education sciences

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Improving Student Success through Supplemental Instruction in an Anatomy and Physiology Laboratory

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Abstract: Anatomy and physiology courses have been identified as a major barrier to the persistence and graduation of undergraduate students seeking careers in the health professions. This break in the health profession's educational pipeline may have implications for perpetuating racial/ethnic educational attainment disparities that further health disparities through a lack of representation in healthcare providers. Although Supplemental Instruction (SI) is a well-developed, evidence-based program for improving student success, it has traditionally been used primarily in lecture-based courses. In addition, much of the literature on peer-assisted learning in anatomy and physiology focuses on medical school students. Therefore, it is difficult to extrapolate the effectiveness of SI on freshman and sophomore undergraduate students in a laboratory-based course. Here, we describe the expansion of our SI program, in conjunction with a complete curricular redesign, to address student success in an undergraduate gateway anatomy and physiology laboratory. Students who participated in the SI laboratory sessions held outside of instructor-led class time were significantly more likely to be high performers in the course, and there were no students who participated in SI sessions who earned a final course grade below a C. In addition, students expressed high satisfaction with the SI program and indicated that SI leaders provided both content and emotional support. In conclusion, SI is a valuable program to address student success in a laboratory-based course, particularly when integrated thoughtfully and intentionally with other evidence-based best practices in curriculum.

Keywords: Hispanic-serving institution; laboratory curriculum redesign; health professions; peer-assisted learning; STEM; historically underrepresented; diversity; equity; inclusion; persistence

Citation: Ellison, I.; Esser, F.; Walsh, J.; Lucio, C.; Toglia, J. Improving Student Success through Supplemental Instruction in an Anatomy and Physiology Laboratory. *Educ. Sci.* **2023**, *13*, 1153. https://doi.org/10.3390/educsci13111153

Academic Editor: David Arendale

Received: 26 August 2023
Revised: 10 November 2023
Accepted: 14 November 2023
Published: 17 November 2023

1. Introduction

Across the United States, anatomy and physiology courses too often act as gatekeepers preventing students from pursing their goals to work in healthcare fields [1,2]. Indeed, at Mercy University (formerly College), the largest private, federally designated Hispanic-serving institution (HSI) in New York state, anatomy and physiology courses have been identified as the primary obstacle to persistence in health profession majors. This barrier in foundational coursework plays a key role in lower graduation rates across the United States and has implications for perpetuating racial/ethnic educational attainment disparities that in turn further health disparities through a lack of representation in healthcare providers [3–6]. This long-standing barrier has only been further heightened by the COVID-19 pandemic's impact on and trauma response to learning [7,8]. Indeed in 2022, the Human Anatomy and Physiology Society (HAPS) reported that the majority of nursing students needed to repeat their anatomy and physiology courses [9].

Supplemental Instruction (SI) is an evidence-based and well-established student learning support model that has been demonstrated to be effective at improving student success as measured by course performance outcomes, especially for under-represented minority groups [10]. Indeed, SI was first implemented to address student success in response to

rapid changes in demographics and course preparation [11]. Broadly, SI is correlated with higher mean grades, lower failure and withdrawal rates, and higher retention and graduation rates in undergraduate courses [12]. Although SI programs have been demonstrated to be effective in a variety of undergraduate science, technology, engineering, and math (STEM) courses, these findings are typically limited to lecture-based courses [13–15]. In addition, there are limited references to peer-assisted learning in the context of laboratories associated with selected science courses such as chemistry and physics [16,17]. In the specific area of anatomy and physiology, the majority of literature on near-peer teaching has been focused on medical schools and graduate-level professional schools, thus limiting generalizability to undergraduate students who are in their freshman or sophomore years when this course is typically mapped to student degree progression in the health professions at the undergraduate level [18,19].

Given the impact of undergraduate anatomy and physiology on the retention and graduation rates of health profession students, numerous strategies to improve student learning in anatomy and physiology have been explored. Often, the predictors of success are areas which may be beyond the control of the student and/or the influence of the undergraduate faculty and which may unduly impact historically underrepresented students such as improved prior preparation and limiting workload outside of the course [20]. One area in which faculty can directly impact student success is the delivery of course content and a focus on pedagogical practices that support student learning. Indeed, there is evidence to suggest that when anatomy and physiology instructors reframe their courses with a focus on active learning, including inquiry-based pedagogies, student engagement and performance are improved [21]. In addition, there is limited evidence that students who participate specifically in SI sessions associated with anatomy and physiology lectures have improved scores on summative assessments [22,23].

At Mercy University, Anatomy and Physiology is a high-enrollment two-semester course, with Anatomy and Physiology 1, which consists of both lecture and laboratory courses, focusing on foundational concepts at the molecular, cellular, and tissue levels, as well as an introduction to the integumentary, musculoskeletal, and nervous systems. Students that enter these classes are often underprepared, with many students not having engaged with biology and chemistry courses, foundational to student success in anatomy and physiology, for several years, often since early in their high school experiences (in New York State, the Regents curriculum suggests biology as a course for 9th-grade students and chemistry as a course for 10th-grade students), if at all. Students may initially underestimate the amount of time needed outside of class time to dedicate to studying, reading, and practicing problems in order to be successful. In addition, they may be unaware and/or lack regular practice in the specific study skills needed to be successful in a high-content-volume, fast-paced, gateway science course. This may lead students to quickly become overwhelmed or stressed and to lack confidence in their ability to succeed. The Anatomy and Physiology laboratories at Mercy University were structured traditionally, utilizing fetal pig and cat dissections. However, dissection took valuable time away from learning, and students often destroyed key structures during dissection. In addition, students often did not make connections between fundamental anatomy and physiology concepts and their future health science careers.

In response to plummeting student success, our Anatomy and Physiology 1 Laboratory curriculum underwent a complete transformation into an inquiry-based, multi-modal model. To help students become more engaged with the material, we embraced a station-based approach integrated with technology and clinical cases that transformed the lab into a relaxed, supportive, and interactive learning environment. Laboratory content was subdivided into approximately four different activities or modules within each lab. Students spent approximately thirty minutes at each station and collaborated together in small groups to complete worksheets and activities. Traditional undergraduate fetal pig or cat dissections were eliminated, and instead, the use of the Anatomage table as part of a rotating station was incorporated into our model. The Anatomage table is a 3D human

anatomy visualization and virtual human dissection tool. Anatomy is presented as a fully interactive, life-sized touch screen experience, in operatory bed form to provide students with the opportunity to visualize anatomy exactly as they would on a fresh cadaver. In addition, laboratory experiences were embedded within clinical contexts to help students connect their learning to real-life health-related problems and conditions to enhance the meaningfulness and generalization of their lab experiences.

Given prior challenges in student success coupled with the transformation to a highly interactive pedagogical model, our students needed additional support in the laboratory. Although SI has traditionally been exclusively implemented as a lecture-based course support and we have previously reported on the successful implementation of SI in our Anatomy and Physiology 1 lecture, we wanted to expand our SI program by integrating it into our laboratory setting as we felt this support was essential to the success of the students in lab [24]. We piloted our SI program in the Anatomy and Physiology 1 Laboratory where SI sessions provide a structured, low-stakes opportunity for students to practice laboratory skills and concepts, to develop study skills, and to forge and fortify connections with near-peer mentors and peers.

A key element of SI is the utilization of near-peer SI leaders, which we termed Learning Fellows in our model. In a traditional anatomy and physiology laboratory, the use of laboratory teaching assistants who support the instructor's teaching experience has been well established [25]. However, in our model, SI leaders focus on supporting the student's learning experience. In addition to leading lab SI sessions where they facilitate student learning outside of instructor-led class time, which has previously been demonstrated to be a successful student support in undergraduate anatomy and physiology laboratories, they also support students during the instructor-led laboratory classroom sessions through interactive stations and lab activities [26]. Our near-peer SI leaders engage in extensive training both pre-semester and bi-weekly throughout the semester on multiple areas, including the various technologies utilized throughout the laboratory such as the Anatomage table, as well as training on methods to facilitate student learning, to manage behavioral challenges, and to further professional development. Both during instructor-led laboratory class time and in SI leader-led SI sessions, SI leaders were expected to follow best practices such as continuous engagement with students through various facilitation techniques that investigate understanding and practice recall, treating all students equitably and inclusively, being enthusiastic and relatable, and asking for assistance from the SI team leadership and/or from the instructor, when necessary [26].

One of the challenges at our HSI and at many institutions that have experienced rapidly changing demographics in their population is a lag in faculty representation mirroring student demographics. There are widespread implications for the impact that this can have on student success [27]. An additional benefit to our SI model is that our student SI leaders are representative of the general demographics of the university and the courses. Although neither a substitute nor an excuse for lagging faculty representation, SI leader representation is valuable nonetheless and provides students with real-time near-peer mentors who reflect them because they are them (or were just a few semesters prior).

In our study, we sought to determine the impact of SI and SI leaders on student success in a high-failure/high-withdrawal-rate laboratory course by expanding our existing SI program into the Anatomy and Physiology 1 Laboratory. Specifically, we examined (1) whether academic outcomes measured as course grades differed between students who attended SI sessions and those who did not attend SI sessions and (2) student perceptions of laboratory-based SI sessions and interactions with SI leaders.

2. Materials and Methods

2.1. Study Development

In Fall 2022 and Spring 2023, the Anatomy and Physiology 1 Laboratory underwent a complete curricular transformation at Mercy University. The new model was based on an inquiry-based, multi-modal, station-based pedagogical approach incorporating interactive

technologies such as the Anatomage table and the use of clinical cases to create a context for learning. To further support the success of the students, our existing SI program in the lectures was expanded to include SI in the laboratory. SI leaders were embedded in the instructor-led laboratory classroom, where they were tasked with supporting student learning as students rotated through various activity stations, as well as leading laboratory-based SI sessions outside of instructor-led class time.

SI leaders were near-peer students who had previously earned grades of B or better in the course. Leaders applied to the program and were then selected through an interview process by the leadership team of the SI program. SI leaders were compensated at an hourly rate in line with but slightly above the minimum wage in the New York metropolitan area.

SI leaders were trained in faculty-guided professional development workshops both prior to the start of and throughout the semester. In these workshops, SI leaders worked collaboratively to demonstrate their ability to organize and conduct the SI sessions.

2.2. Protocol

Two SI leaders were embedded in each section of instructor-led laboratory classroom sessions and were tasked with supporting student learning as students rotated in groups through the various activity stations each week throughout the semester. The laboratory classes met for approximately three hours each week of the fifteen-week semester for a total of approximately forty-five hours.

In addition, SI leaders also led twenty-nine structured laboratory-based SI sessions outside of instructor-led class time throughout the fifteen-week semester (no sessions were held during Spring Break). Sessions were offered between one to four times per week based upon curricular needs (with more frequent sessions held closer to major assessments) and SI leader availability. Consistency across all sections of SI laboratory sessions was ensured by SI leaders attending the same training sessions; working from a standardized common laboratory course curriculum; using similar active learning activities such as mock practical exams and virtual dissections developed under the oversight of faculty; and using the same relevant models, equipment, and technologies, such as projection microscopes and an Anatomage virtual dissection table.

SI sessions were voluntary and open to students from any of the six Anatomy and Physiology 1 Laboratory sections taught by 3 different instructors, i.e., SI sessions were not tied to specific instructor's laboratory sections. Student and SI leader attendance at SI sessions was collected in Spring 2023 through college identification card swipes at SI sessions. Student course performance and demographic data were obtained retrospectively in Summer 2023 from the Office of Institutional Research at Mercy College and merged with data about attendance at SI sessions.

An anonymous satisfaction survey on the laboratory experience was distributed to all Anatomy and Physiology 1 Laboratory students in Spring 2023 through Qualtrics. The survey included questions pertaining specifically to the student's experience interacting with laboratory-based SI session as well as with SI leaders.

In addition, anonymous student course evaluations were collected in Fall 2022 and Spring 2023. Comments were collected and analyzed for qualitative themes that emerged.

All studies were approved by the Institutional Review Board at Mercy University protocol numbers 22–54, initially on 28 June 2022. Informed consent was obtained from all subjects in the study, as detailed in the approved protocols.

2.3. Data Analysis

Data were analyzed with IBM SPSS Statistics (Version 25; IBM Corporation, Armonk, NY, USA). Descriptive statistics (frequency and percentages) were used to summarize student characteristics. Differences between categorical variables such as gender, major, ethnicity, commuter status, and income (above or below an estimated family contribution of 10,000) were analyzed with a chi-square test while differences between average grades was examined using a Mann–Whitney U test.

3. Results

In Spring 2023, the total number of students who enrolled in the Anatomy and Physiology 1 Laboratory was 97. Overall, the students who were enrolled in Anatomy and Physiology 1 Laboratory in Spring 2023 were predominantly Black, Indigenous, and People of Color (BIPOC) students (94%) represented primarily by Hispanic students (59%) (Table 1). In addition, the majority were from low-income households (78%), as defined as an estimated family contribution of less than USD 10,000; female (72%); commuter students (86%); and Health Science majors (70%).

Table 1. Dominant characteristics of students enrolled in Anatomy and Physiology 1 Laboratory (Spring 2023).

Demographic Category	Dominant Group (%)	Dominant Group (*n*)
BIPOC/White	BIPOC (94%)	BIPOC (n = 92/97)
Race/Ethnicity	Hispanic (59%)	Hispanic (n = 57/97)
Income Status	Low Income (78%)	Low Income (n = 76/97)
Gender	Female (72%)	Female (n = 70/97)
Commuter/Residential Status	Commuter (86%)	Commuter (n = 83/97)
Major	Health Science (70%)	Health Science (n = 68/97)
Age	<20 years (59%)	<20 years (n = 57/97)
Number of Credits	≤30 credits (49%)	≤30 credits (n = 48/97))

A total of 13 unique SI leaders were assigned to leading six laboratory sessions in Spring 2023; 23% (n = 3) of the SI leaders for lab were also SI leaders for Anatomy and Physiology 1 lectures. The demographics of the SI lab leaders were comparable to student demographics with SI leaders: predominantly BIPOC (85%) represented primarily by Hispanic students (54%), female (77%) and Health Science majors (54%).

Of those who were enrolled in the Anatomy and Physiology laboratories in Spring 2023, 27% (n = 26/97) participated in one or more SI sessions throughout the semester. The average number of sessions attended was 2.15 sessions (SD 1.6). Of those who attended SI sessions, 42% attended one session (n = 11), 31% attended two sessions (n = 8), 19% attended three sessions (n = 5) and 8% attended more than six sessions (n = 2).

An analysis of the demographic characteristics indicated that there were no significant differences in demographics between those who participated in SI sessions and those who did not participate in SI sessions in regard to race/ethnicity, income status, gender, commuter/residential status, and major.

Students who participated in one or more SI sessions were significantly more likely to earn a final course grade of B or better (p = 0.00). Indeed, there were no students who participated in SI sessions who earned a final course grade below a C, which is the minimum standard to successfully complete the course and to move on to the next course in the sequence. Comparatively, 10% of students who did not attend SI sessions earned a course grade below a C. While this is a significant difference, it should be noted that overall, our curricular transformation and simultaneous incorporation of SI and SI leaders into our program resulted in an approximate 30 percentage point improvement in student success rates in the course when compared with pre-COVID-19/pre-program implementation (Figure 1).

It is important to underscore that the demographic data of the students who enrolled in the course in Spring 2019 were similar to the demographic data of the students who enrolled in the course in Spring 2023 (Table 2). In addition, the sequencing of the course within the degree mapping of the majors remained unchanged during the time period from Spring 2019 to Spring 2023.

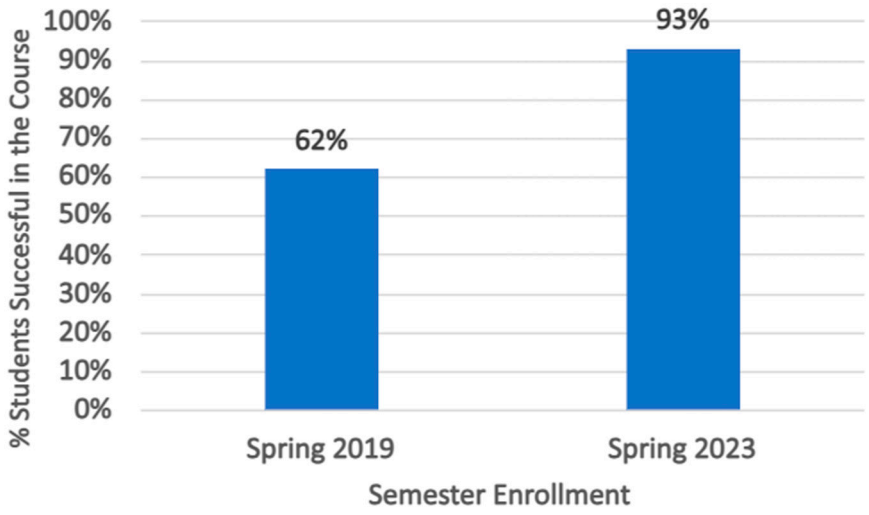

Figure 1. Improvements in student success compared with pre-program implementation.

Table 2. Dominant characteristics of students enrolled in Anatomy and Physiology 1 Laboratory (Spring 2019).

Demographic Category	Dominant Group (%)	Dominant Group (*n*)
BIPOC/White	BIPOC (88%)	BIPOC (*n* = 119/136)
Race/Ethnicity	Hispanic (42%)	Hispanic (*n* = 57/136)
Income Status	Low Income (75%)	Low Income (*n* = 102/136)
Gender	Female (79%)	Female (*n* = 107/136)
Commuter/Residential Status	Commuter (80%)	Commuter (*n* = 109/136)
Major	Health Science (66%)	Health Science (*n* = 90/136)
Age	≤20 years (52%)	≤20 years (71/136)
Number of Credits	<30 credits (*n* = 57%)	<30 credits (*n* = 74/136)

Student feedback was collected with an anonymous lab satisfaction survey. On a Likert Scale of 1–5, where 1 was equal to strongly disagree and 5 was equal to strongly agree, 38% of students (*n* = 37) responded to the perceived benefits of attending SI lab sessions. Students had a mean score of 4.22 (SD 0.99) in response to the statement "I was more prepared for the practical exam" as a result of participating in SI and a mean score of 4.35 (SD 1.10) in response to the statement "My knowledge and understanding of the lab material improved" as a result of participating in SI. Students were also asked about the impact of the SI leader contributing to their learning. Students had a mean score of 8.68 (SD 2.07) on a 1–10 Likert scale, where 1 was equal to did not contribute at all and 10 was equal to contributed a great deal.

Student feedback was also obtained from anonymous student course evaluations. In 66% of the course sections (*n* = 4/6), students made specific unsolicited references to the impact of SI and SI leaders in the comment section of the course evaluation. Students from 50% of the section (*n* = 3/6) spontaneously listed the SI program as the "most effective activity/aspect of the course." In analyzing the comments made by students, two major themes emerged in reference to the impact of the SI leaders: improved understanding/learning of the content and provision of emotional support. Examples of student quotes that reflect these themes are presented in Table 3.

Table 3. Themes and examples that emerged from student's qualitative responses.

Themes from Student Feedback	Examples of Student Quotes
Learning/Understanding	"My SI leader made it easier to understand concepts." "My SI leader played a big role in helping me have a high grade in this class." "SI leaders worked hard to help student understand the subject."
Emotional Support	"My SI Leader provides a huge support." "The SI leader helped to alleviate some of the stress I experienced as an SI student."

4. Discussion

As per the SI Program Accreditation Rubric, this pilot SI program in the Anatomy and Physiology 1 Laboratory exceeded the Level 2 requirement, meaning that 25% or more of the students participated in one or more SI sessions [28]. Given the nature of a pilot program and the voluntary basis for participation, we fully anticipate increased attendance in lab-based SI sessions moving forward, particularly given our outcomes that can be shared with students to demonstrate the effectiveness of participation in the program to improve their outcomes.

The results of our pilot study extend the benefits of SI for historically underrepresented students reported in the literature to laboratory-based SI sessions associated with undergraduate anatomy and physiology [10]. We found that laboratory-focused SI leaders in Anatomy and Physiology 1 supported student success in a myriad of ways, consistent with the findings of other studies that demonstrated the effectiveness of peer-assisted learning in laboratory settings in other disciplines [13–15]. Our data demonstrate that SI is an effective way of improving student course outcomes in a laboratory-based course setting, as measured by final course grades. Students who participated in the voluntary SI lab sessions received no course grades below a C (the minimum grade needed to successfully complete the course and to move on to the subsequent course in the sequence), nor did they withdraw from the course. In addition, students who participated were significantly more likely to achieve a high course grade (B or better) than their non-SI-attending counterparts. However, a larger sample size of students participating in SI sessions is needed to analyze subgroups and to investigate the effect of the number of open lab sessions attended or time spent on learning activities on final course grades as well as to compare benefits for high achieving students versus at-risk students.

The commonality of the demographics between those who attended SI and those who did not attend SI, support our findings that the differences in student outcomes between these two groups appear to be related to the impact of SI and not to demographic factors. However, there may be other factors that were not directly explored through this study that are represented by participation in SI attendance such as differences in student schedules which may permit additional time to dedicate to studying and assessment preparation apart from participation in SI sessions, which could also impact the student outcomes in the course.

The student response to SI sessions as well as to their SI leaders was overwhelmingly positive. In alignment with the course-grade-based data, students also perceived that the program improved their course learning and course performance, as evidenced by our survey results. Additionally, students perceived that their SI leaders provided emotional support, as evidenced by our analysis of qualitative student comments. The representation of student racial/ethnic demographics in our near-peer SI leaders may contribute to both student's qualitative perceived positive feelings in both content and emotional support of the SI leaders as well as to student's quantitative positive outcomes of the program on course outcomes as racial/ethnic representation of students in teacher roles has a positive impact on student achievement [10].

Given the worldwide impacts of the COVID-19 pandemic on student learning and student success, as well as the impacts on mental health particularly across higher education, with trends of higher stress and anxiety post-pandemic among college students, the themes that have emerged from students on the impacts of their leaders are particularly important [29]. Our pilot study suggests that in addition to examining objective academic outcomes and perceptions regarding increased knowledge or understanding of material, future studies need to investigate the impact of SI leaders on persistence and key non-academic student outcomes such as social–emotional factors including reduced stress, self-efficacy, or sense of belonging; perceptions of the classroom environment or learning atmosphere; and motivation.

While we recognize that SI played a crucial and significant role in supporting the success of the students, we also recognize that the simultaneous total curricular transformation of our lab in conjunction with the implementation of the SI program is likely where the true strength lies in the dramatic improvements in our course outcomes for all of our students pre- vs. post-program implementation. For this model, the outcomes are amplified by more than the simple sum of their means. The coordinated approach to integrate evidence-based student support thoughtfully and intentionally in conjunction with curricular redesign is an important and powerful message for those seeking to address student success in traditionally challenging gateway courses. Nowhere is this more important than in gateway science courses which act as barriers to retention and graduation and may contribute not only to ethnic/racial disparities in educational attainment but also to health disparities due to a lack of representation in the health professions.

Author Contributions: Conceptualization, I.E., J.W., F.E. and J.T.; Methodology, I.E. and J.T.; Validation, I.E. and J.T.; Formal Analysis, I.E. and J.T.; Investigation, C.L., F.E., I.E. and J.W.; Data curation, C.L., I.E. and J.T.; Writing—original draft preparation, I.E.; Writing—review and editing, F.E., J.W. and J.T.; Visualization, I.E., C.L. and J.T.; Supervision, J.T.; Project Administration, C.L., F.E., I.E. and J.T.; Funding Acquisition, I.E. and J.T. All authors have read and agreed to the published version of the manuscript.

Funding: This research was part of the Project: Advancing Curricular Change to Enhance Student Success (ACCESS) funded by the Title V Developing Hispanic-Serving Institutions Program, US Department of Education (Grant # P031S200074).

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board (or Ethics Committee) of MERCY UNIVERSITY (protocol code 22-54 initial approval date 28 June 2022).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The datasets used for this manuscript are not publicly available because it is still part of an active IRB research protocol. Requests to access the datasets should be directed to the corresponding author.

Acknowledgments: The authors are grateful for the generous support of and collaboration between the Mercy University School of Health and Natural Sciences, Center for Academic Enhancement and Innovation and Institutional Research. Special appreciation is extended to Amanda Bireline, Neal Mettler, Andres Botero, Nicholas Durso and Tatiana Pineiro for their continued dedication to supporting this project.

Conflicts of Interest: The authors declare no conflict of interest. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manu-script; or in the decision to publish the results.

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