Nutrition-Based STEM Education in Community Public Libraries Promotes Science Learning: A Pilot Study

ARTICLE

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ABSTRACT

This pilot study examined perceived science learning and attitudes of youth participants (N=100) in a four-lesson, hands-on, nutrition-based STEM (science, technology, engineering, and mathematics) education backpack program offered for children in kindergarten through eighth grade at a public library in rural Appalachian Mississippi. Using a constructivist theoretical framework, our team developed the program and implemented it via drive-through distribution. Science kits included all materials, supplies, and books; postage-paid evaluation postcards; and shelf-stable lunches and snacks meeting USDA summer meal guidelines. Twenty-three of 100 youth participants (23% response rate) returned at least one evaluation postcard. Participants were primarily female (65%), non-Hispanic (90%), White (90%), and in kindergarten through second grade (54.5%). The majority of youth "agreed" or "super-agreed" with the following: I learned about science from the activity (94.2%); I liked doing the science activity (94.3%); I liked reading the related book (90.4%); I had fun completing the activity (98.1%); I would recommend the activity to others (94.2%); I would do the activity again (93.3%). Learning about science was positively correlated with most factors measured, including recommending an activity to others (Tau-b=0.471, p<.001). Liking the science lesson activity had the strongest positive correlation with recommending an activity (Tau-b=0.792, p<.001). Both pre- and post-program, participants perceived the library as "a good place to find science information and activities," with more than 85% of participants "agreeing" or "super-agreeing" with the statement. Hands-on, nutrition-based STEM education promotes perceived science-learning and positive attitudes toward science, warranting their further development for and implementation in public libraries across Mississippi to promote both science-learning and pursuit of science and health careers.

KEYWORDS

public library, STEM education, science learning, science, nutrition

Science, technology, engineering, and mathematics (STEM) education for youth takes place across time in a variety of settings where learning occurs (NAEYC, 2021). Schools, colleges, and universities are considered formal learning environments, whereas informal learning environments can include any setting such as clubs, youth programs, city parks, waterways, forests, deserts, zoos, aquariums, museums, and public libraries (Tawfk, Gatewood,

Armstrong, & Shepherd, 2022; Xia, Bentley, Fan, & Tai, 2024). Although both formal and informal science learning opportunities are vital for children, up to 95% of lifetime science learning occurs in informal settings (NAEYC, 2021).

Public libraries serve as long-standing locations for informal education for children from elementary school through high school. Rather than simply being portals for information access, public libraries provide opportunities for children to interact with information in meaningful ways (Tawfk et al., 2022). As community hubs embedded in diverse communities, public libraries have been cited as ideal locations for expanding informal science education (ISE) and promoting science equity—that is, equal opportunities for patrons to learn science and engage in scientific practices regardless of background or circumstances (Shtivelband, Roberts, & Jakubowski, 2016; Tawfk et al., 2022). In addition to tangible learning resources, public libraries have valuable human resources—staff and volunteers, who can serve as inspiration and role models for children (National Research Council, 2015; Shtivelband et al., 2016).

High-quality ISE programs typically implement a three-pronged approach by combing three complementary strands: discovery, exploration, and pursuit. The discovery strand introduces learners to discipline-specific topics and facilitates practice of basic scientific principles. Discovery engages learners in confidence-building activities and develops relationships among community members—students, staffers, parents, teachers, and scientists. Introducing science education at a young age is especially vital (Shtivelband et al., 2016). Next, the exploration strand promotes use of inquiry-based methods to develop learners' critical-thinking, collaboration, and public-speaking skills. Exploration empowers learners to articulate their interests and develop science-minded identities. Finally, the pursuit strand underscores the possibilities of STEM career paths. Additional research is needed to clarify the magnitude of science education's influence on students choosing STEM careers, but as learners gain skills and experience in science engagement, their likelihood of pursuing science-based careers increases (Shtivelband et al., 2016).

A constructivist theoretical framework complements the three-pronged discovery, exploration, and pursuit approach to ISE encouraged by Shtivelband and colleagues (2016). As summarized by McLeod (2025), a constructivist theoretical framework is a learner-centered approach, which facilitates deeper learning by relating new ideas to—and promoting active knowledge construction around—prior experiences and frameworks. This approach allows learners to interpret and understand new knowledge from the context of their existing worldview. As such, the learner's perspective, interests, and cultural background shape the learning process.

Nutrition science presents a uniquely engaging and connective opportunity. Since children interact with food every day, they are exposed daily to scientific concepts. Further, nutrition education can empower children to make food choices for chronic disease prevention (Centers for Disease Control and Prevention, 2023). Therefore, implementing ISE through a nutrition science lens in public libraries leverages opportunities not only for improved science achievement but also for improved health of primary school students—now and in the future.

As well as providing ideal ISE environments and potential bridges to improving science inequities, public libraries are potential key collaborators for public health education and promotion (Lenstra & McGehee, 2022; Lenstra & Roberts, 2023; Tawfk et al., 2022). Lenstra and McGehee interviewed 59 public library partners in 18 communities within 16 states across the United States, as part of a larger study on how public librarians work with or include community partners to promote healthful eating and active living. The community partners

included local nonprofits, public health departments, parks and recreation agencies, and K–12 schools. Community partners participating in the study self-identified as being actively involved in public health initiatives. Findings indicate that librarians are generally viewed as trusted connectors, community experts, and professionals who share goals with public health partners. Public health partners tend to perceive librarians as those who can help increase reach and create opportunities for new voices to be heard in community planning. Further, Lenstra and McGehee stressed that forming coalitions and bringing librarians to the planning table are vital for successful public health programming in public libraries.

As a first step toward developing a comprehensive nutrition-based STEM program for public libraries, this pilot study examined perceived science learning and attitudes of schoolchildren participating in a four-lesson, nutrition-based STEM education backpack program developed in collaboration with public library staffers and offered at a public library in rural Appalachian Mississippi.

Methods

Setting and Intervention

The setting for the informal science education (ISE) program was a community public library in the Southern United States (rural Appalachian Mississippi). The library is situated in an economically at-risk (Appalachian Regional Commission, 2025), rural (Economic Research Service, 2025) Appalachian county with a population of 12,754 (U.S. Census Bureau, 2024). The population is 51.4% female, with 21.9% younger than 18 years and 21.2% at or older than 65 years of age. Overall, 6.6% are Hispanic, 29.4% are Black, and 69.3% are White. Finally, 79% of residents have a high school education or higher, and 17.5% live in poverty.

Using a constructivist theoretical framework (McLeod, 2025), the research team in collaboration with public library staff developed a four-lesson, take-home backpack for youth in kindergarten through eighth grade, in keeping with recommendations from Lenstra and McGehee (2022). Prior to implementation, lessons were piloted at the library, evaluated, and revised according to youth feedback. Student participants completed brief satisfaction surveys with 98.7% (unpublished data, 2021) and 92.3% (Tarr & Holben, 2019) of youth reporting high satisfaction with the program and its lessons. Survey questions were based on a 5-point Likert scale—"super agree," "agree," "kind of agree," "do not agree," "really do not agree"—supplemented with smiley faces to enhance response judgment of youth respondents (Arsiwala, Afroz, Kordy, Naujoks, & Patalano, 2021). Likert scales are used to rate the degree to which respondents agree or disagree with a survey statement (Sullivan & Artino, 2013).

Prior to distribution of the backpacks, library staff promoted the ISE program as part of the summer programming marketing campaign, which included flyers, posters, and social media. A drive-through distribution of backpacks was organized at the rural public library, as part of its summer reading program. The take-home, nutrition-based backpack science kits included all necessary STEM materials, supplies, and books; postage-paid evaluation postcards; and shelf-stable lunches and snacks meeting U.S. Department of Agriculture (USDA, 2025) summer meal menu guidelines.

USDA's child nutrition programs include the National School Lunch Program, School Breakfast Program, Child and Adult Care Food Program, Summer Food Service Program (SFSP), and Afterschool Snack Service. These programs help ensure children receive nutritious meals and snacks that promote health and educational readiness. During summer months, when most

schools do not provide full classroom instruction, SFSP provides free meals to children through eligible organizations, including public libraries, schools, camps, parks, playgrounds, community centers, churches, and other sites. Generally, the sites operate in areas where half or more of the children served are from families with incomes at or below 185% of the federal poverty level. Meals and snacks must meet USDA summer meal menu nutrition guidelines (USDA, 2025).

Four self-contained science kits in each backpack provided lesson objectives, instructional materials, and all supplies for the learning activities, including children's books related to the topics. The four science kit lessons were as follows: Growing Peanuts and Beans, Making Butter, Popping Corn, and Sprouting Spuds. As an example, for Growing Peanuts and Beans, after reading a narrative (fiction) book and two informational (nonfiction) books related to the topic, youth grew beans and peanuts in small containers at home to observe how a seed changes throughout its life cycle. Books, seeds, and containers were provided in the packs. Youth observed germination and growth of the plants and recorded observations in a journal provided.

Evaluation and Statistical Analysis

Students evaluated each of the four lessons in the program, using prepaid postcards to measure perceived science learning and attitudes from the following statements: I would recommend this activity to others; I liked reading the book; I liked doing the science activity; The science I learned was related to the book; I learned about science; It was fun to complete the activity; I could easily do the science activity; I would do an activity like this again. A 5-point smiley-face Likert scale was utilized with anchors of "super agree" and "really do not agree" (Arsiwala et al., 2021; Sullivan & Artino, 2013).

Prepaid seven-item evaluation postcards were utilized for students' pre- and post-evaluations of the entire program. Statements on the pre- and post-evaluation were as follows: I think science is cool; Science is fun; I like to do science experiments; My family likes science; My family likes to do science experiments at home; I like to learn science with my family; The library is a good place to find science information and activities. Evaluation statements used the aforementioned 5-point smiley-face Likert scale.

IBM SPSS Statistics software (Version 26) was used to tabulate and summarize all data (e.g., frequency and percentage) on perceived science learning and attitudes as follows: for each science kit lesson, for all science kit lessons as a group, and at points pre- and post-program. To assess for possible relationships between individual backpack lesson responses and selected outcomes by respondents, two-sided correlation coefficients (Kendall's Tau-b) were computed (Laerd Statistics, n.d., a). Kendall's Tau-b measures the strength and direction of association between two variables. A p value less than .05 was considered to be significant.

Results

One hundred youth participated in the hands-on, nutrition-based STEM education program, with 23 of 100 youth participants returning at least one evaluation postcard (23% response rate). Table 1 summarizes respondents' characteristics.

During the course of the ISE program, 16 youth completed an evaluation for Growing Peanuts and Beans, 15 completed one for Making Butter, nine completed Popping Corn, and 12 completed Sprouting Spuds. Due to poor response rates for all four individual lesson kits, evaluations were merged, yielding 52 responses.

Table 2 summarizes overall views of participants for all backpack lessons. Overall, the majority of youth reported that they learned about science from the activities, liked doing the science activities and reading the related books, had fun completing the activities, and would recommend the activities to others and do the activities again.

Survey responses were used as a proxy for determining respondents' favorite science lesson kit of the four-lesson program. Though all lesson kits had favorable ratings (83.3% or greater), only the Growing Peanuts and Beans lesson had ratings at or above 93.8% for each statement, based on the percentage of youth agreeing or super-agreeing to the following: I would recommend this activity to others (n = 16/16, 100%); I liked reading the book (n = 15/16, 93.8%); I liked doing the science activity (n = 16/16, 100%); The science I learned was related to the book (n = 15/16, 93.8%); I learned about science (n = 15/16, 93.8%); It was fun to complete the activity (n = 16/16, 100%); I could easily do the science activity (n = 15/16, 93.8%); I would do an activity like this again (n = 16/16, 100%).

Since students' learning about science is the primary goal of our program, correlations were computed for the relationship of "I learned about science" to the other statements. Learning about science was moderately positively correlated with all items measured, with the exception of "I could easily do the science activity," as follows: I would recommend this activity to others (Tau-b = 0.471, $p < .001$); I liked reading the book (Tau-b = 0.395, $p = .003$); I liked doing the science activity (Tau-b = 0.415, $p = .002$); The science I learned was related to the book (Tau-b = 0.425, $p < .001$); It was fun to complete the activity (Tau-b = 0.382, $p = .005$); I would do an activity like this again (Tau-b = 0.466, $p < .001$).

Since "I would recommend this activity to others" was the greatest factor correlated with learning about science, correlations of the other statements to "I would recommend this activity" were also computed. "I liked doing the science activity" had the strongest positive correlation (Tau-b = 0.792, $p < .001$).

Table 1

Characteristics of Responding Participants in a Nutrition-Based STEM Education Backpack Program

Characteristic	Frequency (Percentage)					
Gender (*n* = 20)	Boy (male)			Girl (female)		
	7 (35%)			13 (65%)		
Race (*n* = 20)	White			Black		
	18 (90%)			2 (10%)		
Ethnicity (*n* = 20)	Hispanic			Non-Hispanic		
	2 (10%)			18 (90%)		
Grade completed in school (*n* = 22)	Kinder-garten	First grade	Second grade	Third grade	Fourth grade	Eighth grade
	6 (27.3%)	5 (22.7%)	1 (4.5%)	2 (9.1%)	7 (31.8%)	1 (4.5%)

Table 3 summarizes pre- and post-program evaluation results for respondents. Although the number of respondents was small, most participants perceived the library as "a good place to find science information and activities," with more than 85% agreeing or super-agreeing at points pre- and post-program. Because only four of 22 respondents completed both pre- and post-program evaluations, and the response rates at pre- (n = 15) and post-program (n = 7) were small, differences in program evaluation items were not assessed from pre- to post-program among respondents (Laerd Statistics, n.d., b; Lial, Hungerford, Holcomb, & Mullins, 2021; Wadhwa & Marappa-Ganeshan, 2023).

Table 2

Evaluation Results of Respondents for Lesson Kits of a Nutrition-based STEM Education Backpack

Evaluation Statement	Frequency (Percentage)				
	Super agree	Agree	Kind of agree	Do not agree	Really do not agree
I would recommend this activity to others. (*n* = 52)	32 (61.5%)	17 (32.7%)	3 (5.8%)	0 (0%)	0 (0%)
I liked reading the book. (*n* = 52)	24 (46.2%)	23 (44.2%)	1 (1.9%)	0 (0%)	4 (7.7%)
I liked doing the science activity. (*n* = 52)	33 (63.5%)	16 (30.8%)	2 (3.8%)	0 (0%)	1 (1.9%)
The science I learned was related to the book. (*n* = 52)	23 (44.2%)	21 (40.4%)	6 (11.5%)	2 (3.8%)	0 (0%)
I learned about science. (*n* = 52)	26 (50%)	23 (44.2%)	3 (5.8%)	0 (0%)	0 (0%)
It was fun to complete the activity. (*n* = 52)	37 (71.2%)	14 (26.9%)	1 (1.9%)	0 (0%)	0 (0%)
I could easily do the science activity. (*n* = 52)	31 (59.6%)	18 (34.6%)	2 (3.8%)	1 (1.9%)	0 (0%)
I would do an activity like this again. (*n* = 52)	31 (59.6%)	17 (32.7%)	3 (5.8%)	0 (0%)	1 (1.9%)

Note. A 5-point Likert scale supplemented with smiley faces to enhance the youth's response judgment was used to rate to what degree respondents agreed or disagreed with the evaluation statement (Arsiwala et al., 2021; Sullivan & Artino, 2013).

Table 3

Pre- and Post-Program Evaluation Results of Responding Participants for a Nutrition-Based STEM Education Backpack Program

Evaluation Statement	Frequency (Percentage)				
	Super agree	Agree	Kind of agree	Do not agree	Really do not agree
I think science is cool.					
Pre-program (*n* = 15)	9 (60.0)	4 (26.7)	1 (6.7)	1 (6.7)	0 (0.0)
Post-program (*n* = 7)	7 (100%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Science is fun.					
Pre-program (*n* = 15)	11 (73.3)	3 (20.0)	0 (0.0)	1 (6.7)	0 (0.0)
Post-program (*n* = 7)	7 (100%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
I like to do science experiments.					
Pre-program (*n* = 15)	10 (66.7)	4 (26.7)	1 (6.7)	0 (0.0)	0 (0.0)
Post-program (*n* = 7)	7 (100%)	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
My family likes science.					
Pre-program (*n* = 15)	7 (46.7)	6 (40.0)	2 (13.3)	0 (0.0)	0 (0.0)
Post-program (*n* = 7)	4 (57.1)	2 (28.6)	1 (14.3)	0 (0.0)	0 (0.0)
My family likes to do science experiments at home.					
Pre-program (*n* = 15)	4 (26.7)	9 (60.0)	2 (13.3)	0 (0.0)	0 (0.0)
Post-program (*n* = 7)	4 (57.1)	3 (42.9)	0 (0.0)	0 (0.0)	0 (0.0)
I like to learn science with my family.					
Pre-program (*n* = 15)	9 (60.0)	4 (26.7)	1 (6.7)	1 (6.7)	0 (0.0)
Post-program (*n* = 7)	5 (71.4)	2 (28.6)	0 (0.0)	0 (0.0)	0 (0.0)
The library is a good place to find science information and activities.					
Pre-program (*n* = 15)	9 (60.0)	4 (26.7)	1 (6.7)	1 (6.7)	0 (0.0)
Post-program (*n* = 7)	6 (85.7)	0 (0.0)	0 (0.0)	1 (14.3)	0 (0.0)

Note. A 5-point Likert scale, supplemented with smiley faces to enhance response judgment of youth respondents, was used to rate the degree to which respondents agreed or disagreed with each evaluation statement (Arsiwala et al., 2021; Sullivan & Artino, 2013).

Discussion

As a first step toward developing a comprehensive nutrition-based STEM program for public libraries, this pilot study examined perceived science learning and attitudes of schoolchildren participating in a four-lesson nutrition-based STEM education backpack program developed in collaboration with public library staff and offered at a public library in the rural, Southern United States—in Appalachian Mississippi.

Public Libraries: Key Locations for Informal Science Education Related to Health Education and Promotion

Overall, this pilot study confirms perceived science learning and attitudes significantly improved for schoolchildren participating in a hands-on, nutrition-based STEM education backpack program. The pilot study results confirm previous assertions that public libraries are key locations for informal science education (ISE) for children (Shtivelband et al., 2016; Tawfk et al., 2022). Based on the positive evaluation results for youths' perceptions of and attitudes toward science learning, our program proved to be an effective collaboration with a Southern public library (rural Appalachian Mississippi) for health education and promotion. As other programs are developed for and implemented in public libraries, expanding measurement to the views of public library staff members, as well as parents and caregivers, may also be beneficial. Ultimately, involving public library staff and parents would likely bolster the "discovery" aspect of ISE programming, further engaging learners in activities that build confidence in science and strengthening relationships among community members (Shtivelband et al., 2016).

Overall, these findings support the work of Lenstra and McGehee (2022), confirming the importance of community organizations, public health agencies, schools, and others forming coalitions with librarians and bringing them to the planning table for public health programming in public library settings. The findings also confirm the efficacy of using a learner-centered constructivist framework (McLeod, 2025); combining discovery, exploration, and pursuit in developing programs (Shtivelband et al., 2016); and forming coalitions to effectively collaborate with public libraries for health education and promotion (Lenstra & McGehee, 2022; Lenstra & Roberts, 2023; Tawfk et al., 2022).

Although participants were not necessarily representative of the overall child population in Appalachian Mississippi, our study results support the concept that youth enjoy combining children's literature with hands-on, nutrition-based science activities. Furthermore, our findings indicate that introducing learners to discipline-specific topics by way of fun, learner-centered, hands-on activities is paramount to youth engagement in activities that build confidence by relating new ideas to prior experiences and frameworks (McLeod, 2025; Shtivelband et al., 2016).

Larger-scale studies are needed to identify differences in science learning and attitudes between boys and girls, as well as for other demographic traits (e.g., learner's race, or rural versus urban). Similarly, larger-scale studies can perhaps better assess ISE's impact on science learning and attitudes from pre- to post-program. Our results support the notion that the most engaged participants (i.e., those returning both pre- and post-program surveys) trust libraries to deliver science information and activities, find science to be "fun," and enjoy engaging in science alongside family. As ISE programs are developed for and implemented in public libraries, engaging youth, their families, and other community members via hands-on science learning appears to be vital for programmatic success.

Closing the Science Achievement Gap, and Improving Science Learning and Attitudes of Children by Way of Informal Science Education

A primary motivation for developing our nutrition-based STEM program was a desire to address the science achievement gap, particularly that in rural, low-income areas like Appalachian Mississippi. Research indicates early exposure to STEM can significantly influence career choices, but disparities persist, especially among underserved groups (Morgan et al., 2016).

Morgan et al. (2016) explored factors and mechanisms underlying science achievement gaps in U.S. elementary and middle schools, using a longitudinal sample of 7,757 children. By third grade, student disparities exist and persist

through at least eighth grade. Morgan et al. concluded that modifiable factors, such as reading achievement and literacy, should be addressed by way of education. To close the science achievement gap, they suggested multifaceted intervention efforts (e.g., science coupled with reading) using outside-the-classroom ISE. The National Academies of Science, Engineering, and Medicine (2022), too, advocate integration of science into language arts. Blending science content and literacy gives students purpose to guide their reading and opens up a host of learning activities to advance science literacy (Marohn, 2023).

While we are not able to quantify the backpack program's impact on students' science achievement, 94.2% of youth in our program "super agreed" or "agreed" that they learned something about science from the backpack kit activities. Our multifaceted program blending science and reading literacy supports the aforementioned programming suggestions (Marohn, 2023; Morgan et al., 2016; National Academies, 2022) and has the potential to contribute to closing the science achievement gap. Our program was implemented in an economically at-risk, rural Appalachian county in Mississippi, highlighting the potential role of ISE in bridging the science achievement gap in similar settings.

Generally, Appalachian Mississippi is characterized by high rates of poverty and limited access to affordable, nutritious food. This context underscores the relevance of nutrition-based STEM education in a rural Appalachian community, and it is conceivable that similar communities could benefit from such programs. By teaching youth the underpinnings of life science related to plants, growing food, and the role of nutrition in overall health, the program dually addresses educational and practical needs. This hands-on, nutrition-based ISE program was initiated in response to findings from Sandha and Holben (2022), who investigated the perceptions of youth in regard to the summer food environment by using photovoice methodology during a four-week summer food education program similar to our backpack program. Participating youth indicated an improved food environment—availability of and access to a more healthful, affordable food supply—was needed in their community. Youth specifically cited gardening as a solution for those needs, leading to more robust, hands-on, nutrition-based ISE in the public library. Addressing needs and problems identified by community members appears to be vital to successful programming. Further exploration of the intersection of science education and food security is needed. Providing summer meals as part of the backpack lesson kits improved access to food and illustrates the potential for public libraries to provide meals and snacks during summer reading programs via federally funded summer meal programs (USDA, 2025). Providing snacks with after-school programming should also be considered.

Conclusion

Our hands-on, nutrition-based ISE backpack program improves perceived science learning and attitudes of schoolchildren. This pilot study on the efficacy of a take-home ISE program is only the first step toward developing a comprehensive hands-on, nutrition-based STEM program in collaboration with and for public libraries. An expanded, evidence-based ISE program is needed for implementation across Mississippi public libraries to better impact science achievement of youth. With success across Mississippi, this type of programming has the potential for successful implementation also in similar communities.

These results support hands-on, nutrition-based STEM education to promote perceived science learning and positive attitudes toward science, warranting further development and implementation of such science kits for public libraries across Mississippi. These kits have the potential to promote science

learning as well as pursuit of science and health careers among youth. Future iterations should include a broader range of nutrition topics, such as food sustainability and composting, and apply the life science concepts of plants and animals to healthful eating principles for people. Additionally, involving community members—especially family, parents, caregivers, and public library staff—in program design and implementation could increase cultural relevance and community buy-in. Further research should examine the long-term influence of such programs on health behaviors and STEM career aspirations. Finally, empowering public library staff to deliver the programming through professional development will be prudent, as to expand program reach.

Science literacy among U.S. children buoys their understanding of the natural world, opens a gateway for them to pursue scientific careers, and prepares them to address challenging issues in their communities and across the nation. It also offers them foundational scientific principles to apply to many facets of their lives, including health (U.S. Department of Education, 2019). Making an accessible, effective education system, including ISE, more broadly available to U.S. children at an early age through public libraries could promote not only elevated science literacy but also good health. Specifically, implementing ISE through a nutrition science lens in public libraries leverages opportunities for greater science achievement and improved health.

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Ethics Approval

This study was approved by the University of Mississippi Institutional Review Board as exempt under 45 CFR 46.101(b) for categories 1 and 2.

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