public health challenge, with 45% of cases attributable to 14 modifiable risk factors. Midlife represents a critical window for prevention. Hispanic/Latino adults face disproportionate ADRD risk, compounded by health inequities such as limited healthcare access and higher prevalence of cardiovascular and metabolic conditions. In Rhode Island, where 17.6% of residents identify as Hispanic/Latino, culturally tailored interventions are urgently needed. This study aims to inform the cultural adaptation of the TEACH intervention (Tailored Education for Aging and Cognitive Health), an evidence-based, multidomain behavioral intervention designed to reduce ADRD risk through lifestyle modification, to ensure its cultural relevance for Hispanic/Latino adults.

DESIGN AND METHODS: The research team will follow the Cultural Adaptation Process (CAP) model to guide the adaptation of the TEACH intervention, emphasizing linguistic and cultural relevance for Hispanic/Latino adults in southern New England by incorporating the views and perspectives of key stakeholders. We will conduct semi-structured qualitative interviews with bilingual stakeholders (N=6-8) and Hispanic/Latino adults aged 40-69 (N=10-12) recruited from clinical and community settings. Interviews will explore brain health beliefs, perceived intervention needs, barriers, and cultural values. Qualitative data will be analyzed using framework matrix and applied thematic analysis approaches to identify adaptation priorities across language, content, and delivery.

RESULTS: This project was funded in September 2023. Data collection began in 2024, and analysis is projected to be completed in 2026.

CONCLUSIONS: Findings will guide cultural adaptation of the TEACH intervention using the CAP model. This work addresses a critical gap in ADRD prevention for U.S. Hispanic/Latino populations and lays the foundation for a future randomized controlled trial to evaluate efficacy of the adapted intervention.

KEYWORDS: Alzheimer's disease and related dementias; dementia prevention; cultural adaptation; Hispanic/Latino; Latinx; behavioral intervention

INTRODUCTION

Alzheimer's disease and related dementias (ADRD) are a growing health concern, with major implications for individuals, families, and healthcare systems. A recent report from the Lancet Commission on Dementia Prevention identified 14 modifiable risk factors that account for 45% of dementia cases worldwide.[1] Modifying risk factors such as low physical activity, increased stress, and social isolation in middle age and early older adulthood could prevent or delay the onset of ADRD. Neuropathologies start to accumulate 10-15 years before the onset of symptoms, making middle age a critical window for ADRD intervention.[2,3]

This early intervention period is particularly important for populations such as Hispanic/Latino Americans who are at elevated risk for developing AD and constitute a rapidly growing segment of the U.S. population. Hispanic/Latinos in the U.S. are 1.5 times more likely than non-Hispanic Whites to develop Alzheimer's disease and related dementias (ADRD) and 12% of older adults in the Hispanic/Latino population are diagnosed with Alzheimer's disease.[4,5] Between 2022 and 2023, Hispanic individuals accounted for nearly 71% of total U.S. population growth, contributing the majority of the overall population gain.[6] Hispanic/Latinos of any race now make up approximately one-fifth of the U.S. population, the largest group after non-Hispanic Whites. This rapid growth emphasizes the public health relevance of ADRD disease prevention efforts in Hispanic/Latino communities.

ADRD rates differ across Hispanic/Latino subgroups, which is thought to be due to migratory, cultural, and socioeconomic differences, among other factors. For example, ADRD rates are disproportionately higher among individuals of Caribbean Latino subgroups (e.g., Puerto Rican, Dominican, and Cuban) compared to non-Hispanic White adults and Latino individuals from Central American or Mexican origin.[7] This is particularly salient for intervention efforts in Rhode Island, where the majority of Latino residents are of Dominican (4.9% of the total RI population)

and Puerto Rican (3.8%) origin. This subgroup-specific risk profile makes culturally and linguistically responsive intervention strategies especially critical for effective engagement.

Elevated ADRD risk in Hispanic/Latino older adults is, in part, related to individual health risk factors, such as higher rates of overweight/obesity,[8] cardiovascular disease,[9] diabetes,[10] and hypertension,[9] compared to non-Hispanic Whites. However, these are associated with and compounded by societal barriers, including economic disparities, higher rates of un- or under-insurance, lower access to medical resources, cultural and linguistic barriers, and discrimination.[11] These health inequities are particularly acute in Rhode Island, where in 2022, 21% of the Hispanic/Latino population was uninsured, 23.7% reported having no doctor, and 17.6% reported being unable to afford medical care.[12] Therefore, there is a strong need for scalable, culturally appropriate, lifestyle medicine interventions to reduce risk for ADRD.

Multi-domain interventions targeting lifestyle factors have been shown to reduce ADRD risk in older adults in U.S. and international studies.[13] For example, the U.S. POINTER study randomized 2,111 older adults at elevated risk for ADRD to a structured lifestyle intervention, including physical activity, dietary recommendations, cognitive challenge, social engagement, and cardiovascular health monitoring, compared to a lower-intensity self-guided intervention. The study found that the structured, multidomain, behavioral intervention showed greater cognitive benefits over two years compared to the self-guided intervention, providing evidence for the efficacy of this approach. However, only 5.9% of participants enrolled in the U.S. POINTER trial identified as Hispanic/Latino despite representing 19.5% of the total U.S. population.[9] Because these interventions are often designed for English-speaking, non-Hispanic White populations, they may not be culturally appropriate or address the barriers faced by Hispanic/Latino individuals.[4] This raises concern about the generalizability of these findings to this growing population.

The goal of this study is to lay the groundwork for a cultural adaptation of a multidomain behavioral intervention, Tailored Education for Aging and Cognitive Health (TEACH). The existing TEACH intervention was designed using principles from the science of behavior change to motivate long-term maintenance of target health behaviors to prevent or delay the onset of ADRD. TEACH has been delivered to English-speaking middle-aged adults in an eight-week, video conference-based format, which makes it briefer and potentially more scalable than the two-year, in-person group sessions in the U.S. POINTER trial. The intervention provides education about modifiable risk factors for ADRD, along with a structured framework for goal setting and problem solving for long-term behavior change. One of the core elements of the TEACH intervention is using the Health Belief Model to educate participants about health belief factors, including perceived threat of disease, perceived benefits, and self-efficacy.[15] Participants undergo a comprehensive assessment of modifiable ADRD risk factors and intrapersonal health beliefs. They receive a profile showing their scores on seven intrapersonal health belief factors, including future-time perspective, self-efficacy, reward sensitivity, response inhibition, executive control, consideration of future consequences, and ability to defer gratification. By integrating personalized education about these intrapersonal health beliefs with targeted information about modifiable ADRD risk factors, TEACH gives individuals a tailored framework for initiating and sustaining health behavior changes relevant to their own ADRD risk.

Research shows that culturally adapted treatments are more effective than their non-adapted versions, particularly when they incorporate adapted language and culturally relevant values.[14] We therefore will adapt TEACH for Hispanic/Latino adults living in southern New England, many of whom are from Caribbean and Central American heritage groups. This study will use the Cultural Adaptation Process (CAP) model to culturally adapt the TEACH intervention for Rhode Island Hispanic/Latino adults. The CAP model is an evidence-based framework for adapting interventions to better fit target populations, using Bronfenbrenner's Ecological Validity Model to guide adaptation along eight relevant dimensions.[16] The model emphasizes collaboration between researchers, community stakeholders, cultural experts, and community members to ensure that adaptation is relevant. The CAP model has three primary phases. The first phase, which is the focus of this study, involves identifying the need for adaptation, reviewing relevant empirical and cultural literature, and involving stakeholders from the community to evaluate cultural fit and barriers. The second phase focuses on modifying intervention content and delivery through surface (e.g., language translation) and deep (e.g., incorporating cultural beliefs and social norms that influence behavior) structure adaptations. Finally, the third stage involves pilot testing the adapted intervention, evaluating the feasibility, and refining the intervention based on the feedback and outcome data.

METHODS

Stakeholder Interviews

We will conduct individual, semi-structured, qualitative interviews with key multilingual and multicultural stakeholders, including community leaders, healthcare providers who serve predominantly Hispanic/Latino patients in Rhode Island, and Hispanic/Latino adults who are potential end users of the intervention (2-3 per stakeholder group). Stakeholders will be purposively selected based on their professional roles, community engagement, and experience with working with Hispanic/Latino adults.

Interviews will be conducted in either English or Spanish based on stakeholder preference and will last 30–45 minutes.

All interviews will be digitally audio-recorded and transcribed. Spanish language interviews will be transcribed in Spanish and translated into English for analysis by the wider study team, though Spanish-speaking study team members will ensure that cultural and linguistic nuance is maintained when interpreting findings.

A semi-structured interview guide has been developed to draw out stakeholders' perspectives on brain health, ADRD, and the cultural adaptation of TEACH. This was informed by the CAP model, which uses the Ecological Validity Model to identify eight dimensions across which an intervention may need to be adapted [**Table 1**].[16] Interview questions focused on two primary areas: the perceived need for a brain health intervention and developing a culturally adapted version of TEACH. Regarding perceived need for brain health interventions, stakeholders will be asked about common cultural beliefs related to brain health and aging within their local community (e.g., whether dementia is perceived as preventable, where community members receive information about ADRD). We will specifically elicit information about awareness of modifiable risk factors for ADRD. Intervention development questions will address potential barriers within the stakeholders' local community (e.g., time constraints, trust of healthcare establishments, access to technology), elements that would enhance the effectiveness of the intervention, and culturally relevant values or practices that should be incorporated into the program (e.g., *familismo*, a Hispanic/Latino cultural value emphasizing family closeness and wellbeing; specific Spanish words or phrases that may promote understanding of core intervention targets, and relevant community norms). Stakeholders will also be asked to identify qualities that are perceived as important to promote acceptability of the intervention (e.g., intervention being led by a healthcare provider versus community health worker, importance of bilingual and/or bicultural interventionist, intervention setting).

Table 1. Dimensions of cultural adaptation from Ecological Validity Model, which is embedded in the Cultural Adaptation Process Model

Dimensions	TEACH Adaptation
Language	Professional Spanish translation; refinement of language by working group
	Evaluate appropriateness for those with lower literacy skills
Persons	Consider cultural context and traditions for different Latino origin groups
	Intervention delivery by bilingual/bicultural providers
Metaphors	Incorporate *dichos* (sayings or proverbs) and specific language participants use to describe health
Content	Incorporate cultural knowledge about values, traditions, and customs
Concepts	Evaluate health belief descriptions to ensure they are culturally appropriate
	Adapt intervention concepts (e.g., diet or physical activity recommendations) to align with cultural context
Goals	Ensure goal-setting framework aligns with positive cultural values
Methods	Consider logistics of intervention delivery (e.g., preferences for in-person vs online format, location)
	Develop measure of intervention fidelity
Context	Incorporate social determinants of health and structural barriers to behavior change into the intervention

Individual Qualitative Interviews

To prepare for adaptation of intervention content, we will conduct 10–12 individual qualitative interviews with Spanish speaking participants recruited from the Rhode Island Hospital Neuropsychology Program and through community organizations and events (e.g., libraries and community centers). We will enroll participants aged 40–69, as this is the target age for the TEACH intervention. We will purposively sample to ensure representation from multiple countries of origin reflective of Rhode Island's Hispanic/Latino demographics (e.g., Dominican Republic, Puerto Rico, Guatemala, Mexico). Individual interviews were preferred over focus groups because of the potential to collect in-depth personal perspectives on health beliefs and behavior change for topics that may be sensitive or abstract. During interviews, participants will be presented with descriptions of seven health belief constructs that have been identified as mediators or moderators of health behavior change: future time perspective,[17] consideration of future health consequences,[18] delay discounting,[19] deferment of gratification,[20] response inhibition,[21] executive control,[22] and self-efficacy.[23] Participants will be asked to reflect on the acceptability, appropriateness, applicability, and perceived relevance of each construct to their own health behaviors and perceived risk for ADRD.

A phenomenographic approach will guide the interview process. Phenomenography is a well-established qualitative method used to examine how individuals understand and experience certain concepts within educational and healthcare settings.[24,25] This approach focuses on two aspects of learning: the referential aspect (the meaning individuals give to a concept) and the structural aspect (how the concept relates to their own experience). For example, interview questions will address appropriateness of intervention concepts (e.g., "In your own words, what does self-efficacy mean?") and applicability (e.g., "Does self-efficacy feel relevant to your own health, in relation to your risk for dementia?"). Interviews will be conducted both in person and remotely to increase accessibility. All interviews will be audio-recorded, transcribed, and translated into English for analysis.

Qualitative Analysis

In consultation with the Advance RI-CTR Biostatistics,

Epidemiology, and Research Design (BERD) core, we created an analysis plan for qualitative data. To rapidly integrate stakeholder perspectives into the planned intervention adaptation, we will use a framework matrix approach.[26] A framework will be developed based on codes and summaries of participants' comments will be abstracted from the qualitative agenda. Relevant quotes will also be collected and entered into a matrix summaries. Two team members will review the matrix and summarize key codes for completeness and accuracy.

To ensure a rich understanding of participants' experiences, we will use an applied thematic analysis approach for the individual qualitative interviews. A codebook of both deductive and inductive codes will be created. Deductive codes will be developed based on the study aims and theoretical frameworks guiding the research, including health belief concepts and cultural adaptation domains. Inductive codes will be generated from participants' responses and feedback to capture themes. Code summaries will be written, reviewed and discussed with the study team. Data will be managed and coded using NVivo software.

DISCUSSION, IMPACT, AND FUTURE DIRECTIONS

The goal of this study is to adapt a personalized, multidomain, behavioral intervention for primary prevention of ADRD in middle-aged Hispanic/Latino adults in Rhode Island and neighboring areas. While international studies such as the Latin American Initiative for Lifestyle Intervention to Prevent Cognitive Decline (LatAm-FINGERS) are currently underway, there are no known multidomain behavioral interventions for dementia prevention adapted for a U.S. Hispanic/Latino population.[27] This is a critical gap, given the growing U.S. Hispanic/Latino population and disproportionately higher prevalence of modifiable risk factors that increase dementia risk.

Following completion of data collection, we will review qualitative data from stakeholders and potential end users of the intervention. While the relevant empirical and cultural literature points to a need for culturally adapted interventions for Hispanic/Latino adults at risk for ADRD, the CAP model asks that we consider whether the community has an identified need for intervention adaptation and how stakeholders evaluate cultural fit and potential barriers. These data will directly address these considerations and will inform the next phase of the CAP model, which is to modify intervention content at both the surface level (translation of intervention materials into Spanish) and deep level (incorporating important cultural beliefs or community norms). Because the intrapersonal health belief constructs are conceptually abstract, we specifically elicit words and phrases from participants that can be used to describe these concepts effectively. The goal is to not only translate intervention material into Spanish, but to ensure its cultural relevance and appropriateness for our local community, considering language dialects, acculturation status, common idioms, and cultural norms.

There is a robust literature in implementation science examining contextual determinants of implementation outcomes.[28] Patient perspectives, clinician characteristics, organizational and health care systems, and broader sociocultural context all affect the adoption, effectiveness, and maintenance of interventions. These factors are especially important to consider when adapting an intervention to a different population or cultural context, as the core intervention elements and mechanisms of action may differ across settings. We therefore view the present study as a preliminary step in the adaptation of the TEACH intervention. Considering the perspectives of stakeholders, including community members and prospective end users of the intervention, will provide data about the perceived need of a health behavior intervention, core intervention characteristics, appropriateness of the methods, and implementation determinants.

In conclusion, this study will directly prepare our team to conduct a community-informed linguistic and cultural adaptation of the TEACH intervention, with a long-term goal of designing a randomized controlled trial to examine the efficacy of TEACH versus basic health education in U.S. Hispanic/Latino. This has the potential to address health disparities and reduce risk of ADRD through long-term maintenance of target behaviors to promote brain health.

References

1. Livingston G, Huntley J, Sommerlad A, et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet*. 2020;396(10248):413-446. doi:10.1016/S0140-6736(20)30367-6
2. Jack CR, Andrews JS, Beach TG, et al. Revised criteria for diagnosis and staging of Alzheimer's disease: Alzheimer's Association Workgroup. *Alzheimers Dement*. 2024;20(8):5143-5169. doi:10.1002/alz.13859
3. Braak H, Thal DR, Ghebremedhin E, Del Tredici K. Stages of the Pathologic Process in Alzheimer Disease: Age Categories From 1 to 100 Years. *J Neuropathol Exp Neurol*. 2011;70(11):960-969. doi:10.1097/NEN.0b013e318232a379
4. Vega IE, Cabrera LY, Wygant CM, Velez-Ortiz D, Counts SE. Alzheimer's Disease in the Latino Community: Intersection of Genetics and Social Determinants of Health. *J Alzheimer's Dis*. 2017;58(4):979-992. doi:10.3233/JAD-161261
5. Hispanic Americans and Alzheimer's | Alzheimer's Association. Accessed December 27, 2025. https://www.alz.org/help-support/resources/hispanics-and-alzheimers
6. Bureau UC. New Estimates Highlight Differences in Growth Between the U.S. Hispanic and Non-Hispanic Populations. Census.gov. Accessed December 27, 2025. https://www.census.gov/newsroom/press-releases/2024/population-estimates-characteristics.html
7. González HM, Tarraf W, Fornage M, et al. A research framework for cognitive aging and Alzheimer's disease among diverse US Latinos: Design and implementation of the Hispanic Community Health Study/Study of Latinos—Investigation of Neurocogni-

tive Aging (SOL-INCA). *Alzheimers Dement*. 2019;15(12):1624-1632. doi:10.1016/j.jalz.2019.08.192
8. Isasi CR, Ayala GX, Sotres-Alvarez D, et al. Is Acculturation Related to Obesity in Hispanic/Latino Adults? Results from the Hispanic Community Health Study/Study of Latinos. *J Obes*. 2015;2015(1):186276. doi:10.1155/2015/186276
9. Daviglus ML, Pirzada A, Talavera GA. Cardiovascular Disease Risk Factors in the Hispanic/Latino Population: Lessons From the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Prog Cardiovasc Dis*. 2014;57(3):230-236. doi:10.1016/j.pcad.2014.07.006
10. Cordero C, Schneiderman N, Llabre MM, et al. Diabetes Incidence Among Hispanic/Latino Adults in the Hispanic Community Health Study/Study of Latinos (HCHS/SOL). *Diabetes Care*. 2022;45(6):1482-1485. doi:10.2337/dc21-1543
11. Discussing the Interplay of Social Determinants of Health, Aging, and Alzheimer's Biomarkers in U.S. Latinos | The Journals of Gerontology: Series A | Oxford Academic. Accessed January 7, 2026. https://academic.oup.com/biomedgerontology/article/80/8/glaf020/8063397?login=false
12. Healthcare Access | Department of Health. Accessed January 7, 2026. https://health.ri.gov/data/healthcare-access
13. Baker LD, Espeland MA, Whitmer RA, et al. Structured vs Self-Guided Multidomain Lifestyle Interventions for Global Cognitive Function: The US POINTER Randomized Clinical Trial. *JAMA*. 2025;334(8):681. doi:10.1001/jama.2025.12923
14. Domenech Rodríguez MM, Baumann AA, Schwartz AL. Cultural Adaptation of an Evidence-Based Intervention: From Theory to Practice in a Latino/a Community Context. *Am J Community Psychol*. 2011;47(1-2):170-186. doi:10.1007/s10464-010-9371-4
15. Rosenstock IM. The Health Belief Model and Preventive Health Behavior. *Health Educ Monogr*. 1974;2(4):354-386. doi:10.1177/109019817400200405
16. Hammond KR. Ecological Validity: Then and Now.
17. Lang FR, Carstensen LL. Time counts: Future time perspective, goals, and social relationships. *Psychol Aging*. 2002;17(1):125-139. doi:10.1037/0882-7974.17.1.125
18. Joireman J, Shaffer MJ, Balliet D, Strathman A. Promotion Orientation Explains Why Future-Oriented People Exercise and Eat Healthy: Evidence From the Two-Factor Consideration of Future Consequences-14 Scale. *Pers Soc Psychol Bull*. 2012;38(10):1272-1287. doi:10.1177/0146167212449362
19. Kirby KN, Marakovic NN. Delay-discounting probabilistic rewards: Rates decrease as amounts increase. *Psychon Bull Rev*. 1996;3(1):100-104. doi:10.3758/BF03210748
20. Liu X, Wang L, Jiang J. Generalizability of Delay of Gratification: Dimensionality and Function. *Psychol Rep*. 2013;113(2):464-485. doi:10.2466/03.09.PR0.113x20z6
21. Donders FC. On the speed of mental processes. *Acta Psychol (Amst)*. 1969;30:412-431. doi:10.1016/0001-6918(69)90065-1
22. Fan J, McCandliss BD, Sommer T, Raz A, Posner MI. Testing the Efficiency and Independence of Attentional Networks. *J Cogn Neurosci*. 2002;14(3):340-347. doi:10.1162/089892902317361886
23. Bandura A. Self-efficacy: Toward a unifying theory of behavioral change. *Psychol Rev*. 1977;84(2):191-215. doi:10.1037/0033-295X.84.2.191
24. Han F, Ellis RA. Using Phenomenography to Tackle Key Challenges in Science Education. *Front Psychol*. 2019;10:1414. doi:10.3389/fpsyg.2019.01414
25. Stenfors-Hayes T, Hult H, Dahlgren MA. A phenomenographic approach to research in medical education. *Med Educ*. 2013;47(3):261-270. doi:10.1111/medu.12101
26. Joanna Smith JF. Qualitative data analysis: the framework approach. doi:10.7748/nr2011.01.18.2.52.c8284
27. Crivelli L, Calandri IL, Suemoto CK, et al. Latin American Initiative for Lifestyle Intervention to Prevent Cognitive Decline (LatAm-FINGERS): Study design and harmonization. *Alzheimers Dement J Alzheimers Assoc*. 2023;19(9):4046-4060. doi:10.1002/alz.13101
28. Context matters in implementation science: a scoping review of determinant frameworks that describe contextual determinants for implementation outcomes - PMC. Accessed December 27, 2025. https://pmc.ncbi.nlm.nih.gov/articles/PMC6432749/

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The Impact of an Advance RI-CTR Award on Tuberculosis Infection Management in Rhode Island

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ABSTRACT

OBJECTIVES: To evaluate the impact of a Rhode Island (RI) Latent Tuberculosis Infection (TB Infection) Extension of Community Healthcare Outcomes (ECHO) telementoring program on primary care clinicians' self-reported learning and performance.

METHODS: Utilizing an exploratory, sequential, mixed-methods design, we first conducted 24 qualitative interviews with RI primary care clinicians and nurses to identify TB infection management gaps. These findings informed the curriculum for a six-session RI TB Infection ECHO course launched in 2021. Participant learning and performance were evaluated using pre- and post-course-structured questionnaires and follow-up qualitative interviews.

RESULTS: Qualitative analysis revealed that participating clinicians felt comfortable with TB infection screening but lacked confidence in treatment initiation and selection. Following the ECHO course, participants demonstrated significant increases in self-reported confidence across the majority of TB infection practice areas ($P<0.05$). Notably, 75% of post-survey respondents reported making specific practice changes, such as adopting shorter treatment regimens and improving newer test interpretation.

CONCLUSIONS: The mentored research award was instrumental in the establishment of the first Project ECHO hub at The Warren Alpert Medical School of Brown University. By achieving Level 5 (Performance) on Moore's Educational Framework through documented practice change, the program demonstrated that telementoring can effectively democratize specialized TB infection knowledge. This framework has since scaled to a regional TB infection ECHO program.

KEYWORDS: Tuberculosis infection; Project ECHO

BACKGROUND

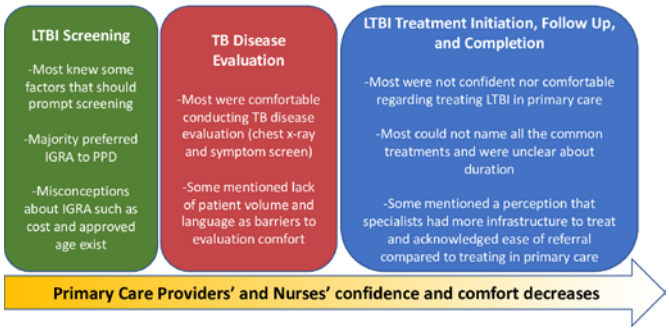
In Rhode Island (RI), there are currently an estimated 44,000 people with latent tuberculosis infection (LTBI).[1] If untreated, 5% to 10% of individuals with TB infection will develop TB disease, which is the major contributor to transmission of TB in the United States.[2,3] While this progression can be averted with TB infection treatment, decreasing progression to TB disease by 80%, only about 30% of individuals with TB infection have successfully completed treatment.[4,5]

Historically, TB infection and TB disease have been treated within specialty clinics. In RI, the RISE clinic in partnership with the RI Department of Health is traditionally staffed by academic-based specialty departments (infectious disease specialists or pulmonologists) caring for patients with both TB infection or TB disease. One of the reasons TB infection management was centralized within specialty clinics related to insurance coverage—TB infection screening only became a Grade B recommendation by the US Preventive Services Task Force (USPSTF) in 2016, opening a path for primary care coverage for TB infection screening and treatment.[6,7] However, barriers such as transport, time, language, and finances continue to contribute to individuals with TB infection being unable to access specialty care for TB infection treatment.[8,9]

Democratizing specialized care into primary care clinics that are easier to access is a potential solution to improving TB infection treatment outcomes in the United States. For example, a Massachusetts TB infection educational initiative led to increased self-reported confidence among clinicians across multiple TB infection management steps.[10] This educational initiative utilized an innovative telementoring model (Project ECHO–Expansion of Community Healthcare Outcomes) that incorporates a hub-and-spoke framework.[11,12] A hub team of specialists connects virtually via Zoom with primary care team members to create a learning community in which specialized knowledge is taught to individuals who are trusted clinicians for the patients they serve. The Massachusetts (MA) Introductory TB infection ECHO was the first TB ECHO in the United States to focus on TB infection training for primary care team members to manage TB infection.

The model had never been replicated before and it was not known whether primary care clinicians in RI had the same knowledge gaps in TB infection management. With support from Advance Rhode Island Clinical and Translational Research (Advance RI-CTR), an exploratory sequential pragmatic study was conducted. The first aim was to conduct a qualitative study to further explore primary care team

Figure 1. Primary care providers' and nurses' knowledge, attitudes, skills regarding LTBI Management—Major themes throughout the care cascade



members' knowledge, attitudes, and skills (KAS) regarding TB infection management. The results from this aim have been published, and demonstrated that primary care team members expressed more knowledge and comfort with TB infection testing, and less knowledge and comfort with TB infection treatment [**Figure 1**].[13] Afterwards, the study team updated the design of the RI TB infection ECHO program and evaluated the impact of this program on RI primary care team members' learning and performance. The purpose of this paper is to share results from this post-course study.

DEVELOPING A RI TB INFECTION ECHO HUB AND PROGRAM

We found that the existing MA TB Infection ECHO curriculum adequately addressed the knowledge gaps identified by RI primary care team members. The qualitative interviews reiterated the fact that primary care team members feel less comfortable with treatment selection. Therefore, we replicated the MA TB Infection ECHO curriculum in RI and ensured inclusion of cases related to treatment to see if we would get similar quantitative results. In order to run an ECHO course, an ECHO hub had to be created at Brown. In collaboration with leadership at The Warren Alpert Medical School, legal documents were signed with the University of New Mexico (the founding institution of Project ECHO) to become an official ECHO hub. Once that infrastructure was developed, members of the study team met with TB experts at the RI Department of Health and the RISE clinic to finalize the curriculum, discuss recruitment, create a website and obtain CME accreditation.[14] A launch session followed by a six-session RI TB Infection ECHO course took place in 2021.

QUANTITATIVE EVALUATION OF RI TB INFECTION ECHO COURSE PARTICIPANTS' LEARNING AND PERFORMANCE

The curriculum and session attendance can be found in **Table 1**. Structured questionnaires were distributed electronically for continuing medical education evaluation purposes. We asked participants whether they changed their practice as a result of the TB Infection ECHO course. Seventy-five percent of post-survey respondents stated that they changed their practice. The percentage of post-survey respondents who reported they would make a practice change and ratings of session quality are also found in **Table 1**. When considering continuing medical education activities, the Moore's Educational Framework suggests that practice change that can impact patient care is one of the highest achievements (aside from community impact).[15] That our ECHO led to 75% of participants stating practice change is noteworthy.

Twelve individuals completed the pre-survey, and eight completed the post-survey. Despite lower than anticipated enrollment, the ability to assess participant confidence and performance was not impacted. When comparing pre- and post-survey responses, there were significant increases in self-reported confidence across the majority of latent TB infection practice areas [**Figure 2**].

Given the lower than anticipated survey completion, qualitative interviews were conducted with ECHO participants to further explore the quantitative findings. Four interviews were conducted, and data analysis was completed. **Table 2** includes the final topics and illustrative quotes. Participants consistently indicated practice change. For example, participants mentioned being able to interpret interferon gamma

Table 1. RI TBI ECHO Curriculum, session attendance, participants' intention to make practice change, and participants' rating of session quality

	Name of session	Number of attendees	Attended 2+ sessions (%)	Would make practice changes (%)	Rated session quality "Very Good to Excellent" (%)
Session 1	TB Infection Background and Risk Assessment	n=26	88%; n=23 (Launch Meeting)	41%; 7/17	100%; 17/17
Session 2	TB Infection Diagnosis, Testing Options, and Testing Nuances	n=18	94%; n=17	64%; 9/14	94%; 13/14
Session 3	Ruling Out TB Disease, TB Infection Treatment Options	n=18	94%; n=17	58%; 7/12	100%; 12/12
Session 4	TB Infection Treatment Considerations, Monitoring, and Side Effects	n=20	100% n=20	45%; 5/11	91%; 10/11
Session 5	TB Infection in Children, Special Considerations	n=18	89%; n=16	36%; 4/11	91%; 10/11
Session 6	LTBI Advanced Considerations	n=16	100%; n=16	89%; 8/9	100%; 9/9

Figure 2. ECHO Participants' Self-Reported Confidence in various TBI practice areas before and after the ECHO

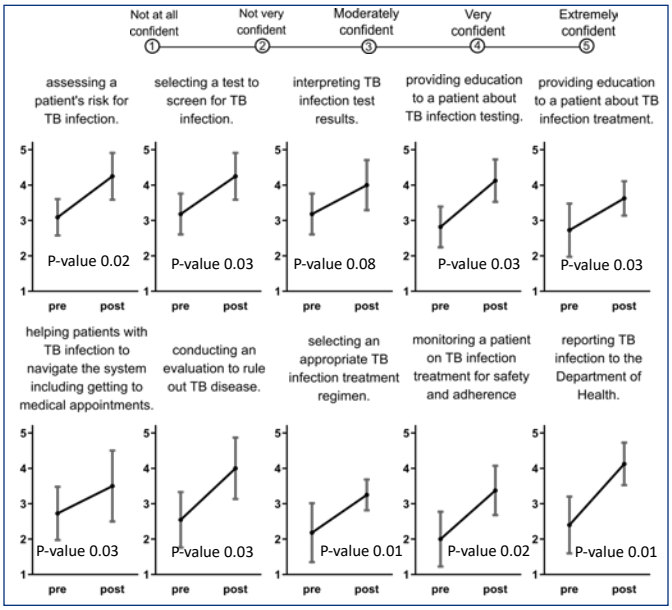


Table 2. Summary of topics and select quotes from post-TBI ECHO course qualitative interviews

Topics	Sample Quotes
Improvement in test interpretation	"I can now interpret IGRA results which I really couldn't do before..."
Practice change in LTBI treatment	"I changed to rifampin from INH and B6 which is much better for my population. And you know, the smile on their [the patient's] face when it's only four months instead of nine months is pretty good" "Well you know I think I would be more inclined to take on treatment on my own and not send the person out..."
Improvement in patient counseling	"I can now better explain LTBI to my patients. I have a better understanding of it now. It's not only the course—I mean the course sort of pushed me to do more reading, get into the studies and such like that, so the course was a motivator do that."

release assay (IGRA) results. The IGRA test requires only one venous blood draw compared to the older tuberculin skin test, which required two patient visits for placement and interpretation. Participants also mentioned changing to rifampin, a shorter course regimen. Both of these practice changes decrease the number of patient appointments.

IMPACT OF AN ADVANCE RI-CTR MENTORED RESEARCH AWARD ON TB INFECTION EDUCATION

The study supported by the Advance RI-CTR Mentored Research Award to investigate the impact of the implementation of a TBI ECHO program in RI ended in 2022. Since the course replicated the Massachusetts course and showed comparable impact on primary care team member self-reported confidence, individuals from other states began reaching out asking if the course could be replicated in other states. TB education in the United States is supported by the Centers for Disease Control and Prevention (CDC), and is decentralized across four regions through the funding of regional Centers of Excellence. RI and MA are included in the Northeast region covered by the Global TB Institute (GTBI) at Rutgers University.[16] Members from both MA and RI TB Infection ECHO hub teams met with the GTBI to discuss the possibility of creating a regional TB Infection ECHO program.

Through The Warren Alpert Medical School of Brown University ECHO hub that was developed with support from the Advance RI-CTR Mentored Research Award, and with funding support from GTBI and the Pittsfield Anti-TB Association, a regional TB Infection ECHO course has taken place over four iterations (2021, 2022, 2024, 2025). The hub has also supported other ECHO courses such as a Telemedicine for Educators ECHO, a Hepatitis C ECHO, and a Perinatal Opioid Use Disorder ECHO.[11]

References

1. Sterling TR, Bethel J, Goldberg S, Weinfurter P, Yun L, Horsburgh CR, Tuberculosis Epidemiologic Studies Consortium. The Scope and Impact of Treatment of Latent Tuberculosis Infection in the United States and Canada. Am J Respir Crit Care Med. 2006 Apr 15;173(8):927-931. doi: 10.1164/rccm.200508-1218OC. PMID: 16456011.
2. CDC. Tuberculosis Data. 2025 [cited 2026 Feb 11]. Available from: https://www.cdc.gov/tb-data/index.html.
3. Menzies NA, Wolf E, Connors D, Bellerose M, Sbarra AN, Cohen T, Hill AN, Yaesoubi R, Galer K, White PJ, Abubakar I, Salomon JA. Progression from latent infection to active disease in dynamic tuberculosis transmission models: a systematic review of the validity of modelling assumptions. Lancet Infect Dis. 2018 Aug;18(8):e228-e238. doi: 10.1016/S1473-3099(18)30134-8. Epub 2018 Apr 10. PMID: 29653698.
4. Holzman SB, Perry A, Saleeb P, Pyan A, Keh C, Salcedo K, Narita M, Ahmed A, Miller TL, Pettit AC, Khurana R, Whipple M, Katz D, Largen A, Krueger A, Shah M, Tuberculosis Epidemiologic Studies Consortium. Evaluation of the Latent Tuberculosis Care Cascade Among Public Health Clinics in the United States. Clin Infect Dis. 2022 Nov 14;75(10):1792-1799. doi: 10.1093/cid/ciac256. PMCID: PMC11075804. PMID: 35380632.
5. Shea KM, Kammerer JS, Winston CA, Navin TR, Horsburgh CR. Estimated Rate of Reactivation of Latent Tuberculosis Infection in the United States, Overall and by Population Subgroup. Am J Epidemiol. 2014 Jan 15;179(2):216-225. doi: 10.1093/aje/kwt246. Epub 2013 Oct 23. PMID: 24152526.
6. US Preventive Services Task Force, Bibbins-Domingo K, Grossman DC, Curry SJ, Bauman L, Davidson KW, Epling JW, García FAR, Herzstein J, Kemper AR, Krist AH, Kurth AE, Landefeld CS, Mangione CM, Phillips WR, Phipps MG, Pignone MP. Screen-

ing for Latent Tuberculosis Infection in Adults: US Preventive Services Task Force Recommendation Statement. JAMA. 2016 Sep 6;316(9):962-969. doi: 10.1001/jama.2016.11046. PMID: 27599331.

7. USPSTF. Who We Are & How We Work [Internet]. [cited 2026 Feb 11]. Available from: https://www.uspreventiveservicestaskforce.org.
8. Verma S, Pacheco C, Carter EJ, Szkwarko D. Latent Tuberculosis Infection Treatment Outcomes in an At-Risk Underserved Population in Rhode Island. J Prim Care Community Health. 2022;13:21501319221111106. doi: 10.1177/21501319221111106. PMCID: PMC9310062. PMID: 35861111.
9. Liu Y, Birch S, Newbold KB, Essue BM. Barriers to treatment adherence for individuals with latent tuberculosis infection: A systematic search and narrative synthesis of the literature. Int J Health Plann Manage. 2018 Apr;33(2):e416-e433. doi: 10.1002/hpm.2495. Epub 2018 Feb 9. PMID: 29424451.
10. Szkwarko D, Urbanowski ME, Thal R, Iyer P, Foley S, Randall LM, Bernardo J, Savageau JA, Cochran J. Expanding Latent Tuberculosis Infection Testing and Treatment in Massachusetts Primary Care Clinics via the ECHO Model. J Prim Care Community Health. 2022 Jan-Dec;13:21501319221119942. doi: 10.1177/21501319221119942. PMID: 36000470.
11. Szkwarko D, Cabral L, Patry G. Project ECHO in Rhode Island. R I Med J (2013). 2024 Jan 4;107(1):51-53. PMID: 38166079.
12. Project ECHO. Home [Internet]. [cited 2026 Feb 11]. Available from: https://projectecho.unm.edu/.
13. Szkwarko D, Kim S, Carter EJ, Goldman RE. Primary care providers' and nurses' knowledge, attitudes, and skills regarding latent TB infection testing and treatment: A qualitative study from Rhode Island. PLoS One. 2022 Apr 15;17(4):e0267029. doi: 10.1371/journal.pone.0267029. PMID: 35427387.
14. Project ECHO at Brown University. Democratizing Knowledge Through Telementoring [Internet]. [cited 2026 Feb 11]. Available from: https://sites.brown.edu/project-echo/.
15. Moore DE Jr, Green JS, Gallis HA. Achieving desired results and improved outcomes: integrating planning and assessment throughout learning activities. J Contin Educ Health Prof. 2009 Winter;29(1):1-15. doi: 10.1002/chp.20001. PMID: 19288562.
16. Global Tuberculosis Institute. Global TB Center [Internet]. Rutgers University; [cited 2026 Feb 11]. Available from: https://globaltb.njms.rutgers.edu/.

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Study Design, Methods, and Modeling in Networks to Inform HIV Interventions and Policy in Marginalized Populations

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ABSTRACT

The Networks and Causal Inference for Public Health Research (NCIPHER) Lab at the University of Rhode Island (URI) was established in 2018, with an initial pilot project supported by Advance Rhode Island Clinical Translational Research (RI-CTR), to develop methodological and computational approaches for evaluating interventions in real-world settings where individuals are connected in ways that impact their health. Leveraging bioinformatics and high-performance computing resources through Advance RI-CTR, we integrate empirical and simulation methods to estimate causal intervention effects (i.e., change in an outcome caused by a specific intervention) beyond treated individuals, including spillover through social and healthcare networks and clusters. Our work demonstrates that accounting for spillover improves understanding of the effectiveness of HIV and opioid use disorder (OUD) interventions. In the Transmission Reduction Intervention Project Athens, Greece, participants not exposed themselves to community alerts about HIV risk, with 50% of their immediate contacts exposed, reported three fewer unsafe injection behaviors (per 100 participants), compared to those who had 20% of their contacts exposed (95% CI: –7, 0). We also found 26 fewer reports (per 100 persons) at six months under individual treatment with medication for opioid use disorder with 60% of other individuals in the network treated, compared to no treatment with 20% of others treated (95% CI: -38, –13). Understanding effects in networks can improve translation from intervention delivery to population-level impact, supporting evidence-based policy.

KEYWORDS: Agent-based models; HIV/AIDS; interference; spillover; marginalized populations; substance use

BACKGROUND

Many public health interventions aimed at addressing the syndemics of HIV and overdoses likely not only affect the treated, but also others in the treated individuals' networks. This is known as *spillover*, a systematic, often unintended treatment effect on individuals who were not treated themselves. This is especially important for the marginalized and stigmatized populations with lower access and uptake of health interventions who are disproportionately impacted by these syndemics.[1] There are large disparities in healthcare and outcomes of individuals living with HIV, including men who have sex with men (MSM), and people who inject drugs (PWID).[2-4] Measuring and quantifying spillover can improve disease outcomes by expanding the reach of interventions beyond traditional research and clinical settings, informing intervention policy development, and mitigating infectious diseases.[5,6]

Studying causal mechanisms allows us to understand the processes by which HIV-related outcomes occur.[7] Causal mechanisms include biological, behavioral, or social processes through which an intervention affects health outcomes. Causal inference quantifies what would happen under different interventions and determines whether observed differences in health outcomes are caused by specific interventions. Readers may be familiar with confounding bias, in which a third variable distorts the relationship between an exposure and outcome, and we aim to isolate the effect of an exposure by removing confounding either by design or analysis. Causal inference using a potential outcomes framework can assess causal effects from both randomized and observational study data. In the setting of no interference/spillover, each individual's (potential) outcome is indexed by their own exposure; however, with spillover, each person's outcome is indexed by their own exposure and the exposure of others.[6] Heuristically, we can estimate spillover by comparing outcomes among individuals with similar characteristics and exposure histories but differing exposure patterns among their contacts.[6] By summarizing contacts' treatments through exposure mapping (e.g., the number or proportion treated in the group) and appropriately weighting or modeling the data, we can assess how modifying the intervention for network contacts changes the average outcomes, even for untreated individuals.

Although spillover has been traditionally studied for therapies like vaccines, other interventions may cause meaningful spillover, such as treatment as prevention (TasP) and pre-exposure prophylaxis (PrEP) for HIV, medication for opioid use disorder (MOUD), and naloxone for opioid overdose rescue. Standard evaluation methods may underestimate the benefits of these interventions by overlooking these effects, so we must account for them in the design, analysis, and modeling of public interventions. For example, PrEP

provides a 90% reduction in HIV acquisition in randomized trials among participants with high medication adherence.[8] However, if we evaluate the exposure as receipt of PrEP on preventing HIV acquisition only among treated individuals, we will miss the additional spillover benefit due to a reduction in onward transmission to their partners and possibly partners' partners. The Networks and Causal Inference for Public Health Research (NCIPHER) lab (co-Directors: Buchanan and Katenka) seeks to understand how interventions affect groups of people impacted by these syndemics, rather than individuals, recognizing that people are socially connected in complex and meaningful ways that can be leveraged to improve public health.

Marginalized populations continue to face a disproportionately high burden of HIV, including PWID and MSM. In 2022, the Centers for Disease Control and Prevention found that PWID accounted for 10% of all people living with HIV in the US.[9] PWID face HIV-transmission risk due to sexual and injection-related behaviors and often have limited access to harm reduction services, further constrained by stigma, incarceration, housing instability, and socioeconomic challenges.[10-12] In the PWID population, the majority inject unregulated opioids, and many of those individuals are also diagnosed with HIV.[13,14] Although three FDA-approved medications, including buprenorphine, methadone, and naltrexone, are available for treating OUD, major treatment gaps persist, with fewer than 20% of individuals with OUD receiving MOUD in 2022.[14-21] Because PWID are members of social, drug-use, and sexual networks,[22] increased MOUD uptake may protect both treated individuals and their contacts, including via medication sharing or the diffusion of harm-reduction information,[6,23-30] and reducing HIV injection-related risk behaviors of others in the network.[16-22,31]

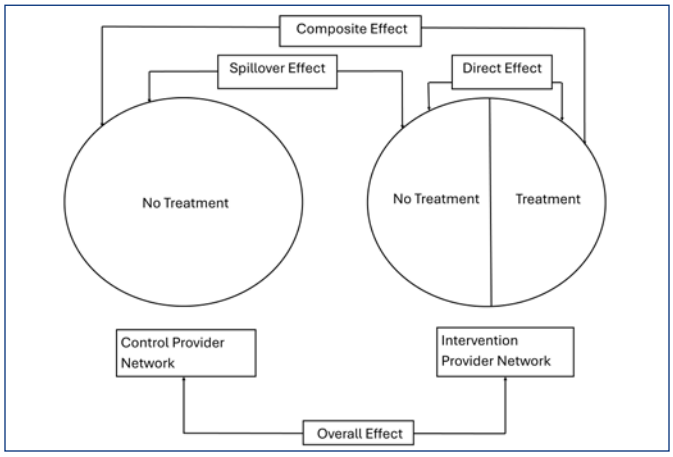
Young Black MSM (BMSM) face substantial barriers to optimal use of HIV-prevention modalities, including PrEP, due to factors such as misinformation, mistrust, and co-occurring substance use disorders that elevate HIV-transmission risk.[32-36] Between 2008 and 2014, HIV incidence increased among young BMSM in the United States while declining in other groups.[37] Network-based interventions show promise for addressing these disparities.[3,38-40] For example, The Transmission Reduction Intervention Project (TRIP) in Athens, Greece, and Chicago, IL, successfully used network recruitment to identify recently infected individuals and link them to care,[41,42] and PrEP Chicago demonstrated that peer-based network interventions can increase PrEP uptake among young BMSM.[36,43] Yet, how to most efficiently leverage networks to maximize spillover effects of peer-change agents, treatment as prevention (TasP), and PrEP remains unclear. Because many traditional trials and cohorts ignore underlying network structure, they risk bias from network dependence.[44] Developing methods to account for this dependence and statistically valid approaches to appropriately assess spillover are therefore essential for a wide range of study designs and research questions.

REVIEW OF ADVANCE RI-CTR SUPPORT

The NCIPHER lab was launched with support from an initial pilot project by the Advance Rhode Island Clinical Translational Research (RI-CTR) in 2018 that improved statistical methodology for quantifying spillover (disseminated) effects using administrative health claims databases. In this pilot project and subsequent federally funded research, our team has leveraged bioinformatics and computing resources from the Advance RI-CTR service cores. We have also gained access to important health databases to advance our research and impact, including the Rhode Island All-Payer Claims Database and the National COVID Cohort Collaborative. Through the Advance RI-CTR network, NICPHER lab members at URI access the service cores, which offer consultative services from experienced investigators skilled in key areas such as epidemiologic methods and qualitative research.

Our work in the Advance RI-CTR pilot project provided new insights into how interventions may be leveraged to more effectively and efficiently advance OUD prevention and treatment among patients receiving medical care across the United States. Patients are part of provider-based networks (based on medical claims data) and may exert social influence on others' treatment behaviors through shared clinical environments, overlapping provider relationships, and geographic proximity. These dynamics have the potential to shape collective norms surrounding opioid use and OUD treatment. In this framework, patients who are prescribed MOUD are considered index patients, and individuals who are not prescribed MOUD, but who share a provider-based network with an index patient, are defined as network members [(**Figure 1**]. The *individual* (direct) effect refers to the impact of MOUD on the index patients themselves, while the *spillover* (indirect or disseminated) effect represents the impact of these treatments on network members who share a connection (in this case, the same healthcare provider) with an index patient.[45]

Figure 1. Schematic diagram of the subsets of data used for each estimator (direct, spillover, composite and overall) based on a format provided in.[59] A provider network is a group of patients who share the same provider for their medication for opioid use disorder claims.



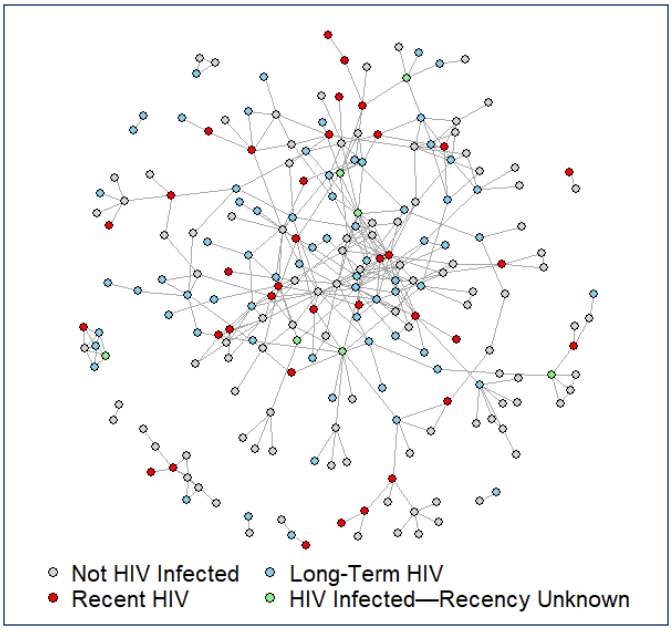
PUBLICATIONS AND FINDINGS

We summarized the primary findings from the Advance RI-CTR pilot project and subsequent key findings during the National Institute on Drug Abuse (NIDA) Avenir Award. NIDA's Avenir Awards focus on innovation and potentially transformative research from early-stage investigators, and our award was the first given nationally to a biostatistician. We examined the impact of timely initiation of buprenorphine/naloxone following an OUD diagnosis in a large cohort of insured adults using Optum's Clinformatics® Data Mart from 2010 to 2018 (n=8,388).[46] Prior to assessing spillover, we quantified the health outcomes and healthcare costs associated with timely MOUD initiation. We classified patients who started treatment within 30 days of diagnosis as early initiators and compared them to late initiators (those initiating later within one year). We employed generalized linear models to compare outcomes between groups, adjusting for baseline covariates and using multiple imputation to address missing data. After adjustment for baseline covariates, early initiation was associated with a 42% lower rate of opioid overdose (adjusted rate ratio [aRR] = 0.58, 95% CI: 0.52–0.64), a 51% lower rate of opioid overdose–related emergency department visits (aRR = 0.49, 95% CI: 0.44–0.55), and a 31% reduction in total healthcare costs (adjusted cost ratio = 0.69, 95% CI: 0.66–0.72) during the year after diagnosis compared with late initiation. Early initiation was associated with lower overdose risk, fewer ED visits, and lower healthcare costs among insured adults with OUD.

We proposed a novel application of causal inference methods for spillover in retrospective studies using administrative claims data, which can be employed to emulate a target trial when randomized trial data is not available. Extending this framework to an idealized two-stage randomized trial, an evaluation of direct and spillover effects within provider-based networks is possible. We developed an approach to build a provider network among individuals based on their primary MOUD providers using MOUD prescription claims and National Provider Identifiers, then assessed the proportion of patients in a provider network who were prescribed MOUD (i.e., coverage). Using generalized estimating equations with covariate adjustment, we constructed estimators for both individual and disseminated effects tailored to retrospective observational study designs in claims data. There were 2,273 patients in 722 provider networks, and 64% had a MOUD prescription.[45] We found modest evidence of direct and spillover effects in this setting. For the estimated spillover effect, we would expect 3 fewer overdoses per 100 people (95% CI: –5, –1) in untreated patients within high-coverage clusters compared to within low-coverage clusters. The direct effect was protective with an estimated 3 fewer cases per 100 people (95% CI: –6, –0) receiving treatment (vs no treatment) within 33% coverage clusters.

From 2018 to 2023, our team worked on the Avenir project funded by the NIDA. We evaluated the spillover of interventions and treatments using both secondary data analyses of existing datasets and simulation approaches, requiring the development of novel study designs and inferential and modeling methods in networks. We developed and implemented a novel methodology to evaluate spillover among networks of people who use drugs. Our work was largely motivated by TRIP in Athens, Greece, which successfully recruited and intervened in this population by identifying and engaging injection and sexual networks of recently-infected PWID through contact tracing [**Figure 2**]. We developed and evaluated approaches to quantify spillover in a network-based study with a non-randomized intervention.[47] These methods were used to evaluate spillover of HIV interventions, including community alerts, MOUD, and antiretroviral treatment (ART). Most estimates of the risk differences for community alerts reduced HIV-risk behavior, including spillover from sexual and drug use partners.[47] We estimated spillover effects of the alert intervention coverage on risk behavior, with 3 fewer reports per 100 participants under 50% versus 20% coverage (95% CI: –7, 0). We also employed causal inference methods to evaluate the spillover effects of MOUD and ART on subsequent HIV-risk behaviors with the spillover set defined by network communities or neighbors. Although the magnitude of these effects was sometimes sensitive to the community detection method, we found significant and protective effects of MOUD on HIV-risk behaviors and the estimated total effect was more robust to the community detection method used to define the interference set. For example, we expect 26 fewer reports

Figure 2. The TRIP network by HIV status. This network originally consisted of 10 connected components, and a community detection algorithm was used to further divide it into 20 components.[49] Individuals (nodes) are shaded by their HIV-infection status at baseline.



per 100 persons (95% CI = –38, –13) at the 6-month visit under MOUD in communities with 60% coverage, compared to under no MOUD in communities with 20% coverage.[31] However, our team did not observe any significant spillover effects of ART in TRIP Athens.[48]

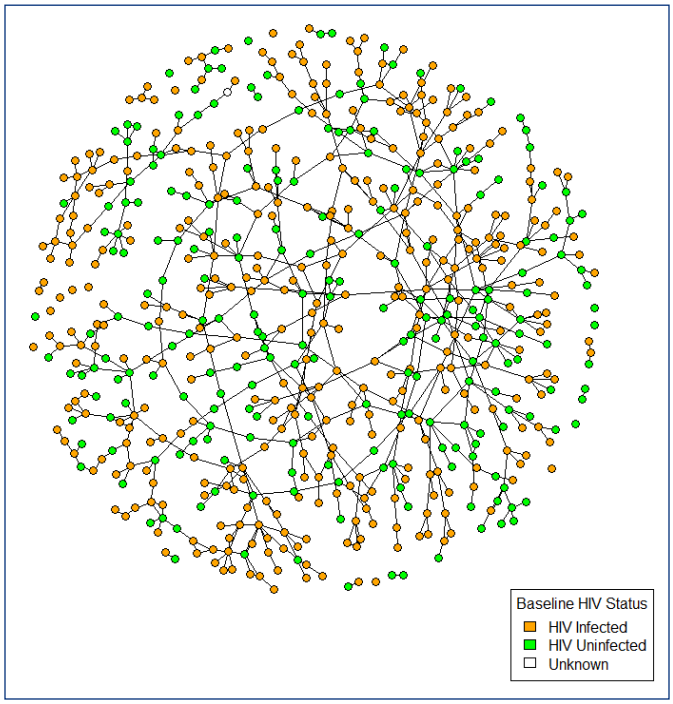
We developed an agent-based model (ABMs; computational models to study the impact of the individual's actions on the disease processes in the population) using a novel trial emulation framework to quantify spillover effects of pre-exposure prophylaxis (PrEP) among a sexual network of MSM in Atlanta, GA.[50-52] The estimated composite (total: direct and spillover) effect was an 85% reduction in the cumulative incidence of HIV, comparing agents on PrEP within intervention components to agents within control components (RR = 0.15, 95% SI = 0.11, 0.20).[50] As coverage levels increased, the spillover effect of PrEP was larger in magnitude, while the direct effect attenuated towards the null. Other publicly available resources included R programs to implement the new methodology for networks through Github[53] and a curated TRIP Athens data set.[54]

Significance and Future Work

Our current R01 project funded by NIDA will develop and apply new methods to evaluate HIV interventions using both secondary data analyses and simulation approaches. This project will inform intervention-coverage levels considering spillover and will be used to determine the types of individuals who could benefit the most from interventions with spillover. This project will provide new insights into spillover in the following network studies of MSM in Chicago, Illinois: uConnect [**Figure 3**], PrEP Chicago, and the Neighborhood and Networks Cohort Study.[4,36,55] We developed new methods to quantify spillover in a network setting with a variance estimator that better accounts for the network structure. We now need new approaches to address missing data and network dependence when assessing spillover, ensuring valid analyses in the more realistic data settings. We will develop a framework using agent-based models to evaluate the spillover of PrEP change agent interventions and PrEP delivery focused on those with substance use. Our team is also advancing methods for more flexible estimation approaches in networks that rely less on strong modeling assumptions, including targeted learning.[56] Targeted learning first learns patterns in the data, then adjusts those estimates to quantify a specific causal effect.[57,58] These methods make minimal and realistic assumptions about data distributions and are therefore a critical improvement for generating meaningful knowledge from real-world data.

Our research will provide new insights into spillover to reduce the spread and morbidity of HIV and other infectious diseases, often complicated by a high burden of substance use in marginalized populations. Estimated spillover effects in public health are modest at times, but can have a substantial population-level impact across connected individuals.

Figure 3. The uConnect study network with respondent-driven sample (RDS), social and sex partner ties, by baseline HIV status. Entity resolution was conducted to identify unobserved ties and individuals appearing in the network multiple times.[55] Individuals (nodes) are shaded by their baseline HIV-infection status.



Accounting for spillover is needed for valid inference to avoid bias and spillover remains largely unknown in many settings, especially in HIV prevention and treatment, where networks play a major role in disease transmission yet are often unmeasured. These advancements in methods and study design resources can be used to design and evaluate interventions for reducing HIV- risk behavior, increasing engagement in HIV-prevention measures, and strengthening HIV treatment among marginalized populations. These methods will also be applicable to studies of other infectious diseases, including sexually transmitted infections, hepatitis C, tuberculosis, and SARS-CoV-2, and are an important contribution to intervention research methodology. Although network structures may differ across contexts, the methods developed in our motivating settings may apply to a wide range of network types. Collectively, these findings illustrate how network causal inference methods can improve translation from intervention development to community impact, supporting evidence-based policy and demonstrating the translational value of Advance RI-CTR-supported infrastructure.

References

1. Baah FO, Teitelman AM, Riegel B. Marginalization: Conceptualizing patient vulnerabilities in the framework of social determinants of health-An integrative review. *Nurs Inq*. Jan 2019; 26(1):e12268. doi:10.1111/nin.12268
2. Althoff KN, Chandran A, Zhang J, et al. Life-Expectancy Disparities Among Adults With HIV in the United States and Canada: The Impact of a Reduction in Drug- and Alcohol-Related Deaths Using the Lives Saved Simulation Model. *Am J Epidemiol*. Dec 31 2019;188(12):2097-2109. doi:10.1093/aje/kwz232
3. Mustanski B, Morgan E, D'Aquila R, Birkett M, Janulis P, Newcomb ME. Individual and network factors associated with racial disparities in HIV among young men who have sex with men: results from the RADAR cohort study. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2019;80(1):24-30.
4. Duncan DT, Hickson DA, Goedel WC, et al. The social context of HIV prevention and care among black men who have sex with men in three US cities: the neighborhoods and networks (N2) cohort study. *International journal of environmental research and public health*. 2019;16(11):1922.
5. Benjamin-Chung J, Arnold BF, Berger D, et al. Spillover effects in epidemiology: parameters, study designs and methodological considerations. *Int J Epidemiol*. Feb 1 2018;47(1):332-347. doi:10.1093/ije/dyx201
6. Buchanan AL, Katenka N, Lee Y, et al. Methods for Assessing Spillover in Network-Based Studies of HIV/AIDS Prevention among People Who Use Drugs. *Pathogens*. Feb 15 2023;12(2) doi:10.3390/pathogens12020326
7. Little RJ, Rubin DB. *Statistical analysis with missing data*. John Wiley & Sons; 2019.
8. Plosker GL. Emtricitabine/Tenofovir Disoproxil Fumarate: A Review of its Use in HIV-1 Pre-Exposure Prophylaxis. *Drugs*. Mar 2013;73(3):279-91.
9. Centers for Disease Control and Prevention. *Estimated HIV incidence and prevalence in the United States, 2018–2022*. 2024; Vol. 29. https://www.cdc.gov/hiv-data/nhss/estimated-hiv-incidence-and-prevalence.html
10. Galea S, Karpati A, Kennedy B. Social capital and violence in the United States, 1974–1993. *Social Science & Medicine*. 2002/10/01/ 2002;55(8):1373-1383. doi:https://doi.org/10.1016/S0277-9536(01)00274-X
11. Degenhardt L, Peacock A, Colledge S, et al. Global prevalence of injecting drug use and sociodemographic characteristics and prevalence of HIV, HBV, and HCV in people who inject drugs: a multistage systematic review. *The Lancet Global Health*. 2017; 5(12):e1192-e1207.
12. Arum C, Fraser H, Artenie AA, et al. Homelessness, unstable housing, and risk of HIV and hepatitis C virus acquisition among people who inject drugs: a systematic review and meta-analysis. *The Lancet Public Health*. 2021;6(5):e309-e323.
13. Bradley H, Glick SN, Hall EW. Estimated Number of People Who Inject Drugs in the United States, 2022. *American Journal of Public Health*. 2025;(0):e1-e4.
14. Larney S, Peacock A, Leung J, et al. Global, regional, and country-level coverage of interventions to prevent and manage HIV and hepatitis C among people who inject drugs: a systematic review. *The Lancet Global Health*. 2017;5(12):e1208-e1220.
15. Abuse S, Administration MHS. *Key Substance Use and Mental Health Indicators in the United States: Results from the 2019 National Survey on Drug Use and Health*. 2020. https://www.samhsa.gov/data/report/2019-nsduh-annual-national-report
16. Karki P, Shrestha R, Huedo-Medina TB, Copenhaver M. The impact of methadone maintenance treatment on HIV risk behaviors among high-risk injection drug users: a systematic review. *Evidence-Based Medicine & Public Health*. 2016;2:e1229.
17. Sypsa V, Psichogiou M, Paraskevis D, et al. Rapid decline in HIV incidence among persons who inject drugs during a fast-track combination prevention program after an HIV outbreak in Athens. *The Journal of Infectious Diseases*. 2017;215(10):1496-1505.
18. Edelman EJ, Chantarat T, Caffrey S, et al. The impact of buprenorphine/naloxone treatment on HIV risk behaviors among HIV-infected, opioid-dependent patients. *Drug and Alcohol Dependence*. 2014;139:79-85.
19. Gowing LR, Farrell M, Bornemann R, Sullivan LE, Ali RL. Brief report: Methadone treatment of injecting opioid users for prevention of HIV infection. *Journal of General Internal Medicine*. 2006;21(2):193-195.
20. Ball JC, Lange WR, Myers CP, Friedman SR. Reducing the risk of AIDS through methadone maintenance treatment. *Journal of Health and Social Behavior*. 1988:214-226.
21. Larney S. Does opioid substitution treatment in prisons reduce injecting-related HIV risk behaviours? A systematic review. *Addiction*. 2010;105(2):216-223.
22. Friedman SR, Williams L, Young AM, et al. Network Research Experiences in New York and Eastern Europe: Lessons for the Southern US in Understanding HIV Transmission Dynamics. *Current HIV/AIDS Reports*. 2018/06/01 2018;15(3):283-292. doi:10.1007/s11904-018-0403-2
23. Doernberg M, Krawczyk N, Agus D, Fingerhood M. Article Commentary: Demystifying Buprenorphine Misuse: Has Fear of Diversion Gotten in the Way of Addressing the Opioid Crisis? *Substance Abuse*. 2019;40(2):148-153.
24. Carroll JJ, Rich JD, Green TC. The more things change: Buprenorphine/naloxone diversion continues while treatment remains inaccessible. *Journal of Addiction Medicine*. 2018;12(6):459-465.
25. Kenney SR, Anderson BJ, Bailey GL, Stein MD. The relationship between diversion-related attitudes and sharing and selling buprenorphine. *Journal of Substance Abuse Treatment*. 2017; 78:43-47.
26. Gwin Mitchell S, Kelly SM, Brown BS, et al. Uses of diverted methadone and buprenorphine by opioid-addicted individuals in Baltimore, Maryland. *American Journal on Addictions*. 2009;18(5):346-355.
27. Carlson RG, Daniulaityte R, Silverstein SM, Nahhas RW, Martins SS. Unintentional drug overdose: Is more frequent use of non-prescribed buprenorphine associated with lower risk of overdose? *International Journal of Drug Policy*. 2020;79:102722.
28. Friedman SR, Maslow C, Bolyard M, Sandoval M, Mateu-Gelabert P, Neaigus A. Urging others to be healthy:"Intravention" by injection drug users as a community prevention goal. *AIDS Education and Prevention*. 2004;16(3):250-263.
29. Mateu-Gelabert P, Guarino H, Quinn K, et al. Young drug users: a vulnerable population and an underutilized resource in HIV/HCV prevention. *Current HIV/AIDS Reports*. 2018;15(4):324-335.
30. Shen L, Assanangkornchai S, Liu W, et al. Influence of social network on drug use among clients of methadone maintenance treatment centers in Kunming, China. *PLoS One*. 2018;13(7): e0200105. doi:10.1371/journal.pone.0200105
31. Puleo J, Buchanan A, Katenka N, Halloran ME, Friedman SR, Nikolopoulos G. Assessing Spillover Effects of Medications for Opioid Use Disorder on HIV Risk Behaviors among a Network of People Who Inject Drugs. *Stats*. 2024;7(2):549-575.
32. Compton WM, Jones CM. Substance use among men who have sex with men. *New England Journal of Medicine*. 2021; 385(4):352-356.
33. Grant RM, Lama JR, Anderson PL, et al. Preexposure chemoprophylaxis for HIV prevention in men who have sex with men. *New England Journal of Medicine*. 2010;363(27):2587-2599.
34. Grant RM, Anderson PL, McMahan V, et al. Uptake of pre-exposure prophylaxis, sexual practices, and HIV incidence in men and transgender women who have sex with men: a cohort study. *The Lancet Infectious Diseases*. 2014;14(9):820-829.
35. Mutchler MG, McDavitt B, Ghani MA, Nogg K, Winder TJ, Soto JK. Getting PrEPared for HIV prevention navigation: young black gay men talk about HIV prevention in the biomedical era. *AIDS Patient Care and STDs*. 2015;29(9):490-502.
36. Young LE, Schumm P, Alon L, et al. PrEP Chicago: A randomized controlled peer change agent intervention to promote the adoption of pre-exposure prophylaxis for HIV prevention among young Black men who have sex with men. *Clinical Trials*. 2018;15(1):44-52.
37. Hess KL, Hu X, Lansky A, Mermin J, Hall HI. Lifetime risk of a diagnosis of HIV infection in the United States. *Annals of Epidemiology*. 2017;27(4):238-243. doi:https://doi.org/10.1016/j.annepidem.2017.02.003
38. Bonett S, Meanley S, Stevens R, Brawner B, Bauermeister J. The Role of Networks in Racial Disparities in HIV Incidence Among Men Who Have Sex with Men in the United States. *AIDS and Behavior*. 2020/10/01 2020;24(10):2781-2796. doi:10.1007/s10461-020-02798-1

39. Hermanstyne KA, Green Jr HD, Cook R, et al. Social network support and decreased risk of seroconversion in black MSM: results of the BROTHERS (HPTN 061) study. *JAIDS Journal of Acquired Immune Deficiency Syndromes*. 2018;78(2):163-168.
40. Shah NS, Iveniuk J, Muth SQ, et al. Structural bridging network position is associated with HIV status in a younger Black men who have sex with men epidemic. *AIDS and Behavior*. 2014;18(2):335-345.
41. Morgan E, Skaathun B, Nikolopoulos GK, et al. A network intervention to locate newly HIV infected persons within MSM networks in Chicago. *AIDS and Behavior*. 2019;23(1):15-20.
42. Williams LD, Korobchuk A, Pavlitina E, et al. Experiences of stigma and support reported by participants in a network intervention to reduce HIV transmission in Athens, Greece; Odessa, Ukraine; and Chicago, Illinois. *AIDS and Behavior*. 2019;23(5):1210-1224.
43. Young LE, Schneider JA. The co-evolution of network structure and PrEP adoption among a large cohort of PrEP peer leaders: implications for intervention evaluation and community capacity-building. *International Journal of Environmental Research and Public Health*. 2021;18(11):6051.
44. Lee Y, Ogburn EL. Network Dependence Can Lead to Spurious Associations and Invalid Inference. *Journal of the American Statistical Association*. 2021;116(535):1060-1074. doi:10.1080/01621459.2020.1782219
45. Buchanan A, Sun T, Wu J, et al. Toward evaluation of disseminated effects of medications for opioid use disorder within provider-based clusters using routinely-collected health data. *Statistics in Medicine*. 2022;41(18):3449-3465.
46. Sun T, Aroke H, Kogut S, Katenka N, Bratberg J, Buchanan A. Early buprenorphine-naloxone initiation for opioid use disorder reduces opioid overdose, emergency room visits, and healthcare cost compared to late initiation. *The American Journal of Drug and Alcohol Abuse*. 2022;48(2):217-225.
47. Lee T, Buchanan AL, Katenka NV, et al. Estimating Causal Effects of HIV Prevention Interventions with Interference in Network-based Studies among People Who Inject Drugs. *Ann Appl Stat*. Sep 2023;17(3):2165-2191. doi:10.1214/22-aoas1713
48. Nikolopoulos G, Buchanan A, Katenka N, et al. Evaluation of spill-over effects of antiretroviral treatment on sharing injecting equipment in a sociometric network of people who inject drugs. *AIDS Care*. 2025/08/03 2025;37(8):1380-1392. doi:10.1080/09540121.2025.2530411
49. Lee Y, Buchanan AL, Ogburn EL, et al. Finding Influential Subjects in a Network Using a Causal Framework. *Biometrics*. 2023;79(4):3715-3727. doi:10.1111/biom.13841
50. Buchanan AL, Bessey S, Goedel WC, et al. Disseminated Effects in Agent-Based Models: A Potential Outcomes Framework and Application to Inform Preexposure Prophylaxis Coverage Levels for HIV Prevention. *American Journal of Epidemiology*. 2020;190(5):939-948. doi:10.1093/aje/kwaa239
51. Buchanan AL, Park CJ, Bessey S, et al. Spillover benefit of pre-exposure prophylaxis for HIV prevention: evaluating the importance of effect modification using an agent-based model. *Epidemiology and Infection*. 2022;150:e192. e192. doi:10.1017/S0950268822001650
52. Murray EJ, Marshall BD, Buchanan AL. Emulating target trials to improve causal inference from agent-based models. *American Journal of Epidemiology*. 2021;190(8):1652-1658.
53. Buchanan A, Lee Y, Zhang K, et al. Networks and Causal Inference for Public Health and Education Research, The University of Rhode Island. Webpage. GitHub. https://github.com/uri-nci-pher
54. Nikolopoulos GK, Friedman SR, Buchanan AL. Data from: Transmission Reduction Intervention Project (TRIP), Athens, Greece Site, 2013-2015. 2025. doi:10.3886/ICPSR39059.v2
55. Hotton AL, Keene L, Corbin DE, Schneider J, Voisin DR. The relationship between Black and gay community involvement and HIV-related risk behaviors among Black men who have sex with men. *Journal of Gay & Lesbian Social Services*. 2018;30(1):64-81.
56. Buchanan A, Zhang K, Adhikari S. Targeted and Double/Debiased Machine Learning with Applications to Public Health Studies with Interference. presented at: American Causal Inference Conference; May 13-16, 2025 2025; Detroit, MI.
57. Gruber S, Lee H, Phillips R, Ho M, Van Der Laan M. Developing a Targeted Learning-Based Statistical Analysis Plan. *Statistics in Biopharmaceutical Research*. 2023;15(3):468-475. doi:10.1080/19466315.2022.2116104
58. Laan MJvd. Targeted Estimation of Nuisance Parameters to Obtain Valid Statistical Inference. *The International Journal of Biostatistics*. 2014;10(1):29-57. doi:doi:10.1515/ijb-2012-0038
59. Halloran ME, Struchiner CJ. Study designs for dependent happenings. *Epidemiology*. 1991;2(5):331-338.

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