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Article

Constructing Directed Acyclic Graphs (DAGs) to Inform Tobacco Cessation Intervention Research: A Methodological Extension Using Evidence Synthesis

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Abstract

Background: Tobacco use remains a leading preventable cause of morbidity and mortality in the United States, with persistent disparities in cessation outcomes across socioeconomic and racial groups. While numerous interventions exist, their effectiveness is shaped by complex interrelated factors at individual, social, and healthcare system levels. Identifying and modeling these causal pathways is essential to inform equitable intervention design. Methods: This study applied the Evidence Synthesis for Constructing Directed Acyclic Graphs (ESC-DAG) protocol to integrate empirical findings from 35 quantitative studies examining barriers and facilitators of tobacco cessation intervention uptake in the United States. Using the Andersen and Aday Health Services Research Model as a guiding framework, we extracted, harmonized, and synthesized significant causal relationships into a unified DAG, distinguishing exposures, outcomes, mediators, and confounders. Results: The integrated DAG revealed that structural factors such as socioeconomic disadvantage, digital inequities, rurality, and cultural barriers exerted substantial influence on cessation outcomes. These upstream determinants operated through mediators including motivation, treatment engagement, and access barriers, while healthcare system factors such as provider engagement and proactive outreach emerged as consistent facilitators. Digital access and culturally tailored interventions were identified as underexplored yet potentially high-impact pathways. Discussion: The ESC-DAG methodology provided a structured approach to visualize and synthesize causal mechanisms beyond traditional review synthesis, highlighting points of intervention at both policy and practice levels. The findings underscore the importance of multi-level strategies, including financial support, digital equity initiatives, provider outreach, and culturally tailored cessation services. Conclusion: By applying ESC-DAG methodology, this study contributes a novel causal framework for understanding disparities in tobacco cessation intervention uptake. The resulting DAG can inform future statistical modeling, simulation studies, and equity-focused program design, supporting more effective public health strategies to reduce smoking prevalence and associated inequities.

Keywords: tobacco cessation; directed acyclic graph; evidence synthesis; health disparities; socioeconomic factors; digital equity; provider engagement

1. Introduction

Smoking is one of the leading preventable causes of premature death and health inequities in the United States. According to a study conducted in the U.S. from 2014 to 2019 using U.S. population data, a persistent sociodemographic inequality was identified. Although a similar or higher quit interest exists among non-White and lower socioeconomic status groups, significantly lower sustained cessation rates, i.e., only about 7.5% were observed. The tobacco cessation treatment uptake

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remained low, i.e., 34% and the disparities in treatment receipt did not improve significantly [1]. The NHIS data examination reported similar underlying trends in disparities in receiving professional cessation advice. Those who are older adults, reside in urban areas, have access to primary care, and are diagnosed with COPD were highly likely to receive tobacco cessation treatment assistance, disproportionately affecting rural, younger, uninsured, and racial minority smokers [2,3].

As per a recent CDC MMWR report, about 50% of adult smokers among 28.8 million U.S. adult smokers tried to quit, but only about 10% succeeded, and less than 40% utilized tobacco cessation interventions, i.e., medical or non-medical interventions [4]. Lower access to tobacco cessation interventions and lower sustained quitting are associated with lower socio-economic status and rural residence. Although the cessation intervention exists, access to pharmacotherapy, counselling, or other types of cessation interventions remains limited due to unaligned care coordination, cost, or lower healthcare engagement [2,3,5]. Prior work has identified key barriers and facilitators of cessation intervention utilization in the United States at both the population and healthcare system levels. The key barriers identified across diverse cessation intervention types are digital inequities for digital interventions, socioeconomic disadvantage, and low motivation at the population level. At the healthcare system level, barriers to care access and inadequate healthcare provider engagement have been identified as further system-level barriers in effective tobacco cessation intervention utilization in the U.S. While the key facilitators identified are financial incentives, culturally tailored interventions, and digital engagement strategies [6].

The effectiveness of treatment interventions outside a strict clinical trial environment is affected by several confounding barriers and facilitating factors [7]. It is crucial to identify such factors to develop a Directed Acyclic Graph (DAG) a visual representation of complex relationships between key factors affecting the exposure and outcome variables relationship in any observational data study, as it informs the statistical modeling for causal inferences [6–8]. A conventional statistical model due to parametric assumptions might not capture the comprehensive causal relationship of a study context; however, a DAG can graphically depict the complex causal relationship between a key exposure and outcome factors. According to PubMed, Embase, Web of Science, and Google searches, there exists no scientific literature that develops evidence-based DAG on factors affecting tobacco cessation intervention utilization in the United States. As established, it is vital to build such DAGs to identify causal relationships that affect the tobacco cessation intervention utilization to improve the health inequities and smoking prevalence rate in the United States. Although evidence-based cessation intervention exists, there is a need to identify measurable factors that affect the causal relationship between socioeconomic factors and cessation or quit outcomes in the presence of key confounders. Hence, this study builds upon a prior systematic review to develop an evidence synthesis DAG [6].

2. Materials and Methods

2.1. Study Design and Evidence Base

This study utilized the Evidence Synthesis for Constructing Directed Acyclic Graphs (ESC-DAG) protocol to identify the causal factors affecting tobacco cessation intervention uptake in the United States. In observational research, the ESC-DAG methodology helps to integrate causal relationships from existing empirical evidence [9].

A total of 35 studies were identified in the prior extension of this work, a systematic review [6] about barriers and facilitators to tobacco cessation interventions at the population and healthcare system levels. The study included randomized control trials, quasi-experimental, and observational quantitative studies that examined determinants of smoking cessation intervention uptake and treatment disparities at both the population and healthcare system level.

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2.2. ESC-DAG Protocol Application

The mapping stage included edge identification and coding in DAGitty software [10]. Each study included was reviewed to extract empirically supported causal relationships (edges) between exposure and outcome variables. Edges were extracted verbatim that were statistically significant between exposure and outcome variables and coded within the original study context. The direct and indirect pathways were established without any directionality rules implied to preserve the original study context.

The translation stage included thematic grouping and categorization by imposing ESC-DAG protocol directionality rules. The conceptual framework used to determine the temporality and directionality of constructs was frequently the Andersen and Aday Health Services Research framework [11]. Overlapping constructs, such as digital access and digital inequities, were combined into a single standardized category. The bidirectionality was assessed, and constructs were aligned with theoretical determinants from the conceptual framework.

The integration stage involved synthesis into a final compiled ESC-DAG. The harmonized constructs and their edges were synthesized into a single DAG that included confounders, mediators, and potentially other effect modifiers.

2.3. Conceptual Framework and Quality Assurance

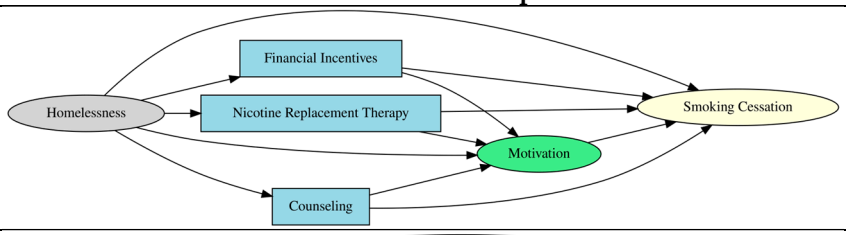
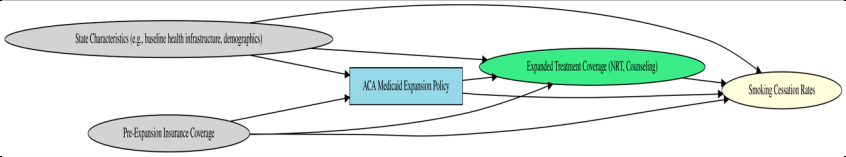
The Andersen and Aday Health Services Research Model was utilized as an organizing framework to contextualize constructs across predisposing, enabling, and need-based factors. The protocol recognized the need for a conceptual framework to inform its translation stage, ensuring that the DAG represented statistical associations aligned with established theory on healthcare access and utilization. Two independent reviewers conducted edge extraction and thematic grouping, with discrepancies resolved through consensus involving the third reviewer to minimize subjectivity.

3. Results

3.1. Mapping Stage Findings

A total of 35 included studies identified a wide range of causal pathways that linked individual, social, and structural factors to smoking cessation outcomes (Table 1). Each study contributed multiple causal pathways, i.e., edges establishing several potential pathways. Frequently mapped factors included socioeconomic disadvantage, digital access and literacy, motivation to quit, and healthcare system barriers, i.e., provider engagement and treatment availability. Nicotine Replacement Therapy (NRT), financial incentives, and mobile-based supports were recurrent intervention-specific nodes. As depicted in Table 1, the yellow nodes represent outcome variables, the blue nodes represent exposure variables, the green nodes represent mediators, and the grey nodes represent confounders, as identified across each included study.

Table 1. Mapping stage, individual study implied DAGs.

Study	Graph
[12]	
[13]	

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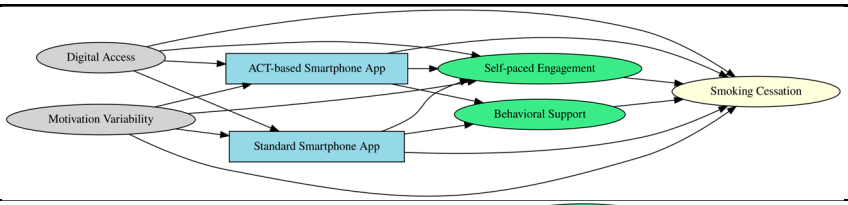
[14]



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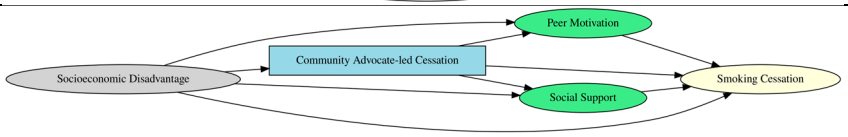

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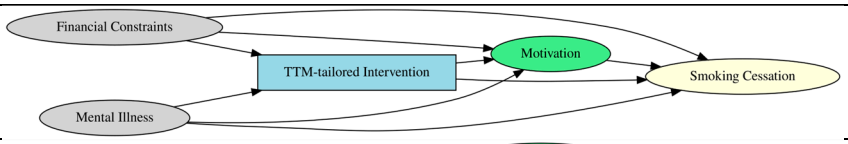

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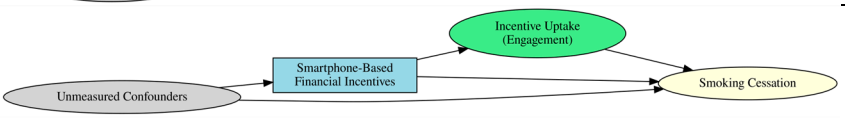

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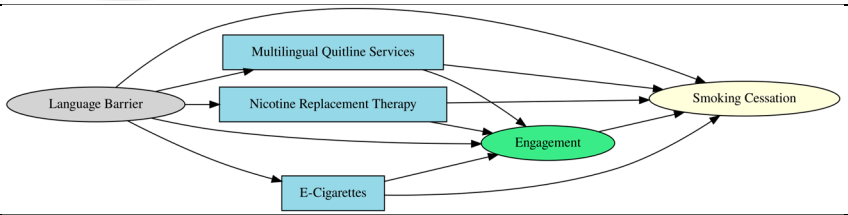

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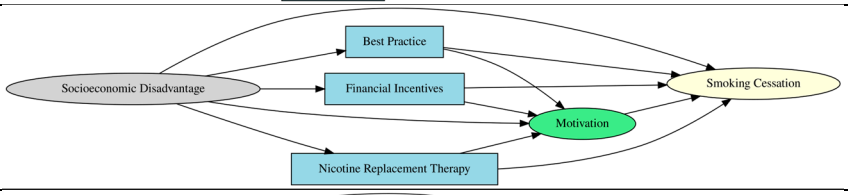

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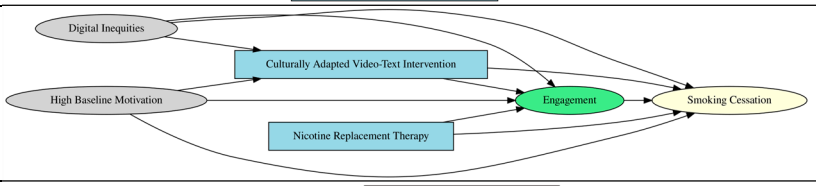

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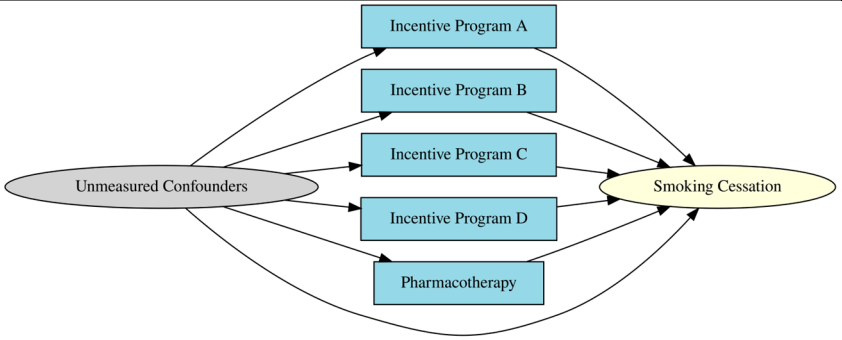

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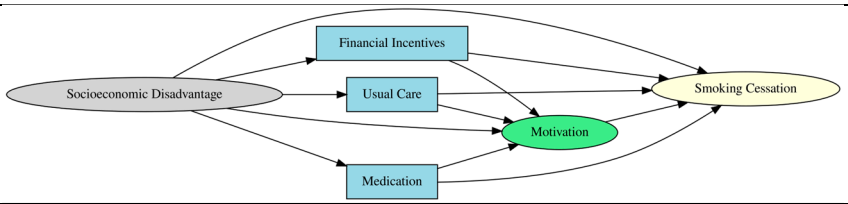

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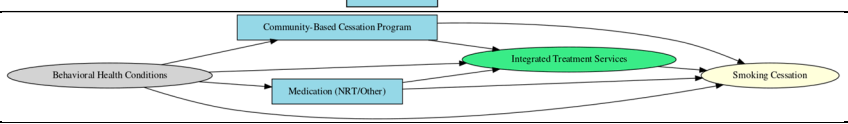

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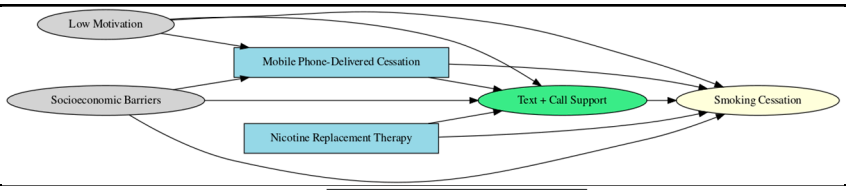

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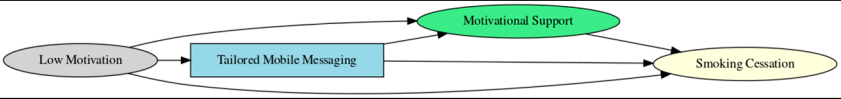

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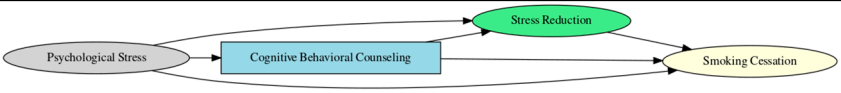

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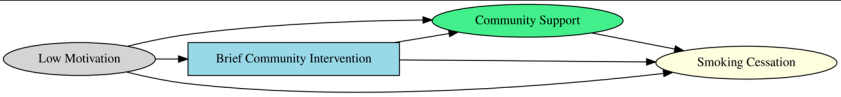

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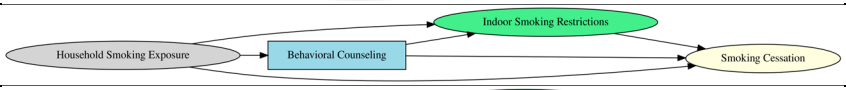

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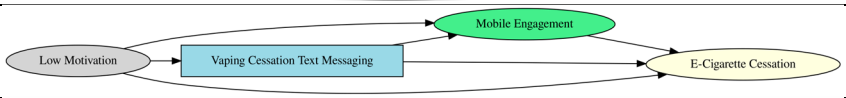

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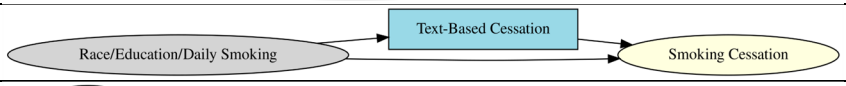

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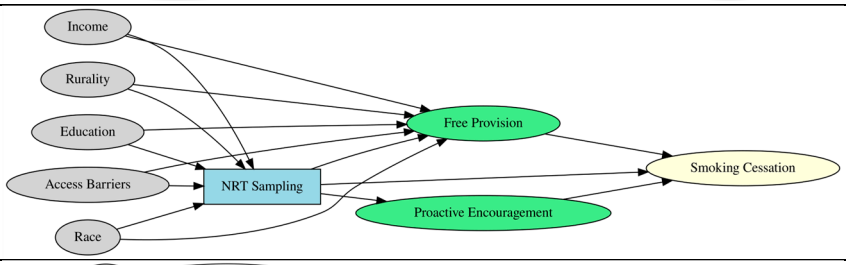

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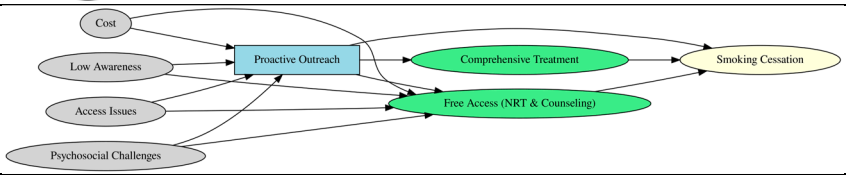

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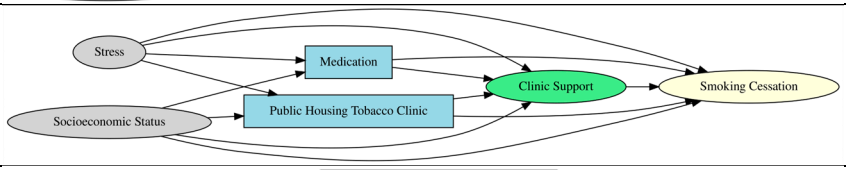

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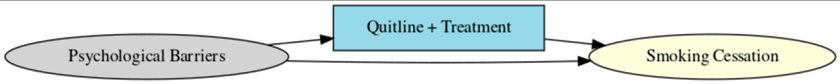

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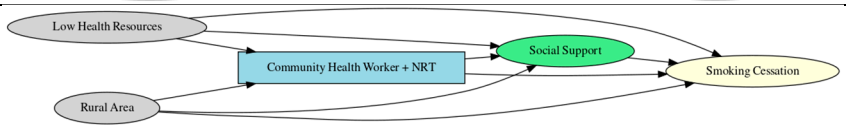

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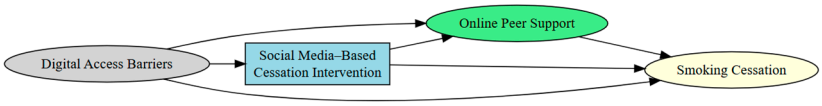

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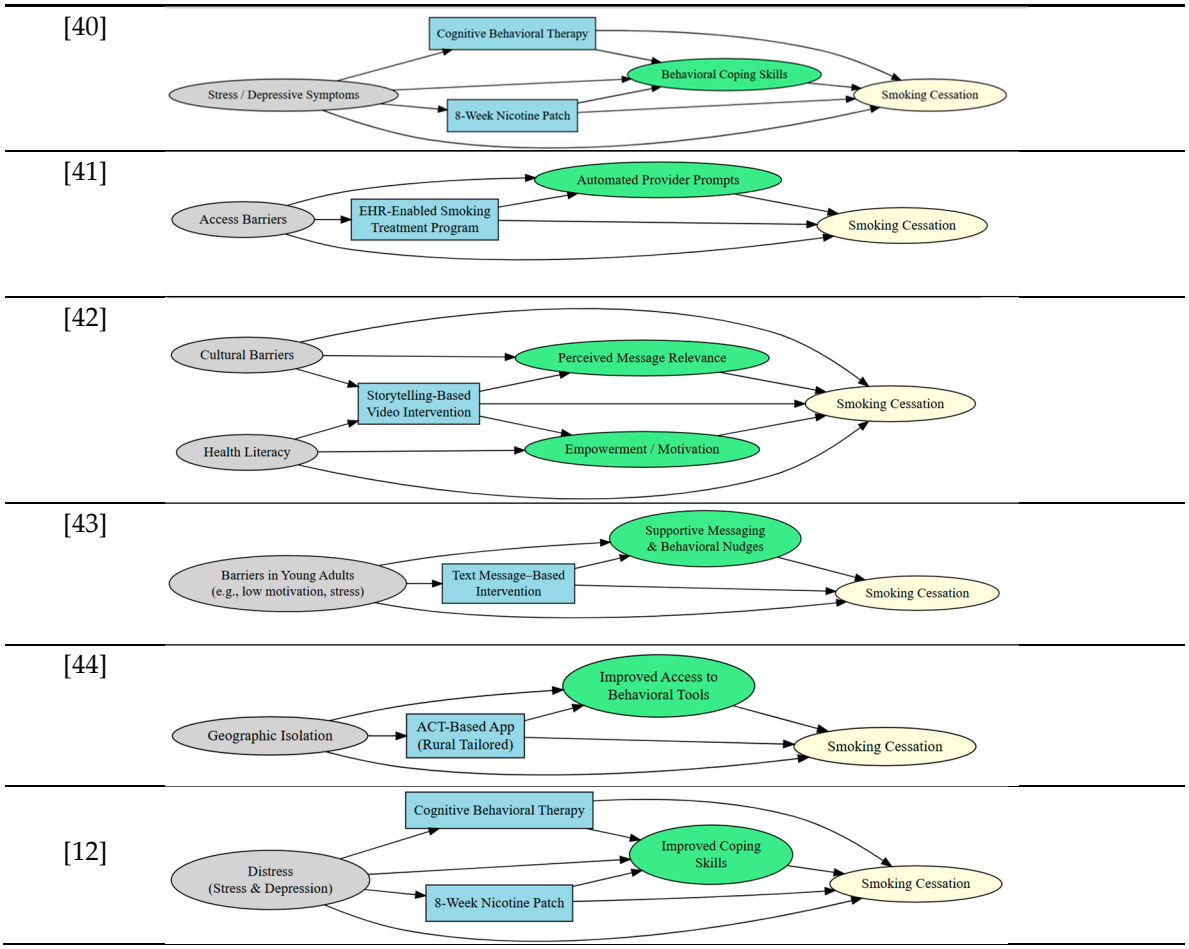

3.2. Translation Stage Synthesis

To reduce redundancy and allow for cross-study comparison, the extracted edges were consolidated into thematic constructs (Appendix A1 Table). Constructs, such as digital inequities, digital access barriers, and digital literacy barriers, were grouped under a broader category, namely digital access. The stage highlighted several consistent causal pathways. It included socioeconomic disadvantage and provider engagement. The socioeconomic disadvantage was linked to both reduced engagement with cessation interventions and lower improvement gains in cessation intervention success. Financial constraints, access barriers, and lower motivation served as mediators in the causal pathways. Provider engagement, identified as a facilitator, has been established by existing studies as a means to increase the receipt of cessation advice and successful quitting.

3.2. Integrated DAG

The integrated DAG, as depicted in Figure 1, illustrates how smoking cessation outcomes are influenced by the causal pathways originating from structural, psychosocial, and healthcare system factors. The socioeconomic disadvantage is established as a central key determinant. Factors such as lower income, lower educational attainment levels, and rural residence have been consistently linked to both reduced treatment access and lower engagement in healthcare access. These disadvantages directly affected smoking cessation outcomes as well as indirectly served as mediators of the pathway, i.e., financial constraints, limited digital access, and low motivation to quit. Additionally, psychological factors, i.e., stress, depression, and other minor mental health problems, were established to affect cessation outcomes through causal pathways. Several included studies established that interventions addressing these barriers, such as cognitive behavioral therapy, motivational support, or culturally tailored messages, could help mitigate the negative effects to some extent.

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Digital access is another important causal pathway, as studies have established that inadequate access to devices, internet connectivity, or digital literacy limits access to cessation interventions. At the healthcare system level, the causal pathway established that provider engagement, proactive outreach, and integrated EHR-enabled prompts were identified as key facilitators of smoking cessation intervention uptake. Overall, the DAG establishes that effective smoking cessation interventions are not just associated with a single factor, but with multiple factors, including structural determinants, individual readiness, resilience, and system-level support mechanisms. This emphasizes the need for a multicomponent intervention that can address barriers across these domains simultaneously.

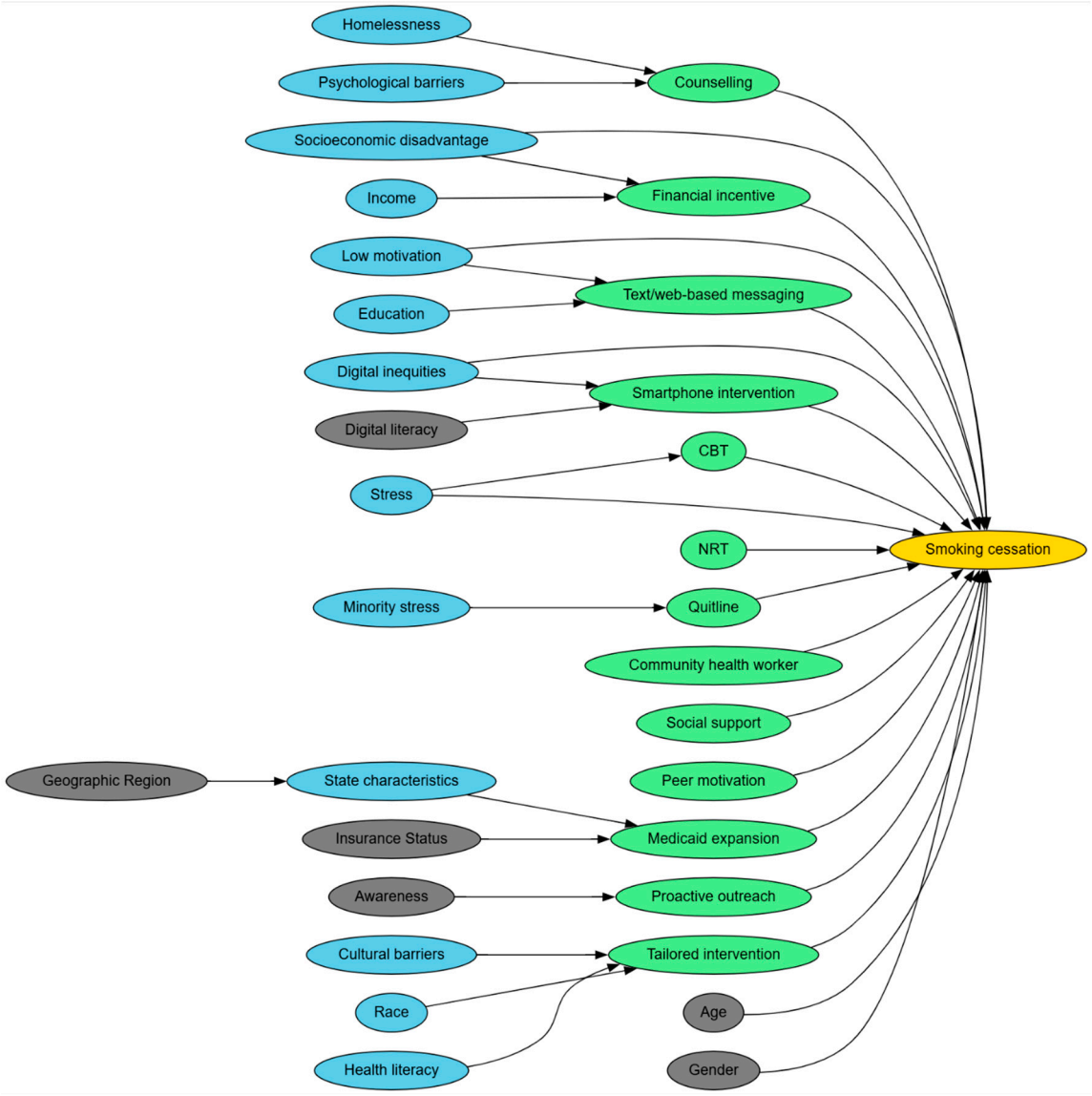

Figure 1. Integrated DAG Establishing Causal Pathways from Exposure to Outcome Nodes.

4. Discussion

4.1. Interpretation of DAG Structures

The integrated ESC-DAG establishes complex and multifactorial causal pathways that affect tobacco cessation intervention outcomes in the United States. One of the key identified barriers was structural, i.e., socioeconomic disadvantage, digital inequities, and rurality, which affected access to interventions. These factors affected both the direct cessation outcomes and indirect mediators, including motivation, engagement, and treatment adherence. One of the key identified facilitators

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was provider engagement, emphasizing that healthcare system interactions remain crucial for cessation success.

Some of the underexplored pathways, i.e., cultural tailoring, minority stress, and stigma, emphasize crucial gaps in existing evidence as only a few edges supported these domains from existing empirical studies.

4.2. Methodological Contributions

This study demonstrates the added value of the ESC-DAG methodology over traditional narrative or systematic reviews. By translating empirical evidence into a unified graphical model, we identified confounders, mediators, and moderators that are often overlooked in conventional statistical synthesis. Unlike meta-analysis, which emphasizes effect sizes, ESC-DAG enables researchers to map relationships across diverse study designs and uncover the underlying causal architecture. This methodological innovation is particularly valuable for complex behavioral and health services interventions, where context and interaction effects are critical.

4.3. Policy and Practice Implications

The integrated DAG provides insights for designing equity-focused and targeted cessation interventions. It encompasses digital equity, socio-economic support, provider engagement, and cultural tailoring, which reinforces the need for multi-level interventions addressing not only individual motivation but also other systemic barriers to healthcare access.

The integrated DAG could be utilized to guide confounder adjustment in observational studies of tobacco cessation interventions by applying DAG-informed simulation models to predict the potential impact of scaling specific strategies. It could guide the design of tailored digital platforms that account for motivation levels, literacy, and socio-economic context.

5. Conclusions

This study extends the methodological application of ESC-DAG to tobacco cessation research, synthesizing evidence from 35 studies into a unified causal framework. The integrated DAG highlights the central role of structural inequities, digital access, and provider engagement in shaping cessation outcomes.

By visualizing these relationships, our analysis demonstrates how DAGs can inform statistical modeling, guide intervention design, and prioritize equity-oriented policy solutions. Future research should build on this framework through simulation studies, quasi-experimental evaluations, and longitudinal designs to test targeted strategies for reducing disparities in cessation uptake.

Author Contributions: Conceptualization, S.S. and N.P.; methodology, N.P., S.S, J.I.; software, N.P; validation S.S., J.I., and N.P; formal analysis, S.S., N.P. J.I.; investigation, S.S., J.I., N.P; resources, writing—original draft preparation, N.P., S.S. ; writing—review and editing, N.P., S.S., J.I.; visualization, N.P., S.S., J.I. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: Not applicable as a review study of secondary data where no human subjects were involved.

Informed Consent Statement: Not applicable.

Data Availability Statement: No new data was generated.

Conflicts of Interest: The authors declare no conflicts of interest.

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Appendix A

Appendix A.1

Table A1. Translation stage results of included studies.

Study citation number	Edge originates	Edge terminates	Bi directional
23	Homelessness	Smoking cessation	No
	Homelessness	Financial incentive	No
	Homelessness	NRT	No
	Homelessness	Motivation	No
	Homelessness	Counselling	No
	Financial incentive	Smoking cessation	No
	Financial incentive	Motivation	No
	NRT	Smoking cessation	No
	NRT	Motivation	No
	Counselling	Smoking cessation	No
	Counselling	Motivation	No
12	State characteristics	Smoking cessation	No
	State characteristics	Expanded treatment coverage	No
	State characteristics	ACA medicaid expansion policy	No
	Pre-expansion insurance coverage	ACA medicaid expansion policy	No
	Pre-expansion insurance coverage	Expanded treatment coverage	No
	Pre-expansion insurance coverage	Smoking cessation	No
	ACA medicaid expansion policy	Expanded treatment coverage	No
	ACA medicaid expansion policy	Smoking cessation	No
	Expanded treatment coverage	Smoking cessation	No
31	Digital Access	Smoking cessation	No
	Digital Access	Self paced engagement	No
	Digital Access	ACT based smartphone app	No
	Digital Access	Standard smartphone app	No
	Motivation variability	Smoking cessation	No
	Motivation variability	Self paced engagement	No
	Motivation variability	ACT based smartphone app	No
	Motivation variability	Standard smartphone app	No
	ACT based smartphone app	Smoking cessation	No
	ACT based smartphone app	Self paced engagement	No
	ACT based smartphone app	Behavioral support	No
	Standard smartphone app	Smoking cessation	No
	Standard smartphone app	Self paced engagement	No
	Standard smartphone app	Behavioral support	No
8	Socioeconomic disadvantage	Smoking cessation	No
	Socioeconomic disadvantage	Social support	No
	Socioeconomic disadvantage	Community led cessation	No

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	Socioeconomic disadvantage	Peer motivation	No
	Community led cessation	Smoking cessation	No
	Community led cessation	Social support	No
	Community led cessation	Peer motivation	No
	Social support	Smoking cessation	No
	Peer motivation	Smoking cessation	No
24	Language barrier	Smoking cessation	No
	Language barrier	Multilingual quitline service	No
	Language barrier	NRT	No
	Language barrier	Engagement	No
	Language barrier	E-cigarettes	No
	Multilingual quitline service	Smoking cessation	No
	Multilingual quitline service	Engagement	No
	NRT	Smoking cessation	No
	NRT	Engagement	No
	E-cigarettes	Smoking cessation	No
	E-cigarettes	Engagement	No
	Engagement	Smoking cessation	No
36	Low motivation	Smoking cessation	No
	Low motivation	Brief community intervention	No
	Low motivation	Community support	No
	Brief community intervention	Community support	No
	Brief community intervention	Smoking cessation	No
	Community support	Smoking cessation	No
37	Household smoking exposure	Indoor smoking restrictions	No
	Household smoking exposure	Behavioral counselling	No
	Household smoking exposure	Smoking cessation	No
	Behavioral counselling	Indoor smoking restrictions	No
	Behavioral counselling	Smoking cessation	No
	Indoor smoking restrictions	Smoking cessation	No
40	Income	Free provision	No
	Income	NRT sampling	No
	Rurality	Free provision	No
	Rurality	NRT sampling	No
	Education	Free provision	No
	Education	NRT sampling	No
	Access Barriers	Free provision	No
	Access Barriers	NRT sampling	No
	Race	Free provision	No
	Race	NRT sampling	No
	NRT sampling	Free provision	No
	NRT sampling	Smoking cessation	No
	NRT sampling	Proactive encouragement	No

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	Free provision	Smoking cessation	No
	Proactive encouragement	Smoking cessation	No
41	Cost	Proactive outreach	No
	Cost	Free NRT and counselling access	No
	Low awareness	Proactive outreach	No
	Low awareness	Free NRT and counselling access	No
	Access issues	Proactive outreach	No
	Access issues	Free NRT and counselling access	No
	Psychosocial challenges	Proactive outreach	No
	Psychosocial challenges	Free NRT and counselling access	No
	Proactive outreach	Free NRT and counselling access	No
	Proactive outreach	Smoking cessation	No
	Proactive outreach	Comprehensive treatment	No
	Free NRT and counselling access	Smoking cessation	No
	Comprehensive treatment	Smoking cessation	No
42	Stress	Smoking cessation	No
	Stress	Clinic support	No
	Stress	Medication	No
	Stress	Public housing tobacco clinic	No
	Socioeconomic status	Smoking cessation	No
	Socioeconomic status	Clinic support	No
	Socioeconomic status	Medication	No
	Socioeconomic status	Public housing tobacco clinic	No
	Medication	Smoking cessation	No
	Medication	Clinic support	No
	Public housing tobacco clinic	Smoking cessation	No
	Public housing tobacco clinic	Clinic support	No
	Clinic support	Smoking cessation	No
38	Low Motivation	Mobile engagement	No
	Low Motivation	Vaping cessation text messaging	No
	Low Motivation	Smoking cessation	No
	Vaping cessation text messaging	Mobile engagement	No
	Vaping cessation text messaging	Smoking cessation	No
	Mobile engagement	Smoking cessation	No
27	Minority stress and stigma	Smoking cessation	No
	Minority stress and stigma	Web and text based intervention	No
	Web and text based intervention	Smoking cessation	No
33	Financial constraints	TTM tailored intervention	No
	Financial constraints	Motivation	No
	Financial constraints	Smoking cessation	No
	Mental illness	TTM tailored intervention	No
	Mental illness	Motivation	No
	Mental illness	Smoking cessation	No

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10	Socioeconomic disadvantage	Smoking cessation	No
	Socioeconomic disadvantage	Best practice	No
	Socioeconomic disadvantage	Financial incentive	No
	Socioeconomic disadvantage	NRT	No
	Socioeconomic disadvantage	Motivation	No
	Best practice	Motivation	No
	Best practice	Smoking cessation	No
	Financial incentive	Motivation	No
	Financial incentive	Smoking cessation	No
	NRT	Motivation	No
	NRT	Smoking cessation	No
	Motivation	Smoking cessation	No
25	Digital inequities	Culturally adapted video text intervention	No
	Digital inequities	Engagement	No
	Digital inequities	Smoking cessation	No
	High baseline motivation	Culturally adapted video text intervention	No
	High baseline motivation	Engagement	No
	High baseline motivation	Smoking cessation	No
	Culturally adapted video text intervention	Engagement	No
	Culturally adapted video text intervention	Smoking cessation	No
	NRT	Engagement	No
	NRT	Smoking cessation	No
	Engagement	Smoking cessation	No
26	Education	Smoking cessation	No
	Race	Smoking cessation	No
	Daily smoking	Smoking cessation	No
	Education	Text based cessation	No
	Race	Text based cessation	No
	Daily smoking	Text based cessation	No
39	Socioeconomic disadvantage	Smoking cessation	No
	Socioeconomic disadvantage	Financial incentive	No
	Socioeconomic disadvantage	Usual care	No
	Socioeconomic disadvantage	Motivation	No
	Socioeconomic disadvantage	Medication	No
	Financial incentive	Smoking cessation	No
	Usual care	Smoking cessation	No
	Medication	Smoking cessation	No
	Financial incentive	Motivation	No
	Usual care	Motivation	No

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	Medication	Motivation	No
	Motivation	Smoking cessation	No
28	Psychological barriers	Quitline plus treatment	No
	Psychological barriers	Smoking cessation	No
	Quitline plus treatment	Smoking cessation	No
44	Smartphone based financial incentive	Smoking cessation	No
	Incentive engagement	Smoking cessation	No
	Smartphone based financial incentive	Incentive engagement	No
11	Provider engagement	Cessation advice reciept	No
	Provider engagement	Smoking cessation	No
	Cessation advice reciept	Smoking cessation	No
43	Psychological stress	Smoking cessation	No
	Psychological stress	Cognitive behavioral counselling	No
	Psychological stress	Stress reduction	No
35	Low motivation	Motivational support	No
	Low motivation	Tailored mobile messaging	No
	Low motivation	Smoking cessation	No
	Tailored mobile messaging	Motivational support	No
	Tailored mobile messaging	Smoking cessation	No
	Motivational support	Smoking cessation	No
34	Behavioral health condition	Community based cessation program	No
	Behavioral health condition	Integrated treatment services	No
	Behavioral health condition	Medication(NRT/other)	No
	Behavioral health condition	Smoking cessation	No
	Community based cessation program	Integrated treatment services	No
	Medication(NRT/other)	Integrated treatment services	No
	Community based cessation program	Smoking cessation	No
	Medication(NRT/other)	Smoking cessation	No
	Integrated treatment services	Smoking cessation	No
29	Low motivation	Mobile phone delivered cessation	No
	Low motivation	Text plus call support	No
	Low motivation	Smoking cessation	No
	Socioeconomic barriers	Mobile phone delivered cessation	No
	Socioeconomic barriers	Text plus call support	No
	Socioeconomic barriers	Smoking cessation	No
	Mobile phone delivered cessation	Text plus call support	No
	Mobile phone delivered cessation	Smoking cessation	No
	NRT	Text plus call support	No
	NRT	Smoking cessation	No
	Text plus call support	Smoking cessation	No
30	Digital literacy barriers	Personalized engagement	No
	Digital literacy barriers	Tailored text and web intervention	No
	Digital literacy barriers	Smoking cessation	No

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	Tailored text and web intervention	Personalized engagement	No
	Tailored text and web intervention	Smoking cessation	No
	Personalized engagement	Smoking cessation	No
32	Low health resource	Community health worker plus NRT	No
	Low health resource	Social support	No
	Low health resource	Smoking cessation	No
	Rurality	Community health worker plus NRT	No
	Rurality	Social support	No
	Rurality	Smoking cessation	No
	Community health worker plus NRT	Social support	No
	Community health worker plus NRT	Smoking cessation	No
	Social support	Smoking cessation	No
45	Digital access barriers	Social media based cessation intervention	No
	Digital access barriers	Online peer support	No
	Digital access barriers	Smoking cessation	No
	Social media based cessation intervention	Online peer support	No
	Social media based cessation intervention	Smoking cessation	No
	Online peer support	Smoking cessation	No
9	Stress	CBT	No
	Stress	Behavioral coping skills	No
	Stress	8 week nicotine patch	No
	Stress	Smoking cessation	No
	Depressive symptoms	CBT	No
	Depressive symptoms	Behavioral coping skills	No
	Depressive symptoms	8 week nicotine patch	No
	Depressive symptoms	Smoking cessation	No
	CBT	Behavioral coping skills	No
	CBT	Smoking cessation	No
	8 week nicotine patch	Behavioral coping skills	No
	8 week nicotine patch	Smoking cessation	No
	Behavioral coping skills	Smoking cessation	No
46	Access barriers	EHR enabled smoking treatment program	No
	Access barriers	Automated provider prompts	No
	Access barriers	Smoking cessation	No
	EHR enabled smoking treatment program	Automated provider prompts	No
	EHR enabled smoking treatment program	Smoking cessation	No
	Automated provider prompts	Smoking cessation	No

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47	Cultural barriers	Smoking cessation	No
	Cultural barriers	Percieved message relevance	No
	Cultural barriers	Storytelling based video intervention	No
	Health literacy	Smoking cessation	No
	Health literacy	Storytelling based video intervention	No
	Health literacy	Motivation	No
	Storytelling based video intervention	Smoking cessation	No
	Storytelling based video intervention	Percieved message relevance	No
	Storytelling based video intervention	Motivation	No
	Percieved message relevance	Smoking cessation	No
	Motivation	Smoking cessation	No
14	Stress	Supportive messaging and behavioral nudges	No
	Stress	Text based cessation	No
	Stress	Smoking cessation	No
	Low motivation	Supportive messaging and behavioral nudges	No
	Low motivation	Text based cessation	No
	Low motivation	Smoking cessation	No
	Text based cessation	Supportive messaging and behavioral nudges	No
	Text based cessation	Smoking cessation	No
	Supportive messaging and behavioral nudges	Smoking cessation	No
13	Cultural barriers	Acceptance of sensations, emotions, and thoughts	No
	Cultural barriers	ACT based indigenous tailored app	No
	Cultural barriers	Smoking cessation	No
	ACT based indigenous tailored app	Acceptance of sensations, emotions, and thoughts	No
	ACT based indigenous tailored app	Smoking cessation	No
	Acceptance of sensations, emotions, and thoughts	Smoking cessation	No
48	Geographic isolation	Improved access to behaviorla tools	No
	Geographic isolation	ACT based rural tailored app	No
	Geographic isolation	Smoking cessation	No
	ACT based rural tailored app	Improved access to behaviorla tools	No
	ACT based rural tailored app	Smoking cessation	No
	Improved access to behaviorla tools	Smoking cessation	No
49	Depression and stress	CBT	No
	Depression and stress	Improved coping skills	No
	Depression and stress	8 week nicotine patch	No
	Depression and stress	Smoking cessation	No

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	CBT	Improved coping skills	No
	8 week nicotine patch	Improved coping skills	No
	CBT	Smoking cessation	No
	8 week nicotine patch	Smoking cessation	No
	Improved coping skills	Smoking cessation	No

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