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Academic Success of STEM College Students with Attention Deficit Hyperactivity Disorder and the Role of Classroom Teaching Practices: Project Update

Nolgie O. Oquendo-Colón, University of Michigan

Nolgie O. Oquendo-Colon is an Engineering Education Research PhD student at the University of Michigan. He holds a MS and BS in Industrial Engineering from the University of Puerto Rico at Mayaguez.

Laura Carroll, Purdue University at West Lafayette (COE)

Laura Carroll is a PhD candidate in Engineering Education Research at the University of Michigan. Laura's research interests are focused on academic success of neurodiverse STEM students, faculty development and change, and instructional barriers to imple

Dr. Cynthia J. Finelli, University of Michigan

Dr. Cynthia Finelli is Professor of Electrical Engineering and Computer Science, Professor of Education, and Director and Graduate Chair for Engineering Education Research Programs at University of Michigan. She is Fellow of both the ASEE and the Institute for Electrical and Electronics Engineers (IEEE), associate editor for the European Journal of Engineering Education, and member of the Governing Board of the Research in Engineering Education Network. She was previously chair of EECHA, chair of the ERM Division of ASEE, co-chair of the ASEE Committee on Scholarly Publications, deputy editor for the Journal of Engineering Education, and associate editor for IEEE Transactions on Education.

Dr. Finelli studies the academic success of students with attention-deficit/hyperactivity disorder (ADHD), social justice attitudes in engineering, and faculty adoption of evidence-based teaching practices. She also led a project to develop a taxonomy for the field of engineering education research, and she was part of a team that studied ethical decision-making in engineering students.

Academic Success of STEM College Students with Attention Deficit and Hyperactivity Disorder and the Role of Classroom Teaching Practices: Project Update

Abstract

This paper provides an update on our research exploring the college experience of science, technology, engineering, and math (STEM) college students with attention-deficit/ hyperactivity disorder (ADHD). Individuals with ADHD make up a growing fraction of college students. Despite their increasing college presence, little is known about their college experiences and academic success. This project involves three sequential studies guided by the social model of disability. Study 1 is a quantitative analysis investigating the relationship between pre-college factors, college experiences, and academic success of college students with ADHD. Study 2 is a scoping literature review of the college experiences of these students, and Study 3 is a qualitative, interview-based study focusing on the role of teaching practices as a precursor to academic success. The overarching goals of our project are to (1) understand the role of teaching practices on the academic success of students with ADHD and (2) disseminate actionable recommendations to higher education instructors and administrators. This paper provides an update on our first two studies.

1. Introduction

1.1. *Neurodiversity and ADHD*

Neurodiversity is "the idea that people experience and interact with the world around them in many different ways" [1]. Students with ADHD and/or other neurodiversities experience difficulties that neurotypical students do not [2]; thus, there is a need to study the challenges these students face in higher education. The population of students with neuro-diversities comprises 11% of college undergraduates in the U.S. [3].

One sector of the population of U.S. college undergraduates with neuro-diversities that has shown significant growth in the past few years is college students with ADHD. The percentage of incoming college students with ADHD has increased from 5.0% in 2010 to 7.4% in 2018 [4]. Higher education institutions are beginning to include students with ADHD in their efforts to support a diverse group of learners [5]. Even though higher education institutions have started to recognize the need to provide inclusive education, the college experiences of students with ADHD are still under-researched.

1.2. *ADHD, College Students, and STEM*

Despite their growing presence in college, little is known about the academic success of college students with ADHD, and even less is known about students with ADHD in STEM [6]. Individuals who have been diagnosed with ADHD exhibit inattention, impulsivity, and hyperactivity [7]. College students with ADHD can experience academic failure and underachievement [8], and they also face challenges with motivation, anxiety, time management, and general study skills [9]. Additionally, college students with ADHD often have more difficult

than their peers with executive functioning skills (i.e., time management, information processing, planning, and organization)—neurocognitive processes responsible for problem solving-behaviors and attention control—that have been shown to be required to achieve academic success [9], [10].

Although college students with ADHD face challenges, they also exhibit strengths which are considered "assets for STEM-related pursuits" [11]. Students with ADHD often have greater resiliency (i.e., adaptability in difficult circumstances) than students without ADHD [12], they tend to be more creative and innovative [13], and they exhibit divergent thinking [14]. Additionally, some are capable of achieving intense focus (hyper-focus) when engaging in high-interest activities and tasks [15], and they commonly identify other characteristics, such as high energy levels and courage, to be strengths [16].

In order to increase and improve student diversity at the college level and promote equitable classrooms, it is important include students with ADHD in studies about how to promote success. Stevens and coauthors (2020) suggested that classroom teaching practices may play a critical role in promoting the academic success of college students with ADHD – and though there is ample evidence demonstrating the positive effects of student-centered teaching practices (e.g., active learning [18], evidence-based practices [19], inquiry-based learning [20]) for undergraduates in general, there is little research about their impact on the learning, retention, and engagement of students with ADHD. Our project aims to fill this gap by studying the role of college experiences on the academic success of STEM students with ADHD.

1.3. Project overview

This project involves three sequential studies. Study 1 is a quantitative analysis investigating the relationship between pre-college factors, college experiences, and academic success of college students with ADHD. Study 2 is a scoping literature review of the college experiences of these students. Study 3 will focus on the role of teaching practices in the college experience as a precursor to academic success.
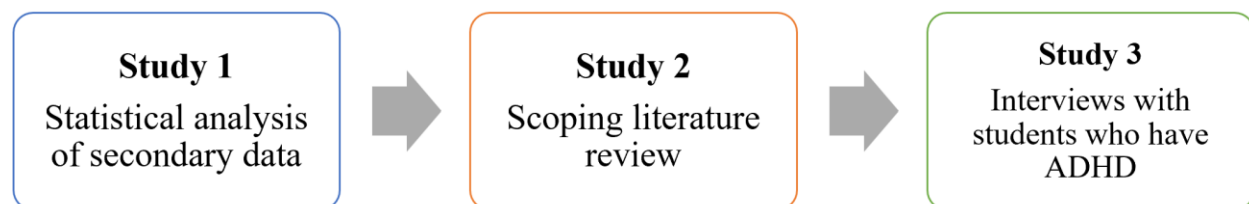

Figure 1. Research project studies.

2. Project Lens

The Social Model of Disability guides this study. This model, created by people with disabilities, supports the view that people who have disabilities face barriers resulting from the way the system and society operate, not resulting from the impairment itself [21], [22]. The Social Model of Disability model centers on identifying and removing systemic and environmental barriers

that affect people with disabilities. It differs from the medical model, which focuses on what people with disabilities are not able to do because of their impairment [22].

The Social Model of Disability emphasizes two reasons it is important to understand the college experiences of neurodivergent students, particularly students with ADHD. First, it will provide additional insight on equitable classrooms. An equitable classroom encourages students to engage, participate, and learn by identifying and removing barriers that hinder the academic success of those students. For example, studies have identified the impact of lecture length on student learning, finding that long-duration lectures (2 to 3 hours) are less effective for students' learning than shorter-duration lectures (10-15 minutes) with interspersed active learning[23]. This may be particularly true for students with ADHD, and designing shorter-duration lectures may result in a more inclusive classroom that supports a more diverse group of learners. The second reason it is important to understand the college experiences of students who have ADHD is as a framework to increase diversity. Previous studies have shown the benefits of having people from different backgrounds and life experiences in different settings, particularly academic and research settings. Understanding their experiences and designing learning environments to support them will likely recruit and retain more students with ADHD and will therefore increase diversity.

3. Conceptual Framework

To explore both the academic success of students with ADHD and elements of those studnets' collegiate experience, we developed a conceptual framework [24] based on Terenzini and Reason's [25] extension of Astin's Input-Environment-Output (I-E-O) college impact model [26]. The I-E-O model is a lens for studying students' college outcomes, and it theorizes that both inputs (e.g, demographic characteristics) and the environment (e.g., students' experiences in college) influence student outcomes. Expanding on that model, Terenzini and Reason proposed a model to account for multiple interrelated factors affecting student outcomes.

Our conceptual framework (shown in Figure 1) builds on Terenzini and Reason's model and posits that students' academic success is influenced by pre-college characteristics and experiences as well as the college experience (organizational context and individual student experience [24]. For our study of academic success, we include neurodiversity in pre-college characteristics and experiences, and we introduce other factors that may be particularly relevant for students with ADHD such as creativity, having close friends, and short-term motivation. Our framework also includes sociodemographic traits, prior academic preparation and performance, and student dispositions within precollege characteristics and experiences, it captures both the organizational and individual student experience within the college experience, and it encompasses conventional student outcomes such as academic achievement and student dispositions within academic success.
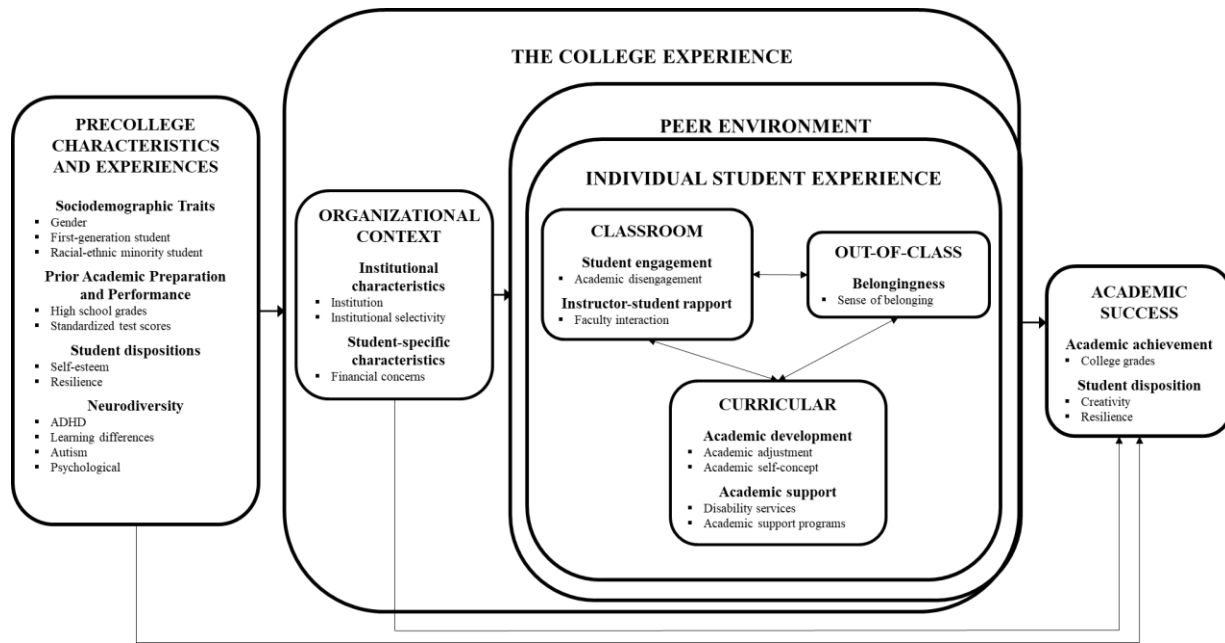
Figure 2. Our conceptual framework [22].

4. Study 1

This study is a quantitative analysis of a secondary, longitudinal dataset (comprising data from approximately 45,000 first-year students, including over 2,000 students with ADHD [24]). Our research question is: *How does the **college experience** mediate the relationship between **pre-college** student characteristics and experiences and **academic success** for students with and without ADHD?* To answer this Study 1 uses structural equation modeling and mediation analysis to investigate the relationships between pre-college factors, college experiences (i.e., academic adjustment, faculty interaction, and sense of belonging), and academic success of college students with ADHD.

Specifically, our Study 1 aims to understand the role of the college experience for a large number of college students with ADHD and will guide further exploration, by identifying aspects of the environment (i.e., the college experience) on which to focus future explorations for reducing systematic barriers for students with ADHD.

4.1. Data

To answer our research question, we use secondary data from the Higher Education Research Institute [27]. Our data is longitudinal and multi-institutional, and it is composed of responses from 45,915 undergraduate students who both (a) completed the Your First Year of College (YFCY) survey in 2011, 2013, 2015, and 2017, and (b) completed The Freshman Survey (TFS) during the previous year (i.e., 2010, 2012, 2014, and 2016) [24]. The matched YFCY/TFS Data includes 2,177 responses from students who report having previously been diagnosed with

ADHD, as indicated in Table 1. These students account for approximately 4.5% of incoming first year students in this data set. ADHD, as indicated in Table 1.

Table 1. Number (N) and percent of responses to survey item about previous ADHD diagnosis for Study 1.

YFCY year	College students (N=45,915)		
	without ADHD	with ADHD	unknown
2011	16,576 (90.8%)	768 (4.2%)	917 (5.0%)
2013	14,635 (92.5%)	668 (4.2%)	519 (3.3%)
2015	6,020 (88.1%)	335 (4.9%)	460 (6.7%)
2017	4,425 (88.6%)	291 (5.8%)	281 (5.6%)
Total	41,656 (90.7%)	2,082 (4.5%)	2,177 (4.7%)

4.2. Methods

We operationalize each component of our conceptual framework using HERI variables, as summarized in Table 2 and described previously [24]. To handle missing data, we use Stata's [29] "multiple imputation by chained" equations (MICE; StataCorp, 2021a). Multiple imputation fills in missing data through an analysis of other variable responses and a random draw from a distribution of estimated values [31]. In our case, we created 30 imputed data sets based on our analysis of this imputation process for our data and the recommendations of [32].

Following imputation, we use structural equation modeling to analyze our data [33], first considering theory and model fit and then conducting a mediation analysis, as shown in Figure 3 [24]. Structural equation modeling enables us to assess the direct path between the precollege characteristic of whether a student reports an ADHD diagnosis as an incoming college freshman and academic success, operationalized as first-year GPA.

4.3. Future Plans

We are currently completing the structural equation modeling and associated mediation analysis for two academic success variables, college grades a (i.e., first year GPA) and creativity. Preliminary findings suggest that specific college experiences have a greater influence on first-year GPA and that students with ADHD are more likely to self-report high levels of creativity. We also plan to conduct the analysis for resilience, a less-common measure of collegiate academic success that may be relevant for students who have ADHD.

Table 2. Model components, constructs, and survey items from the HERI instrument [32], [33].

Components and constructs of our model		Item(s) from the HERI instruments
Precollege characteristics & experiences		
Sociodemographic Traits	Gender	Gender of respondent; Survey choices: Female, Male
	First-generation student	Parent has a college degree
	Racial-ethnic minority student	Racial-ethnic minority student
Prior Academic Preparation and Performance	High school grades	High school grades
	Standardized test scores	ACT composite score; Reading SAT score; Math SAT score
Student Dispositions	Creativity	Creativity (self-rating)
	Resilience	Accepts mistakes as part of the learning process (self-rating)
Neurodiversity	ADHD	Student has ADHD
	Learning difference	Student has a learning difference
	Autism	Student has autism
	Psychological disorder	Student has a psychological disorder
The College Experience		
Organizational Context	Institutional characteristics	Institution; Institutional selectivity
	Student-specific characteristics	Financial concerns, incoming freshman; Financial concerns, end of first year
Individual Student Experience: Classroom	Instructor-student rapport (faculty interaction[1])	Interact with faculty outside of class or office hours; Asked a professor for advice after class; Communicated regularly with your professors; Amount of contact with faculty; Interact with faculty during office hours[2]
Individual Student Experience: Curricular	Academic development (academic adjustment[1])	Adjust to the academic demands of college; Develop effective study skills; Manage your time effectively; Understand what your professors expect of you academically[2]
Individual Student Experience: Out-of-class	Belongingness (sense of belonging[1])	Feel member of college; Sense of belonging to campus; Part of campus community; Recommend college to others[2]
Outcomes		
Academic Success	Academic achievement	First-year college grades
	Student dispositions	Creativity; Resilience

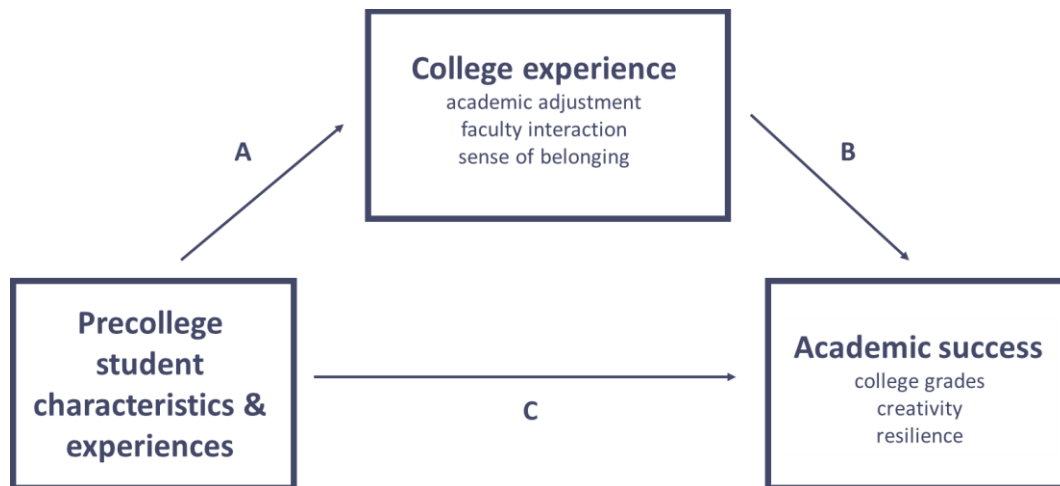Notes. [1]HERI construct [28]. [2]HERI construct items [28]. Adapted from [24]

Figure 3. Schematic of the mediation model [22].

5. Study 2

Our second study involves a scoping literature review about the role of college experiences on the academic success of STEM students with ADHD. This study is also informed by our conceptual framework (Figure 2). We are applying Arksey and O'Malley's (2005) framework as a guide for our Scoping Literature review, following the five steps they define: (1) identifying the research question, (2) identifying relevant studies, (3) selecting studies, (4) charting the data, and (5) collating, summarizing, and reporting the results. Our work aligns with two of the four reasons Arksey and O'Malley (2005) identify to conduct a scoping review: (1) to summarize and disseminate research findings and (2) to identify research gaps in the existing literature.

5.1. Step 1: Identifying the research question

The first step of the scoping literature review is identifying the research questions. For this project, we define three questions:

1. What is known about the academic adjustment and classroom experiences of college students with ADHD?
2. What are the gaps and opportunities in the literature about academic adjustments?
3. What approaches are being used to understand the academic adjustment and classroom experiences of college students with ADHD?

5.2. Step 2: Identifying relevant questions

The next step is identifying relevant studies to potentially include in the review. For our search, we selected seven databases in which to search for our studies: Scopus, Education Abstracts, Web of Science, Overton, Engineering Village, ERIC ProQuest, and IEEE Xplore. Using our conceptual framework (Figure 1) as a guide, we developed a search protocol with 17 total keywords in four categories: classroom (student engagement, academic disengagement, instructor-student rapport, and faculty interaction), out-of-class (belongingness and sense of belonging), curricular (academic development, academic adjustment, academic self-concept,

academic support, disability services, and academic support programs), and academic success (academic achievement, persistence, creativity, self-confidence, post-graduation plans). The resulting 17 search blocks then consisted of the population – ("college students") AND ("ADHD" OR "attention deficit and hyperactivity disorder") AND ("science, technology, engineering, and math" OR "STEM") – and the individual keyword (from the 17 listed previously) capturing the element of interest from the framework (e.g., "student engagement").

We conducted 17 searches in each of the seven databases following the same protocol. These searches yielded 3,493 studies stored on Rayyan, a systematic literature review software [34].

5.3. Step 3: Selecting studies

Step 3 is selecting studies that are relevant to our research questions. We started by identifying 904 duplicate studies from our original 3,493 and deleting them from our sample, leaving us with 2,589 possible studies. We then established inclusion and exclusion criteria to guide both our abstract screening and full-text screening processes.

The abstract screening process comprised one exclusion criterion for all studies based on medical intervention or malingered presentation or conducted on populations of people with ADHD other than college students (children, adults, adolescents). A total of 2,279 studies were eliminated from our sample based on the exclusion criteria, leaving 310 potential studies.

In addition, the abstract screening process used three inclusion criteria, guided by the following questions: 1) Does the abstract emphasize the college experiences or academic outcomes of college students with ADHD? (2) Does the abstract focus on academic adjustment and classroom experiences? (3) The study must be published in peer-reviewed journals or conference papers. A total of 236 studies were not included because they did not meet the inclusion criteria (41 did not meet the first inclusion criterion, 194 did not meet the second, and 1 did not meet the third). Thus, the abstract screening process yielded 74 studies (shown in Figure 4).

5.4. Future plans

Currently, we are engaged in full-text screening, and we are guided by four questions for inclusion: (1) Is this study focused on undergraduate college students? (2) Does the study discuss students' academic adjustment to college? (3) Does the study discuss students' classroom experiences? and (4) Was this article published in a peer-review journal? After we complete the full text screening, we will proceed with the last two steps of the framework – Step 4: charting the data (incorporating a numerical summary and a qualitative thematic analysis), and Step 5: collating, summarizing, and reporting the results (identifying the implications of the study findings for policy, practice or research).

6. Study 3

Study 3 involves in-depth interviews with STEM college students with ADHD to gain a more in-depth understanding of our results. We are currently drafting an interview protocol, based on preliminary results from Studies 1 and 2, and we will begin interviewing students after we complete those two studies.

Identification

Records identified through

| Scopus n = 975 | Engineering Village n = 105 | ERIC Pro n =463 | Web of Science n = 1,661 | Education Abstracts n = 219 | IEEE Xplore n = 4 | Overton. io n = 66 |

Screening

Records after duplicates removed: 2,589 → Duplicates removed: 904

Abstract screening: 2,589 → Records excluded by abstract screening: 2,515
- Medical symptoms, intervention, malingered presentation, other populations: 2,279
- College experience or academic outcomes: 41
- Academic adjustment or classroom experiences: 194
- Peer-reviewed journal or conference paper: 1

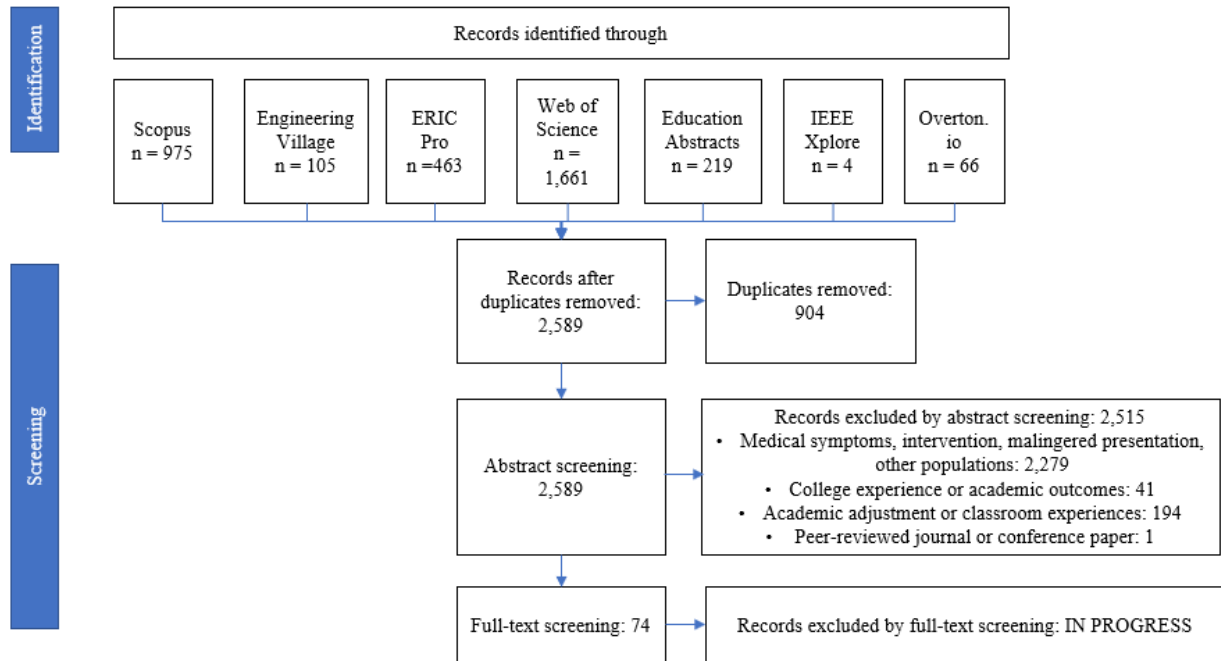Full-text screening: 74 → Records excluded by full-text screening: IN PROGRESS

Figure 4. Preferred Reporting Items for Systematic Reviews (PRISMA) flow diagram demonstrating the search and screening process of studies to be included in this review.

7. Acknowledgments

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