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Introduction to the 9th Global Issues Conference Special Edition

Władysław Chłopicki, Guest Editor

PANS University of Applied Sciences, Krosno, Poland

This special issue comprises the selected articles presented at the 9th Global Issues Conference—an international, student-led forum where students serve as primary authors and their faculty advisers as coauthors. The collection showcases rigorous inquiry across education, culture, technology, health governance, and sustainability, reflecting how emerging scholars are engaged and address global challenges with methodological diversity and contextual sensitivity.

Learning, well-being, and equity in education

We open with five contributions that examine how teaching and learning environments can better support resilience, inclusion, and fairness. “Assessing North Carolina Pre-K Teachers’ Knowledge, Confidence, and Experience on Trauma Informed Care” maps educators’ understanding and confidence in trauma-informed practices, pinpointing training needs to strengthen early childhood settings. “Trauma-Informed Teaching in Lebanon: Teacher Awareness and Preparedness” raises a timely issue of the level of teachers’ readiness to deal with their students’ traumas in the very special circumstances of Lebanon schools. “Investigating the Implementation of Cooperative Learning in Lebanese Private Schools and Its Impact on Students’ Academic Performance and Behavior” evaluates collaborative pedagogy as a lever for motivation, engagement, and achievement. Extending to higher education, “Navigating Anxiety and Uncertainty: International Students’ Challenges and Strategies to Cultural Adjustment” illuminates the adaptive strategies students employ to manage cultural distance and stress. Complementing these perspectives, “Gender Equality in Higher Education: A Comparative Study of Universities in Algeria, Poland, and North Macedonia” analyzes representation and institutional mechanisms, recommending concrete actions to advance Sustainable Development Goals 4 and 5 within universities.

Culture, media, and perception

Two articles probe how meaning is made and mobilized across public discourse and sensory experience. “Ghanaian Female Celebrities’ Digital Engagements as Rhetorical Feminism: A Rhetorical Analysis of Celebrity Instagram Rhetoric in Amplifying Unique Literacies” demonstrates how invitational rhetoric and transliteracy can galvanize civic awareness and amplify marginalized voices in social media spaces. In dialogue with cultural cognition, “Individual and Cultural Differences in Sound Perception: An Exploratory Study” broadens sound research beyond Western samples, revealing how culture, neurodivergence, and musical training shape cross-modal associations and therapeutic implications.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Technology and the future of work

In “Technology Industry Employees’ Consciousness and Readiness for AI and Automation in Taiwan,” the authors present mixed-methods evidence on preparedness gaps and training ambitions among tech workers. The findings underscore both the urgency and the opportunity for inclusive upskilling ecosystems that democratize access to AI tools and competencies.

Global health governance and equity

“The Great Drug Regulation Divide: How Resource Imbalance Is Strangling Global Health Equity” interrogates disparities in pharmaceutical regulatory capacity across income levels, arguing that the technical divide is, at root, a justice issue. The study’s policy recommendations—cooperation, capacity building, and digital enablement—offer pragmatic pathways to strengthen safety, quality, and access worldwide.

Energy transitions and climate-smart development

The issue concludes with two perspectives on sustainable growth anchored in regional realities. “The Role of Algeria in African & Global Energy Markets: Challenges & Opportunities for Local Economic Development” assesses hydrocarbon legacies alongside solar potential, framing a just transition that tangibly improves local livelihoods. “Cultivating Aloe Vera: An Economic and Environmental Asset in a Changing Climate” examines supply-chain vulnerabilities and proposes resilient cultivation models—positioning desert agriculture (including Algeria’s) as a strategic response to volatility and demand.

Taken together, these eleven articles exemplify student scholarship from four continents that is empirically grounded, globally aware, and solutions-oriented. They invite educators, policymakers, industry leaders, and civil society to engage with evidence-based practices that advance human well-being and planetary sustainability—while foregrounding the voices of the next generation of researchers who will inherit and reshape these debates.

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February 2026, Vol. 12, No. 1
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Assessing North Carolina Pre-K Teachers' Knowledge, Confidence, and Experience on Trauma Informed Care

Chalyne Barrow, Archana V. Hegde, Mary Cate Komoski, and Erin Roberts

East Carolina University, Greenville, NC, USA

Abstract

The purpose of this study was to assess NC Pre-K teachers' knowledge on trauma and trauma-informed practices, their confidence in actions with students who have experienced trauma, and training – received or desired by teachers – on trauma-informed care (TIC). Quantitative data was collected using a standardized Primary Early Childhood Educators Trauma-Informed Care Survey for Knowledge, Confidence, and Relationship Building scale (PECE-TICKCR, 2017). All participating NC Pre-K teachers (n=68) were females and had a 4-year degree in early childhood or another related field. Teachers' knowledge on trauma and their confidence in their own actions were highly correlated (r=.73). Similarly, mean scores indicated that teachers understand how trauma affects student behavior (M=3.93), and on the confidence scale teachers felt most confident in their ability to maintain positive relationships with students. However, teachers need more training on some items on the scale of knowledge (e.g. Community resources for families who have experienced trauma) and confidence (appropriate steps to be taken if a student has experienced trauma). Teachers who have experience working with children of trauma were more knowledgeable and confident in their actions related to TIC, compared to teachers with no experience. Teachers continue to express their interest in receiving more training on topics related to TIC.

Keywords: trauma-informed care, NC Pre-K teachers, teacher knowledge, teacher confidence, early childhood education, training need

Introduction

Trauma is defined as "an event, series of events, or set of circumstances experienced by an individual as physically or emotionally harmful or life-threatening with lasting adverse effects on the individual's functioning and mental, physical, social, emotional, or spiritual well-being" (Substance Abuse and Mental Health Administration [SAMHSA] , 2014, p. 7). Early trauma exposure can significantly impact children's socioemotional development, self-regulation, student-teacher relationships (Loomis & Mogro-Wilson, 2019), academic performance, and behavior (Jimenez et al., 2016).

In North Carolina, the prevalence of adverse childhood experiences (ACEs) has increased. In 2019, 26.4% of children had experienced at least one ACE, and 15.3% had experienced two or more (Parks & Gitterman, 2022). By 2022, about 40% had experienced at least one ACE, and 20% had experienced two or more. Exposures to ACEs are linked to internalizing and externalizing behaviors, social difficulties, and problems with play and attention (Liming & Grube, 2018). Such issues are especially concerning as children enter structured environments like school.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The quality of the learning environment depends on the skills and training teachers receive to support students' emotional and behavioral needs (Kelly et al., 2024). For early childhood educators (ECEs), trauma-informed care training helps manage challenging behaviors and fosters a supportive space for emotional and academic growth (Mortensen & Barnett, 2016). Addressing trauma early can create a ripple effect that benefits children, families, and educators.

Despite its importance, little research exists on how NC Pre-K teachers address trauma in their classrooms. To better support educators, especially in Eastern NC, a baseline understanding is needed. This study aims to assess NC Pre-K teachers' knowledge of trauma and trauma-informed practices, their confidence in supporting affected students, and the training they have received or still need.

Literature Review

Adverse Childhood Experiences and Their Impact on Child Development

Research consistently shows that early exposure to adverse childhood experiences (ACEs) is linked to academic and behavioral challenges. Choi et al. (2019) showed that ACE exposure at ages three, five, nine, and fifteen increased the risk of future behavioral problems. Similarly, Jimenez et al. (2016), using data from the Fragile Families and Child Wellbeing Study reported that children with more ACEs were more likely to have below-average academic skills, particularly in literacy, and exhibit behavioral difficulties in kindergarten.

Other studies have highlighted the broader impact of ACEs on school functioning. Blodgett and Lanigan (2018), using educator reports from 10 classrooms across four districts, found that ACE exposure was associated with academic failure, attendance issues, and behavioral problems. McKelvey et al. (2018) extended these findings by examining ACEs in infancy and toddlerhood. Children exposed to three or more ACEs before age three were more likely to have an IEP and show internalizing and attention-related behaviors.

Together, these studies underscore the lasting consequences of early trauma on children's ability to succeed in school. ACE exposure increases the likelihood of academic and behavioral struggles, disrupts learning, and contributes to attendance problems. These findings reinforce the importance of equipping teachers with the knowledge and skills to recognize and respond to trauma, positioning them as potential buffers between students and the effects of trauma.

Teachers as Buffers Against Effects of Adverse Childhood Experiences (ACEs)

Teacher-student relationships play a critical role in shaping children's development, particularly in early childhood. While these interactions are essential for fostering growth, research suggests that their quality varies across the country (Pianta et al., 2005). For example, Kuhfeld et al. (2019) revealed that children from low-income backgrounds and African American children were less likely to experience effective interactions in early

February 2026, Vol. 12, No. 1
ISSN 2163-758X

childhood programs. To prevent such disparities, it is essential that early childhood educators (ECEs) are trained to meet the diverse needs of all students.

Positive teacher-student relationships may also serve as a protective factor against the negative effects of ACEs. Murphy and Sacks (2019) emphasize that stable, supportive relationships with caregivers—including teachers—can buffer children from the impact of early trauma. These relationships are linked to improved academic achievement (Hu et al., 2016), increased motivation, and better behavioral and social outcomes (Wang et al., 2020).

Early Childhood Education (ECE) teachers play a vital role in supporting both the educational and socioemotional development of young children. Their daily interactions directly influence children's emotional well-being and classroom behavior (Mortensen & Barnett, 2016). A nurturing classroom environment contributes to children's behavioral, emotional, and physical development (Ritblatt et al., 2017). Factors such as teachers' experience and educational background also affect their ability to foster positive socioemotional learning (Clotfelter et al., 2011; Glock & Böhmer, 2018). Ensuring that ECE teachers are well-prepared and supported is essential for promoting equitable and trauma-informed care in early learning settings.

Teachers' Age, Experience, and Ethnicity and Their Relation to/Impact on Trauma-informed Care

Research suggests that teacher age and experience influence how they interpret student behavior when using a trauma-informed framework. Glock and Böhmer (2018) revealed that teachers with less experience (average of 12 weeks) held fewer negative attitudes toward ethnic minority students than those with more experience (average of 15 years). Among experienced teachers, younger individuals were least biased toward minority students, suggesting that age and experience interact in shaping perceptions.

While teaching experience is often linked to improved student achievement (Kini & Podolsky, 2016), its role in trauma-informed care is less clear. Studies show no significant difference between novice and experienced teachers in their ability to support students affected by trauma (Graham et al., 2020; Stuhlman & Pianta, 2009). A review of literature revealed a gap in research specifically comparing novice and experienced teachers' capacity to respond to trauma in early childhood settings.

Teacher ethnicity may also influence responses to students from different backgrounds. Glock and Kleen (2019) found that teachers from ethnic minority groups showed less bias toward minority students than those from majority groups. Frühauf et al. (2024) explored how preservice teachers of Turkish and German backgrounds were perceived in terms of bias. Results of this study indicated that teachers belonging to an ethnic minority group were perceived as less biased towards immigrant students compared to teachers belonging in ethnic minority groups. The demographic mismatch between teachers and students has received growing attention in recent years (Gottfried & Fletcher, 2023; Lindsay & Hart, 2017), yet little research has examined how this disparity affects trauma-informed care.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

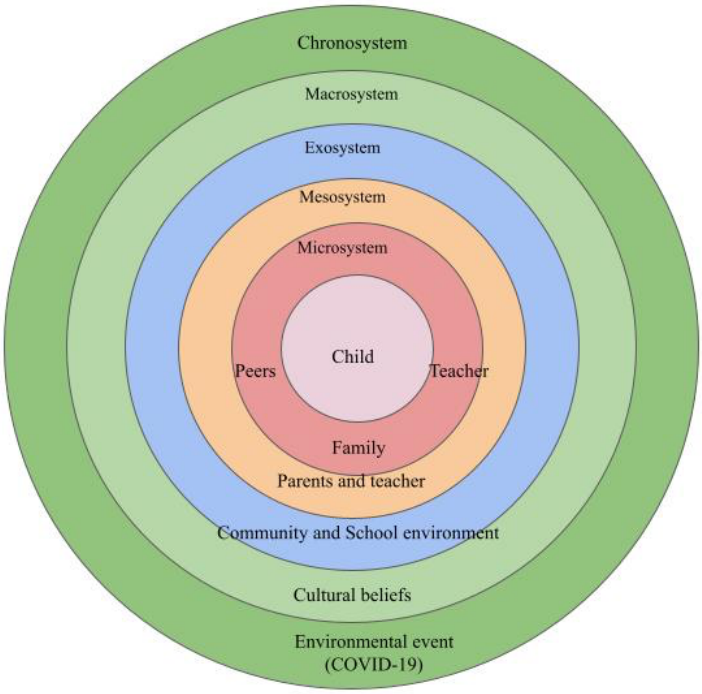
Impact of Trauma Informed Training and Implementation on Teachers

A growing body of research highlights the effectiveness of trauma-informed training in increasing teachers' knowledge and confidence. One study evaluated a two-day professional development using pre- and post-training measures, based on SAMHSA's (2014) four key assumptions: realizing the impact of trauma, recognizing its signs, responding with appropriate strategies, and avoiding re-traumatization. Results showed a clear increase in teachers' understanding and acceptance of trauma-informed practices following the training.

The University of California, San Franscisco's Healthy Environments and Response to in Schools initiative aimed to create trauma-informed environments in under-resourced schools (Dorado et al., 2016). Training focused on understanding trauma and its influence on student behavior. Findings indicated significant gains in staff knowledge and use of trauma-informed strategies. Similarly, Brown et al. (2022) assessed educators' knowledge, attitudes, and skills related to working with trauma-impacted students. Post-training surveys revealed increased preparedness, clarity in roles, and a desire for more resources and strategies to support students effectively. Overall, the literature underscores both the effectiveness of trauma-informed training and educators' strong interest in continued professional development.

Theoretical Framework

Figure 1
Bronfenbrenner's Ecological Systems Model



February 2026, Vol. 12, No. 1
ISSN 2163-758X

Bronfenbrenner's Ecological Systems Theory offers a valuable framework for understanding how trauma-informed practices influence teacher-student interactions. According to Bronfenbrenner (1977), a child's development is shaped by multiple systems, including family, school, and community. Exposure to trauma at home can influence a child's behavior and learning, making daily teacher-student interactions critical for supporting emotional and social growth (Ansari & Pianta, 2018). The mesosystem reflects the connections between these environments, such as collaboration between teachers and families. When educators share strategies with caregivers to support children exposed to trauma, it can strengthen developmental outcomes and foster consistency across settings.

The outer systems—exosystem, macrosystem, and chronosystem—also shape children's experiences. School policies that prioritize trauma-informed care and invest in teacher training can create supportive environments, even if children are not directly involved in those decisions. The chronosystem includes historical and environmental events that impact development over time. The COVID-19 pandemic, for example, intensified existing educational inequalities (Zahedivash et al., 2023), leading to declines in Early Start and Early Childhood Special Education enrollment (Friedman-Krauss & Barnett, 2023). Overall, Bronfenbrenner's theory helps explain how teachers' trauma-informed knowledge and practices can shape the environments children interact with daily, ultimately influencing their developmental trajectories.

Purpose of Study

To understand what support is needed in Eastern NC to assist NC Pre-K teachers in implementing trauma-informed care, a baseline must be established. Thus, the purpose of this study was to obtain an understanding of the attitudes, knowledge, and confidence that NC Pre-K teachers have in trauma-informed care. The following research questions guided the research study:

1. How knowledgeable are NC Pre-K teachers about trauma-informed care (TIC)?
    a. Does teachers' age, experience level correlate with their knowledge on trauma-informed care?
    b. Does teachers' knowledge on TIC differ based on their ethnicity?
2. How confident are NC Pre-K teachers about their actions with students who have experienced trauma?
    c. Does teachers' age, experience level correlate with their confidence levels?
    d. Does teachers' confidence differ based on their ethnicity?
    What experiences do NC Pre-K have with regards to working with children who have experienced trauma?
    e. Do teachers' knowledge and confidence scores on TIC differ for teachers who have experience working with children of trauma versus teachers who have no experience working with children of trauma?
3. What training have NC Pre-K teachers received and want more on trauma-informed care?

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Method

Design

This exploratory study utilized a standardized survey to assess NC Pre-K teachers' knowledge, confidence working with traumatized children, prior experience working with children who have experienced trauma, and training they have received and want on this topic. To our knowledge, this topic has not been studied with this specific population of teachers.

Participants

Eligible participants for this study were lead NC Pre-K teachers throughout Eastern North Carolina, associated with the University Early Educator Support (EES) Hub. The EES functions as a unit of the North Carolina Division of Child Development and Early Education. A purposive sampling technique was employed to recruit and survey NC Pre-K teachers. The EES coordinator was emailed to request assistance in sending out the initial email invitation to NC Pre-K teachers. The email sent to teachers described the study and included the survey as an attachment.

Procedure for Data Collection

The survey was administered utilizing the survey software, Qualtrics, which was made available for participants through a link emailed by the EES coordinator. Participants were informed that the survey would take 15-20 minutes to complete. To ensure anonymity and confidentiality for participants, survey responses were not linked to any identifying information such as Internet protocol addresses, and data was reported in aggregate form.

Measures

The Primary Early Childhood Educators Trauma-Informed Care Survey for Knowledge, Confidence, and Relationship Building (PECE-TICKCR) scale was created by Bilbrey et al. (2022). The scale was adapted from the TIC-DS scale (Goodwin-Glick in Impact of trauma-informed care professional development of school personnel perceptions of knowledge, disposition, and behaviors towards traumatized students, Graduate College of Bowling Green State University, 2017). This scale has been validated and has a strong reported Cronbach's alpha for each of thesubscales; Knowledge of Trauma (n = 11, α = .948); Confidence in Providing Trauma-Informed Strategies (n=13, α=.940); and Confidence in Creating Supportive Relationships (n=4, α=.865). The Cronbach's alpha acquired within the current study was strong as well; Knowledge of Trauma (n = 11, α = .944); Confidence in Providing Trauma-Informed Strategies (n=13, α=.945).

Description of the Survey and Subscales:

There were 6 sections in this survey. The first section that was measured on a Likert scale consisted of eleven questions that asked participants how knowledgeable they were about a variety of topics related to trauma-informed care in early childhood. The second section had thirteen questions that asked how confident participants were about a variety of actions related to trauma-informed care. This section was measured on a Likert scale ranging from "1" not confident at all to "5" very confident.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The third section consisted of three questions, which were asked about participants' experience of working with children who have been traumatized. The fourth section consisted of nine questions, which were specific to training on trauma-informed care that participants have received and future trainings that they might want. The fifth section consisted of eight questions that asked for information regarding participants' work. The last section contained demographic questions that asked participants about their age, race/ethnicity, educational level, licensure, and experience in the field.

Data Management

At the end of the data collection period, participants' responses were exported from Qualtrics to the primary researcher's SPSS software, which is software protected.

Data Analysis

Mean, standard deviation, and frequency were used to describe demographic data and describe overall scores on different subscales (e.g., knowledge or confidence in action). Pearson's Correlation Coefficient was utilized to examine the relationships between ratio level variables (e.g., age and experience level), while one-way ANOVA was used to compare subscale means on teacher knowledge and confidence level in actions across racial/ethnic groups and between teachers who had worked with children who had experienced trauma and teachers who had not worked with children who had experienced trauma.

Results

Demographic Information

NC Pre-K teachers based in the Eastern North Carolina region associated with the EES hub were the participants in this study. The survey was sent out to over 200 teachers, with a total of 81 individuals responding. Thirteen participants were removed because they did not consent to participate in the study.

There were three participants who had partially completed the knowledge scale. So, the researcher ran the Missing Completely at Random Data Analysis (MCRDA) within SPSS, and the MCRDA test was not significant ($P>0.05$), which indicated that the data were missing completely at random, and the researcher could go in for a mean imputation. Thus, after a mean imputation for the scale, there were 68 complete responses from the participants.

Table 1

Participants' Demographic Information

Demographics	Descriptive Statistics
Gender: Female (*n=68)*	68 (100%)
Race/Ethnicity (*n=65)*	
White/Caucasian	31 (48%)
Black/African American	26 (40%)
Hispanic/Latino(a)	4 (6%)
Native American	2 (3%)
Biracial	2 (3%)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Age (*n=61)*	*M*= 44.36, *SD*= 10.25
Years employed as a teacher (*n=63)*	*M*=6.77, *SD*= 5.77
Less than a year	1 (1.6%)
1-5 years	11 (17.5)
6-10 years	12 (19%)
11-20 years	24 (38%)
More than 20 years	15 (24%)
Licensure (*n=65)*	
Birth to Kindergarten (BK)	50 (77%)
B-K Add-on	9 (6%)
Pre-K Add-on	1 (1.5%)
Elementary	1 (1.5%)
Other	4 (6.2%)
No licensure	3 (4.6%)
School setting	
Suburban	11 (17.2%)
Rural	16 (25%)
Urban	16 (25%)
Combination	6 (9.4%)
Not sure	15 (23.4%)
Students receiving free/reduced price meals (*n=65*)	
Unknown	20 (31%)
Less than 25%	3 (5%)
26-50%	2 (3%)
51-75%	4 (6%)
76-85%	9 (14%)
86-100%	27 (42%)

Teachers' Knowledge about Trauma

The first research question addressed *how knowledgeable NC Pre-K teachers were about trauma-informed care*. To examine teachers' knowledge on the topic of trauma-informed care, mean composite scores were calculated from the 11 questions in the PECE-TKR scale. The overall means on the knowledge scale ranged between 1.45 and 5.00, while participant responses concerning trauma ranged between very little knowledge (3.15) and very knowledgeable (3.93).

Teachers' Confidence in Providing Trauma-Informed Strategies

The second research question addressed *how confident NC Pre-K teachers are in their actions while working with students of trauma*. To examine teachers' confidence in taking action, mean composite scores were calculated for the 13 questions in the PECE-TKR scale. The overall mean scores for this sub-scale ranged between 2.08 to 5.00. Participant responses ranged between slightly confident (3.53) to very confident (4.31).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Correlations Between Teacher Knowledge and Confidence Levels and Teacher Age and Years of Experience

The correlation analysis revealed a significant and strong positive relationship between teachers' knowledge and confidence, thus indicating that teachers' higher knowledge scores were associated with their higher confidence scores.

However, teachers' age and knowledge on TIC (r = 0.09) and teachers' experience level and knowledge on TIC (r=-0.20) did not correlate significantly. Similarly, teachers' confidence in action with students and their age (r= - 0.16) and teachers' confidence in action with students and their experience level (r= -0.16) did not significantly correlate with each other.

Table 2

Correlation Matrix among Knowledge, Confidence, Age, and Experience of NC Pre-K Teachers (n=68)

Variable	1	2	3	4
1. Knowledge	---	.73**	-.90	-.03
2. Confidence	.73**	---	-.16	-.06
3. Age	-.09	-.16	---	---
4. Years of experience	-.03	-.06	---	---

Correlation is significant at the 0.01 level (2-tailed).

Differences in Teacher Knowledge and Confidence Levels Based on Teacher Ethnicity

Table 3

Mean, Standard deviation, and One-Way Analyses of Variance of differences in teachers' knowledge and confidence based on ethnicity

Measure	Race/Ethnicity	M	SD		Sum of Squares	*df*	Mean Square	*F*	p
Knowledge	White/Caucasian	3.55	.69	Between	1.76	4	.44	.797	.532
	Black/African American	3.48	.79	groups					
	Hispanic/Latino(a)	3.98	.81						
	Native American	2.95	.96	Within	33.05	60	.55		
	Biracial	3.86	.19	groups					
Confidence	White/Caucasian	3.94	.61	Between	.36	4	.09	.203	.936
	Black/African American	3.87	.74	groups					
	Hispanic/Latino(a)	4.08	.54						
	Native American	3.65	1.03	Within	26.89	60	.45		
	Biracial	4.08	.11	groups					

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Teachers' Experience of Working with Children Who Have Experienced Trauma

We investigated if teachers who have worked with trauma-affected students differed in their knowledge and confidence scores from teachers who have not worked with such students. The One-way ANOVA results were highly significant for teacher knowledge scores ($F(1, 66) = 4.88$, $p<.03$) and teacher confidence scores ($F(1, 66) = 7.40$, $p<.01$). This indicates that teachers who have had experience with trauma-affected children are more knowledgeable and more confident in their actions as they work with traumatized students, compared to teachers with no such experience.

Training Received and Wanted on Trauma-Informed Care

The fourth research question examined the amount of trauma-informed training received and wanted by the teachers. Participants were asked about the frequency of trainings they attended as well as the topics they received training in. Most participants indicated they attended one or two trainings (32.7% & 23.6% respectively) within the last three years, while 3.6% attended more than 10 trainings. Some topics of trainings attended by most participants included: what is early childhood trauma, the impact of trauma in early childhood years, causes of early childhood trauma, and the impact of early trauma in childhood years. Topics that were discussed the least in trainings were: how to support parents of children who experienced trauma, available resources for families and children dealing with trauma, and self-care strategies for teachers who worked with children experiencing trauma.

Discussion

This study examined NC Pre-K teachers' knowledge, confidence, and training needs related to trauma-informed care. Many teachers reported being knowledgeable about how trauma affects student behavior and learning, as well as how their own actions may impact students who have experienced trauma. However, they also noted limited awareness of available community resources to support families—findings consistent with previous research (Alisic et al., 2012; Bilbrey et al., 2022).

Regarding confidence, teachers felt most assured in their ability to maintain positive relationships with students, which aligns with their educational philosophy. Yet, they expressed lower confidence in identifying trauma through behavioral observations, taking appropriate steps when trauma is suspected, and supporting students who have experienced trauma. These skill-based areas are typically developed through targeted training, suggesting a need for more professional development. These findings mirror those of Alisic (2012), who found that elementary teachers often struggled to provide actionable support to trauma-affected students.

A strong, positive correlation was found between teachers' trauma-related knowledge and their confidence in supporting students, indicating that increased knowledge may enhance confidence. This reinforces the importance of equipping educators with trauma-informed training to help them meet students' socioemotional needs (Russell et al., 2024).

The study also explored whether teacher age and experience correlated with knowledge and confidence. Although it was hypothesized that older and more experienced teachers

February 2026, Vol. 12, No. 1
ISSN 2163-758X

would report higher levels, results were not significant. This aligns with prior research showing no meaningful differences between novice and experienced teachers in their ability to support trauma-affected students (Graham et al., 2020; Stuhlman & Pianta, 2009). Interestingly, other studies suggest younger teachers may be less biased in working with trauma-affected students (Conaway & Bethune, 2015), but this was not reflected in the current findings.

Differences in knowledge and confidence across ethnic groups were also examined. While previous research suggests that teachers from minority backgrounds may show less bias toward minority students (Glock & Kleen, 2019), ANOVA results in this study were not significant, indicating no differences in trauma-related knowledge or confidence across ethnicities.

Most teachers reported having worked with students who experienced trauma. Further analysis revealed that those with direct experience had significantly higher knowledge and confidence scores than those without, suggesting that firsthand exposure may enhance preparedness.

Finally, teachers shared the types of trauma-related training they had received and their interest in future training. Most had learned about early childhood trauma and its causes and impacts. However, they expressed a strong desire for additional training on self-care, community resources, classroom strategies, and how to identify and respond to trauma. These findings echo prior studies (Alisic, 2012; Bilbrey et al., 2022; Brown et al., 2022), highlighting educators' need for both foundational knowledge and practical strategies to support trauma-affected students and families.

Strengths and Limitations

The findings from this study serve to provide insight into the knowledge, confidence, and training that exist within NC Pre-K settings that teachers have access to, andtopics for future training that can be explored further. Thus, this study is unique and required within the early childhood setting. A limitation of this study was its sample size and location. A larger sample size with a more diverse sample recruited across the different counties of North Carolina could be utilized to make the findings more generalizable. It is also important that future researchers consider that for one of the variables studied (teachers with experience working with children of trauma and not) the study had unequal group sizes.

Since this was a quantitative study, which utilized a standardized survey, researchers were limited in how responses were collected. The measurement tool used, which relied on self-reporting data, had little to no scope for open-ended responses. Future research may benefit from adding a few more open-ended questions at the end of the survey to collect more thoughts from the teachers on this topic. It is also worth considering that participants may have evaluated themselves in a more positive light, which could have impacted the data.

Conclusion

February 2026, Vol. 12, No. 1
ISSN 2163-758X

This study shed light on the knowledge, confidence, and training needs of NC Pre-K teachers in the area of trauma-informed care. The findings reveal a strong correlation between teachers' understanding of trauma and their confidence in their own actions, underscoring the importance of training on this topic. Training in trauma-informed care not only equips teachers with essential knowledge about trauma and its effects on student behavior but also has the potential to boost their confidence in effectively interacting with and supporting students who have experienced trauma. By enhancing teachers' skills and self-assurance, such training can significantly improve their ability to create a supportive and responsive classroom environment for all students.

This study has significant implications for both pre-service and in-service teacher training programs. It suggests that training should prioritize the areas where teachers have shown the most interest. This includes understanding and utilizing community resources for children and families, effective classroom strategies, and response strategies they can utilize to support student behaviors that stem from trauma responses. As research suggests, teachers without strategies for supporting students experiencing trauma might inadvertently impede those students' ability to self-regulate and participate in learning (Brunzell et al., 2018). By focusing on these critical topics, training programs can better equip teachers to meet the diverse needs of their students and foster a more supportive educational environment.

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Author Notes

Chalyne Barrow is a dedicated scholar at East Carolina University, where she pursued her master's in Human Development and Family Science. Her academic interests include early childhood education, trauma-informed care, and Family Life Education with a particular focus on Teacher preparedness. Chalyne has contributed to various research projects and continues to engage in scholarly activities that aim to improve understanding and practice in her field.

Archana V. Hegde, PhD, BK is a Nancy Darden Endowed Professor in the Department of Human Development and Family Science, housed in the College of Health and Human Performance at East Carolina University. She has extensively published on topics related to quality childcare, inclusion, STEM education and teacher professional development.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

She has parallel interest in trauma informed care and practices, and this current publication is part of her mentee's work; she chaired this project.

Mary Cate Komoski, PhD is an assistant professor in the Department of Human Development and Family Science, housed in the College of Health and Human Performance at East Carolina University. With her background in educational psychology, Dr. Komoski focuses on the intersection of wellbeing and schools. Her interests include how adolescents conceptualize trauma and teacher burnout prevention.

Erin Roberts, Ph.D., LMFT is a trained and licensed therapist, who has also led efforts on work related to Trauma, and help establish The Consortium for Trauma and Resiliency Research (CTRR). at East Carolina University. Since then she has started her own private practice and serves the community at large. She was an integral part of this thesis committee.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Trauma-Informed Teaching in Lebanon: Teacher Awareness and Preparedness

Nadeen Aridi, Silvana Sobh, Rania Abou Dargham, Fatima Halwani

Modern University for Business and Science, Beirut, Lebanon.

Abstract

Early life experiences and relationships, both negative and positive, significantly shape a person's development and growth, influencing the course of their life (Psypost, 2023). Childhood trauma is frequent and has significant impacts on students' behavior, learning, relationships, physical and emotional well-being (Perfect et al., 2016; Tishelman et al., 2010), and brain development (Bick & Nelson, 2016). Crises, whether personal (e.g., job loss, divorce) or global (e.g., pandemics, wars), disrupt children's sense of security and often lead to trauma. In recent years, the Arab world has faced numerous crises, including armed conflicts, political instability, and economic challenges. Lebanon, in particular, has experienced overlapping crises, including the COVID-19 pandemic, the economic collapse, the Beirut Port explosion, and the recent regional war, all of which might have impacted negatively children's mental health. This research study investigated the level of knowledge and preparedness of Lebanese teachers to recognize and respond to traumatized students. Using part of the *Trauma-Informed Care Dispositions Survey*, this quantitative study surveyed teachers all across Lebanon to assess their knowledge and preparedness to provide emotional and psychological support to traumatized students. Results revealed that a significant number of teachers lack the knowledge and skills needed to identify and address trauma in children. The study identified gaps in professional development and proposed evidence-based strategies and recommendations to enhance teachers' capacity to create supportive and inclusive learning environments for traumatized students.

Keywords: Childhood trauma, teacher preparedness, trauma-informed care, Lebanese education, crisis impact, student mental health

Purpose of the Study

The purpose of this research is to evaluate the existing level of awareness and readiness among Lebanese educators in recognizing and responding to the needs of students who have faced trauma, especially considering Lebanon's recent compounding crises. By analyzing the deficiencies in teachers' knowledge and abilities regarding trauma-informed care, this study intends to offer evidence-based approaches and recommendations for professional development. Ultimately, the research strives to improve teachers' ability to foster supportive and inclusive educational settings, ultimately enhancing the educational and psychological well-being of students who have experienced trauma in Lebanon.

Significance of the Study

February 2026, Vol. 12, No. 1
ISSN 2163-758X

This study examines the impact of crises on childhood trauma through the lens of Lebanon's multifaceted challenges, creating a connection between global issues and local realities. While crises like pandemics and wars affect people worldwide, Lebanon's unique sociopolitical and economic struggles worsen their impact. By assessing Lebanese educators' knowledge and preparedness to address trauma in students, the study integrates context-specific strategies with global trauma-informed practices. It provides specific recommendations for Lebanon's education system while contributing to the broader global conversation on trauma and education, highlighting the connection between international frameworks and regional needs.

Research Question

How equipped are Lebanese teachers to identify and address the needs of traumatized students, and what strategies can enhance their capacity to provide trauma-informed care in the classroom?

Literature Review

Lebanon, a country struggling with various issues including economic crisis, political instability, and the persisting effects of the 2020 Beirut port explosion, and the recent war, presents a context where trauma is prevalent among its students (UNDP, 2021). This requires a strong educational response, specifically through trauma-informed teaching (TIT). TIT focuses on understanding and responding to the impact of trauma on students' learning and behavior and creating safe and supportive classroom environments (Cole et al., 2005). However, the extent to which Lebanese teachers are aware of and prepared to implement TIT remains unexplored. This research highlights the global need for teacher training in trauma-informed practices (Sun et al., 2024), while studies assured on the critical role of teachers in reducing the impact of trauma on students (Nicolai & Triplehorn, 2003). This review aims to collect data from existing literature to set up a foundation for understanding teacher awareness and preparedness in Lebanon, highlighting the gaps and informing future research.

Prevalence of Trauma and its Impact on Lebanese Students

The various crises in Lebanon have significantly impacted the mental health and well-being of students. Studies show high levels of anxiety, depression, and post-traumatic stress symptoms among Lebanese youth (Maalouf et al., 2022). Food hunger and financial instability brought on by the economic crisis have a direct impact on kids' capacity to concentrate and learn (World Bank, 2023). Additionally, the collective trauma of the war and the Beirut port explosion has affected students' feeling of safety and security and left long-lasting psychological scars (Maalouf et al., 2022). These escalating problems provide a framework for comprehending how trauma affects academic performance.

Teacher Awareness of Trauma-Informed Practices

February 2026, Vol. 12, No. 1
ISSN 2163-758X

There are considerable differences in teacher awareness of TIT around the world, according to research. Some studies show that the significance of addressing trauma in educational settings is well understood (Walkley & Cox, 2013), while other studies show that there is a dearth of knowledge on how trauma manifests in the classroom (Skaalvik & Skaalvik, 2017). Research explicitly looking at teacher understanding of TIT is lacking in Lebanon. Nonetheless, research on stress and teacher well-being in Lebanon shows that educators are going through a lot of psychological pain, which may affect their capacity to help traumatized pupils (Skaalvik & Skaalvik, 2017). This raises the possibility of a gap in instructors' capacity to identify and address trauma in pupils as a result of their own experiences.

Teacher Preparedness and Training in Trauma-Informed Strategies

Enough support and training for teachers is necessary for TIT to be implemented effectively. Professional development programs that give instructors the tools they need to establish secure and encouraging learning environments are crucial, according to studies (Wolpow et al., 2009). Training initiatives in conflict-affected areas have demonstrated promise in improving educators' ability to meet the psychological and social needs of their students (Nicolai & Triplehorn, 2003). However, there is little proof that TIT training programs have been implemented in Lebanon. Given its limited resources, the current educational system might not be able to offer thorough and efficient instruction (United Nations Educational, Scientific and Cultural Organization, 2023). This lack of readiness may make it more difficult for educators to assist traumatized pupils.

Challenges and Barriers Facing Implementation

There are a number of obstacles to TIT implementation in Lebanon. Due to the economic crisis, schools now lack essential resources, such as counseling services and mental health professionals (World Bank, 2023). The problems are made more difficult by social exhaustion and political instability, which fosters a stressful and uncertain atmosphere (UNDP, 2021). Additionally, instructors may be less inclined to discuss trauma in the classroom due to cultural reasons like the shame associated with mental health. Opposition to implementation is further exacerbated by Lebanon's lack of uniform TIT regulations and guidelines. Discussion: According to the literature analysis, more research on teacher awareness and readiness in TIT in Lebanon is desperately needed. The fact that trauma is pervasive among students as a result of the mixed crises emphasizes how urgent it is to adopt trauma-informed methods. The significance of teacher preparation is emphasized by international research, but little is known about the unique requirements and difficulties experienced by Lebanese educators. It is extremely difficult for the current educational system, which is already constrained by resource constraints, to offer thorough instruction and assistance. Subsequent investigations ought to concentrate on evaluating the present awareness and readiness of educators, recognizing implementation obstacles, and creating educational initiatives. In order to ensure that teachers can support their kids, research should also be done on their mental health and overall wellbeing. Lebanon may make progress in developing a more trauma-

February 2026, Vol. 12, No. 1
ISSN 2163-758X

informed and supportive educational system that caters to the needs of its pupils by filling in these deficiencies.

In summary, our assessment of the literature demonstrates the need for a thorough comprehension of teacher awareness and readiness in trauma-informed instruction within the context of Lebanon's crisis education system. There is widespread student trauma in this setting due to the impact of the current crises. Global research emphasizes how crucial teacher preparation is in lessening the effects of trauma, yet there is a significant knowledge vacuum about the requirements and difficulties faced by Lebanese educators. Political unpredictability, cultural shame, and resource scarcity impose restrictions that exacerbate these problems. It will be crucial to conduct focused study in the future on evaluating teacher preparedness, creating training programs, and removing obstacles in order to establish a trauma-informed and supportive learning environment that benefits Lebanon's children' academic performance and general well-being.

Methodology

Research Method and Design

A quantitative survey research design is used in this study to evaluate the knowledge and readiness of Lebanese teachers to assist kids who have experienced trauma. Data was collected from a broad sample of instructors throughout Lebanon at one particular moment using a cross-sectional approach. An unbiased assessment of teachers' knowledge, comprehension, and preparedness to use trauma-informed teaching methods is made possible by this design. Descriptive in nature, the study seeks to pinpoint patterns, deficiencies, and difficulties in trauma-informed teaching among Lebanese educators. Through the use of a structured survey, the study offers quantifiable insights into teacher readiness, pointing out areas that require policy and professional development. Especially in areas affected by crises, the findings add to local and international conversations about trauma-informed education. The study focuses on public and private school teachers from various educational levels (kindergarten, elementary, middle, and high school), ensuring a comprehensive understanding of how trauma awareness and preparedness vary based on teaching experience, school type, and geographical location.

Data Collection Tool

The *Trauma-Informed Care Dispositions Survey* (adapted) was used as the primary data collection tool. This standardized survey assesses teachers' awareness, knowledge, and preparedness to recognize and respond to student trauma. The survey consisted of Likert-scale questions ranging from "Strongly Agree" to "Strongly Disagree" to measure respondents' confidence and understanding of trauma-informed practices.

The questionnaire was divided into the following sections:

February 2026, Vol. 12, No. 1
ISSN 2163-758X

1. Demographic Information: Gender, age, teaching experience, grade level, and school type (public/private).

2. Knowledge of Trauma and Its Impact: Teachers' familiarity with different types of traumas, symptoms in students, and effects on behavior and learning.

3. Readiness to Respond to Trauma: Ability to identify trauma-related behaviors, knowledge of intervention steps, and awareness of how teachers' actions impact traumatized students.

4. Trauma-Informed Classroom Practices: Understanding of communication strategies, behavior management techniques, and the ability to create safe and supportive learning environments.

5. Training and Professional Development Needs: Teachers' self-assessed need for further training in trauma-informed education.

Population and Sample

The target population for this study includes teachers from public and private schools in Lebanon. Given the widespread impact of crises on children, it is essential to assess teachers from different educational sectors to understand the variations in their readiness and response strategies. A convenience sample of 85 teachers from various regions in Lebanon participated in the study. Because the sample's schools are spread across both urban and rural regions, the data collection process is guaranteed to represent the nation's varied educational and socioeconomic environments.

Ethical Considerations

When conducting research, ethical considerations are especially important when handling delicate subjects like trauma. To protect participants and maintain the integrity of the research process, this study complies with ethical standards. A permission form explaining the study's goals, methods, possible dangers, and advantages was given to participants prior to data collection. Respondents were free to discontinue participation at any time without facing any repercussions as participation was considered optional. All responses were anonymized to ensure that no private data revealed, protecting confidentiality. Furthermore, by refraining from dishonesty and making sure that the questions were created to reduce participants' suffering when they discussed trauma-related events, the study complied with ethical research standards.

Data Analysis and Discussion

Table 1

Demographic Information of Surveyed Educators

Demographics	Description	Number	Percentage (%)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Gender	Female Male	78 4	95.1 4.9
Age Range	< 29 30 – 39 40 – 49 50 +	24 29 25 4	29.3 35.4 30.5 4.9
Number of years of employment in school district(s)	0 – 5 6 – 10 11 – 15 16 – 20 20 +	30 12 16 6 18	36.6 14.6 19.5 7.3 22
Grade Level	Kindergarten Elementary School (1 - 6) Middle School (7 - 9) High School (10 - 12)	12 31 17 22	14.6 37.8 20.7 26.8

According to demographic data, the majority of educators in the education sector are female (95.1%), with the majority being between the ages of 30 and 39 (35.4%) or 40 and 49 (30.5%). Only 4.9% of educators are 50 years of age or older, while 29.3% are under the age of 29. While 22% have more than 20 years of experience, showing long-term stability, 36.6% are in their first five years of work, representing a sizable portion of early-career educators. The majority teach at the elementary level (37.8%), followed by high school (26.8%), middle school (20.7%), and kindergarten (14.6%). These findings highlight a diverse workforce with a balance of new and experienced educators, predominantly serving in elementary and secondary education.

Table 2

Educators' Knowledge and Awareness of Trauma in Students

Statement	**Description**	**Number**	**Percentage (%)**
I am familiar with the symptoms traumatized students display.	SA A N D SD	13 52 16 1 0	15.9 63.4 19.5 1.2 0
I am knowledgeable about the impact of trauma on student success and behavior.	SA A N D SD	24 53 4 1 0	29.3 64.6 4.9 1.2 0

February 2026, Vol. 12, No. 1
ISSN 2163-758X

I know how to make behavioral observations that help identify signs of trauma.	SA A N D SD	12 44 20 5 1	14.6 53.7 24.4 6.1 1.2

Note. Strongly Agree = SA; Agree = A; Neutral = N; Disagree = D; Strongly Disagree = SD

The survey results indicate that while most educators are knowledgeable about trauma's impact on student success (93.9%) and familiar with trauma-related symptoms (79.3%), there is a noticeable gap in their ability to identify signs of trauma through behavioral observations, with 24.4% remaining neutral and 7.3% expressing uncertainty. In order to improve practical abilities, this emphasizes the necessity of focused professional growth. Schools should employ data-driven trauma-informed teaching practices, encourage peer collaboration, and put in place specialized training in order to close this gap. By improving their ability to observe, educators will be prepared to assist traumatized kids and turn theoretical knowledge into practical interventions.

Table 3

Educators' Knowledge of Trauma Types, Intervention Steps, and Behavioral Impact on Traumatized Students

Statement	**Description**	**Number**	**Percentage (%)**
I am knowledgeable about different types of traumas.	SA A N D SD	8 34 30 10 0	9.8 41.5 36.6 12.2 0
I am knowledgeable about the next steps to take once a student has been identified.	SA A N D SD	10 33 25 14 0	12.2 40.2 30.5 17.1 0
I am knowledgeable about how my behaviors impact traumatized students.	SA A N D SD	30 38 10 4 0	36.6 46.3 12.2 4.9 0

Note. Strongly Agree = SA; Agree = A; Neutral = N; Disagree = D; Strongly Disagree = SD

The survey results indicate diverse levels of educators' knowledge regarding trauma and its implications. While the majority (51.3%) report being knowledgeable about different types of trauma, a significant proportion (36.6%) remain neutral, and 12.2% express

February 2026, Vol. 12, No. 1
ISSN 2163-758X

uncertainty, suggesting a need for further education in this area. Similarly, while 52.4% understand the appropriate steps to take once a student is identified as experiencing trauma, 30.5% are neutral, and 17.1% feel unprepared, highlighting a gap in procedural knowledge. In contrast, awareness of how educators' behaviors impact traumatized students is notably higher, with 82.9% in agreement and only 4.9% in disagreement. These findings emphasize the need for targeted professional development, particularly in trauma identification and intervention strategies, to ensure educators are fully aware of the issue-to support affected students effectively.

Table 4

Educators' Knowledge of Communication, Trauma Impact on Learning, and Behavior Management for Traumatized Students

Statement	Description	Number	Percentage (%)
I am knowledgeable about how to talk to traumatized students.	SA A N D SD	14 41 21 6 0	17.1 50 25.6 7.3 0
I am knowledgeable about the impact of trauma on student learning.	SA A N D SD	26 45 8 3 0	31.7 54.9 9.8 3.7 0
I am knowledgeable about how to de-escalate and manage traumatized student behaviors.	SA A N D SD	8 36 31 7 0	9.8 43.9 37.8 8.5 0

Note. Strongly Agree = SA; Agree = A; Neutral = N; Disagree = D; Strongly Disagree = SD

The survey results highlight educators' varying levels of confidence in supporting traumatized students. While most respondents (67.1%) feel knowledgeable about communicating with traumatized students, 25.6% remain neutral, and 7.3% lack confidence, indicating a need for improved training in trauma-informed communication. Similarly, understanding the impact of trauma on student learning is strong, with 86.6% in agreement and only 3.7% in disagreement, demonstrating a solid foundation in theoretical knowledge. However, when it comes to de-escalating and managing trauma-related behaviors, confidence decreases, with 37.8% neutral and 8.5% feeling unprepared. According to these findings, teachers are highly aware of the impacts of trauma, but in order to improve their capacity to assist kids in distress, they urgently require hands-on training in intervention and behavioral management techniques.

Table 5

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Educators' Knowledge of Emotional Impact on Learning, Ability to Support Traumatized Students, and Create Safe Learning Environment

Statement	Description	Number	Percentage (%)
I am knowledgeable about the impact of emotional states on brain functioning and learning.	SA A N D SD	23 42 11 6 0	28 51.2 13.4 7.3 0
I believe that I have the ability to assist traumatized students so that they can learn.	SA A N D SD	11 40 23 8 0	13.4 48.8 28 9.8 0
I can create an environment where students feel safe.	SA A N D SD	34 37 10 1 0	41.5 45.1 12.2 1.2 0

Note. Strongly Agree = SA; Agree = A; Neutral = N; Disagree = D; Strongly Disagree = SD

While 79.2% of educators say that they have a solid knowledge of the connection between emotional states, brain function, and learning, a significant 13.4% are neutral, and 7.3% are unsure, according to the survey results, indicating that more reinforcement is needed in this area. What is more, a decrease in confidence in assisting kids with trauma can be observed; 62.2% of respondents think they can help these students academically, while 28% are neutral and 9.8% are unsure, indicating a need for more training in trauma-informed teaching practices. Nonetheless, there is a strong commitment to promoting emotional security in the classroom, as seen by much higher confidence in establishing a secure learning environment (86.6% in agreement and only 1.2% in dissent). These findings suggest that while educators are well prepared to establish supportive environments, targeted professional development is needed to strengthen their practical skills in trauma-sensitive teaching and intervention strategies.

Conclusion and Recommendations

A number of important recommendations are made after examining the research results in order to enhance trauma-informed education in Lebanon. The Ministry of Education must, first and foremost, incorporate trauma-informed education training programs. Teachers can become far more effective at helping traumatized children if they receive professional development workshops on how to identify the symptoms of trauma, use supportive teaching techniques, and control classroom conduct. Secondly, in order to help kids get psychological support when they need it, schools should set up specialized support networks like referral programs or on-site psychologists. Thirdly, policy makers, psychologists, and educators should work together more closely to develop regulations

February 2026, Vol. 12, No. 1
ISSN 2163-758X

that guarantee a secure and encouraging learning environment for kids experiencing issues. In order to provide resources like quiet areas, tools for regulating emotions, and adaptable teaching methods that can suit traumatized youngsters, schools must also be financially supported. In order to evaluate the long-term effects of trauma-informed education on students' academic achievement and general well-being, more longitudinal research needs to be carried out.

The results underscore the pressing necessity of improving educators' understanding and readiness to work with children who have experienced trauma. Even though they deal with a lot of difficulties, instructors are essential in helping kids cope with mental problems. By putting in place focused training programs, enhancing support networks, and pushing for legislative changes, Lebanon may make great strides in creating a more welcoming and encouraging learning environment for all children.

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February 2026, Vol. 12, No. 1
ISSN 2163-758X

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Author Notes

Nadeen Aridi is a recent graduate from the Modern University for Business and Science (MUBS) with a degree in Education, concentrating in Mathematics and Science. She is beginning her career teaching Mathematics for grades 4–7, inspired by student-centered and creative learning approaches. Her teaching philosophy

February 2026, Vol. 12, No. 1
ISSN 2163-758X

emphasizes inclusivity, hands-on learning, and fostering critical thinking. Passionate about equitable education, she aims to grow as an educator and apply innovative practices globally.

Silvana Sobh is a senior student at the Modern University for Business and Science (MUBS), completing her degree in Early Childhood Education. Passionate about trauma-informed practices, she focuses on creating supportive and inclusive learning environments for young children. Her interests include play-based learning, holistic development, and the integration of technology in education. She aims to continue research and apply evidence-based practices to advance early childhood education locally and globally.

Rania Abou Dargham is a senior student at the Modern University for Business and Science (MUBS), pursuing a degree in Education with a concentration in Early Childhood Education. Her academic journey has been shaped by a passion for child-centered learning, including constructivism, play-based methods, and trauma-informed practices. Her teaching philosophy emphasizes inclusivity, hands-on experiences, and recognizing the unique potential of every child.

Fatima Halwani holds a PhD in Education, a Master's degree in Educational Management, and a Bachelor's degree in Analytical Chemistry. She is a Senior Lecturer at the Modern University for Business and Science (MUBS) and a Lecturer at the Fouad Chehab Academy for Command and General Staff (Lebanese Army). With extensive experience in education and research, she specializes in mindfulness and social-emotional learning, with a strong focus and a commitment to promoting well-being in educational settings. Her research interests center on enhancing student support systems and fostering a positive learning environment.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Investigating the Implementation of Cooperative Learning in Lebanese Private Schools and Its Impact on Students' Academic Performance and Behavior

Abeer Al Danaf and Samar Bouzeineddine

Modern University for Business and Science, Beirut, Lebanon

Abstract

Although many schools worldwide continue to rely on traditional teaching methods, an increasing number have embraced cooperative learning (CL). Cooperative learning is a widely recognized pedagogical approach that promotes student engagement, critical thinking, and collaborative problem-solving. This study examines the implementation of CL and its impact on student achievement, motivation, and engagement in Lebanese private schools. Using a quantitative survey design, the research investigates how CL influences students' cognitive and social development. The findings indicate that CL enhances student participation and knowledge retention, offering a framework for educators seeking to improve learning outcomes. The study also addresses challenges in implementing CL and provides practical recommendations for educators and policymakers in Lebanon and internationally.

Keywords: cooperative learning, collaborative activities, academic performance, student behavior, Lebanese private schools

Introduction

The rising globalization has led to rising local diversity, along with the need for interdependence. In such an environment, interpersonal skills and cooperation skills are vital for survival. Therefore, cooperative learning in classrooms can play a significant role. It is a classroom approach where the teacher allows students to work in small groups to achieve their learning outcomes and goals while acquiring the support and guidance of the teacher (Pan et al., 2023). A study by Chen (2021) also revealed that cooperative learning can serve as a tool for the development of interpersonal and cooperation skills that allow students to be functional in today's challenging and diverse local and global environments. Despite its benefits, it is not widely adopted in many countries due to a lack of awareness regarding its benefits and implementations. A recent study by Syamsi (2024) provided a bibliometric analysis of cooperative learning. The author conducted a comprehensive study by drawing samples from 4367 peer-reviewed articles in the Scopus database. The results showed that cooperative learning studies have been rising in recent years, and the majority of publications are from the United States, with a lack of contributions from Asian or Middle Eastern countries. The author further revealed that there is an inconsistency in the study, and most studies are focused on explaining the

February 2026, Vol. 12, No. 1
ISSN 2163-758X

concept of cooperative learning, ignoring its application in different classrooms or its impact on students and their academic outcomes.

Problem Statement

In Lebanon, the focus of the majority of instructors is on the content as they prepare students for the official exams in a limited time frame. Thus, the instructors tend to ignore students' motivations, needs, and characteristics of learning. It is noticeable that the majority of schools in Lebanon utilize lecturing as the main mode of teaching and tend to ignore deep learning methods such as cooperative learning. The literature to support the adoption of cooperative learning in Lebanese schools is limited. A study by Mirza and Halabi (2021) was performed in Lebanon to view the perceptions of teachers regarding cooperative learning. Results suggested that teachers had a positive experience and recommended it for other classes in Lebanon. Another study by Awada and Gutierrez-Colon (2019) also revealed that in Lebanon, using cooperative learning through blog instruction was effective and helped to reduce intercultural communication apprehension. However, further review of the literature revealed a lack of studies to explain the effect of the learning method on students' achievement and behavior. There is a lack of studies performed in private institutions in Lebanon and limited evidence to suggest its implementation, frequency, and appropriate tools and activities. To promote the adoption of cooperative learning techniques in the classroom, further studies on the approach are essential. Thus, to fill this gap in the literature, the present study is conducted. The purpose of the study is to examine how cooperative learning is implemented in private schools in Lebanon and discuss the impact of such implementation on student behavior and their academic outcomes.

Significance of the Study

There is limited evidence regarding the effectiveness of cooperative learning in Middle Eastern classrooms, particularly in Lebanon. This descriptive study explores the frequency and manner in which CL is applied in Lebanese private schools and examines its effectiveness. The study provides valuable insights for educators by identifying appropriate models, structuring group activities, and supporting the evaluation of student learning outcomes. Furthermore, it contributes to policy development by encouraging further empirical research on CL in Lebanon and beyond.

Purpose of the Study

The main purpose of the study is to examine the implementation and effect of cooperative learning on students in private schools in Lebanon. The objectives of the study are the following:

- to determine how teachers implement cooperative learning in Lebanese private schools.
- to analyze the impact of cooperative learning on student behavior in Lebanese private schools.
- to evaluate the effect of cooperation on student performance in private schools across Lebanon.

Research Questions

1. How is cooperative learning implemented in Lebanese private schools?

February 2026, Vol. 12, No. 1
ISSN 2163-758X

2. What is the impact of a cooperative learning strategy on student behavior in Lebanese private schools?
3. What is the impact of a cooperative learning strategy on student academic performance?

Literature Review

Rise of Cooperative Learning Strategies

Historically, lecture-based instruction was the most dominant teaching approach worldwide (French & Kennedy, 2017). However, as early as the 1960s, scholars began to critique this approach for its limited impact on skill development and attitudinal change (Fakoya et al., 2023). Research further indicates that lecture-based methods are restrictive and less effective in enhancing student behavior and academic performance compared to more interactive strategies (Assem et al., 2023).

Cooperative learning emerged in the 1960s as an alternative. Early studies highlighted its positive outcomes compared with traditional methods. Initially introduced by STEM educators and social psychologists in the United States, it aimed to improve both academic learning and student behavior in K–12 settings (Yang, 2023). Since then, cooperative learning has been adopted worldwide and proven effective across diverse contexts (Anderson et al., 2022). Strategies such as jigsaw, brainstorming, and blog writing were developed to support this approach. Despite widespread use, gaps remain in conceptual clarity and classroom application (Chen et al., 2022).

Defining Cooperative Learning

Johnson and Johnson (1999) defined cooperative learning as the instructional use of small groups in which students work together to maximize one another's learning (Beigzadeh et al., 2024). More recently, Buchs and Maradan (2021) emphasized its role as a group strategy that fosters democratic participation in classrooms. Chen et al. (2022) identified three forms of cooperative learning: formal, informal, and base groups. Formal cooperative learning involves sustained collaboration over several sessions to achieve shared goals. Informal cooperative learning is short-term, often lasting only a few minutes during lectures, designed to spark engagement. Base groups are long-term, heterogeneous partnerships that provide consistent peer support throughout a course (Triansyah et al., 2023). Each form incorporates distinct techniques and activities highlighted in the literature.

Cooperative Learning Activities & Procedures

A study by Roy (2024) identified key techniques for cooperative learning, such as jigsaw, think-pair-share, group projects, role assignments, and inquiry-based learning, which effectively promote communication and collaboration. Anand et al. (2021) discussed the round-robin brainstorming strategy, an interactive method that encourages students to develop and refine ideas collaboratively. This technique has been found effective for learning and knowledge transfer across various contexts (Healy et al., 2018).

Adha et al. (2023) explored digital strategies for cooperative learning, particularly during COVID-19, allowing students to engage and collaborate remotely. Suleman and Idayanti

February 2026, Vol. 12, No. 1
ISSN 2163-758X

(2024) proposed additional techniques, but noted that most research focuses on Western and some Asian classrooms, with insufficient attention to Middle Eastern schools.

Dzemidzic Kristiansen (2022) pointed out a lack of systematic approaches among teachers in implementing cooperative learning, leading to unsuccessful outcomes. Abramczyk and Jurkowski (2020) reviewed 1,495 Polish language teachers and found that, despite awareness of cooperative learning, it was rarely utilized. Teachers expressed a need for further training in this area. Similar findings in other Western countries show a general lack of awareness and implementation (Raviv et al., 2019; Dzemidzic Kristiansen et al., 2019), with little research focusing on implementation challenges in Middle Eastern nations like Lebanon.

Impact of Cooperative Learning on Student Behavior and Academic Performance

Research on cooperative learning is limited, with few studies examining its effects on student behavior and academic performance. Bores-Garcia et al. (2021) conducted a systematic review of 15 articles, finding that most literature addresses secondary education and focuses primarily on short-term interventions, often using qualitative or mixed methods.

Cecchini et al. (2021) explored cooperative learning strategies in a study of 332 teacher training students. After 10 low-structured sessions, the students were divided into groups that participated in either highly structured or low-structured cooperative learning. Results showed that those in the highly structured sessions experienced higher motivation, content knowledge, responsibility, and improved behavior, highlighting the effectiveness of the method.

In another study, Garcia (2021) examined the jigsaw learning strategy in computer programming through a pre-test and post-test design over 14 weeks. The experimental group showed significant improvements in attitude and self-efficacy compared to the control group, reinforcing effectiveness of the jigsaw technique in teaching.

Van Ryzin et al. (2020) conducted a randomized trial with 1,460 seventh graders to assess the role of cooperative learning in reducing bullying and improving peer relations. The results indicated that cooperative learning significantly decreased bullying and victimization while enhancing student behavior. Other studies also support its positive impact on academic outcomes (Le et al., 2018). However, there is a notable lack of research focused on private schools in Lebanon.

Challenges in Implementing Cooperative Learning and Gaps in Research

Research on the current issue is insufficient in Middle Eastern countries, and recent studies exploring how various procedures, activities, and tools affect student learning outcomes, academic performance, and attitudes are limited. As a result, cooperative learning worldwide remains less popular than traditional teaching approaches. Teachers who implement cooperative learning are often not well-informed about the proper procedures, protocols, or principles (Adha et al., 2023). Additionally, the awareness of the distinction between collaborative learning and cooperative learning is low (Yang, 2023). Loh and Ang (2020) also found that many teachers in Middle Eastern nations rarely use cooperative learning, as they still prefer the lecture method as their primary teaching approach. Therefore, further quantitative studies are necessary to provide clearer

February 2026, Vol. 12, No. 1
ISSN 2163-758X

guidance on the implementation, effectiveness, and procedures for using cooperative learning. This study aims to address the existing gap in the literature.

Methodology

Research Design

This study examined the implementation and impact of cooperative learning in Lebanese private schools. A quantitative design was employed, using a survey as the primary data collection tool. The survey method is widely applied in quantitative research because it is less time-consuming and resource-intensive (Kaeedi et al., 2023). It also enables researchers to gather data from relatively large samples through online platforms, facilitating more generalizable findings within a limited timeframe (Tehrani et al., 2021).

Population, Sampling & Sampling Method

The study population consisted of teachers working in private schools in Mount Lebanon. A random sampling technique was applied, resulting in a sample of 36 teachers. This approach was selected because it enhances representativeness and increases the likelihood that the results reflect the broader population.

Data Collection Instrument

Data were collected using a structured survey form provided in the Appendix. The instrument included close-ended questions and one open-ended item to solicit recommendations for improving cooperative learning. The survey was organized into sections addressing respondents' demographics, educational background, years of experience, understanding of cooperative learning, classroom implementation, and perceptions of its impact. The instrument contained 28 items, 6 of which measured respondent profiles and knowledge of cooperative learning, while the remaining items focused on implementation, strategies, tools, and effects on students.

Data Collection Procedures

An online survey was distributed digitally to randomly selected teachers in Lebanese private schools. Prior to data collection, participants were informed of the study's purpose, data use, and procedures for data disposal. Informed consent was obtained electronically. The survey link was shared via email, social media, and other online platforms, and participants were asked to complete it within one week. Responses were recorded and stored in Microsoft Excel for further analysis.

Data Analysis

Quantitative data were analyzed using Microsoft Excel. Graphs and charts were generated to display frequencies and percentages, and descriptive statistics were applied to summarize the findings. These analyses provided the basis for interpreting patterns of cooperative learning implementation and its impact on students.

Ethical Considerations

Ethical compliance was a central priority of this study. According to Fleming and Zegwaard (2018), neglecting ethics in research can cause psychological, physical, or emotional harm and produce unreliable findings. Following Arifin (2018), this study adhered to the principles of informed consent, privacy, confidentiality, fairness, and the avoidance of harm. Participants were informed about the study's objectives, the use of their data, and

February 2026, Vol. 12, No. 1
ISSN 2163-758X

its disposal procedures before providing consent. They were assured of their right to withdraw at any time. Confidentiality and anonymity were guaranteed by avoiding disclosure of personal identifiers and storing data in a password-protected file. No participants experienced harm during the research, and fairness, justice, and unbiased procedures were maintained. Finally, the study ensured that results were not fabricated, and plagiarism or misconduct was avoided at all stages.

Research Findings and Data Analysis

Descriptive Statistics

The study was performed to examine cooperative learning implementation and its impacts on students' performance and behavior in Lebanese private schools. A total sample of 36 school teachers ~~is was~~ surveyed online and Table 1 shows the demographic description. It is evident from Table 1 that the majority of the respondents were female teachers (86%) from private elementary schools in Lebanon (53%). There were also teachers teaching secondary and intermediate classes, but the ratio is small. The majority of the sample were language teachers (39%), while many were also teaching mathematics (22%), sciences (31%), or other subjects. The teachers were well educated as the majority of the sample were masters, bachelors, or diploma holders. At last, it is also clear that the majority of teachers in the sample had over 8 years of experience (61%).

Table 1: *Demographic Information about the Study Participants*

Item	Description	N	%
Gender	Female	31	86%
	Male	5	14%
Teaching Experience	0-3y	10	28%
	4-7y	4	11%
	8y and above	22	61%
What level do you teach?	Kindergarten	0	0%
	Elementary	19	53%
	Intermediate	5	14%
	Secondary	12	33%
What is your subject category?	Economics	1	3%
	Languages	14	39%
	Mathematics	8	22%
	Sciences	11	31%
	Social Studies	2	6%
	Sociology	0	0%
	IT	0	0%
	Physical Health	0	0%
	Philosophy	0	0%
What is your level of education?	Bachelor degree	11	31%
	Diploma	14	39%
	Master	11	31%
	PHD	0	0%

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Understanding Cooperative Learning

Firstly, the survey was conducted to determine the level of knowledge of respondents regarding the concept of cooperative learning. The respondents were required to select the correct definition of cooperative learning from the provided incorrect definitions. It is evident from Table 2 that out of the 36 respondents, 97% chose the correct definition of cooperative learning, while one chose an incorrect definition, showing that a very low number of teachers were unaware of the concept., Keeping in mind that the population of private teachers is very large, and the sample only includes 36 representatives , it may be assumed that one in 36 teachers of the entire population, does not know cooperative learning. This shows that a large proportion of teachers in Lebanon need training regarding cooperative learning.

Table 2: *Understanding of Cooperative Learning among Teachers of Lebanese Private Schools*

Question	Description	N	%
Which statement best describes Cooperative Learning?	Students work independently to achieve individual goals.	0	0 %
	Students compete against each other to demonstrate individual mastery.	1	3 %
	Students work together in small groups to achieve a common goal and are mutually accountable for learning.	35	97 %

Frequency of Implementing Cooperative Learning in Lebanese Private Schools

Table 3 shows that out of 36 teachers in private schools in Lebanon, most either often use the cooperative learning strategy or always use it. The respondents were also asked how often they manage to engage students in various group assignments or discussions during classroom routines. Most of the teachers reported doing it frequently , while 13 teachers claimed to do it on a regular basis . Thirdly, the teachers were asked about the frequency of using technology in cooperative learning tasks. The majority of teachers always incorporate or often incorporate it. At last, the teachers were asked about the frequency of using the technique in solving issues problem-solving tasks or projects, and the results show that more than a half of the sample (16) often use it less than a half (12) sometimes use it), while 7 always use it. This shows that very few teachers have chosen the option of *rarely* or *never* revealing a high frequency of use.

Table 3: *Frequency of Implementation of Cooperative Learning*

Questions	Always	Never	Often	Rarely	Sometimes
How frequently do you implement cooperative learning strategies?	9	1	20	2	4
How often do you engage your students in group tasks or discussions as part of their classroom routines?	13	0	18	3	2
How often do you integrate technology in cooperative learning activities?	17	0	12	2	5

February 2026, Vol. 12, No. 1
ISSN 2163-758X

How often do you use cooperative learning to solve problems or complete projects?	7	0	16	1	12

Techniques for Using Cooperative Learning in Private Schools of Lebanon

As shown in Table 4, it is evident that among all the activities, the most widely used are problem-solving-based learning (53%), project-based learning (42%), think-pair-share (75%), and group projects (44%). Other activities used by the teachers of Lebanese private schools are inquiry-based learning (33%), jigsaw (39%), role assignments (25%), and round robin (36%). The results reveal that many teachers diversify activities and tools while implementing cooperative learning in Lebanese private schools.

Table 4: *Techniques of Cooperative Learning*

Cooperative Learning Strategies	N	%
Jigsaw	14	39%
Think-Pair-Share	27	75%
Group Project	16	44%
Round Robin	13	36%
Role Assignments	9	25%
Project-based Learning	15	42%
Problem-solving- based Learning	19	53%
Inquiry-based Learning	12	33%

Procedures for Implementing Cooperative Learning Strategy

The teachers were asked to what extent they followed structured procedures of cooperative learning, and the responses are provided in Table 5 (where SA=strongly agree, A=Agree, N=Neutral, D=Disagree, and SD=Strongly Disagree). It is evident that the majority of the teachers either agreed or strongly agreed that they would implement such procedures. The most frequently selected options were: *agree, neutral*, or *strongly agree*. This shows that the teachers implement the procedures, but they need to improve their consistency

Table 5: *Procedures for Implementing Cooperative Learning in Lebanese Private Schools*

Cooperative Learning Procedures	SD	D	N	A	SA
I design and implement activities that encourage group collaboration and interaction among students.	0	2	4	23	7
I use specific tools or resources (e.g., task cards, manipulatives, digital tools) to facilitate cooperative learning activities.	1	2	4	22	7
My cooperative learning activities are designed to align with lesson objectives and curriculum standards.	0	0	4	16	16

February 2026, Vol. 12, No. 1
ISSN 2163-758X

I monitor and provide feedback on group processes and individual contributions.	1	2	3	17	13
I follow clear and structured procedures to organize cooperative learning activities in my classroom.	0	1	4	17	14
I assign specific roles to group members to ensure balanced participation during cooperative learning tasks.	0	1	8	17	10
I provide guidance to help students develop teamwork and conflict-resolution skills during cooperative learning activities.	0	0	6	18	12

Impact of Strategy on Student Academic Performance in Private Schools of Lebanon:

As shown in Table 6, most teachers believe cooperative learning has either a significant or moderate effect on students' understanding and retention of academic knowledge. Specifically, 22 teachers indicated that it significantly improved students' problem-solving and critical thinking skills, while 12 observed some level of improvement. Additionally, 17 teachers reported that this approach had a significant positive impact on academic performance measures, such as test scores and project outcomes, and 19 teachers noted some improvement in this area as well. This evidence suggests that cooperative learning is an effective strategy for fostering positive changes in students' academic performance. Furthermore, very few teachers reported that it had little impact, remained unchanged, or did not lead to any improvement.

Table 6: *Impact of Cooperative Learning on the Academic Performance of Lebanese Private Schools*

Questions	Significant Improvement	Some Improvement	Little Improvement	No Improvement
How has cooperative learning impacted your students 'understanding and retention of core academic concepts?	24	10	1	1
How do students' problem-solving and critical-thinking skills change after participating in cooperative learning tasks?	22	12	2	0
How does cooperative learning affect students' academic performance (e.g., test scores, project outcomes)?	17	19	0	0

Impact of Strategy on Student Academic Behavior in Lebanese Private Schools

The results in Table 7 show that a majority of teachers stated that students' increased engagement and motivations (19%), developed better communication and collaboration skills (25%), developed positive attitudes towards learning and teamwork (36%), were able to understand complex concepts (25%), and showed improvement in self-confidence and self-esteem (42%). Thus, it can be concluded that there is a significant and positive

February 2026, Vol. 12, No. 1
ISSN 2163-758X

impact of the strategy on the students' academic behavior. The table also shows that agree and strongly agree are the most chosen.

Table 7: *Impact of Cooperative Learning on Student Academic Behavior in Lebanese Private School*

Impacts of Cooperative Learning	SD	D	N	A	SA
Students show increased engagement and motivation during cooperative learning activities	0%	0%	8%	72%	19 %
My students develop better communication and collaboration skills through cooperative learning.	0%	0%	6%	69%	25 %
Cooperative learning has positively influenced students' attitudes toward learning and teamwork	0%	3%	6%	56%	36 %
Cooperative learning helps my students understand complex concepts	0%	0%	17 %	58%	25 %
Cooperative learning helps my students build self-confidence and self-esteem	0%	3%	6%	50%	42 %

Challenges of Cooperative Learning in Lebanese Private Schools

In Table 8, it is evident that the most significant challenge of cooperative learning is diverse student abilities. Another issue identified is a lack of time management (36%). Uneven engagement from students is also a key concern (33%), along with resource limitations (31%) that are overlooked in Lebanese private schools. Other issues that are least identified by teachers are a lack of training and awareness of classroom management. However, these two issues are not widely recognized, but they are very significant as they contribute to a lack of time management, uneven engagement, and assessment challenges.

Table 8: *Challenges Faced in Cooperative Learning in Lebanese Private Schools*

Challenges of Cooperative Learning	**N**	**%**
Uneven engagement	12	33%
Diverse students' abilities	16	44%
Time management	13	36%
Assessment Challenges	9	25%
Resource Limitations	11	31%
Classroom management	5	14%
Lack of training	5	14%

Strategies for Improvement of Cooperative Learning

To improve cooperative learning in private Lebanese schools, the teachers were asked to provide recommendations for improvement. The responses are provided in Appendix A and categorized into three key themes through manual thematic analysis, including 1) improvement of training, tools, and activities in classrooms, 2) enhancing frequency of implementation, and 3) enhancing the overall procedure of cooperative learning.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Some of the respondents provided recommendations on improving training, activities, and resources in the classroom to facilitate cooperative learning. They noted that teachers often lack the necessary resources, training, and tools to effectively implement cooperative learning sessions.

To address this, training can be enhanced through one-on-one peer tutoring, hiring educational specialists to conduct valuable workshops, and establishing annual training programs. Additionally, many respondents emphasized the importance of improving classroom environments by providing resources such as round tables, computers, digital tools, and other materials that support cooperative learning.

Furthermore, some respondents suggested enhancing activities by considering four predominant learning styles: 1) visual, 2) auditory, 3) read/write, and 4) kinesthetic. They proposed that teachers should adopt activities that cater to all these styles to accommodate students with diverse abilities and maximize learning opportunities.

Teachers in Lebanese private schools have suggested several strategies to improve the frequency of cooperative learning in classrooms. They recommend that instead of using cooperative learning activities just once, teachers should integrate them into the curriculum and daily lessons. It is essential to allocate more time for these activities, rather than concentrate solely on delivering brief lectures, which can diminish students' motivation to learn. Many respondents agree that enhancing time management is crucial for facilitating cooperative learning and promoting better student performance.

Improving the implementation of cooperative learning is the most recommended strategy. Respondents believe that teachers are not effectively implementing this approach. There is often a lack of clear goals, expectations, and fair distribution of students within teams. Many teachers struggle to foster teamwork, accountability, and effective communication during activities. Additionally, class sizes can be excessively large or too small, and students frequently receive inadequate instructions. Inappropriate procedures and methods of execution have lowered effectiveness of the strategies. Therefore, it is recommended that teachers carefully plan cooperative learning activities to maximize student engagement, avoid conflicts, and ensure smooth execution within the available time and resources, ultimately enhancing the effectiveness.

Table 9 illustrates the correlation between the frequency of using cooperative learning, the procedures followed, and their impact on students. The data reveals that both the frequency of cooperative learning activities (0.63) and the procedures used (0.68) have a significant and strong impact on students' academic performance. When teachers increase the use of cooperative learning activities and closely follow established procedures, they observe improvementin students' academic results.

Additionally, student behavior is significantly and positively affected by a higher degree of adherence to cooperative learning procedures (0.68). However, the frequency of these activities has a more limited impact on student behavior outcomes. Therefore, it is clear that the respondents’ recommendations are practical: enhancing the frequency, procedures, activities, tools, and resources associated with cooperative learning can indeed lead to better outcomes in this approach.

Table 9: *Correlation between Frequency, Procedures, and Impact of Cooperative Learning*

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Correlation Items	*Frequency*	*Procedures*	*Academic_ Performance*	*Student_ ehavior*
Frequency	1			
Procedures	0.68	1		
Academic Performance	0.63	0.45	1	
Student Behavior	0.36	0.68	0.36	1

Discussion

The current examination of cooperative learning implementation and its impact on student outcomes in Lebanese private schools strongly suggests that this pedagogical solution is an effective teaching strategy with potential benefits extending beyond this specific context to public schools and educational settings globally. The findings, indicating enhanced academic performance and positive behavioral changes among students engaged in cooperative learning activities, underscore its value. This aligns with a substantial body of international research that champions cooperative learning as a means to foster student engagement, critical thinking, and collaborative skills (Johnson & Johnson, 1999).

The relatively high frequency of cooperative learning implementation reported by the surveyed teachers in Lebanese private schools, coupled with their adherence to structured procedures and the utilization of varied activities, provides a positive indication of its feasibility within this educational system. This suggests that despite the acknowledged challenges, such as time constraints and curriculum demands, educators in Lebanon recognize and apply the benefits of collaborative learning environments. The perceived positive influence on student motivation, communication skills, and self-confidence further strengthens the argument for the broader adoption of cooperative learning strategies.

Additionally, the alignment of these findings with existing research, such as the work by Cecchini et al. (2021), which demonstrated that structured cooperative learning can lead to improved motivation, enhanced content knowledge, and better classroom behavior, supports the idea that the benefits observed in this study are not exclusive to the context of Lebanese private schools. Similarly, Van Ryzin et al. (2020) found that cooperative learning helps reduce bullying and fosters positive peer relationships and behaviors. The consistent positive outcomes reported across different cultural and educational settings highlight the potential of cooperative learning to address common educational goals, such as improving student understanding, promoting critical thinking, and fostering positive social interactions. Therefore, the insights gained from this study advocate for a wider embrace of cooperative learning as a valuable tool for educators in diverse school environments, both locally in Lebanon and internationally.

Limitations

The study design has several limitations that deserve consideration when interpreting the findings. The relatively small sample size of 36 teachers, drawn exclusively from private schools in Mount Lebanon, restricts the generalizability of the results. Therefore, the findings may not be representative of the perceptions and practices of teachers in public schools or private school teachers across other regions of Lebanon. The reliance on a

February 2026, Vol. 12, No. 1
ISSN 2163-758X

quantitative survey method, while efficient for data collection, provides a snapshot of teacher perceptions and practices at a specific point in time and may not capture the nuances of classroom implementation or the complexities of student experiences. Furthermore, the study did not delve deeply into the specific challenges encountered by teachers in implementing cooperative learning, such as managing diverse student abilities or addressing issues of uneven participation within groups.

Recommendations

Based on the findings and limitations of this study, several recommendations can be made. Policymakers and school administrators should prioritize the provision of ongoing professional development opportunities for teachers, focusing on the principles, diverse strategies, and effective implementation of cooperative learning. These initiatives should include practical workshops, resource sharing, and opportunities for collaborative learning among educators. Schools should also ensure the availability of adequate resources, including flexible classroom layouts, appropriate materials, and technological tools, to facilitate the effective execution of various cooperative learning activities. Integrating cooperative learning as a consistent and integral component of the curriculum, rather than an occasional activity, is also recommended to maximize its potential benefits.

Future research should address the limitations of the present study by employing larger and more representative samples across different regions and types of schools in Lebanon. Longitudinal studies and experimental designs could provide more robust evidence regarding the long-term impact of cooperative learning on student achievement and behavior. Qualitative investigations, such as classroom observations and in-depth interviews with teachers and students, could offer valuable insights into the challenges and facilitators of effective cooperative learning implementation in the Lebanese context. Exploring potential moderating factors, such as subject matter, grade level, and student characteristics, would also enhance our understanding of the conditions under which cooperative learning is most effective.

Conclusion

In conclusion, this study addressed the identified gap in the literature regarding the implementation and impact of cooperative learning in Lebanese private schools, stemming from a noted reliance on traditional teaching methods and a limited understanding of alternative pedagogical approaches. The primary purpose was to examine how cooperative learning is implemented and its effects on student behavior and academic outcomes within this specific educational context. The findings indicated that most surveyed teachers had a basic understanding of cooperative learning, applied various structured methods, and observed positive effects on students' academic performance, including better understanding, problem-solving skills, and overall outcomes. Also, they noted improvements in student behavior, such as increased engagement and enhanced communication and collaboration skills.

The study results offer valuable insights into cooperative learning in Lebanese private schools and its positive impact on student development. Recommendations include ongoing professional development for teachers, adequate resources, and consistent integration of cooperative learning. Future research should aim for larger-scale studies

February 2026, Vol. 12, No. 1
ISSN 2163-758X

and deeper qualitative analyses to further explore effective practices in cooperative learning. Overall, this study supports cooperative learning as an effective strategy for enhancing students' academic and social-emotional growth.

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Author Notes

Abeer Al Danaf is a committed advocate of lifelong learning, dedicated to advancing excellence in education through leadership and innovation. She holds a Master of Education from the University of Adelaide and a Teaching Diploma from MUBS, equipping her with strong expertise in research, pedagogy, quality assurance, and global educational practices. In her role as Head of Department at Elite International School, she fostered a collaborative culture of inquiry, guided academic operations, and mentored diverse teams. Her leadership was marked by the successful implementation of strategic initiatives that improved both student achievement and teacher performance. With proven strengths in educational leadership and academic administration, Abeer is passionate about creating learning environments where excellence is attainable, innovation is embraced, and positive change is consistently realized.

Samar Bouzeineddine is an experienced educator and researcher with expertise in educational management, leadership, and environmental education. She holds a Bachelor of Science in Business and Computer from Beirut University College, a Teaching Diploma, and a Master of Arts in Education with a focus on Educational Management and Leadership from the Lebanese American University. Currently, she serves as a Senior Instructor and Researcher at the Modern University for Business and Science (MUBS). She has also taught at the Center for Continuing Education at Haigazian University and has spent over two decades working as an English Language

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Arts teacher and coordinator at Al Manar Modern School. Her research and training emphasize professional development, 21st-century teaching, and social-emotional intelligence. A committed advocate for sustainability, Samar has been recognized with the Green Mind Award for her contributions to advancing environmental education in Lebanon.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Navigating Anxiety and Uncertainty: International Students' Challenges and Strategies to Cultural Adjustment

Addison H. Carrasquillo and Sachiyo M. Shearman

East Carolina University, Greenville, NC, USA

Abstract

International students face unique challenges when transitioning from their home countries to another culture. Guided by Gudykunst's (2005) Anxiety-Uncertainty Management (AUM) Theory, the current research highlights how international students in the U.S. manage their uncertainty, anxiety, and cultural distance in academic and social settings. This study draws on ten in-depth interviews with international students (five males and five females) at a large public university in the Southeastern United States. We examined how they navigate the cultural adjustment process in a higher education institution located in a rural area of the United States. Thematic analysis of the in-depth interview revealed that international students experienced a variety of challenges such as pre-arrival expectations, navigating American communication styles, adjusting to academic expectations and campus culture, barriers to building social connections, and economic/time constraints. Despite these challenges, the international students managed anxiety and uncertainty by building support systems, engaging in campus involvement, taking on leadership roles, and practicing mindfulness and other strategies to manage stress. The current study highlighted the resilience of international students and identified ways in which institutions can strengthen their support.

Introduction

The U.S. has long been the leading destination for international students. In 2022–2023, over one million students were enrolled, a 12% increase from the previous year and the fastest growth in forty years. Their presence contributes $40 billion annually to the U.S. economy (IIE, 2023) and to the internationalization of the US campuses. The diverse classrooms enhance critical thinking, while international connections strengthen institutional reputation and global awareness (Arthur & Flynn, 2001; Gurin et al., 2004; Smith & Schonfeld, 2000).

At the same time, international students face barriers adjusting to new cultural and academic environments. Language differences, unfamiliar communication styles, and new classroom expectations complicate transitions (Berry, 2005; Liu & Huang, 2015). A key factor is perceived cultural distance—the extent to which an individual presumes the host culture as different from their own. Rooted in Hofstede's (1984) framework and applied by Kogut and Singh (1988), this concept highlights how perceptions of difference shape stress, involvement, and belonging (Yan & Berliner, 2010). Students may feel caught between adapting to U.S. norms and maintaining their culture. Assimilation risks

February 2026, Vol. 12, No. 1
ISSN 2163-758X

identity loss, while isolation limits integration, both underscoring the role of perceived cultural distance (Tang et al., 2024; Yan et al., 2024).

Challenges International Students Face

International students may face many challenges when adjusting to a new country, including culture shock, discrimination, language barriers, financial stress, visa restrictions, and academic differences, all affecting well-being and success (Khanal & Gaulee, 2019; Lorenzetti et al., 2023). Culture shock is unpredictable and unique to each student (Berry, 2005; Demes & Geeraert, 2015; Yan & Berliner, 2010). Discrimination lowers satisfaction and heightens stress (Lee, 2010; Lee & Rice, 2007).

Studies show language barriers persist even among students with high English proficiency, who may struggle to keep up with lectures, readings, and social interactions (Chen, 1999; Dao et al., 2007; Neumann et al., 2018). Classroom expectations such as self-directed learning and participation can add stress when unfamiliar (Frambach et al., 2012; Wang, 2004). Together, these challenges restrict involvement and heighten isolation, making culturally aware institutional support critical for success (Gebhard, 2012; Glass et al., 2015; Kim et al., 2022).

Although well-documented, less is known about how these challenges play out in rural U.S. settings, where resources and cultural exposure may be limited. In light of global events and media influence, further research is needed. This leads to the first research question.

Research Question 1: What challenges do international students face in adapting to American campus life?

Anxiety Uncertainty Management Theory

Anxiety-Uncertainty Management (AUM) Theory, developed by Gudykunst (2005), explains how people communicate across cultures by building on Uncertainty Reduction Theory (Berger & Calabrese, 1975). AUM suggests effective communication depends on keeping anxiety and uncertainty within optimal levels. Too much anxiety leads to withdrawal or poor judgment, while too little reduces motivation to adapt. Similarly, excessive uncertainty causes hesitation, while very low uncertainty can result in overconfidence (Gudykunst, 2005).

In intercultural contexts, individuals often experience anxiety in unfamiliar environments and uncertainty when they cannot predict others' behavior (Knowles & Olatunji, 2020; Ni & Wang, 2011). Moderate levels are most beneficial, motivating people to engage, seek information, and learn (Gudykunst & Nishida, 1986; Presbitero & Attar, 2018). Strategies such as mindfulness, information-seeking, and building social networks help manage stress and improve adaptation (Kashima et al., 2017; Ting-Toomey & Dorjee, 2015).

International Student Anxiety and Uncertainty

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Studies show that international students who approach experiences with awareness of potential challenges can better manage anxiety and uncertainty, leading to stronger adjustment (Nahla, 2021). Szabo et al. (2016) found that difficulties often depend less on the new environment itself and more on how students respond. Those able to reframe anxiety adjusted more successfully, supporting AUM theory (Gudykunst, 2005). Finding cultural similarities with the host culture reduces apprehension and motivates engagement with peers (Gudykunst & Nishida, 1986; Neuliep, 2012; Taniguchi et al., 2022). Recognizing anxiety as natural and actively managing it, allows students to focus on opportunities for growth (Szabo et al., 2016).

Supporting Adjustment

University resources, social networks, and coping strategies play important roles in adjustment. Academic support and faculty guidance mitigate differences in teaching styles, and positive faculty relationships influence student satisfaction (Khanal & Gaulee, 2019; Lorenzetti et al., 2023; Martirosyan et al., 2019; Morin, 2007; Zhou & Cole, 2017). Social integration is equally critical; co-national groups provide comfort, but overreliance can limit broader connections (Rose-Redwood, 2013; Sheng et al., 2022). Students who participate in clubs, mentorships, or events often report stronger adjustment and better relationships (Glass & Westmont, 2014; Tieu et al., 2010).

Still, many students struggle with homesickness, loneliness, or family pressures (Chavajay & Skowronek, 2008; Yeh & Inose, 2003). Counseling and career services are available but often underused due to stigma or mismatched expectations (Dombou et al., 2023; King & Bailey, 2021; Mori, 2000). Mentoring is effective when culturally sensitive, with students valuing dependability and multicultural awareness (Nilsson et al., 2004; Zhang & Dixon, 2001).

Beyond formal services, many turn to self-directed strategies. Mindfulness, problem-solving, information-seeking, and campus involvement build resilience, manage stress, and create balance (Laoboonchai, 2016; Mei et al., 2004; Presbitero & Attar, 2018). Meaningful activities help with coping and create opportunities for leadership and growth (Astin, 1984; Tieu et al., 2010; Zhou & Cole, 2017).

Although research identifies strategies that support adjustment, less is known about which factors matter in rural U.S. institutions, where resources and cultural exposure may be limited. This study examines how international students manage anxiety and uncertainty while adjusting to campus life in a rural setting.

Research Question 2: How do international students use resources, involvement, and engagement to manage anxiety and uncertainty during their adjustment to an American college campus? What other factors help facilitate their adjustments?

Methods

Participants

February 2026, Vol. 12, No. 1
ISSN 2163-758X

This study focuses on international students at a large public university in a rural area of the United States. Students were interviewed in the Spring of 2025. Five men and five women represented ten countries: Nigeria, South Africa, Norway, Pakistan, Nepal, Brazil, Colombia, Cyprus, Egypt, and Japan. Five were pursuing master's degrees, four were undergraduates, and one was in a PhD program. Time at the university ranged from three months to five years, offering both fresh and longer-term perspectives.

Procedure

Participants were selected as part of a larger study. The university's global affairs department assisted in soliciting participation of the international students on an F-1 Visa. Purposive sampling was used to ensure diverse backgrounds and perspectives. Participants were contacted through email to schedule a virtual or in-person interview. Those interviews varied between 20 and 60 minutes, depending on the participant's engagement. A semi-structured format allowed students to share experiences while focusing on key topics. The informed consent form was reviewed before each session, and pseudonyms were used for confidentiality.

Measures

The interview questions were created based on the proposed research topics. The semi-structured interview had three sections: (1) introductory questions to build rapport (e.g., motivations to study in the U.S.), (2) cultural adjustment and challenges, and (3) campus involvement, resources, and suggestions for improvement. Closing questions invited additional thoughts.

Data Analysis

Interviews were analyzed with thematic analysis (Braun & Clarke, 2016). Thematic analysis enabled a detailed examination of students' experiences, identifying common themes across the ten interviews. NVivo 14 (Lumivero, 2023) was used to assist in organizing the data. The process followed Braun and Clarke's (2016) and Nowell et al.'s (2017) six-step guide. A deductive coding process was utilized; codes were developed based on research questions and existing literature on adjustment, involvement, anxiety, uncertainty, and cultural distance. Inductive flexibility was allowed to account for unanticipated but relevant patterns in students' responses. Themes were organized around two research questions. Six themes highlighted student challenges, and four themes described coping strategies that supported adjustment.

Results

International Student Challenges

The following section explores findings for Research Question 1. Six themes emerged regarding international student challenges: holding unrealistic expectations shaped by the media, navigating unfamiliar communication norms, adjusting to academic life, forming peer connections, managing financial and time constraints, and overcoming anxiety and uncertainty. These themes highlight how cultural distance, uncertainty, and limited

February 2026, Vol. 12, No. 1
ISSN 2163-758X

involvement influenced students' adjustment and shaped the challenges they faced day to day.

Theme 1: Media and Pre-Arrival Expectations

Theme one centered around how media consumption shaped students' pre-arrival preparations. Participants reported that they gathered information about American colleagues and cultures through various media, including movies and YouTube videos. Samir, from Nepal, explained: "I used to watch a lot of Hollywood films, so I kind of expected what kind of language people speak and how they behave." While some felt more prepared, others were taken aback. Marcus, from West Africa, expected skyscrapers and lots of snow, only to find neither.

AUM theory suggests that familiarity with a culture can reduce anxiety and uncertainty (Gudykunst, 2005). Students use social media to learn about American culture and language, which can aid adjustment but also lead to misinformed expectations when portrayals do not align with reality (Yanagihara, 2017). Xie and Chao (2022) found that while social media platforms can ease emotional anxiety and help students stay connected to their home culture, they can also make it harder to build deeper connections within their host country.

Theme 2: Navigating U.S. Communication Styles

The second theme was how students adjusted to everyday communication, including politeness norms, level of directness, and casual interactions. Communication styles are tied to cultural expectations and differences in how Americans express friendliness, set boundaries, or approach conversation, which at times creates uncertainty for students. Peter noted that in Egypt, declining food is disrespectful, while in the U.S., "people take your word for it." Marcus shared a similar example that in West Africa, it is polite to decline an offer at first and only accept if it is offered again. “Here, you only get asked once, and people take your word for it. Some people say it is a respectful thing.”

Such experiences highlight cultural differences in how relationships and boundaries are understood (Hofstede, 1984; Leotescu, 2024). In low-context, individualistic cultures like the U.S., personal space is often prioritized, which can leave students uncertain about how to build closer relationships. These communication differences were one layer of adjustment; students also described changes in academic expectations as another significant challenge.

Theme 3: Adjusting to Academic Expectations

The third theme that emerged was the differences in teaching styles and faculty-student relationships. In some countries, education is primarily lecture-based. American higher education institutions often expect students to engage in extracurricular activities, attend events, and utilize campus resources as part of their learning experience and grade. Ahmed shared, "The students are more involved, and the university organizes stuff for students; that's not common in Pakistan." For students focused on academic success over social opportunities, integrating coursework into campus life may be a solution.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

In some cultures, professors hold an authoritative power distance, but participants found their U.S. instructors approachable. Marcus reflected: "Power is fluid… I am great friends with professors. That's different back home. Power is inaccessible for the most part." American professors tend to encourage open communication, participation, and self-directed learning (King & Bailey, 2021). For students unfamiliar with this style, hesitation may be misinterpreted as disinterest by faculty (Wang, 2004; Yildirim, 2017).

Participants also reported challenges outside the classroom, including difficulty connecting with American peers.

Theme 4: Barriers to Building Social Connections

Domestic students were reported to be generally polite, but participants said connecting required more effort. Camila, from Colombia, described her first weeks in the classroom: "They (classmates) seemed like they all knew each other… having to make your path in trying to make friends, was like, how do I get close to them?" Ana, from Brazil, shared similar frustration, noting that classmates often assumed she was an exchange student: "They don't want to make an effort on someone who is going to leave."

Language barriers added another layer. Curtis and Ledgerwood (2018) found that even motivated students face social constraints that limit connection. In addition to social constraints, one student felt that they adjusted well socially but still faced obstacles that were beyond their control. Emma, from Cyprus, explained: "It's a different thing to joke and be yourself in another language. I felt like all my relationships were at a surface level." She worried about missing chances to join conversations or that her jokes would be misunderstood. In addition to social hurdles, students explained that financial pressures and limited time made it harder to participate in campus life.

Theme 5: Financial and Time Constraints

Over half of the participants mentioned their biggest challenge was finances. Students described struggles affording study abroad and maintaining hobbies they enjoyed back at home. International students can work on campus, but hours are limited and rarely cover all expenses. Camila spoke of being constantly conscious of spending. "There's a lot more things to do. I am very grateful, but sometimes you have to say no to doing things, even though you want to (participate)."

Students also struggled to balance classes and social opportunities. Dewey et al. (2013) found that students' involvement and ability to build connections often depend on time and whether opportunities were accessible. Peter, a PhD student, acknowledged his desire to be a part of more but that it was not realistic due to his studies, "We are so busy to the point that even if you have a problem, you don't have time to think about it." Although the intensity of a PhD program is unique, undergraduate and graduate students expressed similar struggles, emphasizing that academics took priority. Beyond these pressures, students also described deeper challenges tied to anxiety and uncertainty.

Theme 6: Emotional Experiences of Anxiety and Uncertainty

February 2026, Vol. 12, No. 1
ISSN 2163-758X

For many students, uncertainty in a new environment creates stress (Huiwen et al., 2023; Oberg, 1960). Participants shared that anxiety extended beyond personal worries; it included their family back home and the distance between them. Peter expressed, “It’s difficult to pinpoint, everything is new, and anxiety is becoming part of life. I’m living with it.” Others struggled with a persistent mental battle of fitting in “the first year was fun and exciting, but it hit me the second year. It was affecting me more, homesickness, and the feeling that I don’t belong here”.

Students also raised concerns about post-graduation uncertainty and visa limits. Inez said, “Not knowing what comes next is frustrating. I didn’t even get information about career steps until right before graduation.” These reflections underscore that emotional stress, though less visible, can be just as impactful.

The participants described a range of challenges while adjusting to life on an American campus. These included mismatched cultural expectations shaped by media, unfamiliar communication styles, and differences in academic and social norms. Forming friendships with domestic students was especially difficult, often due to cultural misunderstandings, language barriers, or relationships that remained surface-level. Campus involvement was also limited by time and financial pressures, particularly for students in demanding majors or on scholarships who felt added pressure to perform. While each experience was unique, their reflections revealed how cultural distance, anxiety, uncertainty, and external barriers often intersect during the adjustment process.

Factors Supporting Adjustment

The following section summarizes the strategies that the international students used to cope with the challenges. To answer our second research question, we have asked how international students manage uncertainty and anxiety, and how they adjusted to American culture. Four themes emerged: building a support system, managing anxiety and uncertainty, finding meaningful leadership roles, and personal growth through mindfulness. The following sections highlight how these strategies supported students' adjustment.

Theme 1: Developing a Support System

The first theme that emerged was how participants relied on support networks, both on and off campus, to aid adjustment. Social support, including friends, mentors, and community members, can improve overall well-being (Kagan & Cohen, 1990; Sullivan & Kashubeck-West, 2015). Participants described a variety of ways these networks formed. Ana joined a service sorority. "That was something different I wanted to do. You just start finding your people." James described finding the members of his church to be like a second home.

Support extended beyond campus; six of the ten participants applied to this university because this institution was personally recommended. For Ahmed, family influenced his decision, "My brother lived here, my mother only allowed me to go if I had gotten admission into the same school." Research suggests international students are more

February 2026, Vol. 12, No. 1
ISSN 2163-758X

likely to turn to peers, advisors, or informal support rather than counseling staff (Yakushko et al., 2008). Others relied on pre-established networks. Samir, who had classmates from Nepal studying in the U.S., explained “I talk to my parents every few days… I also have friends who are going through the same phase. If you don't have people to share what you are feeling, that makes people more anxious”.

While many found support through campus life, faith-based communities, or personal networks, not all had the same experience. A couple of students gave brief responses about friendships, suggesting they may still be finding their place. These relationships are key to reducing isolation and preparing for adjustment, though the process varies for each student.

Theme 2: Involvement and Leadership Roles

Campus involvement is central to students’ adjustment (Nguyen, 2016). Hearing students discuss their interests and involvement reflected that idea. Samir shared, “I didn’t know what to expect, but I knew I wanted to get involved.” Nine out of ten participants held student jobs, which provided both financial support and opportunities for personal and professional growth. Camila, a graduate student, reflected on her role as a teaching assistant: “I didn’t have the same experience as them (undergraduate students). It is interesting to get to know them (undergraduate students), and hear the differences and small changes from home.” Employment also improved awareness of campus resources; James noted, “As an RA, I get insight into resources I didn’t even know we had during my first year.”

Beyond employment, some students held leadership roles. Previous studies show peers with similar backgrounds improve psychological well-being and adjustment (Martirosyan et al., 2019). Similarly, Rose-Redwood (2013) emphasizes that friendships with other international students are important in the early stages. The International Student Association (ISA) is a primarily student-led organization created to connect international and domestic students. Many of the students spoke about their involvement. Marcus explained, "We became the voice of international students… a place to belong to, identify with, and say, hey, that's our people." Joining clubs, events, or peer groups helps students feel connected, less stressed, and more confident in academic and social life. (Hechanova-Alampay et al., 2002; Kaya, 2020). Finding a sense of belonging during times of change helps international students feel at home and balance the pressures of adjusting to a new culture (Chavajay & Skowronek, 2008; Yeh & Inose, 2003).

Not all students took on leadership roles. Inez worked for financial stability, stating she had no desire to hold a leadership role outside of work. “We don’t have time, so the only time we can have fun is during our break.”. Employment helped students navigate campus life but was not always tied to leadership. For many, jobs were a necessity shaped by workload or finances, leaving little time for extra roles. Still, involvement, through work, leadership, or organizations, was described as essential to making the institution feel like home.

Theme 3: Managing Anxiety and Uncertainty

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Following the experiences of anxiety and uncertainty discussed in theme five, participants shared the way they managed. Many found that staying productive helped them avoid feeling overwhelmed. Attending campus events provided distraction and relief: "When I'm there, I'm not stressed. I'm seeing people, talking, and interacting." Some students relied on mindfulness to regulate anxiety, an idea emphasized by AUM Theory, which highlights awareness and emotional management as key in uncertain situations. Ana reflected: "There are days when I'm crying… but you have to let yourself feel it. Then ask, what am I going to do after? How am I going to move forward?"

Managing anxiety early, rather than after it becomes unmanageable, can shape adjustment (Gudykunst, 2005). In this study, students who managed anxiety more effectively were more likely to report better psychological adjustment. Ahmed credited a class: "I had a stress management course, and they taught me the correct way to breathe to calm my nerves. I use that a lot." Controlled breathing and mindfulness regulate emotions, especially in stressful or unfamiliar situations (Misra & Castillo, 2004). These methods give students practical tools to calm themselves and feel more in control. Although all participants reported struggles with anxiety and uncertainty, only one used formal counseling. Emma stated, "I started counseling this semester. We made an appointment right away. I would suggest it for anyone thinking about it." Other students said they did not use counseling due to cultural norms, or belief they could manage it alone. Overall, these strategies helped students manage day-to-day stress and paved the way for deeper personal growth.

Theme 4: Personal Growth and Mindfulness

Over time, many students shifted from resisting uncertainty to embracing it. While some focused on adapting to American culture, others found ways to blend their culture to create a new sense of belonging. One student said they recreated familiar experiences to maintain a connection to home:

> “I miss home. I miss the feeling and touch of home and all those things, too. A lot of what I try to do is recreate some of those experiences and spaces here, which is why a sense of belonging and a sense of place are a huge part of the work I do here. Whether it's creating spaces for international student belonging, or helping increase and maintain a sense of positivity in this place.”

Students recognized that although they were adapting, it was okay to express their cultural identity: "I try to adapt, but I also like certain things about my culture, I'm not going to change." Others accepted uncertainty as part of learning: "You learn from mistakes, and you feel a lot more comfortable with time."

AUM Theory suggests that as students learn to manage uncertainty, their confidence grows. This was reflected by Ana’s self-acceptance: "I'm never going to be like them, and that's okay… I love being Brazilian." Practicing mindfulness involves self-awareness and recognizing stress triggers. Mindfulness allows individuals to reflect on their own and others' cultures, finding similarities and fostering respect for differences. Ting-Toomey

February 2026, Vol. 12, No. 1
ISSN 2163-758X

and Dorjee (2015) argue that mindfulness is central to intercultural competence, enabling cultural sensitivity, ethnorelative mindsets, and stronger communication.

Conclusion

The current study documents the challenges that international students may face: pre-arrival expectations, different communication and academic expectations, campus culture, barriers building social connections, and economic/time constraints. The study highlighted the resilience of international students and identified ways institutions can strengthen their support. Students managed anxiety by building support systems, engaging in campus involvement, leadership roles, practicing informal and formal stress-management strategies, and experiencing personal growth through mindfulness. Many discovered resources later in the semester or through word of mouth, suggesting a need for enhanced outreach and coordination among campus departments. Integrating the importance of wellness into orientation, advising, and everyday interactions, rather than relying only on traditional counseling, may make support feel more approachable, especially for students from cultures where mental health services are less common (Nilsson et al., 2004; Yakushko et al., 2008).

Peer mentorship stood out as a practical step. Orientation provided students with an initial connection, but many felt left alone afterward. Ongoing mentorship between international and domestic students could bridge cultural gaps, foster belonging, and reduce uncertainty (Bowman et al., 2024; Rose-Redwood, 2013). Simple initiatives like check-ins or group events could directly support students' adjustment.

This study is limited by a small sample size and reliance on self-reported narratives, which may exclude other perspectives or invite social desirability bias (Smeding et al., 2017). Future research should include larger, more diverse samples and methods that capture the perspectives of students less likely to volunteer. Still, the findings underscore the importance of intentional outreach, wellness initiatives, and mentorship programs in helping international students feel prepared, connected, and supported.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

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Author Notes

Addison H. Carrasquillo is a recent graduate of East Carolina University's School of Communication, earning both a Master of Arts in Strategic Communication and a Bachelor of Science in Interpersonal & Organizational Communication. During her graduate program, she served as a Teaching Assistant and as the Undergraduate and Graduate Program Liaison, gaining experience in student engagement and academic support. Her thesis, *Navigating Anxiety and Uncertainty: Cultural Adjustment of International Students at ECU*, examined the challenges international students face and the strategies that support their adjustment. This interest grew from her own study abroad experience in ECU's Tuscany study abroad program in 2021 and an internship with the ECU Office of Global Affairs in 2022. She presented this research at the 2025 Global Issues Conference. Addison now works as an Admissions Counselor at Barton College in Wilson, North Carolina, where she focuses on recruitment and inclusive student support.

Sachiyo M. Shearman is a professor in the School of Communication at East Carolina

February 2026, Vol. 12, No. 1
ISSN 2163-758X

University. She has taught in both the undergraduate and graduate programs in the School of Communication as well as in the International Studies Master's Program. She has taught courses such as Conflict and Communication, Intercultural Communication, and Research Methods in both traditional face-to-face classes and distance education formats. Her research interest lies in the analysis of culture, conflict, and communication, focusing on the examination of cultural impact, individual differences, and cognition during information processing. She has written an electronic textbook, "*Communication Across Cultures*," and authored several book chapters. Her research studies have been published in *Communication Teacher, Communication Quarterly, Human Communication Research, The International Journal of Human Resources Management, Journal of Family Communication, and the Howard Journal of Communication*.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Gender Equality in Higher Education: A Comparative Study of Universities in Algeria, Poland, and North Macedonia

Jihane S. Mahi[1], Natasza Maj[2], Filip Belczyk[3], Mokhtari Ryad[4], Nehar Benameur[5] And Kalina Markovska[6]

[1 4 5]University of Abou Bekr Belkaid Tlemcen, Algeria

[2 3]PANS Krosno University, Poland

[6]American College Skopje University, Macedonia

Abstract

Gender equality in higher education is a key global goal, yet significant disparities persist in academic roles and institutions. While women now constitute the majority of university enrollees in many areas, their representation among faculty and leadership remains low, highlighting ongoing horizontal and vertical segregation. Most existing research focuses on national or single-institution trends, leaving cross-institutional comparisons largely unexamined. This study addresses this gap by analyzing gender representation among students, faculty, and administrative staff at three universities: Tlemcen University (Algeria), PANS Krosno University (Poland), and Macedonia University (North Macedonia). We examined institutional data from 2020 to 2025 and contextualized our findings with reports from OECD, EIGE, and UN Women. Our results show significant variations: at Tlemcen University, women comprise 64% of students but are underrepresented among senior faculty. PANS Krosno University has near parity among professors (50.5% female) and a substantial female majority in administration (67%). Macedonia University reports balanced administrative staffing (49% female) but only 44% female professors, especially in STEM. Despite Gender Equality Plans and gender-mainstreaming efforts, women encounter barriers such as biased merit systems and limited leadership opportunities. We recommend targeted strategies to dismantle these obstacles, including embedding gender perspectives in quality assurance processes, implementing equitable hiring practices, expanding mentorship programs, and establishing transparent monitoring of gender outcomes. These measures are crucial for advancing Sustainable Development Goals 4 (quality education) and 5 (gender equality).

Keywords: comparative study, higher education, gender equality, UN SDGs.

Introduction

Gender equality in higher education has gained increasing attention in recent decades (Alam et al., 2025; David, 2015), reflecting its importance in global development agendas and institutional reforms. Significant progress has been made in promoting women's access to higher education and increasing their participation in academic roles (UNESCO, 2024). Education is widely recognized not only as a pathway to individual empowerment but also as a driver of social and economic transformation (Roshan & Rahman, 2025).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

However, persistent gender disparities remain within universities, shaping enrollment patterns, career opportunities, and institutional dynamics (OECD, 2023).

Despite numerous institutional and national initiatives, a gap often exists between policy intentions and practical outcomes. Many higher education institutions have adopted Gender Equality Plans (GEPs) and related strategies (Solem et al., 2025; Tagliacozzo & Ilaria, 2021); however, inequalities persist in affecting recruitment, promotion, and representation in academic roles. Barriers linked to cultural norms, institutional structures, and implicit biases remain influential, though their impact varies across social and policy contexts (Abubakar et al., 2021; European Institute for Gender Equality EIGE (2025).

While existing studies have often examined gender representation at national or regional levels (Ash et al., 2025; Frech, 2025; Ruedin, 2010; Tuki, 2025), fewer have undertaken comparative analyses focusing on specific universities across distinct socio-cultural environments. Moreover, limited research has simultaneously assessed gender representation among students, professors, and administrative staff within a multi-institutional framework. This lack of comparative, institution-level evidence restricts understanding of how local contexts and institutional practices influence gender dynamics in higher education.

To address this gap, this study conducts a focused comparative analysis of three universities located in Algeria, Poland, and North Macedonia, representing diverse socio-cultural and policy settings. These countries have introduced various strategies to promote gender equality; however, the outcomes remain uneven. By analyzing quantitative data on the representation of males and females among students, professors, and administrative staff, the study examines both progress and persistent disparities.

The main objectives of this research are:

- To examine gender representation among students, professors, and administrative staff in the three selected universities.
- To analyze observed disparities within the context of institutional, cultural, and policy factors, drawing on existing literature for interpretation and understanding.
- To highlight similarities and differences in gender representation trends across the three universities.

The significance of this study lies in its comparative and multi-dimensional perspective. By linking representation patterns with policy frameworks and institutional contexts, it provides a deeper understanding of the dynamics of gender equality in higher education. The findings aim to inform universities, policymakers, and international organizations in developing targeted strategies to improve gender balance and promote women's participation in academia. Furthermore, the study aligns with the United Nations Sustainable Development Goals (SDGs), specifically SDG 4 (Quality Education) and SDG 5 (Gender Equality), highlighting the crucial role of higher education in promoting inclusive and sustainable development.

To achieve these objectives, the study is organized into several sections. The literature review provides an overview of previous research on gender equality in higher education,

February 2026, Vol. 12, No. 1
ISSN 2163-758X

establishing the theoretical foundation for the study. The methodology section explains the research design, data sources, and analytical approach. The results section presents the findings on gender representation among students, professors, and administrative staff across the three universities. Subsequently, the discussion interprets the findings in relation to existing studies. Lastly, the conclusion summarizes the study's key insights and contributions, while the final section identifies areas for future research**.**

Literature Review

As institutions of higher learning and knowledge production, universities are expected to promote equity and inclusion. Despite significant improvements in women's access to education, gender disparities continue to persist across different areas of academic life. This literature review examines existing research on gender equality in universities, focusing on three main themes: representation, policy implementation, and institutional practices that influence equality outcomes. The aim is to provide a comprehensive understanding of current challenges and opportunities for fostering a more inclusive academic environment.

Gender equality in universities: a persistent challenge

Gender equality in universities encompasses not only representation but also structural, cultural, and institutional dimensions. Recent studies reveal progress but also highlight enduring disparities. For instance, within the European Union, the proportion of women at the professorial level increased from 24% in 2016 to 26% in 2019; yet, significant barriers still limit women's access to senior academic positions (Rosa & Clavero, 2022). Despite progress in gender representation within academia, women in Australia continue to face barriers to advancement. Although they account for 44% of academic staff, only 31% occupy senior academic roles, highlighting ongoing inequality in leadership positions (Winchester, 2006). Moreover, research from South Africa demonstrates how the intersection of gender and race further complicates equality in higher education, underscoring the need for intersectional approaches (Hlatshwayo, 2020).

Policy implementation: from plans to practice

Many universities have adopted Gender Equality Plans (GEPs) to address structural inequalities. However, their impact varies. Studies indicate that institutional power structures and entrenched organizational cultures often limit the effectiveness of these policies (Clavero & Galligan, 2021). For instance, Germany's "inclusive excellence" framework integrates competitiveness and gender equity, providing a promising model (Zippel et al., 2016).

By contrast, research from Irish and UK universities reveals that policies sometimes focus on "fixing women" rather than addressing systemic barriers, leading to limited progress (Bhopal & Henderson, 2021; Hodgins & O'Connor, 2021)

Gender mainstreaming and pedagogical innovation

Gender mainstreaming initiatives aim to integrate equality into university policies, curricula, and leadership practices. In Albania, such efforts have improved awareness but have not fully overcome horizontal segregation and the underrepresentation of women in

February 2026, Vol. 12, No. 1
ISSN 2163-758X

leadership positions (Titili et al., 2024). Similarly, innovative teaching strategies based on feminist pedagogies have been implemented in some universities; however, their adoption remains inconsistent (Torrico et al., 2023).

Our literature shows that progress toward gender equality in universities has been uneven. Key barriers remain, including representation gaps, limited policy effectiveness, and institutional resistance. Addressing these challenges requires a comprehensive approach that combines effective policy implementation, cultural change, and inclusive pedagogical practices. These insights provide the foundation for the current study, which focuses on gender representation and institutional efforts in Algeria, Poland, and North Macedonia.

Methodology

Understanding gender equality in higher education requires a systematic approach to examining differences in representation. For this reason, the study employs a quantitative descriptive design, which enables an objective analysis of gender-related data collected from the selected universities.

Research design

This study employs a quantitative research design to investigate gender equality in higher education across three universities in Algeria, Poland, and North Macedonia. The objective is to analyze the representation of male and female students, professors, and administrative staff in order to identify patterns of disparity and cross-country differences. A quantitative approach was considered most suitable, as it allowscomparison of numerical data across institutions and supports systematic evaluation of gender distribution.

Population and scope

The target population of this study includes students, professors, and administrative staff from three universities: (1) Tlemcen University (Algeria), (2) PANS Krosno University (Poland), and (3) Macedonia University (North Macedonia). The study focuses on higher education institutions because universities play a key role in promoting gender equality through policies, representation, and academic opportunities.

Sampling and data sources

This study uses secondary quantitative data to ensure the reliability and comparability of the findings. Data were collected from two primary sources:

The research team obtained university datasets directly from institutional records. These datasets include detailed numbers on students, professors, and administrative staff by gender.

Public reports from international organizations and policy bodies, including the OECD Social Institutions and Gender Index (SIGI, 2023), the European Institute for Gender Equality (EIGE, 2023), and UN Women’s Country Gender Equality Profiles (2023).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The data span the period from 2020 to 2025, and reflect changes in gender representation and institutional practices across the three universities.

Data collection process

The datasets used in this study included gender-disaggregated information on: (1) the ratio of male to female students, (2) the ratio of male to female professors, and (3) the ratio of male to female administrative staff.

Additionally, selected reports were reviewed to provide background context on gender equality policies and institutional frameworks. These documents were not analyzed through qualitative coding but were used to support and interpret the quantitative findings.

Data analysis

The quantitative data were organized and analyzed in Microsoft Excel, which facilitated the calculation of ratios and percentages and cross-institutional comparisons. Tables and charts were generated to visualize gender representation across the selected universities. EndNote was used to manage references and maintain a systematic record of all institutional reports and supporting literature.

Ethical considerations

As the study used secondary data, no direct contact with participants was required. However, ethical standards were maintained by: (1) Ensuring that all datasets and institutional records were publicly available and accessed through authorized platforms. (2) Citing all reports and institutional sources accurately. (3) Maintaining academic integrity by using data exclusively for research purposes.

Results

This section presents the study's findings, which are based on gender-disaggregated data collected from three universities: Tlemcen University (Algeria), PANS Krosno University (Poland), and Macedonia University (North Macedonia). The results compare the numbers of male and female students, professors, and administrative staff in these institutions. Information from international reports was also used to provide basic context about national gender equality policies and institutional practices.

Gender equality trends in Algerian higher education

According to the OECD's (2023) Social Institutions and Gender Index (SIGI), Algeria has made progress in gender equality, particularly in education. Women now dominate higher education enrollment, with more female students than male students in many universities. Moreover, despite advancements, the SIGI (OECD, 2023) highlights that women face barriers in leadership roles and employment after graduation.

The SIGI (OECD, 2023) reveals that, although Algeria has made some legal progress, deeply ingrained social norms and specific legal provisions continue to present significant obstacles to achieving gender equality.

Institutional gender policies and academic support in Poland

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Data from the European Institute for Gender Equality (EIGE) (2025) on their Poland page and the University of Warsaw's University of Warsaw (2021) on their Gender Equality Plan states that the first Polish university to adopt a Gender Equality Plan (GEP), focusing on raising awareness, supporting women's academic careers, and ensuring gender-balanced recruitment.

However, Programs like mini-grants for researchers balancing work and childcare aim to address gender disparities.

Domestic burdens and gender gaps in North Macedonian academia

According to the UN Women (2023) Data Hub, North Macedonia has implemented policies to promote gender equality in education and employment. However, the UN Women (n.d.) and the Economic Commission for Africa (ECA) published a Country Gender Equality Profile for North Macedonia, which states that Women spend significantly more time on unpaid domestic work than men, which can impact their academic and professional opportunities. Therefore, the Gender Equality Index for North Macedonia highlights both progress and areas that need improvement.

Trends in gender representation across universities

In this part, we present gender-disaggregated data from three universities: Tlemcen University (Algeria), PANS Krosno University (Poland), and Macedonia University (North Macedonia). The comparison focuses on students, professors, and administrative staff to highlight variations in gender representation across different academic roles. The following table summarizes the overall distribution and provides a basis for understanding existing disparities between the institutions.

Table 1

Gender distribution across universities: quantitative data analysis

Category	PANS Krosno	Tlemcen	Macedonia
Students	1837	37820	1034
Male	871 (47%)	13687 (36%)	536 (52%)
Female	966 (53%)	24133 (64%)	498 (48%)
Staff members	96	-	146
Male	32 (33%)	-	75 (51%)
Female	64 (67%)	-	71 (49%)
Professors	200	2000	64
Male	99 (49.5%)	925 (46%)	36 (56%)
Female	101 (50.5%)	1075 (54%)	28 (44%)

Note. Compiled by the authors from university-provided datasets.

Table 1 presents the gender distribution of students, professors, and administrative staff across the three universities. At ;PANS Krosno University (Poland), female students make up 53% of total enrollment, slightly exceeding male students (47%). The representation among professors is almost balanced, with 50.5% female and 49.5% male, while

February 2026, Vol. 12, No. 1
ISSN 2163-758X

administrative positions are primarily held by women (67%) compared to men (33%). At Tlemcen University (Algeria), the proportion of female students is higher —64% compared to 36% for males —and women also hold a slight advantage among professors (54% versus 46%). However, data for administrative staff were not available. In contrast, Macedonia University (North Macedonia) exhibits a different pattern: male students comprise 52% of the total enrollment, slightly surpassing females (48%), while male professors hold a majority of academic positions (56% compared to 44% held by females). The administrative staff, however, exhibits a near gender balance, with 51% male and 49% female representation. Overall, the data illustrate variations in gender representation across the three universities, highlighting areas of progress in student enrollment and persistent gaps in academic and administrative roles.

Student enrollment patterns across the three universities

After examining the overall gender distribution across students, professors, and administrative staff in Table 1, Table 2 focuses specifically on the gender distribution among students at the three universities. It highlights the proportion of male and female students, providing a clearer view of enrollment patterns and illustrating differences in participation between genders across institutions.

Table 2

Gender distribution among students in three universities

Students	**male**	**female**
PANS Krosno	47	53
Tlemcem	36	64
Macedonia	52%	48%

Note. Compiled by the authors from university-provided datasets.

The data show that at PANS Krosno University, female students represent 53%, while male students represent 47%. At Tlemcen University, the female student population is notably higher at 64%, compared to 36% male students. At Macedonia University, the distribution is relatively balanced, with 52% male and 48% female students.

Gender representation among professors

This table compares the proportion of male and female professors across the three universities, highlighting differences in academic representation.

Table 3

Gender Representation Among Professors Across Universities

professors	**male**	**female**

February 2026, Vol. 12, No. 1
ISSN 2163-758X

PANS Krosno	49,5	50,5
Tlemcem	46	54
Macedonia	56	44

Note. Compiled by the authors from university-provided datasets.

The data show that the gender distribution among professors at PANS Krosno University is nearly equal, with 50.5% female and 49.5% male professors. At Tlemcen University, 54% of professors are female, while 46% are male. Macedonia University has the highest proportion of male professors at 56%, with 44% female.

Gender Representation Among Administrative Staff

The following data present gender-disaggregated information on administrative staff at PANS Krosno University and Macedonia University. Information on administrative staff at Tlemcen University was not available in the datasets used for this study.

Table 4

Gender balance among staff members in three universities

Staff members	**male**	**female**
PANS Krosno	33	67
Tlemcem	/	/
Macedonia	51	49

Note. Compiled by the authors from university-provided datasets.

The table shows that, among staff members, PANS Krosno University has a female majority of 67%, compared to 33% males. At Macedonia University, the gender balance among staff is nearly equal, with 51% male and 49% female.

Discussion of key findings and implications

This comparative study highlights progress and ongoing challenges in achieving gender equality in universities in Algeria, Poland, and North Macedonia. Therefore, the findings focus on the distribution of male and female students, professors, and administrative staff across the three institutions.

The results show that female students comprise a higher proportion of the student population in most universities. At Tlemcen University, women comprise 64% of the student body, indicating a significant gender gap in enrollment, and this is consistent with broader research on the region, which shows that in many countries in North Africa and the Middle East, women's participation in secondary and higher education is surpassing that of men (Mojab, 2022). At PANS Krosno University, the distribution is more balanced,

February 2026, Vol. 12, No. 1
ISSN 2163-758X

with 53% female and 47% male students, whereas at Macedonia University it is nearly equal (48% female, 52% male). These differences suggest that, although women have greater access to higher education, theirparticipation varies across institutions.

Regarding professors, the data reveal mixed trends. PANS Krosno University shows an almost equal distribution, with 50.5% of professors female and 49.5% male. At Tlemcen University, women slightly outnumber men (54% female, 46% male), whereas at Macedonia University, professors are more male-dominated, with 56% male professors compared to 44% female. This variation indicates that achieving gender balance in academic positions remains a challenge.

For administrative staff, PANS Krosno University has a clear female majority, with 67% of staff members being women. At Macedonia University, the distribution is nearly balanced (51% male, 49% female). Data on administrative staff at Tlemcen University were unavailable, which limits direct comparisons for this category.

These findings are broadly consistent with previous studies on gender representation in European and North African universities. The underrepresentation of women in academic leadership and decision-making roles, despite their high enrollment, is a widely documented phenomenon that suggests persistent structural inequalities (Clavero & Galligan, 2021; Hou, 2022; Klenk et al., 2022; Rosa & Clavero, 2022; Wieczorek-Szymańska, 2020). Furthermore, our results support studies highlighting how regional variations and institutional policies shape gender representation differently across countries (Hou, 2022; Klenk et al., 2022).

The gender distribution patterns observed in this study can be better understood within the broader context of national and institutional policies aimed at promoting gender equality. For instance, the finding that women form a clear majority among administrative staff at PANS Krosno University is consistent with cultural job segregation patterns in Poland, where women frequently occupy administrative and support roles (Wieczorek-Szymańska, 2020).

The results also indicate that progress toward gender equality remains uneven across countries. These findings align with earlier research highlighting variations in gender representation and policy effectiveness. While all three countries have introduced Gender Equality Plans (GEPs), their efficacy differs significantly. In Poland, the adoption of the “inclusive excellence” model seeks to combine competitiveness with gender equality, which may explain the relatively balanced gender representation at PANS Krosno University (Zippel et al., 2016). By contrast, in Algeria and North Macedonia, limited policy enforcement and institutional resistance have slowed meaningful progress. The notable gender gap among professors at Macedonia University, despite near parity in administrative staff, further suggests that without strong institutional commitment, gender policies risk remaining symbolic rather than transformative (Clavero & Galligan, 2021; Hou, 2022; Klenk et al., 2022; Rosa & Clavero, 2022; Wieczorek-Szymańska, 2020)

Differences are also evident in gender mainstreaming and pedagogical innovation. In Poland, some universities have integrated gender equality into teaching and research frameworks, aligning with feminist pedagogical principles (Torrico et al., 2023). North Macedonia has introduced gender-sensitive curricula; however, implementation remains

February 2026, Vol. 12, No. 1
ISSN 2163-758X

inconsistent across institutions. In Algeria, gender mainstreaming policies remain limited, often addressing surface-level concerns rather than driving more profound institutional change. These variations demonstrate the multifaceted nature of achieving gender equality in higher education.

Implications of the findings

The findings suggest that achieving genuine gender balance requires a comprehensive approach that involves effective policy enforcement, cultural transformation, and increased promotion of female leadership. The persistent disparities among professors and administrative staff highlight the need for stronger institutional strategies. Universities play a central role in advancing Sustainable Development Goals 5 (Gender Equality) and 10 (Reduced Inequalities), making continuous, targeted efforts toward gender parity essential for long-term progress.

Conclusion

This comparative study highlights the persistent challenges in achieving genuine equity in higher education across Algeria, Poland, and North Macedonia. The data show notable progress in female student enrollment, especially at Tlemcen University and PANS Krosno University. However, disparities persist in academic and administrative roles, with varying degrees of gender balance observed across all three institutions. The observed differences among the universities align with and can be better understood within the broader context of changing national policies, socio-cultural dynamics, and institutional commitments to gender mainstreaming.

The findings from this study reinforce broader research indicating that, although progress has been made, systemic barriers —such as underrepresentation in leadership roles, policy inefficiencies, and cultural biases —continue to hinder efforts to achieve gender equality.

To advance gender equality, universities must take proactive steps, including:

- Implementing targeted recruitment and retention initiatives to ensure equal opportunities for women.
- Enhancing support systems such as mentorship programs, work-life balance policies, and financial aid for female students and faculty.
- Reviewing and revising institutional policies to eliminate discriminatory practices and promote transparency in hiring and promotion.
- Fostering an inclusive and gender-sensitive campus culture by integrating gender awareness into curricula and encouraging diversity in decision-making bodies.

By addressing these issues, universities can create a more equitable academic environment and contribute to achieving Sustainable Development Goals (SDGs) 5 on gender equality and 4 on quality education. Ensuring gender parity in higher education is not just a moral imperative but a strategic necessity for fostering innovation, social progress, and long-term institutional success.

Future Research :

February 2026, Vol. 12, No. 1
ISSN 2163-758X

This study provides a foundational quantitative analysis of gender representation but also reveals areas for further investigation. Future research could benefit from a qualitative approach, such as conducting in-depth interviews with professors and administrative staff to gain a deeper understanding of the cultural and institutional factors influencing career progression. Additionally, expanding the scope to include more universities within each Country would provide a more comprehensive national perspective. A longitudinal study could also be valuable for tracking the effectiveness of Gender Equality Plans over time and determining whether they lead to lasting structural changes.

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Author Notes

Jihane Saousane Mahi is a Ph.D. candidate in Human Resources Management at Abou Bekr Belkaid University, Tlemcen, Algeria. Her research focuses on the quality of work life, employee well-being, and employee performance. She has international academic experience through the Erasmus+ program at the University of Cádiz, Spain, and the European HRM program, and she worked as an HR consultant in Germany. Jihane has published on AI, sustainability, and quality of life. Her work combines HRM, innovation, and sustainability to explore the future of work. She was awarded the best poster at the Tlemcen international conference in Algeria and the best outstanding research at an international conference at Qatar University.

Natasza Maj

She is a student of Herbal Medicine at the University of Applied Sciences in Krosno (PANS in Krosno), Poland. Her academic interests focus on natural medicine, herbal cosmetics, and healthy lifestyle practices. She is particularly passionate about the use of plant-based remedies and sustainable approaches to health and wellness.

Filip Belczyk

He is a student at PANS Krosno University.

Mohammed Ryad Mokhtari

He is a Master's student in Management at Abou Bekr Belkaid University, Tlemcen, Algeria. His academic interests focus on management, digital marketing, and nutrition, with a particular emphasis on innovative approaches to organizational development and communication strategies. He participated twice in the East Carolina University program on Sustainable Development Goals (SDGs), which enriched his international perspective on sustainability and global challenges.

Kalina Markovska

She is a student at the American University College in Skopje.

Nehar Benameur

A dedicated academic specializing in Computing, Environmental Sciences, Biology, and Agriculture. Currently serving in the Department of Ecology and Environment at the University of Tlemcen, this professor is actively involved in international research collaborations, including a global environmental exchange program with East Carolina University (USA). Their work focuses on environmental management and biological

February 2026, Vol. 12, No. 1
ISSN 2163-758X

studies of water systems, with ongoing interests in aquatic ecosystems, database integration, and sustainable environmental practices.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Ghanaian Female Celebrities' Digital Engagements as Rhetorical Feminism: A Rhetorical Analysis of Celebrity Instagram Rhetoric in Amplifying Unique Literacies

Ernestina A. Akorli-Coffie and Wendy Sharer

East Carolina University, Greenville, NC, USA

Abstract

This paper rhetorically explores the symbolic actions of agency exhibited by three Ghanaian female celebrities on Instagram to understand the literacy practices developed from the digital circulation practices of their audience on the platform. It specifically analyzes how Yvonne Nelson's 2024 #DumsorMustStop vigil and Berla Mundi and Anitta Akuffo's embodied rhetorics manifested in their Instagram photo posts and stories in 2024, considering them as symbolic actions that mobilize vernacular, digital, civic, and collaborative literacies among Ghanaian publics. By engaging with Cheryl Glenn's (2018) framework of "invitational rhetoric" as tactics of rhetorical feminism and with Kovalik and Curwood's (2019) theory of transliteracy to understand the celebrities' symbolic actions, this rhetorical analysis highlights the rhetorical dexterity of Ghanaian female celebrities' digital engagements and demonstrates how these engagements transform Instagram into a transmediatory space where dynamic digital and special literacies converge and also emerge. Ultimately, this study contributes to a contextualized understanding of rhetorical feminist tactics on Instagram, the rhetoricity of celebrity digital agency, and the ways this agency amplifies marginalized voices in order to create civic awareness through dialogic and collaborative rhetoric.

Keywords: rhetorical feminism, invitational rhetoric, digital literacy, Instagram, celebrity rhetors

Background: The Literacy Myth and the Wave of Digital Feminist Praxis

Fourth-wave feminist practices on digital platforms are destabilizing the "literacy myth," as literacy sponsorship now extends beyond traditional academic and familial contexts to encompass a diverse range of agencies and sponsors (Banerjee & Kankaria, 2022; Brandt, 1998). The literacy myth claims that literacy cannot be acquired through other means and positions literacy as the sole, independent, and crucial factor necessary for achieving specific outcomes. (Graff & Duffy, 2008). Several literacy scholars have argued that this assumption overlooks the complex social, economic, and cultural factors that shape literacy outcomes (Graff 2023, 1987; Gee 1989; Graff & Duffy 2008). As such, many scholars in contemporary literacy and linguistic studies are actively interrogating the traditional definitions of literacy to unsettle the assumptions embedded in the literacy myth (Canagarajah, 2023; Lee, 2017).

Feminist scholars in the transnational context are similarly engaging in literacy through digital feminist praxis to emphasize how digital literacies are socially situated, intersectional, and shaped by both postcolonial contexts and global feminist activism (Bali, 2019; Scharff, Smith-Prei, & Stehle, 2017). Glenn (2018) challenges traditional

February 2026, Vol. 12, No. 1
ISSN 2163-758X

rhetorical practices and introduces the concept of "rhetorical feminism" as a theoretical stance that is responsive to understanding feminist ideology and digital literacy strategies. Krista Bryson (2012), in her effort to bridge this gap, highlights that the *Digital Archive of Literacy Narratives* (DALN) "is open access and digitally available worldwide," providing a "potential space for subversion of the grand narrative of the literacy myth through little narratives from people across a wide spectrum of literacy and cultural backgrounds, experiences, and ideologies" (p. 257). Kovalik and Curwood (2019) examined Instapoetry on Instagram and its implications for teaching and learning in English classrooms. They note, however, that a disconnect remains between the traditional paper-based literacy practices emphasized in schools and the dynamic, digitally mediated literacy activities young people engage in on platforms like Instagram. This tension highlights the need to broaden our understanding of literacy to include the multimodal, embodied agencies, participatory discourse, and networked practices that shape meaning making in contemporary digital spaces.

Banerjee and Kankaria (2022) note that digital feminism has gained prominence in the twenty-first century, emerging through blogs, hashtags, online magazines, and virtually organized protests. In this context, fourth-wave feminism emphasizes the use of internet tools that have facilitated varied forms of online activism and digital literacy practices that have given visibility to women's issues (Jain, 2020; Banerjee and Kankaria, 2022). As a result, feminist rhetoricians are calling for closer attention to the complex relationship between digital technology and transnational feminist activism, emphasizing that the Internet is deeply enmeshed in global capitalist structures while also serving as a key site for resisting these structures at local, regional, and transnational levels (Queen, 2008; Banerjee & Kankaria, 2022). Recognizing these assertions, this paper contends that the current era, deeply enmeshed in rapidly evolving digital technologies and platforms, provides a critical opportunity to reconceive literacy as more than an isolated skill by examining its dynamic nature and possibilities. Queen (2008) further argues that feminist rhetorical scholars must broaden their scope to examine how digital circulation shapes connections among groups, communities, and nations, often reproducing "binary oppositions and rhetorics of superiority" (p.472).

Building on this call, this paper contends that it is important to study the digital circulatory practices of female celebrities and their audiences to understand the symbolic actions they employ as digital agency in shaping rhetorical traditions, literacies, activism, and civic rhetoric. This analysis will help rhetoricians to understand and account for the kinds of literacies that get amplified through digital embodied practices and the symbolic moves of rhetorical feminist tactics that have impacted feminist activism, digital literacy consumption, and circulatory practices. It also aims to cultivate understanding of the rhetorical dexterity of Ghanaian female celebrities' digital engagements and activism as "the global circulation of digital representations becomes rhetorical and, ultimately, political actions" (Queen, 2008, p.472). More specifically, this article presents an analysis of three selected Ghanaian female celebrities' Instagram symbolic actions and activism as manifested through their Instagram posts to understand their rhetoricity and the kinds of literacies they amplify for the Ghanaian populace. With the term "literacy," this paper refers to the set of practices (material, embodied, spatial, or digital) manifested as ways of meaning making or developed and cultivated through engagement with physical or

February 2026, Vol. 12, No. 1
ISSN 2163-758X

digital bodies, tools, platforms, culture, technology, ideology, and community participation. The goal is to consider how text and context, manifested through symbolic actions of these celebrities' rhetoric posted on Instagram, help us understand rhetorical feminism and transmediation of literacies.

Research Questions

1. What rhetorics do Ghanaian female celebrities on Instagram engage in to foster agency that amplifies the literacy practices of their audience?
2. What symbolic actions do these celebrities employ, and how are they rhetorical feminist endeavors?

Theoretical Framework: The Dialogic Pathways of Rhetorical Feminism and Transliteracy Theory

This paper employs an intersectional theoretical framework that combines Cheryl Glenn's (2018) articulation of "tactics of rhetorical feminism" with Kovalik and Curwood's (2019) theory of "transliteracy" to analyze the Instagram activism of selected Ghanaian female celebrities. This approach offers a rhetorical understanding of the celebrity's digital engagements and activism and the literacy practices that emerge from these posts. Both concepts are essential, as they reveal how rhetorical practices situated on Instagram within the Ghanaian cultural context foster participatory knowledge production.

Glenn (2018) positions rhetorical feminism as "a tactic (actually a set of tactics)—a theoretical stance—that is responsive to the ideology that is feminism and to the key strategy that is feminist rhetoric" (p. 4). She explains further that rhetorical feminism provides several tactics that resist hegemonic rhetorical traditions of knowledge-making by privileging dialogue, reciprocity, and inclusivity. It values marginalized voices, vernacular practices, and alternative modes of delivery that dominant rhetorical histories often dismiss. I employ Glenn's (2018) tactic of "invitational rhetoric" (p. 69) to reveal how Berla Mundi's and Anita Akuffo's Instagram posts, comment sections, and story reposts, as well as Yvonne Nelson's 2024 #dumsormuststop open letter and vigil, embody feminist rhetorical values.

At the same time, transliteracy offers a complementary lens to examine the literacy practices circulating through these celebrities' Instagram engagements. Kovalik and Curwood (2019) identify four defining features of transliteracy: the use of digital tools, multimodal representation, engagement with a global audience, and dynamic movement across physical and virtual contexts (p. 186). Their pluralistic conception of transliteracy highlights how meaning is constructed through "interactions among people, things, texts, contexts, modes, and media" (Stornaiuolo et al., 2017, p. 72). Applying this lens to the emerging Instagram literacies shows the rhetoricity of how Ghanaian celebrities and their audience create and circulate meaning through images, emojis, GIFs, captions, hashtags, reposts, comments, graphics, and multimodality that transcend singular contexts.

Analytical Framework: Rhetorical Analysis

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Because “rhetoric has also taken on an interpretive function” as “rhetoricians attempt to understand how to produce effective acts of verbal and written persuasion” (Selzer, 2003, p. 280), rhetorical analysis provides the method for me to link these frameworks to interpret and appreciate the ways these celebrities and their audience “manipulate language and other symbols for persuasive purposes” (Selzer, 2003, p.281). As Selzer (2003) notes, rhetorical analysis functions as a kind of critical reading that seeks to understand how specific rhetorical episodes persuade: “Through rhetorical analysis, people strive to understand better how particular rhetorical episodes are persuasive” (p. 281). Exploring invitational rhetoric broadens this method and offers what Burke calls “terministic screens,” or symbolic lenses through which rhetoricians interpret and evaluate meaning. Selzer emphasizes how important these terministic screens are for rhetorical analysis because they provide a critical reading into text to appreciate “the ways people manipulate language and other symbols for persuasive purposes” (p.281).

Herrick (2017) reminds us that Burke posits that language not only reflects reality but also selects and deflects it, often concealing alternative possibilities (pp. 243–257). Given this understanding of the importance of language in shaping reality, “Rhetoricians today attempt to understand better every kind of important symbolic action” (Selzer, p.281) used by rhetors in their communication. This article draws on Selzer’s observation and applies this concept of “symbolic action,” understood to mean to the intentional use of verbal and nonverbal language, text, digital literacies like images, captions, reposts, emojis, hashtags, and other multiliteracy strategies like multimodality and vernacular (linguistic and cultural) literacies through which the celebrity rhetors construct meaning, invite audience participation and co-construction of meaning, and shape civic, cultural, entrepreneurial and entertainment discourse on Instagram. By combining the theoretical foundations of transliteracy and rhetorical feminism mentioned above, this analysis foregrounds an understanding of the symbolic actions employed by three Ghanaian female celebrities to engage their audience and to persuade that audience to engage in the digital, vernacular, civic, and collaborative networked literacies on Instagram.

Methods

Screenshots of celebrity posts and audience transliteracy practices on Instagram (see Figure 1) were collected as cases for analysis through a Silicon Snowball Sampling technique of Instagram posts (Lee, 2024). Links, posts, hashtags, stories, tags, and connections were used to trace celebrity and audience digital pathways and uncover digital circulatory literacies (Lee, 2024, p.3). The data set was analyzed through Glenn’s (2018) rhetorical feminist lens to offer a nuanced perspective on Ghanaian feminist celebrity rhetorical practices and audience literacies that is anchored in hope, inclusion, equality, and the amplification of marginalized voices. Vernacular literacies are intentionally included in the analysis, and commenters’ and audience members’ Instagram usernames retained in the dataset, not to cause harm but to recognize and credit their distinctive literacies. This choice reflects a collaborative process of meaning making while adhering to Instagram’s public data policy.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Yvonne Nelson's Activist Culture as Embodiment of Invitational Rhetoric Amplifying Multiliteracies

This section considers the rhetoricity and symbolic action employed by Yvonne Nelson in the "dumsor" vigil she led, as well as in her open letter about "dumsor" that was transmediated from Twitter onto Instagram as a result of audience digital literacy practices. "Dumsor" is a Ghanaian term that literally means "off and on" or "switching." The usage of this lexicon refers to the frequent, irregular power outages experienced by Ghanaians in 2015 and subsequent years. Now it is commonly used to describe any ongoing electricity supply crisis, where power cuts occur unpredictably and disrupt daily life.

Nelson is a prolific Ghanaian actress, producer, and entrepreneur celebrated for her work in Nollywood (Nigeria's film industry) and Ghallywood (Ghana's film industry). She founded the Yvonne Nelson International School (YNIS), inspired by her daughter, and used her personal savings, including selling her house, to offer inclusive preschool through junior high education in Ghana (Larnyoh, 2023; Yamoah, 2024). Beyond her entertainment career, Nelson has become a prominent civic activist, leveraging her celebrity status to merge activism with advocacy to promote social justice and civic engagement in Ghana. Yvonne Nelson led the #dumsormuststop protest in 2015 and again in 2024, calling for accountability for the government's persistent failures with power supply in those years despite Ghana's prior reputation for maintaining relatively stable electricity provision in Ghana and to other West African countries (GhanaWeb, 2024, Eshun & Amoako-Tuffour, 2016). Her heartfelt letter, addressed to her fellow Ghanaians and shared on Twitter, called for a second vigil and heightened awareness of the ongoing power crisis (GhanaWeb, 2024).

Interestingly, this open letter found its way on Instagram through recirculation, exemplifying transliteracy practices that were influenced by Nelson's negotiated celebrity ethos, her invitational rhetoric, and Instagram circulatory dynamics (Gh_tropper, 2024). This symbolic action extended Nelson's activist rhetoric while simultaneously sponsoring digital, civic, and collaborative networked literacies. The exigence for Nelson's 2024 #dumsormuststop activism was the viral news of a newborn's death in one of the maternity wards in Tema due to the power outages. Moved by this tragedy, she wrote a letter and organized a public vigil to demand accountability and immediate action from the government (Utvghana, 2024). Her rhetorical move disrupts the traditional masculinist logic of argument as she employs nonviolent rhetoric in her letter and during the vigil to amplify the voices of most Ghanaians and marginalized expectant mothers. Nelson's continued #DumsorMustStop activism is an example of Glenn's (2018) rhetorical feminist tactic of "disidentification," a practice which resists hegemony by centering marginalized voices' experiences. Through her celebrity and maternal ethos, Nelson challenges inequities in power distribution and advocates for vulnerable groups, especially pregnant women, aligning with rhetorical feminism's goals of equality, justice, inclusion, and coalition across differences.

Figure 1

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Yvonne Nelson's 2024 #dumsormuststop vigil and collaborative networked literacies circulated on Instagram (Instagram posts: Nelson, 2024; Nyhiraba, 2024; Y979fm, 2024; Gharticles, 2024)

In her open letter, which was recirculated on Instagram, Nelson persuasively calls for collective action, stating "……I want to reiterate that I cannot do this alone…Therefore, I am extending an open call to all Ghanaians, organizations, and legal professionals who are willing to join me in pushing for meaningful action to address the current power crisis" (Gh_tropper, 2024). Here, her language functions invitationally, creating a rhetorical space for many Ghanaians and marginalized voices, thus positioning her audience as co-participants in the activism rather than passive recipients, reflecting Glenn's (2018) conception of rhetorical feminism and invitational rhetoric as accessible, dialogic, and mutually transformative (pp.70, 75). Her choice of inclusive and comprehensible language enables her to connect with communities beyond academic circles, reflecting the values of respect for every reader. Nelson's statement, "Together, we can make our voices heard and compel our leaders to prioritize the needs of the Ghanaian people," embraces the tactics of negotiation and understanding, which are values of invitational rhetoric. Her dialogic mediation for Ghanaians' engagement in the dumsor vigil reflects her commitment to rhetorical exchanges grounded in mutual understanding and collective agency rather than persuasion, control, or dominance. Thus, she employs nonviolent rhetoric that appeals to emotional, moral, and ethical reasoning (Glenn, 2018, p.75).

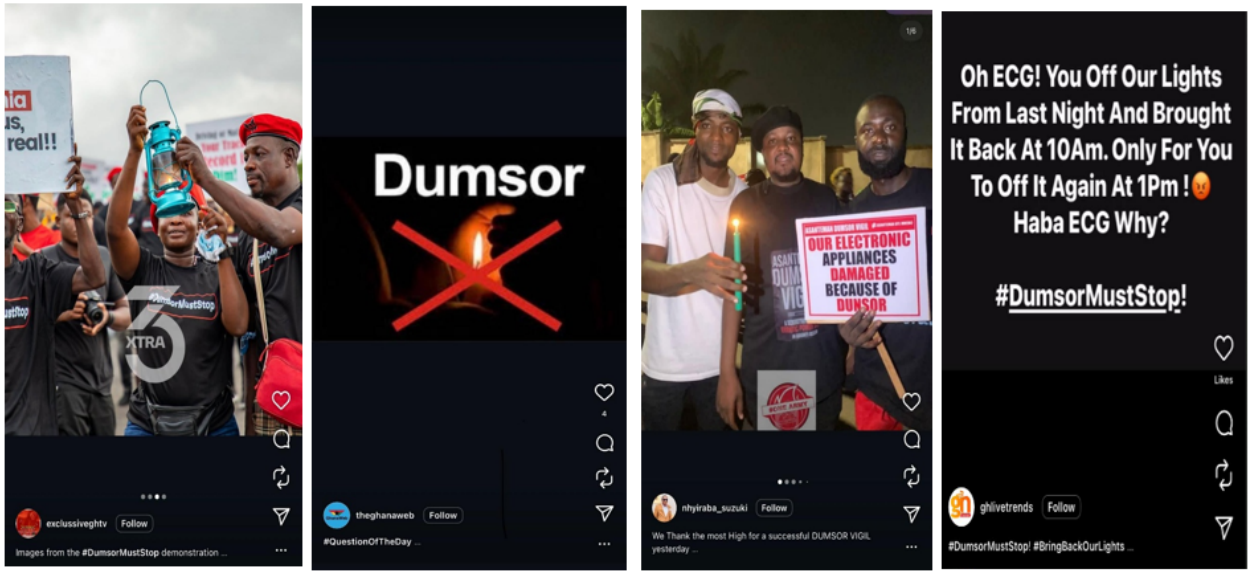
A key symbolic action in her rhetoric is the creation and circulation of the hashtag #dumsormuststop. This literacy tool not only amplified her call but also generated nationwide civic awareness of the effects of dumsor, as audiences circulated her information by reposting her Instagram posts, and, in the process, creating their own remixed graphics and tagging her to extend the message. This #dumsormuststop sparked related hashtags on Instagram, such as #dumsorvigil, which also encouraged audience participation thus curated an archive of collective civic engagement and digital literacies around dumsor. As of now, the #dumsormuststop registers over 1,000 posts on

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Instagram, not only highlighting the lived effects of power outages on most Ghanaians but also illustrating the algorithmic dexterity of the circulation of her embodied rhetorical action towards social change.

Figure 2

The sharing of vigil scenes and posts about dumsor's effects on citizens via Instagram under #DumsorMustStop (Instagram posts: Exclusiveghtv, 2024, Theghanaweb, 2024, Nyhiraba, 2024, Ghlivetrends, 2024)



Screenshots of posts in figure 2 reveal that participants extended the vigil and dumsor's impact into digital spaces, demonstrating digital, vernacular, civic, and collaborative literacies as they engaged critically and mobilized information about people's lived experiences with dumsor to assert their civic and literacy agency through online activism. This hashtag allowed the audience to assert their multiliteracy skills by designing graphics like flyers and memes through the combination of visuals, text, and captions that embodied the #dumsormuststop. It also allowed followers to repost generated content that enabled them to engage with broader questions of governance, accountability, and citizens' rights to power supply in the Ghanaian context. According to Stornaiuolo et al. (2017), in these kinds transliteracy practices, meaning is co-constructed through "interactions among people, things, texts, contexts, modes, and media" (p. 72). The dumsor vigil showcases the coexistence of traditional and spatial literacy practices transcending into the digital space. Several literacy practices during the vigil were documented and shared online through visual skits with commentary, a process that amplified awareness and lived experiences of the power crises. During the vigil, citizens carried placards with concise inscriptions that embodied clarity of thought and precision about the hardships caused by dumsor and their demand for accountability, a rhetorical act that reflected their skill in lobbying through short, legible captions. This embodied act later extended into digital spaces, where the hashtag algorithm on Instagram amplified their reach and made them visible to wider publics (Tv3_Ghana, 2024).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

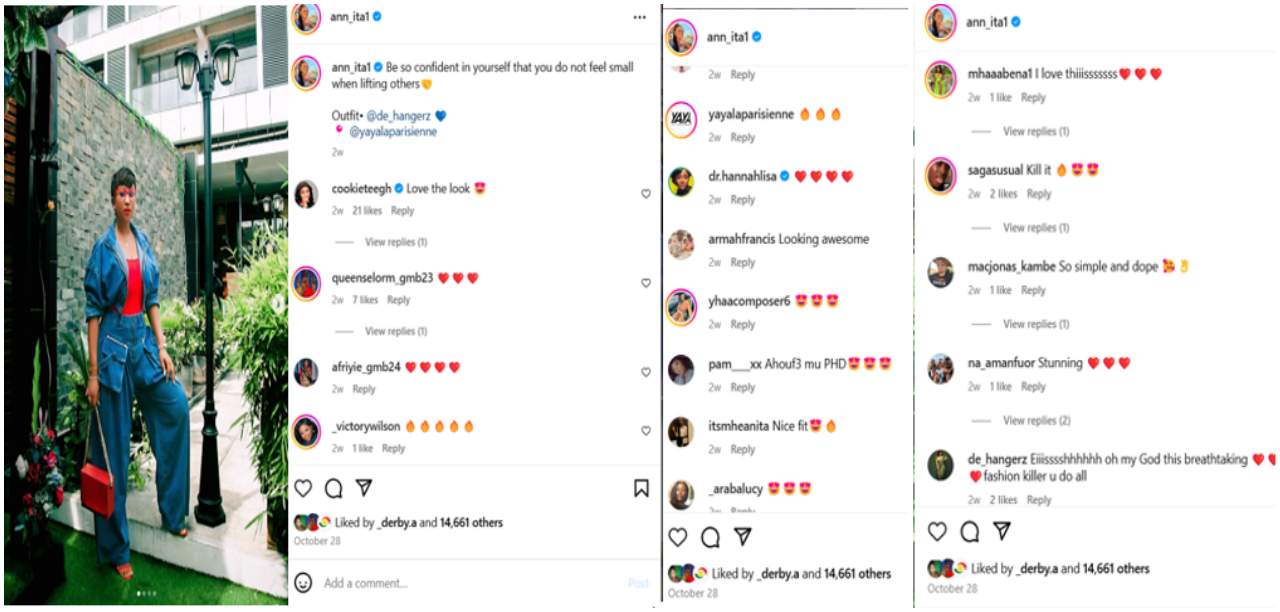
The vigil employs consensual communication and disidentifies with the dominant rhetorical practice of "winning by violent means" (Glenn, 2018, p.75) as the audience strategically complemented the public vigil with shared cultural literacy that recall Ghana's pre-electricity past. The lanterns, torchlights, and candles used during the vigil, as seen in videos posted on Instagram, rhetorically function as symbolic, evoking memories of Ghana's past and signifying both the backwardness and the government's failure in providing lasting solutions to the energy crises and, by extension, stable electricity to remote villages in Ghana (Tv3_Ghana, 2024). The presence of light, however, also signifies an enduring hope and resistance against darkness, thus linking historical experiences to the present energy struggles. These rhetorical practices highlight the importance of collaborative storytelling, as discussed by Dadugblor (2023), through which knowledge is co-produced based on lived experiences rather than imposed from above. Nelson thus shifts the emphasis of political rhetoric from persuasion as a means to gain an advantage or win an argument to persuasion as a cooperative process that values ethical dialogue, inclusivity, and respect for all parties involved.

Berla Mundi and Anita Akuffo's Instagram Engagements as Embodiment of Invitational Rhetoric Amplifying Literacies

To further explore the impact and potential of transliteracy practices as tactics of rhetorical feminism, this section presents analysis of selected comment sections and Instagram stories, presented as datasets, drawn from Instagram posts shared by Berla Mundi and Anita Akuffo. Berlinda Addardey, popularly known as Berla Mundi, and Anita Akua Akuffo, popularly known as Anita Akuffo, are celebrated Ghanaian media personalities, journalists, and brand ambassadors who have built vibrant digital presences through their Instagram presence (Wikipedia, 2025; LinkedIn, 2025). As of the time of this analysis, both celebrities work in the same media house, Media General, balancing their careers in journalism and entertainment with their individual community empowerment projects that highlight their commitment to social impact. Because their Instagram practices embody similar forms of digital agency as they share professionally curated photos with captions, invite audience engagement in the comment section, and reshare followers' posts on their stories to cultivate participatory exchanges, their work is analyzed together here.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Figure 3



Selected comment sections from the Instagram post of Anita Akuffo on 10/28/2024 (source: Akuffo, 2024)

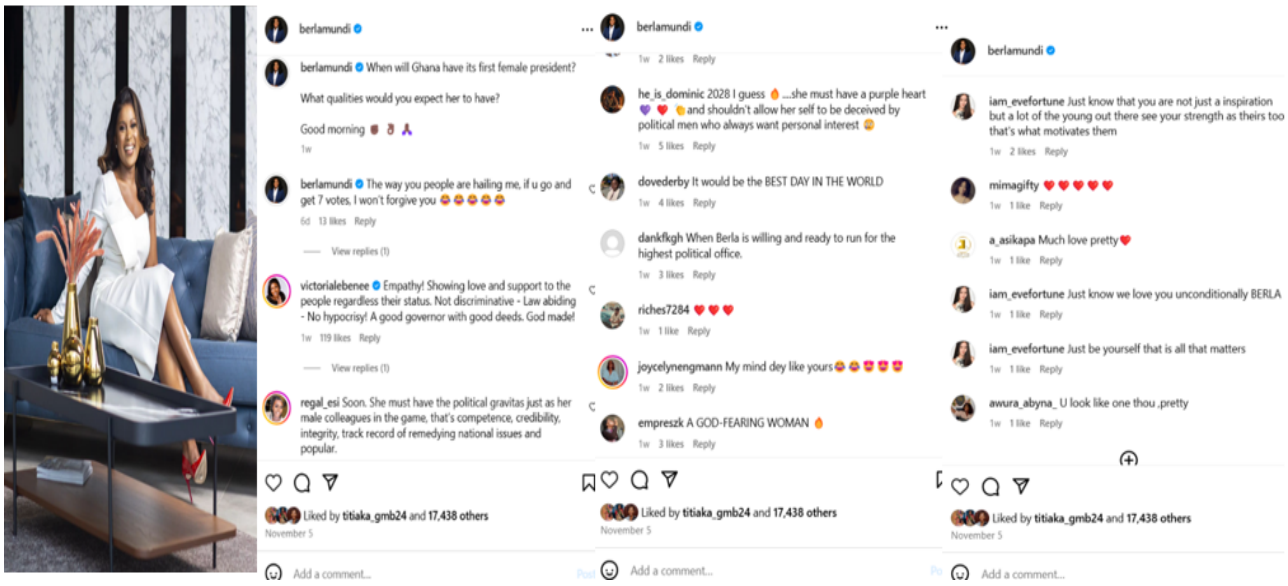
Berla Mundi and Anita Akuffo both employ the symbolic action of captioned photos, comment section features, and resharing followers' posts on Instagram story to invite engagement, validate audience contributions, and foster civic and participatory digital literacies. Figure 3 shows Anita Akuffo, with the verified username ann_ita1, sharing an elegantly stylized photo against a complementary background. Her thought-provoking caption, "Be so confident in yourself that you do not feel small when lifting others 💛", expresses her reflections while tagging her outfit and location as symbolic acts. Berla Mundi with the verified username berlamundi, in Figure 4, employs a similar symbolic action of a deliberately composed, graceful image with an aesthetic background and a caption on civic responsibility "When will Ghana have its first female president? What qualities would you expect her to have? Good morning ✊🏾👌🏾🙏🏾". They both employ emojis in their captions that sponsor emoji literacy culture among their followers, as seen in the comment sections in Figures 3 and 4. Their celebrity ethos, affective captions, and visual rhetoric serve as rhetorical appeals that sponsor vernacular, affective, and collaborative literacies among their audience in the comment section towards entertainment, admiration, empowerment, and civic engagement. Berla Mundi and Anitta Akuffo enacted what Gorsevski, as cited by Glenn (2018), describes as a rhetorical feminism rooted in "experience-, emotion-, and silence respecting" communication (75). Both captions practice silence-respecting rhetoric by conveying a tone that creates space for followers' fluid interpretations and expressions. Anitta Akuffo's concise statement offers encouragement without dictating how followers must react, while Berla Mundi poses open-ended questions that invite dialogue without providing predetermined answers. Berla Mundi's caption in Figure 4 extends the comment section as an invitational rhetorical space for collaborative deliberation that permit the use of civic literacy and a

February 2026, Vol. 12, No. 1
ISSN 2163-758X

diverse articulation of followers' desires, expectations, and perspectives on the qualities they need in a potential female president of Ghana.

Figure 4

Selected comment sections from the Instagram post of Berla Mundi on 11/05/2024 (source: Mundi, 2024)

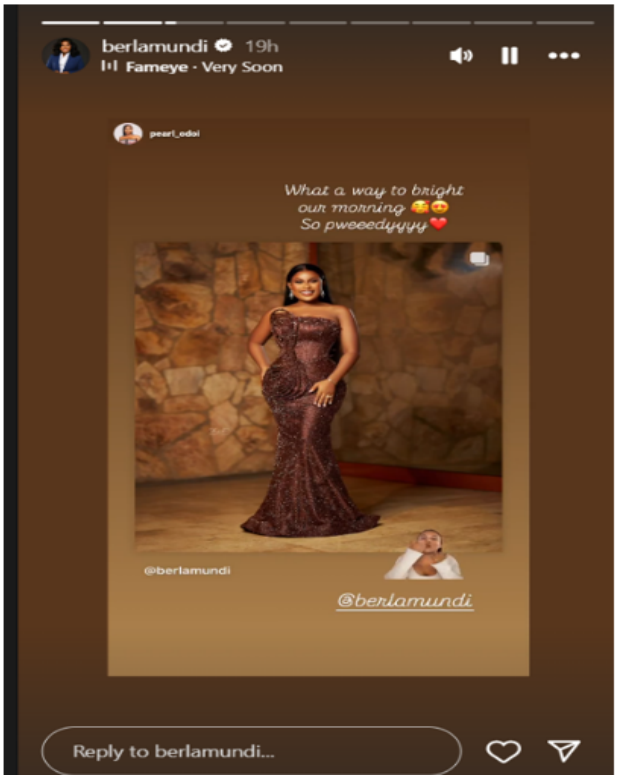


Additionally, both Berla Mundi and Anitta Akuffo employ the symbolic action of resharing followers' Instagram stories that featured the celebrities, as seen in Figure 5. Dadugblor (2023) emphasizes that civically focused collaboration involves "content, dissemination approaches, and translation where applicable" (148). Berla Mundi and Anita Akuffo's digital engagements enact these aspects of collaboration by allowing fluid comments under their posts and by reposting tagged stories. Through Berla Mundi's symbolic action of resharing, we see affective literacy from a follower's story captioned "What a way to bright our morning 🥰😍 So pweeedy ❤️" demonstrating the follower's fluid linguistic and multimodal use of Instagram affordances such as emojis, GIFs, and tagging that remixes the celebrity's initial photo post to signal the follower's thoughts and admiration. Affective literacy in this context refers to the follower's ability to read, understand and participate in the emotional and social cues embedded in Berla Mundi's post by responding with their comment through multiple communicative modes. The celebrity's symbolic act of resharing followers' Instagram stories functions as invitational rhetoric for followers' participation because this act creates a rhetorical agency for the audience to collaborate in circulating celebrity rhetoric while offering communicative options for alternative forms of embodied delivery. These practices also affirm what Nartey (2021) concluded from their study of Ghanaian feminist blogs: feminists leverage online media and its affordances to amplify their voices and (re)construct positive identities.

Figure 5

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Screenshots of Anita Akuffo's and Berla Mundi's Instagram stories on 11/12/2024, reposting their followers' stories.



Employing stories and comment section features on Instagram as rhetorical space provides further evidence that public speaking and traditional writing are not the only rhetorical venues available to women, particularly Black women in Ghana (Glenn, 2018, p.80). The celebrities' symbolic actions sponsor the use of multimodality through platform affordances and vernacular literacies such as the Ghanaian local languages, pidgin, and informal English. The following excerpts from Anitta Akuffo's comment section (see Figure 3) demonstrate symbolic actions that challenge the monolingualism and Standard English structures that have historically been used to constrain and marginalize Black people's fluid linguistic and embodied multiliteracies: "Ahouf3 mu PHD 😍😍😍," which means a PHD level beauty; "Eiiisssshhhhhh oh my God this breathtaking ❤️❤️❤️fashion killer u do all," which means for someone who always looks extremely stylish, you embody this fashion style well; and the informal use of "this" as seen in "I love thiisssssss ❤️❤️❤️." In these Instagram rhetorical practices, Berla Mundi and Anitta Akuffo do not assert authority over their followers but instead curate a communal voice through a legitimization of embodied expressions and multiliteracies of their followers and through "the recognition of immanent value, that of the audience and rhetor alike" (Glenn, 2018, p. 70).

Conclusion

This article illustrates how rhetorically analyzing contextualized social media practices of Ghanaian celebrity women can illuminate multimodal tactics of rhetorical feminism. All

February 2026, Vol. 12, No. 1
ISSN 2163-758X

three celebrities enact rhetorical feminism's understanding of ethos as "negotiated and renegotiated, embodied and communal, co-constructed and thoroughly implicated in shifting power dynamics" (Glenn, p.85). Through their multiliteracy practices on Instagram, these women challenge traditional notions of persuasive rhetoric while prioritizing participatory knowledge-making, collaboration, and the amplification of marginalized voices. Their digital rhetoric and circulatory practices exemplify rhetorical feminism's commitment to hope, transformation, and inclusive literacies.

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February 2026, Vol. 12, No. 1
ISSN 2163-758X

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Author Notes

Ernestina A. Akorli-Coffie is an international student from Ghana, West Africa, currently pursuing her PhD in Rhetoric, Writing, and Professional Communication at East Carolina University. Her research interests lie at the intersections of AI and new media pedagogy and policy; Transnational Black Feminist Digital Rhetoric; Transnational Indigenous Cultural Rhetorics and Literacies; Inclusive Technical Communication and Rhetoric; and Decolonial Composition Theory. As a scholar and teacher, her research is grounded in a commitment to promoting ethical, inclusive, and innovative technical and scientific communication, affirming contemporary digital feminist practices and literacies on social media, and advocating for socially just AI policies and pedagogy. Her work also seeks to liberate rhetorical and pedagogical practices within African and transnational contexts through decolonial approaches that advance her field's diversity in inclusive research.

Wendy Sharer is Thomas Harriot College Distinguished Professor of English at East Carolina University. She served as President of the *Coalition of Feminist Scholars in the History of Rhetoric and Composition* from 2020-2022 and currently co-edits the journal *WPA: Writing Program Administration*. Her books include the co-edited collections *Reclaiming Accountability*: *Using the Work of Re/Accreditation to Improve Writing Programs* (Parlor P, 2016, winner of the Council of Writing Program Administrators' Best Book Award); *Working in the Archives* (Southern Illinois UP, 2009); and *Rhetorical Education in America* (Alabama UP, 2004). She has also authored *Vote & Voice: Women's Organizations and Political Literacy* (Southern Illinois UP, 2004) and co-authored *1977: A Cultural Moment in Composition* (Parlor P, 2007). She has published chapters in several edited collections and articles in journals such as *WPA: Writing Program Administration*, *College English*, *Rhetoric Review,* and *Rhetoric Society Quarterly*.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Individual and Cultural Differences in Sound Perception: An Exploratory Study

Samah Gourari[1], Dominik Wróbel[2], Abdelhak Chikhaoui[3]

[1 3] University of Abu Bekr Belkaid, Tlemcen, Algeria

[2]PANS Krosno University of Applied Sciences, Poland

Abstract

Most studies on sound perception use a two-dimensional arousal–valence model, plotting responses along pleasant–unpleasant and calm–excited scales. Despite being a valuable method, it oversimplifies auditory experience, often neglecting links to shapes, colours or memories. Moreover, most research on sound perception has focused on participants from Western, Educated, Industrialised, Rich, and Democratic (WEIRD) societies, leaving many cultures understudied. For example, little research has examined how Algerians experience sounds. Similarly, uncommon sound types such as infrasound or recordings from space have received negligible attention. This study explores how Algerian and international participants perceive a diverse set of sounds, considering not only emotions but also sensations, memory recall, and cross-modal associations, through testing the influence of neurodivergence, musical training, age and gender. An online survey was conducted among a diverse sample (N=94) with strong representation from Algeria. Participants were asked to listen to ten sound clips and report their experiences. The analysis shows low awareness of neurodivergence in Algeria, while geophonic and classical sounds more often trigger memory recall. Neurodivergent participants express greater tolerance for low-frequency sounds and also exhibit distinct colour–shape mappings along with stronger musical training. These results suggest that cultural background, neurodivergence, and musical training all influence how people perceive sound. Instead of relying solely on traditionally “calming” sounds, therapies, educational programmes, and learning environments, they could benefit from more personalised approaches that consider unconventional frequencies and textures, which may be particularly meaningful or enjoyable for certain groups.

Keywords: Sound perception, culture, neurodivergence, musical training, cross-modal associations

Individual and Cultural Differences in Sound Perception: An Exploratory Study

Sound is a vital channel for communication in the human experience. It is a mechanical wave that is defined by its frequency, amplitude and wavelength. Yet, its perception is far from a passive reception of these vibrations. In fact, the journey of a sound wave from its source to our conscious experience is one of the most intriguing transformations. Upon reaching the auditory system, this complex waveform is deconstructed into neural signals, and this raw data is then processed through neural networks. It shifts from simple mechanical oscillations into a complex reaction shaped by cognition, emotion and cultural

February 2026, Vol. 12, No. 1
ISSN 2163-758X

context (Oxenham, 2017; Herre & Dick, 2019). Understanding how people perceive sounds requires a simultaneous examination of multiple dimensions.

For decades, the dominant framework for studying emotional responses to sound has been the arousal-valence model (Russell, 1980). This model plots subjective experience along orthogonal axes of arousal (calm to excited) and valence (pleasant to unpleasant), which itself is a valuable tool for comparing emotional responses. Nevertheless, its widespread use has come at a cost since it oversimplifies auditory perception. For instance, it cannot easily capture the vivid personal memory triggered by a specific piece of music or the well-documented cross-modal correspondence demonstrated by the bouba-kiki effect, wherein people overwhelmingly associate rounded shapes with sounds like “bouba” and spiky shapes with sounds like “kiki” (Gomez et al., 2013).

A further critical limitation of the existing literature is its overwhelming reliance on participants from Western, Educated, Industrialised, Rich and Democratic (WEIRD) societies, only representing a thin slice of the global psychological diversity (Henrich et al., 2010). This bias severely constrains our understanding of how humanity across the globe perceives sound, with culture being a powerful factor in how it is interpreted. By the same token, Lee et al. (2023) explored emotional responses to Hangul phonemes in Korean and Chinese women and found significant cultural differences in both arousal and valence ratings. Koreans tended to show higher arousal and varied valence patterns compared to the Chinese participants. This indicates that even at the level of individual speech, culture impacts perceived emotions, which proves that research limited to WEIRD populations fails to capture the full diversity of the emotional spectrum of sound.

In Algeria, publicly available datasets on perception and psychology are almost nonexistent, and sound-related studies remain scarce, limiting the development of locally relevant applications in therapy, education and urban design. A few studies have begun to address this gap. For example, research has been conducted on urban soundscapes in coastal cafés using binaural recordings and surveys to analyse how sounds affect social comfort, particularly post-COVID-19 (Berkouk et al., 2023). Other studies examined how Algerian dialect speakers adjust their speech in loud environments to improve intelligibility (Ykhlef & Bouchaffra, 2022), as well as the Sawt El-Djazaïr project, which created a voice database covering 12 regional dialects to support speaker recognition technology (Zergat, 2023). Despite these contributions, the broader and more nuanced ways in which Algerians perceive sound in daily life have not yet been explored. The country still falls short of generating the data needed to inform inclusive practices with regard to sound perception.

At the same time, a limited awareness of neurodivergence further restricts opportunities for developing inclusive approaches to sound perception and its social implications. It is yet another gap reflecting a broader issue in Algerian psychology, which has historically depended on Western models that do not necessarily align with the local culture. Consequently, they often fail to incorporate the distinctive social representations and lived experiences of the Algerian people. This calls for establishing more culturally grounded psychological frameworks capable of better understanding local realities (Mosbah, 2022).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

This study addresses the lack of diverse sound perception datasets by collecting responses from both Algerian and Western participants. More precisely, it examines how participants perceive a variety of both novel and familiar sounds, testing emotional, cognitive, and cross-modal responses (such as memory recall, shapes and colours). It also considers how individual factors, such as musical training, personality traits, and neurodivergence relate to the responses. The research questions guiding this study are as follows: (1) How do Algerian participants differ from international participants in their emotional and cross-modal responses to different sound types? (2) Which categories of sounds most strongly trigger emotional reactions, memories or other cross-modal associations? (3) How do factors such as neurodivergence, musical training, age and gender shape the perception of sounds?

Together, these queries guide an exploratory investigation into how cultural and individual factors shape the perception of a broad range of sound types.

Methods

Participants

The recruitment approach for this online study was the snowball sampling method (Baltar & Brunet, 2012). The link to the survey was shared across multiple social media platforms including Facebook groups focusing on psychology and music, Discord servers and Reddit communities. It was also shared through academic networks in Algeria and Poland, as well as through personal contacts to reach a wider age range. The statistics were as follows:

Table 1. Participant Characteristics

Category	Subcategory	N (%)
Total responses	Completed	83 (56.1%)
	Dropouts	65 (43.9%)
Country	Algeria	97 (65.54%)
	Germany	14 (9.46%)
	Poland	12 (8.11%)
	France	7 (4.73%)
	United States	6 (4.05%)
	Canada	3 (2.03%)
	Netherlands	2 (1.35%)
	Spain, Brazil, South Korea, Romania, Malaysia, Saudi Arabia, Sweden	1 each (0.68% each)
Age	18–24	56 (37.84%)
	25–34	47 (31.76%)
	35–44	34 (22.97%)
	45–54	4 (2.70%)
	55+	7 (4.73%)
Gender	Male	77 (52.03%)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

	Female	70 (47.30%)
	Non-binary	1 (0.67%)

Materials

Sound stimuli: Ten carefully selected sounds were played to the participants. The goal was to include both familiar and unfamiliar sounds to get broader perceptions.

Table 2. Sound Stimuli Characteristics

#	Stimulus Name	Type	Duration	Source
1	Algorithmic Ambient	Synthetic	15 s	Generated with Max/MSP
2	Classical Music	Musical	15 s	Tchaikovsky, "Swan Lake" (excerpt)
3	Rock/Metal	Musical	15 s	Metallica, "Enter Sandman" (excerpt)
4	18 Hz Tone	Infrasound	15 s	Synthesised
5	Space Sounds	Electromagnetic	15 s	NASA recordings of Saturn emissions
6	Overtone Singing	Vocal	15 s	Tuvan throat singing (Batzorig Vaanchig)
7	7.83 Hz Tone	Resonance	15 s	Schumann resonance
8	Microtonal Music	Musical	15 s	Sevish, "Gleam" (excerpt)
9	Industrial Sound	Soundscape	15 s	Factory field recording
10	Geophony	Environmental	15 s	Geyser field recording

Survey measures

The survey gathered several types of information.

Table 3. Collected data. Personality traits were measured using the 10-item Big Five Inventory (Rammstedt & John, 2007)

Variable	Components
Demographics	Age, gender, nationality, native language
Music Expertise	Formal training (Yes/No); Years of practice (1–2, 3–5, 6–10, 10+); Music theory knowledge (None, Beginner, Intermediate, Advanced)
Personality	BFI-10 inventory (10 items → Big Five traits: Openness, Conscientiousness, Extraversion, Agreeableness, Neuroticism); responses on a 5-point Likert scale
Neurodivergence	Self-report of diagnosis or suspicion (Yes/No/Unsure)
Sound Responses	Emotion (10 options), physical sensations (13 options), memory recall (Yes/No), colour association (17 options), shape association (14 options)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Cultural Background	Nationality and native language
Final Feedback	Most liked sound, most disliked sound, most stood out sound; open-ended comments

Procedure

-Participants first completed demographic questions, followed by musical background, neurodivergence, and finally personality measures.

-Participants were asked to use headphones and remain in a quiet environment for better sound perception, though this could not be fully verified.

-The 10 sound clips were presented in a randomised order to reduce order effects and prevent bias.

-After each sound, participants completed rating questions to describe their reactions to each
sound clip.

Data Analysis

Data Cleaning

The dataset was analysed using Python (v3.13) in a Jupyter Notebook environment (Kluyver et al., 2016), with the following libraries: Pandas (McKinney, 2010), NumPy (Harris et al., 2020), Matplotlib (Hunter, 2007), Seaborn (Waskom, 2021) and Scikit-learn (Pedregosa et al., 2011).

Participants who completed only demographic information or answered less than 50% of the survey were dropped from the dataset. For the remaining participants with few missing values, an Iterative Imputer with RandomForestRegressor from Scikit-learn was adopted (Pedregosa et al., 2011). This later predicts each missing value based on previously given information. Subsequently, this operation contributed to valuable, partially completed responses.

Table 4. Data Cleaning Process

Step	Initial Count	Final Count	Action Description
Total responses	148	148	Raw data
Completion filter	148	83	Removed responses with less than 50% completed
Missing value imputation	83	94	Imputed occasional missing

February 2026, Vol. 12, No. 1
ISSN 2163-758X

			values using Iterative Imputer

Variable Transformation and Scoring

-Some variables were harmonised for consistency. Nationalities were standardised to their two-letter ISO codes.

-Native language data showed high collinearity with nationality and was therefore excluded from the dataset to avoid redundancy.

-A music expertise score was calculated from three ordinal measures as described below in Table 5.

Table 5. Music Expertise Score

Component	Response Options	Numerical Coding
Formal Training	Yes/No	1/0
Years of Practice	1-2/3-5/6-10/None	1/2/3/4/0
Theory Knowledge	Beginner/Intermediate/Advanced/None	1/2/3/0

The score was then calculated using the formula:

Music score = 0.4 × (training) + 0.3 × (years) + 0.3 × (theory)

The weighting here emphasises formal training while also considering the duration of practice and theoretical knowledge (Wöllner et al., 2011). The result was min–max scaled to 0-5 range for data analysis.

-For personality traits, scores were calculated according to BF-10 scoring protocols. For each trait, the results of each question were averaged to create scores ranging from 1-5.

-Due to the limited sample size within specific neurodivergence conditions, responses from the neurodivergence categorisation were aggregated into three larger classifications, as shown in Table 6:

Table 6. Neurodivergence Categorisation

Aggregated Category	Original Response Options	Numerical Coding
Confirmed or self-identified neurodivergence	ADHD, Autism Spectrum Disorder, Anxiety, etc.	1
No neurodivergence reported	No diagnosis	0
Unsure	I don’t know	-1

February 2026, Vol. 12, No. 1
ISSN 2163-758X

-Countries were aggregated into three cultural groups to maintain statistical power and allow clearer comparisons between Algerian and non-Algerian participants, as follows:

Table 7. Cultural Group Aggregation

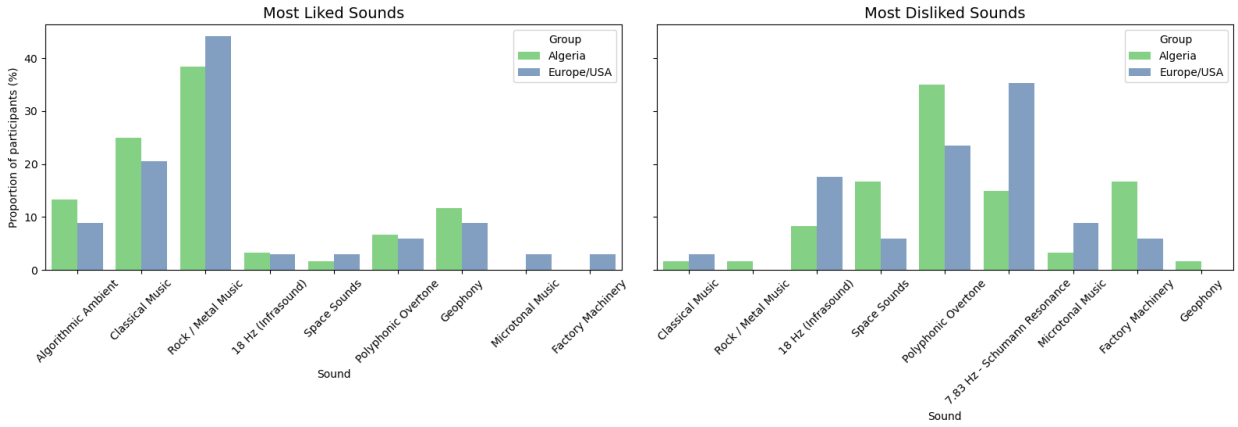
Region	Count	Percentage (%)
Algeria	60	63.83
EU/USA	30	31.91
Asia	2	2.13
Oceania	1	1.06
Latin America	1	1.06

Ethics

This survey was conducted in accordance with basic ethical principles. All participants provided digital consent prior to participation. The data collection ensured full anonymity, with no personal information such as IP addresses or geographic locations being collected or stored.

Results

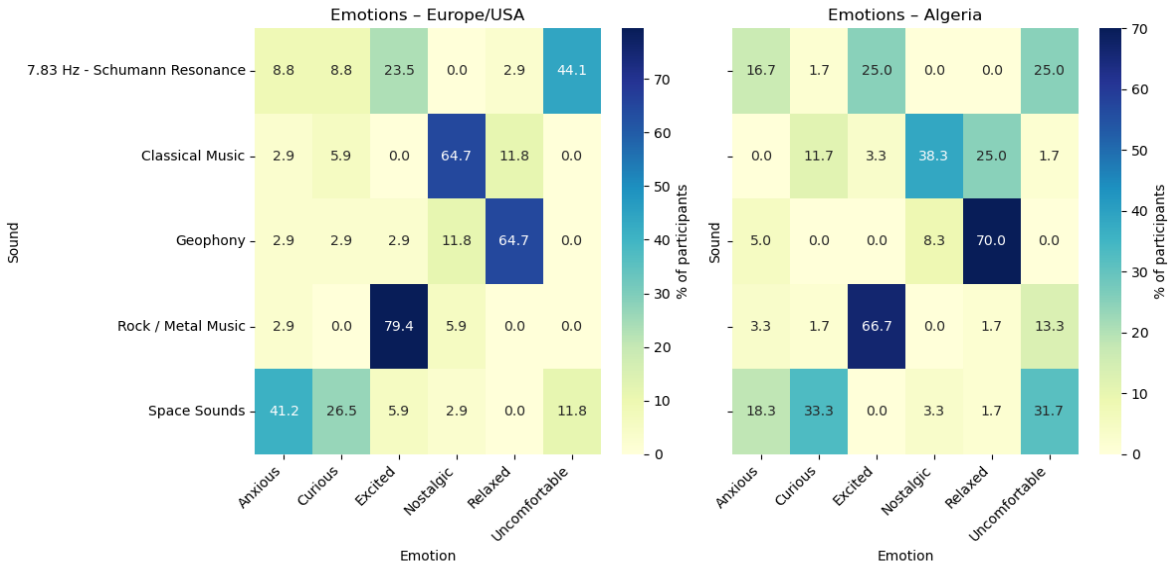
Figure 1. Comparison of Most Liked and Disliked Sounds by Cultural Group



Both Algerian and European/US participants showed a strong preference for Rock/Metal music (Algeria: 38.3%; Europe/USA: 44.1%) and Classical music (25.0% and 20.6%, respectively). Notably, these two categories accounted for nearly two-thirds of all “most liked” selections in both cultural groups (Algeria: 63.3%; Europe/USA: 64.7%). However, the sounds most frequently cited as disliked diverged: Algerian participants most disliked polyphonic overtone singing (35.0%), followed by space sounds and factory machinery (16.7% each). In contrast, European/US participants most disliked the 7.83 Hz Schumann resonance tone (35.3%) and the 18 Hz infrasound (17.6%), indicating a stronger aversion to low-frequency stimuli. Algerian participants showed greater tolerance for these low-frequency tones.

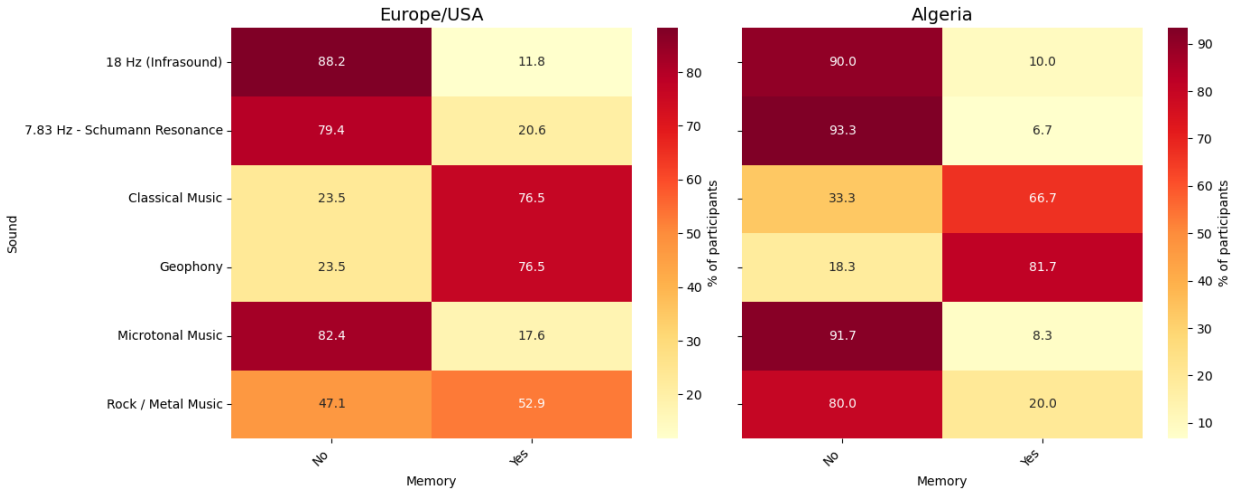
February 2026, Vol. 12, No. 1
ISSN 2163-758X

Figure 2. Emotions for Selected Sounds by Cultural Group



Both groups predominantly felt “excited” by rock/metal music (Europe/USA: 79.4%; Algeria: 66.7%) and “relaxed” by geophony (64.7% and 70.0%, respectively). Classical music evoked stronger “nostalgia” in the Europe/USA group than in the Algerian groups (64.7% vs. 38.3%). Notable differences emerged for unconventional sounds: space sounds provoked “anxiety” in the Europe/USA group (41.2%) but “curiosity” in the Algerian group (33.3%). Furthermore, the 7.83 Hz Schumann resonance was primarily “uncomfortable” for both, but this feeling was more pronounced in the Europe/USA group (44.1% vs. 25.0%).

Figure 3. Memory Recall for Selected Sounds by Cultural Group



Geophony and classical music were the most potent triggers for memory in both cultural groups (Europe/USA: 76.5% for both sound categories; Algeria: 81.7% and 66.7%,

February 2026, Vol. 12, No. 1
ISSN 2163-758X

respectively). Conversely, the low-frequency tones (18 Hz, 7.83 Hz) and microtonal music rarely triggered memories (<20% recall for both groups). A notable cultural difference emerged for rock/metal music, which triggered memories in over half of the Europe/USA participants (52.9%), but only in one-fifth of Algerian participants (20.0%).

Table 8. Colour Associations for Selected Sounds by Cultural Group

Sound Stimulus	Top Colour (EU/USA	% (EU/USA)	Top Colour (Algeria)	% (Algeria)
Geophony	Blue	41.2	Blue	28.3
Space Sounds	Black	38.2	Black	51.7
Rock/Metal Music	Black	41.2	Black	35.0
18 Hz Infrasound	Grey	20.6	None	33.3

Both groups strongly associated geophony with the colour blue (Europe/USA: 41.2%; Algeria: 28.3%), space sounds with black (38.2% and 51.7%, respectively), and rock/metal music with black (41.2% and 35.0%). For more abstract sounds, associations were less consistent.

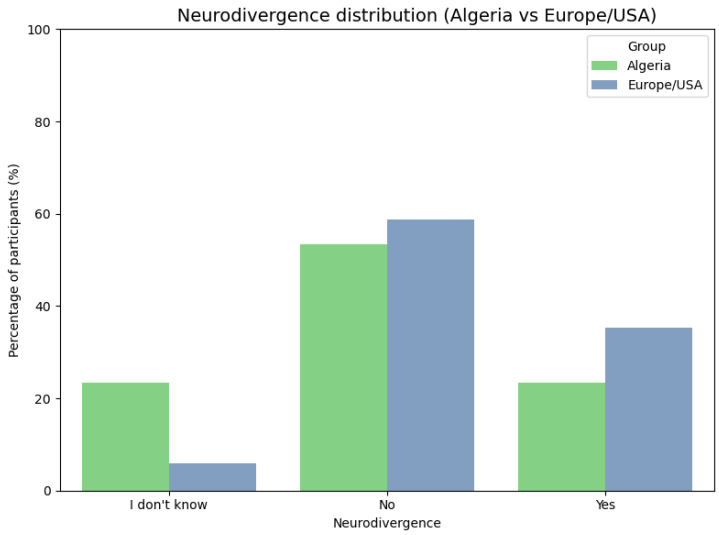
Table 9. Physical Sensations for Selected Sounds by Cultural Group

Sound	Reported Sensations	Range/Group Difference
Low-frequency tones, (7.83 Hz, 18 Hz)	Headache (up to 18.3%), Muscle tension (up to 25.0%)	Consistent across groups → linked to discomfort
Geophony	Floating (20.626.7%), Sleepiness (16.723.5%), Chest heaviness	Stronger chest heaviness in Algerian group (30.0%) vs Western group (17.6%) → cultural nuance
Rock/Music	Increased heart rate (25.0–26.5%)	Similar intensity across groups → associated with arousal

Low-frequency tones consistently cause discomfort (headaches and muscle tension), while geophony provokes floating, sleepiness, and chest heaviness, more widely reported by Algerians than Westerners.

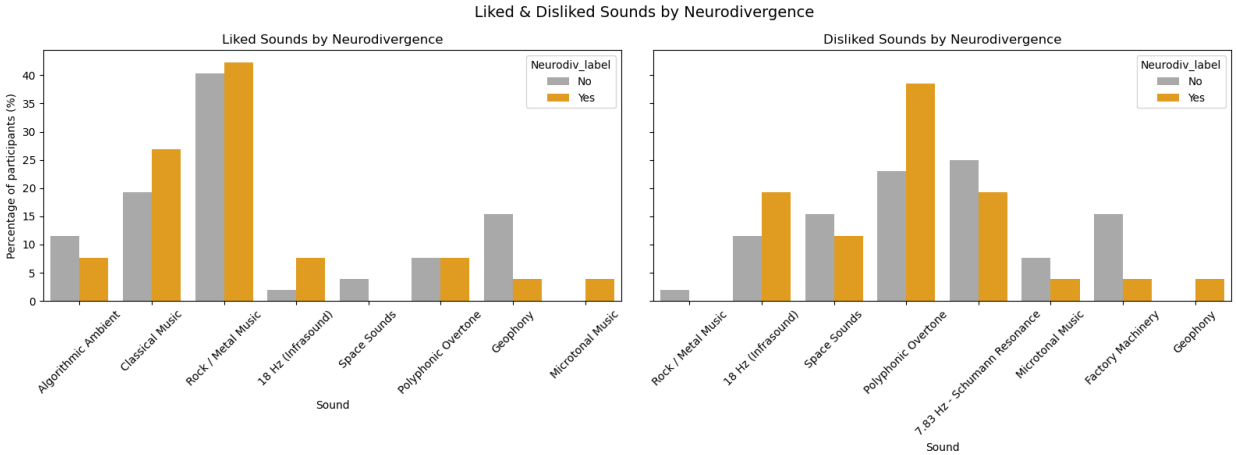
Figure 4. Neurodivergence by Cultural Group

February 2026, Vol. 12, No. 1
ISSN 2163-758X



Significant differences emerged in neurodivergence awareness between cultural groups. Algerian participants were more likely to report uncertainty about their neurodivergence status ("I don't know": 23.3%) compared to Europe/USA participants (5.9%). Correspondingly, the proportion of participants identified as neurodivergent was higher in the Europe/USA group (35.3%) than in the Algerian group (23.3%). This pattern supports observations of lower awareness and diagnostic availability for neurodivergence in the Algerian context.

Figure 5. Liked and Disliked Sounds by Neurodivergence

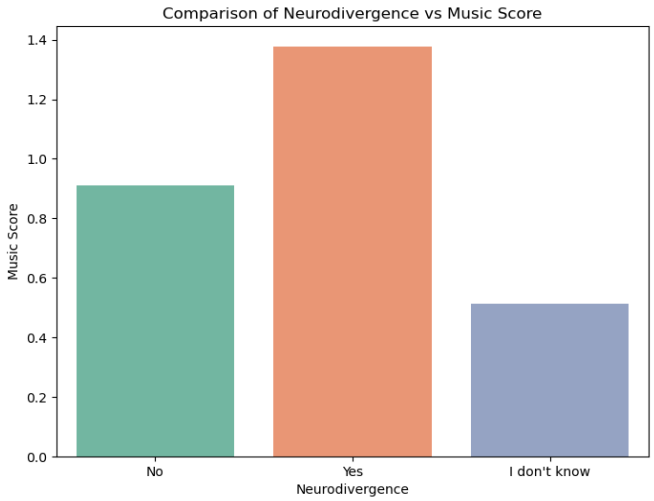


The analysis of sound preferences by neurodivergence status revealed distinct patterns, particularly for low-frequency stimuli. While both groups shared a preference for rock/metal and classical music, neurodivergent participants demonstrated greater tolerance for low-frequency sounds. The 18 Hz infrasound was listed as a favoured sound by 7.69% of neurodivergent participants compared to only 1.92% of neurotypical respondents. The 7.83 Hz Schumann resonance was the primary dislike for neurotypical participants (25.00%), but ranked lower for neurodivergent participants (19.23%).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

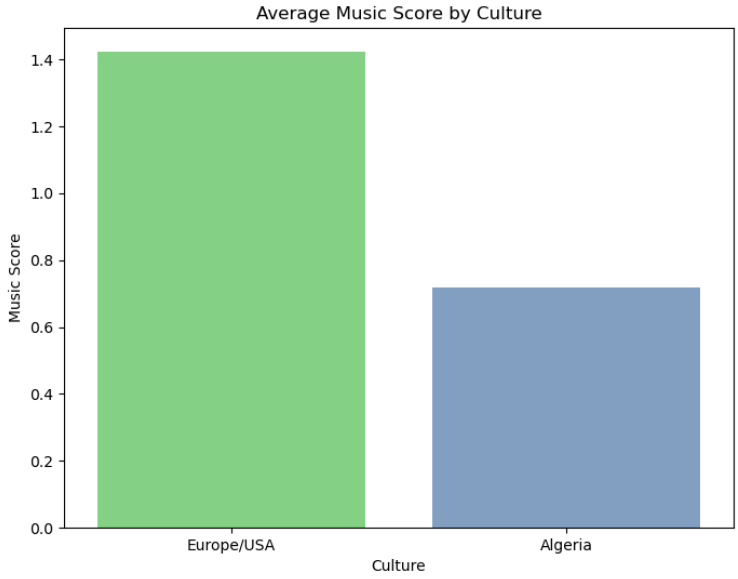
Neurodivergent volunteers indicated a stronger aversion to polyphonic overtone singing (38.46% vs 23.08%).

Figure 6. Music Score by Neurodivergence



Participants who were identified as neurodivergent also reported higher levels of musical training compared to neurotypical participants and those unsure of their status.

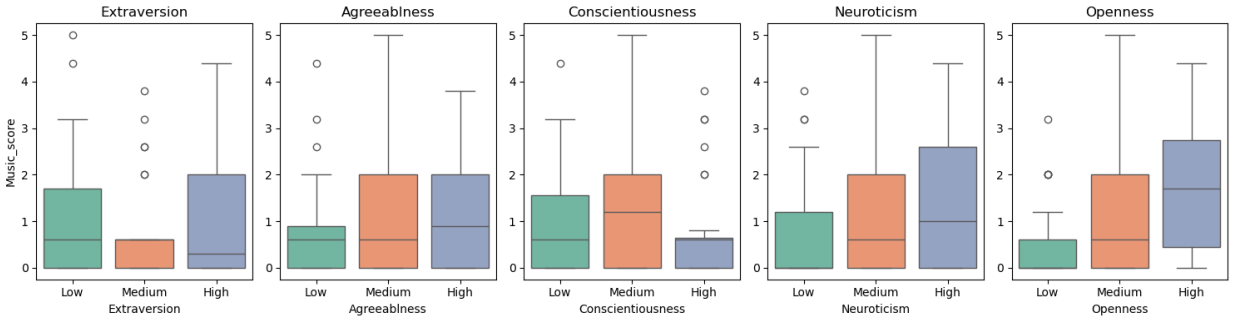
Figure 7. Music Score by Cultural Group



The Europe/USA group demonstrated higher levels of musical training, with a mean music expertise score nearly double that of the Algerian group (1.42 vs 0.72).

Figure 8. Music Score by BFI-10

February 2026, Vol. 12, No. 1
ISSN 2163-758X



Respondents scoring higher in openness and neuroticism reported greater musical training. The category of volunteers with higher conscientiousness reported the lowest musical training.

Additional observations: Neurodivergent participants were more likely to form specific colour associations (e.g., silver for 18 Hz infrasound) for abstract stimuli that neurotypical participants often left unassociated.

Discussion

This exploratory study set out to map the complex terrain of sound perception beyond traditional methods, with a specific focus on the under-researched Algerian society. Investigating a diverse set of sounds allows us to reveal that auditory experience is not universal but is deeply shaped by an interplay of cultural background, neurodivergence, musical expertise and many other traits.

The initial research question investigated cultural differences between Algerian and international participants. The shared remarkable preference for rock/metal and classical music across groups suggests that certain musical structures, chiefly popular ones, may consistently evoke high-arousal, positive valence responses regardless of cultural background. Similarly, the strong association of geophony with relaxation and the colour blue point to a potential cross-cultural, biologically rooted response to naturalistic sounds (Buxton et al., 2021). However, differences in reactions to unconventional sounds are distinctly revealing. Furthermore, the greater tolerance and curiosity towards low-frequency infrasound and space sounds among Algerian participants contrasted with a stronger aversion and anxiety reported by the Europe/USA group. Additionally, it shows that exposure to scientific narratives plays a significant role in shaping the perception of unfamiliar sounds. This aligns with the concept of “semantic mediation,” in which the meaning assigned to a sound influences its emotional impact (Gao et al., 2023). In the same line of thought, the fact that rock/metal music triggered memories in far more European/US participants also reinforces that the link between memory and sound is culturally conditioned.

Memory recall was the strongest for geophony and classical music in both groups, which demonstrates the role of familiar environmental sounds in memory recall (Schulkind et

February 2026, Vol. 12, No. 1
ISSN 2163-758X

al., 1999). However, rock/metal music evoked more memories among Western participants, likely due to differences in everyday listening practices and cultural integration of this genre.

The analysis of neurodivergence adds another dimension to the study's findings. For instance, neurodivergent participants demonstrated greater openness to unconventional sounds, including low-frequency tones, and were more likely to form specific colour associations with abstract auditory stimuli. Such cross-modal tendencies are consistent with findings on sensory processing differences and synesthetic experiences in autism and ADHD (Ward et al., 2017). In addition, the higher levels of musical training among neurodivergent respondents also indicate that music provides a structured and expressive outlet for individuals with heightened auditory sensitivity.

Additionally, differences in awareness of neurodivergence itself highlight a broader social issue. Algerian participants were more likely to be unsure of their neurodivergence status. This fact clearly indicates diagnostic inaccessibility and limited cultural discourse around neurodiversity in North Africa. This disparity aligns with global reports of uneven diagnostic recognition, specifically in non-Western contexts (Mosbah, 2022).

Taken together, these observations suggest that sound perception is not merely biological but is filtered through culture, memory, training, neurodivergence and many other traits. Applications in therapy, education, and AI-driven sound design should take these factors into account, moving away from universalist models of auditory preference and toward more personalised and culturally inclusive approaches.

Potential applications that could be extracted from this study include:

-Personalised music therapy: Instead of only using "calm" music, therapists can adapt soundscapes to individual profiles (e.g., neurodivergent people may respond better to algorithmic or repetitive patterns).

-Learning & memory enhancement: Pairing sounds with shapes/colours (cross-modal associations) may improve memory retention in education.

-Cross-cultural counselling: Therapists working with multicultural populations can adapt sound-based interventions according to cultural sound preferences.
Example: In Algeria, incorporating traditional instruments or desert soundscapes might resonate more deeply than Western piano music.

Illustrative comments from our participants:

"The test was well-structured, but I think it would be interesting to explore how blind individuals perceive sound and colour more accurately than sighted people. Their enhanced auditory processing could provide valuable insights." (Participant, Algeria).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

“Schöne Rhythmen und komponierte Lieder, bleiben länger im Gedächtnis und man hat dann auch im Alltag mehr die Lust dazu etwas aus dem Bauch heraus zu singen, da man sich an solche Lieder deutlich besser erinnert und man viel mehr körperliche Emotionen wahr nimmt.” [translated from German: “Beautiful rhythms and composed songs stay longer in memory, and in everyday life one feels more like singing spontaneously, because such songs are remembered more clearly and evoke stronger bodily emotions.”] (Participant, Germany).

“I usually associate images or scenes instead of just shapes that are abstract with the sounds that were presented.” (Participant, USA).

“Niektóre dźwięki były denerwujące, ale takiej odpowiedzi nie było do wyboru.” [translated from Polish: “Some sounds were annoying, but that option was not available to choose.”] (Participant, Poland).

“Cette expérience m’a donné l’impression qu’elle pouvait révéler certains traits de personnalité et les émotions liées aux difficultés de la vie quotidienne.”
[translated from French: “This experiment gave me the impression that it could reveal certain personality traits and the emotions linked to everyday challenges.”] (Participant, France).

Limitations

Like any exploratory study, this work has several limitations that should be kept in mind. The number of participants was relatively small. As recruitment was done through personal networks and social media, the sample cannot be considered fully representative. The survey was distributed in multiple languages, which may have introduced slight differences in how questions were understood, and the fixed answer options did not always capture the full range of reactions. For instance, some participants noted their open-ended feedback. Another important point is that the study relied entirely on self-report data, without laboratory materials or controlled listening conditions, which limited the precision of the findings. In addition, while the collected dataset is eminently multidimensional, the focus was solely on the information most relevant to the presented research questions. Other dimensions remain unexplored, but the full dataset could be made available for further analysis or educational use. Finally, although the results highlight meaningful findings, these observations remain preliminary and should be followed up with larger and more balanced samples.

Conclusion

This study demonstrates that sound perception is a richly layered experience that extends far beyond the traditional arousal–valence model. By focusing on an understudied population and incorporating a diverse set of sounds and response dimensions, the outcomes have uncovered a complex interplay of cultural, cognitive, and individual factors.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The findings clearly indicate that cultural background significantly shapes how sounds are interpreted, with Algerian participants showing distinct patterns of tolerance and association compared to Western participants. Furthermore, individual neurotype emerged as a powerful influence. The limited awareness of neurodivergence within the Algerian sample itself highlights a critical area for future research and public health consideration.

Ultimately, these results argue against a one-size-fits-all approach to sound in applied settings. Instead, they advocate for more personalised and culturally attuned practices in fields such as sound therapy, education, and urban design. By applying this, they can move toward creating soundscapes that are not only more effective but also more inclusive and meaningful for all.

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Author Notes

Samah Gourari, is a physicist with a Bachelor's degree in Physics (2024) and currently a Master's student in Computational Physics at the University of Tlemcen (UABT), Algeria. Her academic path is centered on computational and numerical methods in physics, with a strong focus on machine learning, data analysis, and Monte Carlo simulations for tackling complex physical systems. She has participated in international academic programmes and conferences, where she explored interdisciplinary questions connecting physics with broader human and environmental concerns. Her current research interests include applying advanced computational techniques to quantum physics, as well as exploring the potential of Physics-Informed Neural Networks (PINNs) in scientific modelling. She is also engaged in practical projects involving medical imaging and radiology software development. Beyond her main field, she remains curious about interdisciplinary topics, which inspired the present work on sound perception.

Abdelhak Chikhaoui is a Professor at the Department of Physics, Abou Bekr Belkaid University of Tlemcen. He holds a PhD in Physics and a University Habilitation (2013). His expertise lies in modelling and simulation of nonlinear systems, electromagnetic phenomena, transport processes and computational physics. His research also covers photonic crystals and renewable energy, with a strong focus on optimisation and energy efficiency. Author of several international publications, he has contributed to the study of optical properties of materials, stability of complex systems, and numerical simulation applied to physics and engineering. He supervises PhD and Master's theses and leads research projects on the applications of modelling in optics and energy. He is also engaged in teaching responsibilities and administrative duties.

Dominik Wróbel is an Assistant Professor at the State University of Applied Sciences in Krosno. He holds a PhD in Biology (2006) from the Institute of Botany of the Polish Academy of Sciences in Kraków. His research focuses on nature conservation, the diversity of river-valley and wetland vegetation, the spread of invasive species, and selected groups of pteridophytes. He is the author of dozens of scientific articles and application studies, including numerous planning documents for Natura 2000 sites and

February 2026, Vol. 12, No. 1
ISSN 2163-758X

nature reserves. He lectures on biology, ecology, botany, environmental protection, evolutionism, and natural philosophy.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Technology Industry Employees' Consciousness and Readiness for AI and Automation in Taiwan

Chia-Jung Wendy Chang and Yu-Chih Doris Shih

Fu Jen Catholic University, New Taipei City, Taiwan

Abstract

This paper explores how employees in Taiwan's technology industry view the effects of automation and artificial intelligence (AI) on their work and how ready they are for these changes. A mixed-methods design was used, combining a survey of 33 respondents with follow-up interviews with five participants. According to the survey results, only 3% of workers felt ready to adapt, even though the majority acknowledged that AI and automation already affected their jobs and the industry as a whole. Due to limited hands-on experience with AI tools, a lack of training opportunities, and restricted access to resources, nearly half of the employees felt unprepared. Almost all participants expressed their interest in further training, suggesting strong motivation despite existing barriers.

Keywords: technology industry employees, artificial intelligence (AI), automation, Taiwan

Introduction

The integration of artificial intelligence (AI) and automation into the workforce marks a transformative era in the global economy. It is necessary to understand these technologies from a cultural and practical perspective since the adoption of AI and automation is not only a technical process but also a social transformation that reflects how people perceive and adapt to technological change. This study examines employee-participants in Taiwan, a leader in technological advancement, to explore how AI and automation affect the workforce.

Using questionnaires and interviews, this study offers insights into workers' consciousness, workforce readiness, and adaptability. The findings highlight the need for worker training and policymaking to ensure the harmonious integration of AI and automation in the workplace.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

This study further explores employees' experiences in Taiwan's technology sector, focusing on the integration of AI and automation in daily work, the need for enhanced training resources and employer involvement, and the role of government regulation in ensuring both technological advancement and workplace security.

AI and Automation in the Workforce

From the early imaginations of Hephaestus forging mechanical helpers to Alan Turing's conception of what would become known as the Turing Test, AI has evolved into computers performing tasks, such as learning, reasoning, problem-solving, perception, and language understanding, which typically require human intelligence (Copeland, 2024). Fast forward to the mid-20th century, where the term "AI" was formally coined at the Dartmouth conference in 1956. The term "artificial intelligence" was coined to capture the belief that every aspect of learning and intelligence could, in principle, be precisely described and simulated by machines (McCarthy et al., 2006).

AI operates on the principle of simulating our cognitive abilities, allowing machines to execute tasks that are complex and intuitive to humans (Laskowski & Tucci, 2023). In recent years, the technology industry has experienced a seismic shift due to the introduction and evolution of AI and automation. "AI discoveries at Google, Microsoft, and OpenAI, and the hardware innovations pioneered by Nvidia" have changed the game of AI development (Laskowski & Tucci, 2023). The impact has been profound, fostering a new era in which machine learning and automated systems are at the forefront of technological advancement (Rayhan, 2023). According to Rayhan (2023), "The rapid advancement of AI and automation technologies has brought about significant transformations in the various sectors." Some examples of how AI technology is used today include automation; robotics; self-driving cars; and text, image, and audio generation. Furthermore, automation increases efficiency across various industries, especially the technology industry, through applications.

The Influence of AI and Automation on the Technology Industry

According to Shen and Zhang (2024), "the recession caused by the COVID-19 pandemic and the rapid development of automation technology are changing the job market much faster than expected, and automation and the new division of labor between humans and machines will disrupt 85 million jobs in 15 industries worldwide over the next five years" (p. 2). In Taiwan, the workforce is currently undergoing significant transformations,

February 2026, Vol. 12, No. 1
ISSN 2163-758X

primarily due to the integration of AI and automation technologies. These advancements are not only reshaping job roles and industries but also altering the public's perception and consciousness about work itself. Shen and Zhang (2024) also pointed out that the integration of AI into various sectors has been viewed positively, with a consensus that AI's impact on employment will be significant and beneficial in the long term. Sears and Smallwood (2023) discussed how AI is disrupting traditional approaches to talent strategy, emphasizing the need for a people-first mindset amid these technological gains. This shift toward embracing AI and automation is driven by the recognition of their potential to augment the workforce rather than displace it. The public consciousness in Taiwan is increasingly aware of the dual nature of AI and automation. Despite concerns about job displacement and income inequality, employees recognize the opportunities that these technologies present for innovation, efficiency, and new job opportunities, such as prompt engineers, AI trainers, AI ethicists, machine managers, and AI business strategists (MacKenzie & Pantelakis, 2023). Thus, the current transformation within the Taiwanese workforce is accompanied by a subtle understanding of a future where technology and human labor coexist more seamlessly.

Research Questions

This study investigates two main research questions that explore how employees in Taiwan's technology industry view the effects of AI and automation:

A. How do workers in Taiwan's technology industry perceive the impact of AI and automation on their current job roles and the wider industry?

B. To what extent are workers in the technology industry in Taiwan prepared to integrate AI and automation into their work?

Methodology of the Research

To assess the impact of AI and automation on the workforce in Taiwan, we used a mixed-methods approach, involving questionnaires and interviews, to understand the perceptions of employees in Taiwan's technology industry.

The questionnaire was designed by the first author of the study (junior-level undergraduate student) and checked by the second author (professor-advisor) and several moderators with similar backgrounds to those of the participants. The online version of the questionnaire was distributed to technology industry workers in Taiwan

February 2026, Vol. 12, No. 1
ISSN 2163-758X

whose roles have been influenced by AI and automation. The first part of the questionnaire gathered demographic information, such as age, gender, occupation, and educational background. The second part assessed workers' perceptions of AI and automation, including their knowledge and personal attitudes, and the perceived impact of these technologies on their current and future work, using a 5-point Likert scale. The third and fourth parts of the questionnaire addressed the participants' awareness and understanding of AI and automation, personal experiences with AI and automation in the workplace, perceived threats or opportunities due to AI and automation, interest in and access to training and upskilling opportunities, and suggestions for improving workforce readiness and adaptation to AI and automation (see Appendix A for the questionnaire).

To gain a deeper understanding of individual experiences, interviews were conducted with five participants—three males and two females—from the technology industry who had previously completed the questionnaire and who were invited to participate in the interviews. The interviews explored the themes that emerged from the questionnaire responses in greater depth, including examples of how AI and automation have changed their daily work tasks, their emotional and psychological responses to the integration of AI and automation, their views on the sufficiency of current training programs and suggestions for improvement, and their long-term career plans and aspirations in the context of an evolving workplace (see Appendix B for the interview questions).

The data from the questionnaire were analyzed using descriptive statistics, and the interview data were analyzed using content analysis to identify key themes and patterns in participants' responses.

Results and Discussion of the Questionnaire and Interview Outcomes

Of the 33 questionnaires collected, 16 were from females and 17 were from males. Nineteen respondents were under 25, four were 24–34 years old, five were 35–44 years old, and five were 45–54 years old. Data collected on their educational backgrounds showed that 22 (66.7%) had a bachelor's degree, 10 (30.3%) had a master's degree, and one (3%) had a doctorate. Among the respondents, 15 (45.5%) were from the hardware manufacturing sector, 10 (30.3%) were from the semiconductor industry, six (18.2%) were from the information technology services sector, and two (6.1%) were from the software development sector. When categorized by department, 20 (60.6%) worked in sales and marketing, six (18.2%) worked in research and development (R&D), five (15.2%) were in

February 2026, Vol. 12, No. 1
ISSN 2163-758X

production/manufacturing, one (3%) was in information technology (IT), and one (3%) was in system applications (SA) (see Figure 1 and Figure 2).

Figure 1

Industry Sectors of Survey Participants

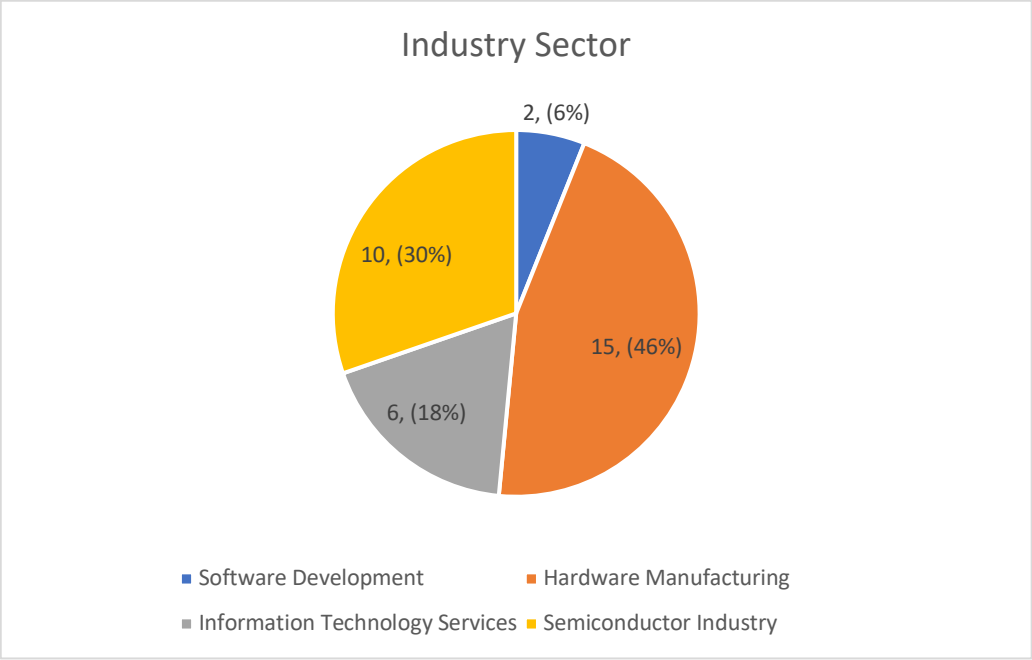
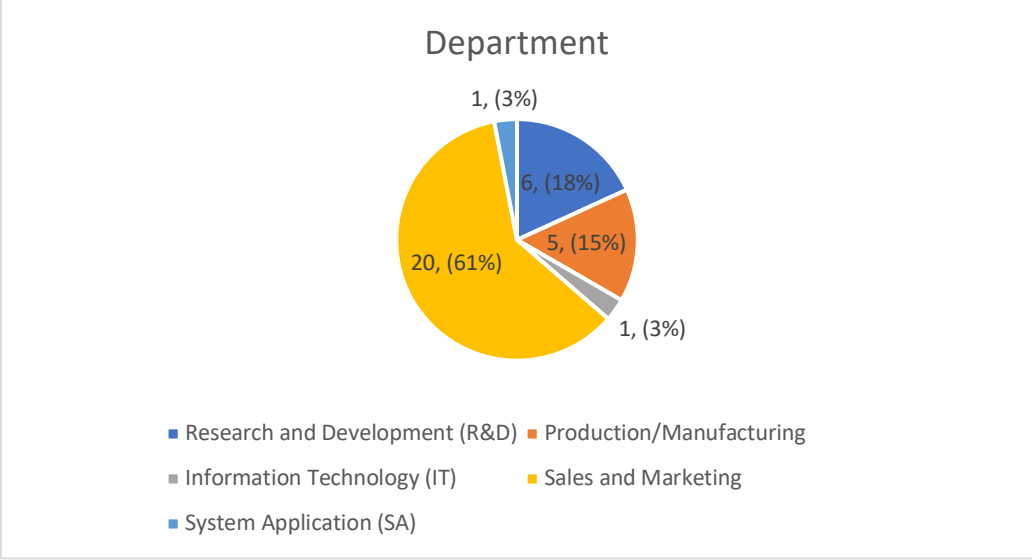


Figure 2

Department of Survey Participants



February 2026, Vol. 12, No. 1
ISSN 2163-758X

Table 1 shows the demographic information of the five interviewees.

Table 1

Demographic Information of the Interviewees

Demographic Information	Age	Gender	Industry Sector	Department or Job Title	Education Background
A	35–44	M	Software Development	Research & Development	Master's degree
B	25–34	M	Hardware Manufacturing	System Application	Master's degree
C	< 25	M	Hardware Manufacturing	Sales and Marketing	Bachelor's degree
D	< 25	F	Hardware Manufacturing	Sales and Marketing	Bachelor's degree
E	< 25	F	IT Services	Sales and Marketing	Master's degree

Note. Participants are labeled A–E to ensure anonymity.

Perceptions of AI and Automation (see Section A of Appendix C)

Regarding the technology industry workers' knowledge level, 18 (54.5%) respondents rated their understanding as moderate (a score of 3), suggesting a basic but not in-depth familiarity with these technologies. In terms of personal attitudes, most workers exhibited a positive outlook, with 72.7% expressing favorable views ("Positive" = 17 [51.5%]; "Greatly positive" = 7 [21.2%]), indicating general optimism or acceptance. Regarding the impact on their current job roles, 72.7% perceived a moderate to high influence ("Positive" = 18 [54.5%]; "Greatly positive" = 6 [18.2%]), reflecting their recognition of the tangible effects of AI and automation on their daily tasks. Of the respondents, 60.6% perceived impacts on the industry at large, acknowledging substantial effects ("Positive" = 12 [36.4%]; "Greatly positive" = 8 [24.2%]). The findings illustrated that while there was positive acceptance of AI and automation, employees in Taiwan acknowledged the significant changes that these technologies are bringing to both individual job roles and the broader industry landscape.

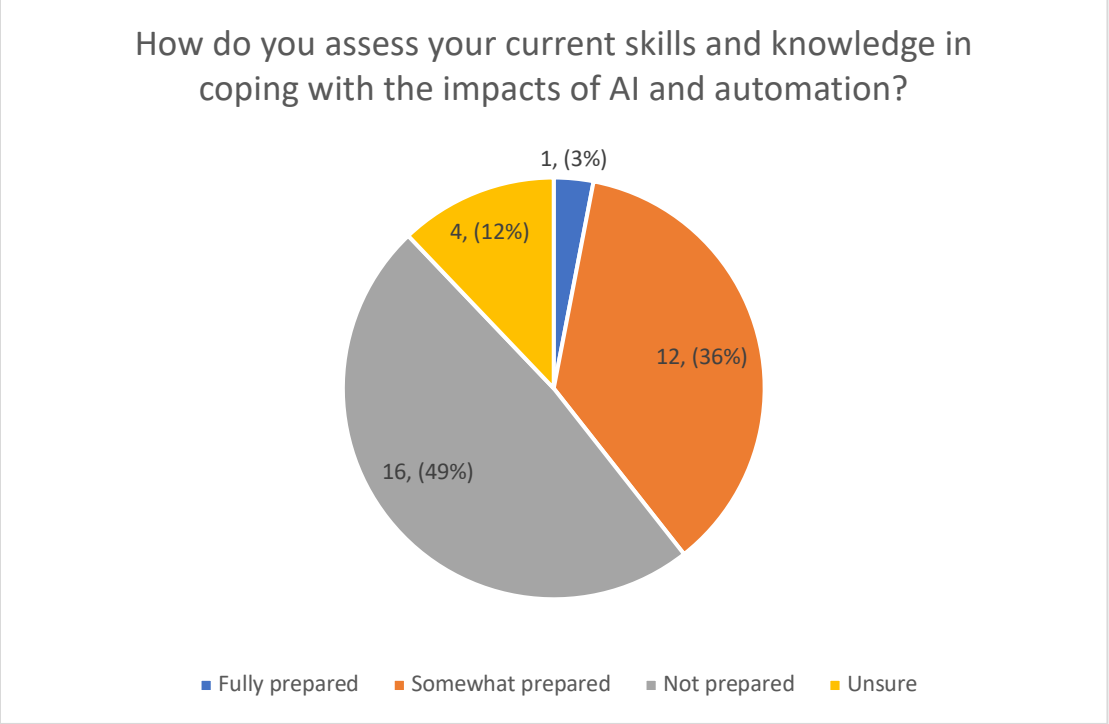
Training and Skills Development (Also see Section B of Appendix C)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The survey data revealed insights into the perceptions of training and skills development in the context of AI and automation within the workforce. Figure 3 shows that 16 (48.5%) respondents felt unprepared to handle the impacts of AI and automation, and four (12.1%) were unsure whether they were ready. These findings indicated a significant gap in readiness, with only one respondent (3%) feeling fully prepared for it, and 12 respondents (36.4%) being somewhat ready.

Figure 3

Distribution of Respondents' Perceived Readiness for AI and Automation



Several factors contributed to feelings of unpreparedness or uncertainty among employees regarding the impacts of AI and automation on their jobs. The most significant concern, as indicated by 18 respondents out of 29 (62.1%), was the lack of practical experience with new technologies (see Figure 4). This finding suggested that while employees are aware of AI and automation, they lack actual hands-on experience.

During the interviews, some participants noted their lack of experience using ChatGPT for customer service, implementing AI-driven analytics, and integrating AI with existing IT systems, which could hinder effective integration and utilization in their work processes. Additionally, concerns about skills becoming obsolete affected seven respondents

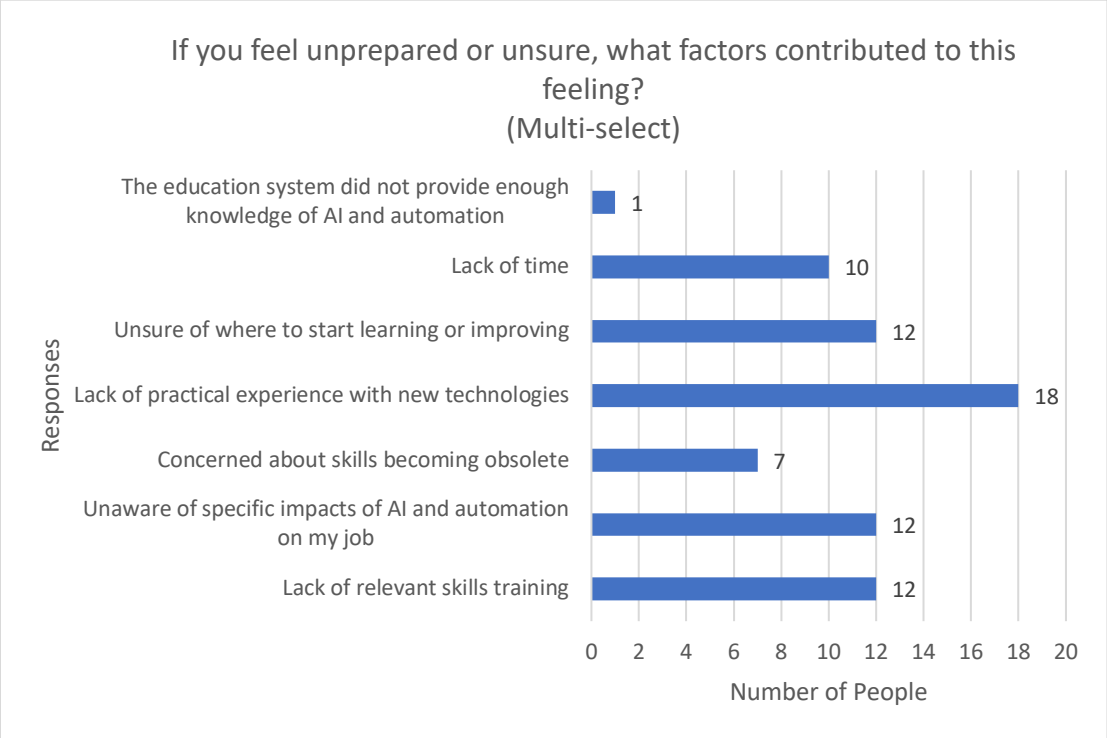
February 2026, Vol. 12, No. 1
ISSN 2163-758X

(24.1%), underscoring fears that the rapid advancement of technology is outpacing professional training programs.

Other significant factors included a lack of time to engage with learning or improvement opportunities (34.5%; 10 people) and uncertainty about where to start in terms of learning or improving skills (41.3%; 12 people). These issues highlighted the logistical and directional challenges that employees face as they attempt to adapt to technological changes.

Figure 4

Factors Contributing to Employees' Unpreparedness or Uncertainty Regarding AI and Automation



Note. The total number of respondents was only 29 for this question.

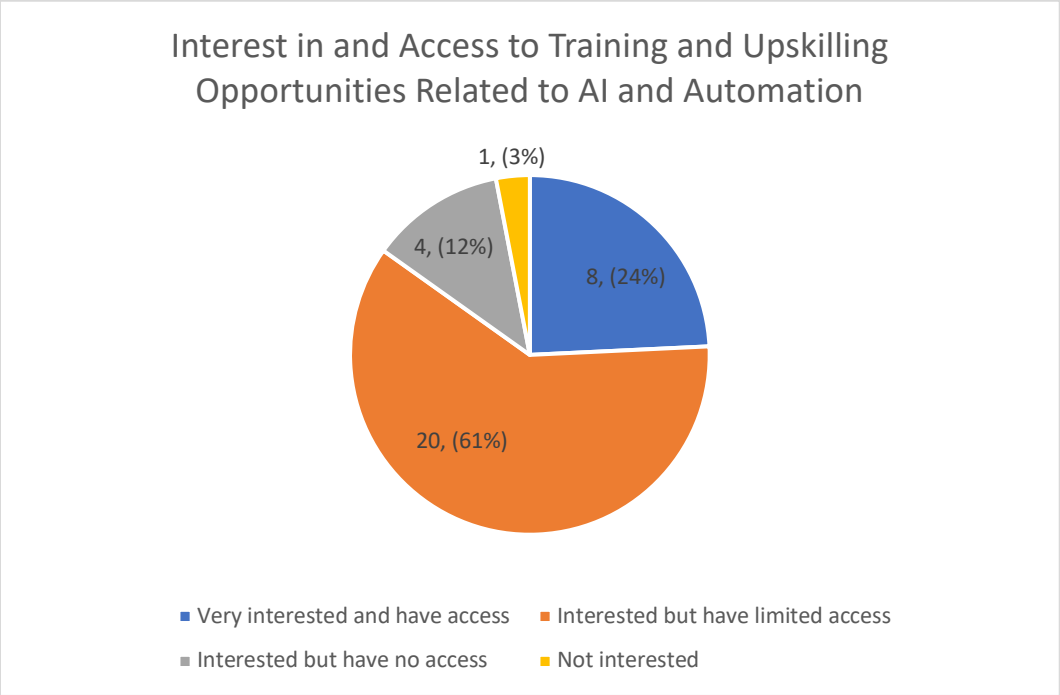
Overall, the data highlighted the need for organizations and educational institutions to offer more comprehensive training and clearer guidance on the implications of technological changes for employees' roles, as well as more accessible learning opportunities that fit into their schedules. Such initiatives could mitigate the anxiety associated with the rapid integration of AI and automation technologies into the workplace.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Of the participants, 32 (97%) were interested in training and upskilling opportunities (see Figure 5); however, a notable proportion (72.1%; 24 people) had limited or no access to training and upskilling opportunities. The respondents identified the major barriers to upskilling as a lack of time for learning and training (67.7%; 21 people), insufficient internal or external training resources (58.1%; 18 people), and a lack of financial support for training courses (35.5%; 11 people) (see Figure 6). These barriers highlighted the need for structured, accessible, and adequately supported training initiatives.

Figure 5

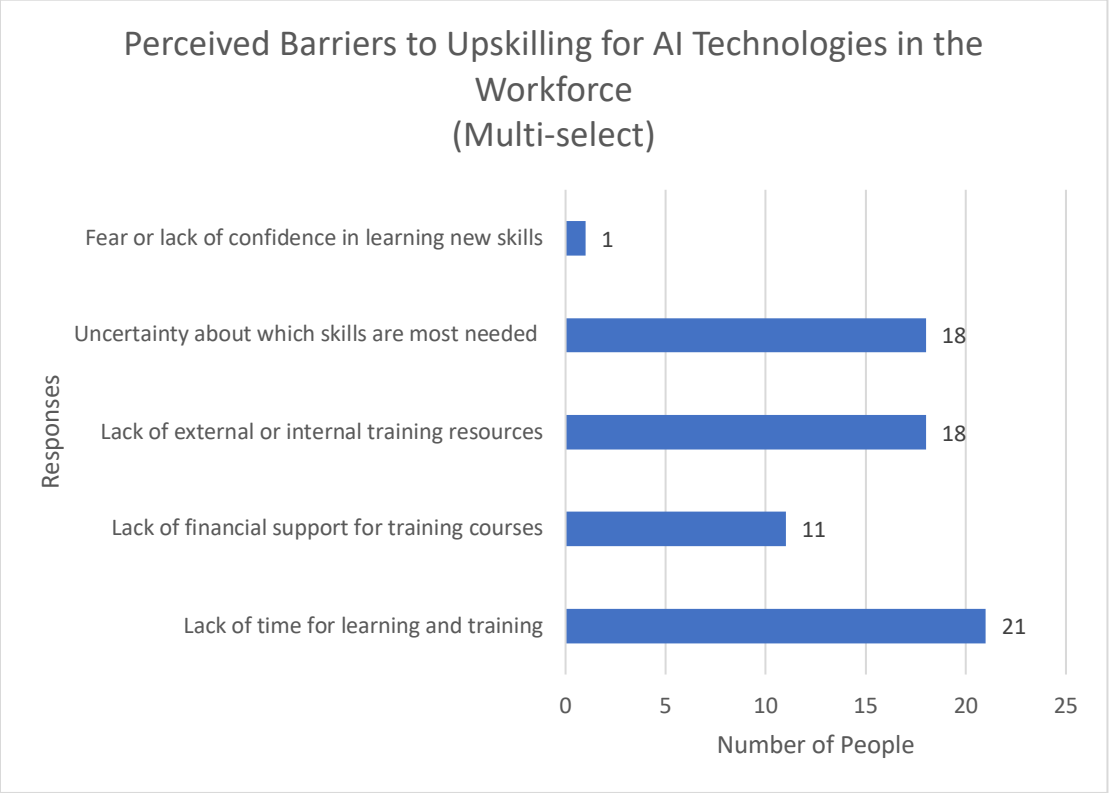
Interest in and Access to AI and Automation Training and Upskilling Opportunities among Employees



February 2026, Vol. 12, No. 1
ISSN 2163-758X

Figure 6

Perceived Barriers to Upskilling for AI and Automation Technologies in the Workforce



Note. The total number of respondents was only 31 for this question.

The results emphasized the need for better distribution and availability of training resources. The data suggested that while there is a high level of interest in learning and adapting to AI and automation technologies, the actual engagement and effectiveness of current training programs are hindered by logistical and resource-based constraints. Addressing these issues is essential for fostering a workforce that is interested in and capable of thriving in an AI-enhanced professional environment.

The responses from the interviews articulated a widespread concern about the adequacy of training programs related to AI and automation technologies within organizations. Many employees reported that while some basic training avenues are provided, they are insufficient for the in-depth learning required to utilize and understand these technologies fully and effectively. The lack of structured and advanced training programs was a common theme, leading many employees to seek information and training on their own. This self-driven approach to learning highlighted a significant gap between the training provided and the needs of employees.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

According to Antonija (2024), “Organizations need to allocate resources and provide training and support to their employees to enable them to use generative AI technology efficiently.” This recommendation aligns with the main barriers to upskilling identified by respondents, which included the lack of time allocated by employers for such activities and the absence of a clear understanding of what specific skills are required. This uncertainty, coupled with the necessity to perform self-learning amid busy work schedules, underscored the challenges faced by the workforce in adapting to rapidly evolving technological landscapes.

Overall, these insights emphasized the need for organizations to rethink their training strategies—potentially by offering more comprehensive, practical, and accessible training solutions that are aligned with the specific demands of AI and automation in the workplace.

Key Findings

In the survey, 72.7% of the respondents reported a positive influence of AI and automation on their daily tasks, and 60.6% acknowledged a beneficial impact on the industry at large. This positive perception underscored the significant transformations brought about by AI and automation, aligning with Rayhan’s (2023) observations that the “rapid advancement of AI and automation technologies has brought about significant transformations in various sectors.” These findings highlighted the evolving nature of the technology industry in Taiwan, where AI and automation not only enhance current workflows but also shape broader industrial practices.

Regarding the challenges and opportunities in AI integration within the workforce, 77.4% of respondents encountered barriers to integrating AI technologies into their work, which included a lack of expertise in technology integration (54.8%), inadequate technical infrastructure (35.5%), and employee resistance to change (12.9%). The results of the interviews highlighted the need for professional guidance on how to use AI tools. Using AI usually requires a background in writing prompts or even programming (in some cases) or knowledge of certain domains. However, AI brings opportunities because it helps people work more efficiently, enabling them to move from entry-level to pro-level in less time.

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February 2026, Vol. 12, No. 1
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Appendix A: The Design of the Questionnaire

Dear respondent,

I am Wendy Chang, a Junior from FJU's English Language and Literature and Economics Department. I am conducting this survey to explore consciousness and readiness for AI

February 2026, Vol. 12, No. 1
ISSN 2163-758X

and automation within Taiwan's technology sector. Your input is vital to understanding the current state and paving the way for a smooth transition into a more AI-integrated workplace. The survey is confidential. There are no wrong answers—just your valued perspective. It will take about 3 minutes to complete.

Once again, thank you for your time and participation. They are a great help to my research!

If you have any questions, please do not hesitate to contact me at this email address: wendym513ro@gmail.com

Researcher: Wendy Chang
Advisor: Doris Shih

Part 1: Demographic Information

1. Have you worked in the technology industry in Taiwan?
- Yes
- No
2. Gender (Single choice)
- Male
- Female
- Prefer not to say
- Non-binary
- Other
3. Age (Single choice)
- Under 25
- 25-34
- 35-44
- 45-54
- 55 and above
4. Industry Sector of Company (Single choice with an option to specify if not listed)
- Software Development
- Hardware Manufacturing
- Information Technology Services

February 2026, Vol. 12, No. 1
ISSN 2163-758X

- Semiconductor Industry
- Biotechnology
- Other (please specify)

5. Department or Job Title (Multiple choice with an option to specify if not listed)

- Research and Development (R&D)
- Production/Manufacturing
- Information Technology (IT)
- Sales and Marketing
- Human Resources (HR)
- Management
- Other (Please specify your role in the technology industry.)

6. Educational Background (Single choice)

- High School Diploma or Equivalent
- Associate Degree
- Bachelor's Degree
- Master's Degree
- Doctorate
- Other (please specify)

Part 2: Perception of AI and Automation (Likert scale)

Explanation of the options for Question 2~4:

- 1.2 Very Negative/ Negative: You believe AI and automation will harm your job or the industry.
- 3 Neutral: You are unsure or believe AI and automation will have neither positive nor negative effects.
- 4.5 Somewhat Positive/Very Positive: You believe AI and automation will benefit your job or the industry.

1. Level of Knowledge About AI and Automation (Single choice)

- No knowledge: 1
- Advanced knowledge: 5

2. Personal Attitude Towards AI and Automation (Likert scale)

- Greatly negative: 1
- Greatly positive: 5

3. Perceived Impact of AI and Automation on Current Job Role (Likert scale)

- Greatly negative: 1

February 2026, Vol. 12, No. 1
ISSN 2163-758X

- Greatly positive: 5

4. Perceived Impact of AI and Automation on the Industry (Likert scale)

- Greatly negative: 1
- Greatly positive: 5

Part 3: Practical Experiences in AI and Automation in the Workplace

1. Personal Experience with AI and Automation in the Workplace (Multiple choice)

- I have used AI/automation tools in my job.
- I have participated in projects related to AI/automation.
- I have received training in AI/automation.
- None of the above.

2. Following the previous question, what software or hardware have you used if you have used AI/automation tools in your work? (multi-select)

- Data analysis software (e.g., Python, R)
- Machine learning frameworks (e.g., TensorFlow, PyTorch)
- Natural language processing tools (e.g., NLTK, spaCy)
- Chatbots (e.g., Dialogflow, Microsoft Bot Framework, ChatGPT)
- Smart sensors
- Robot arms
- Automated Guided Vehicles (AGVs)
- Wearable devices
- Other (please specify)

3. Perceived Barriers to Integration of AI Technologies in the Workforce (multi-select)

- Organizational resistance to new technologies
- Lack of expertise in technology integration
- Lack of support from management
- Inadequate technical infrastructure
- Employee resistance to change
- I haven't encountered any barriers.
- Other (please specify)

4. Interest in and Access to Training and Upskilling Opportunities Related to AI and Automation (Multiple choice)

- Very interested and have access
- Interested but have limited access
- Interested but have no access

February 2026, Vol. 12, No. 1
ISSN 2163-758X

- Not interested

5. Perceived Barriers to Upskilling for AI Technologies in Work Process (multi-select)

- Lack of time for learning and training
- Lack of financial support for training courses
- Lack of internal or external training resources
- Uncertainty about which skills are most needed
- Fear or lack of confidence in learning new skills
- Other (please specify)

6. How do you assess your current skills and knowledge in coping with the impacts of AI and automation?

- Fully prepared
- Somewhat prepared
- Not Prepared
- Unsure

7. If you feel unprepared or unsure, what factors contribute to this feeling? (multi-select)

- Lack of relevant skills training
- Unaware of the specific impacts of AI and automation on my job
- Concerned about skills becoming obsolete
- Lack of practical experience with new technologies
- The education system did not provide enough knowledge of AI and automation
- Unsure of where to start learning or improving
- Lack of time

<u>Part 4: Perspective on AI and Automation in the Workplace</u>

1. Perceived Opportunities Due to AI and Automation (Multi-select, please specify if not listed).

- Enhancement of job skills
- Increased job opportunities
- Increased work efficiency
- Creation of new job roles
- None of the above
- Other (please specify)

2. Perceived Threats Due to AI and Automation (Multi-select, please specify if not listed).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

- Job displacement
- Skill obsolescence
- Decrease in job quality
- Reduced job security
- None of the above
- Other (please specify)

3. What recommendations would you have for employers/ managers to better support their employees/ subordinates in adapting to AI and automation? (multi-select)

- Increase in-house training programs on AI and automation
- Collaboration with educational institutions for tailored courses
- Providing access to online courses and resources
- Encouraging participation in AI and automation projects
- Enhancing awareness about the benefits of AI and automation
- Implementing mentorship programs from experienced employees
- Provide psychological support and change management training to help employees adapt to changes
- Increase investment in new technologies, including software and hardware
- Other (please specify)

Appendix B: The Design of the Interview Questions

A. Introduction to AI and Automation Experience:

Can you describe your first encounter with AI and automation technologies in your workplace? What was your initial reaction? 您能描述一下您在工作場所首次遇到 AI 和自動化技術的經歷嗎？您對 AI 和自動化技術最初的反應是什麼？

B. Daily Work Tasks and AI Integration:

How have AI and automation technologies changed the way you perform your daily job tasks? Can you provide a specific example? AI 和自動化技術如何改變了您執行日常工作的方式？您能提供一個具體的例子嗎？

C. Emotional and Psychological Responses:

How do you feel about integrating AI and automation in your work environment? Have these technologies affected your job satisfaction or stress levels? 您如何看待在您的工作環境中整合 AI 和自動化技術，這些技術是否影響了您的工作滿意度

February 2026, Vol. 12, No. 1
ISSN 2163-758X

或工作壓力？

D. Training and Skills Development:

1. In your opinion, how adequately is your employer providing current training programs for AI and automation technologies? What aspects do you think need improvement? 您認為目前雇主提供的 AI 和自動化技術培訓計劃是否充分？哪些方面需要改進？
2. Have you sought additional training or learning resources outside of work to help you adapt to these changes? If so, what were they? 您有在工作之外尋找過任何額外的培訓或學習資源來幫助您適應這些變化嗎？如果有是什麼呢？
3. In your experience, what have been the most significant barriers to upskilling in AI and automation technologies? How do you think these can be overcome? 根據您的經驗，提升 AI 和自動化技術方面的最大障礙是什麼？您認為如何克服這些障礙？

E. Impact on Career Aspirations:

How do you see AI and automation impacting your career trajectory and aspirations? (e.g., job roles, work processes, career development) Do you see more opportunities or challenges ahead?
您如何看待 AI 和自動化對您的職業軌跡和抱負的影響？（例如，工作角色、工作流程、職業發展）您認為前方有更多機會還是挑戰？

F. Adaptation and Future Readiness:

1. Can you discuss any challenges you've faced in integrating AI technologies into your daily work processes? 您能談談在將 AI 技術整合到日常工作流程中所面臨的挑戰嗎？
2. What skills do you think will be most important for professionals in your field in the next 5-10 years due to the advancements in AI and automation? 您認為由於 AI 和自動化的進步，未來 5-10 年內您的專業領域中哪些技能將最為重要？
3. How do you envision your job role evolving over the next decade with the advancement of AI and automation technologies? 您如何看待在未來十年 AI 和自動化技術進步下，您的工作角色的演變？

February 2026, Vol. 12, No. 1
ISSN 2163-758X

G. Suggestions for Employers and Policymakers:

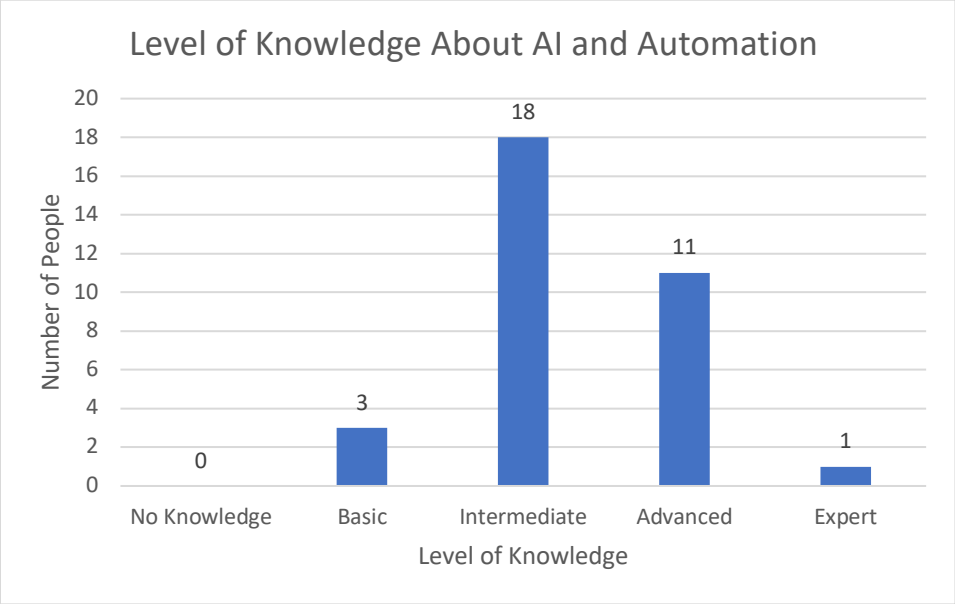
1. Based on your experience, what recommendations would you have for employers to better support their employees in adapting to AI and automation? 根據您的經驗，您對雇主有什麼建議，以更好地支持其員工適應 AI 和自動化？
2. What kinds of support do you find most helpful? 您覺得哪些類型的支持最有幫助？（可能包括：
    - 薪酬和福利調整：獎勵那些學習新技術的員工
    - 職位晉升機會：創建進階路徑，讓員工知道他們學習新技術可以幫助職業上的進步
    - 彈性工作安排：給員工更多彈性來平衡學習和工作）
3. What role do you think government or industry associations should play in preparing the workforce for the future of work? 您認為政府或行業協會在為工作未來做準備上應該扮演什麼角色？

Appendix C: Results for the Questionnaires and Interviews

Section A: Perception of AI and Automation

- **Charts** (N=33)

(1)



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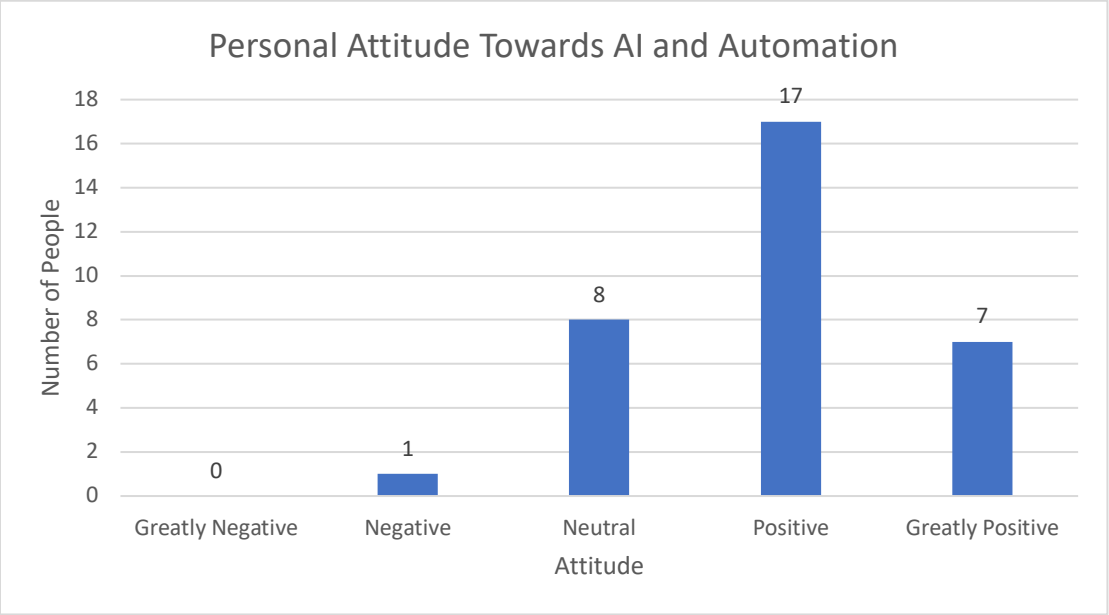
February 2026, Vol. 12, No. 1
ISSN 2163-758X



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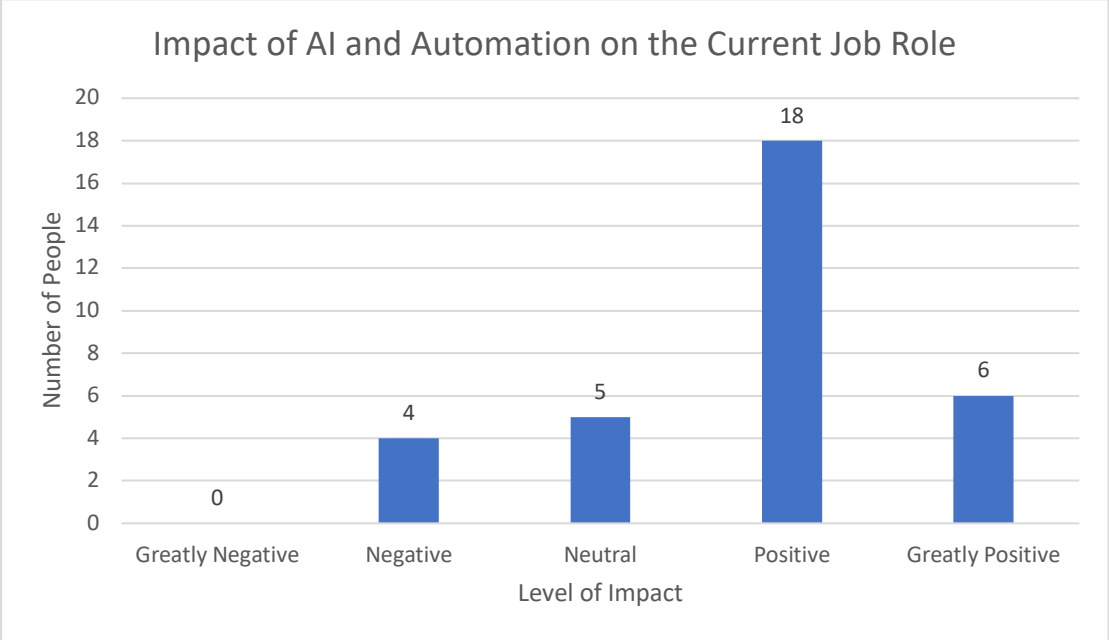

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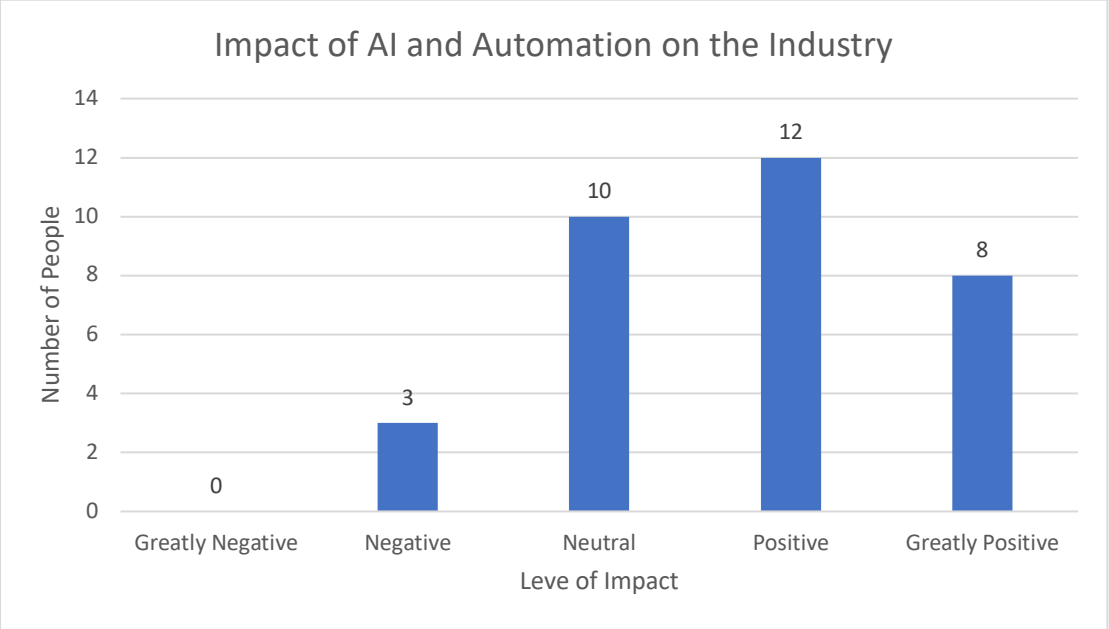
February 2026, Vol. 12, No. 1
ISSN 2163-758X



Interview Results

1. How do you feel about integrating AI and automation in your work environment? Have these technologies affected your job satisfaction or stress levels?
2.

A	"Currently, it is a trend; AI can reduce the margin for error. For me, it seems to have effectively reduced the workload without causing much stress. If we talk about job displacement, it would mostly replace labor-intensive and low-skill jobs."
B	"So far, it has increased my job satisfaction by helping with tedious reading tasks. I can spend more time presenting the information that has been organized. Additionally, I use GPT to polish some foreign correspondence and mail."
C	"AI is a trend, it is inevitable, and I feel it brings quite a lot of job pressure. From a competitive standpoint, the fear of being replaced necessitates familiarity with AI tools. However, it also improves current workflows and enhances job performance."
D	"There is both satisfaction and stress. The satisfying aspect is that work is much more efficient, but there's a fear that one

February 2026, Vol. 12, No. 1
ISSN 2163-758X

	day ChatGPT might replace real human responses, although that probably won't happen yet."
E	"Currently, there hasn't been a significant increase in satisfaction because it hasn't helped much. Customers are still not very receptive to AI responses, so it hasn't reduced my workload much. However, as this technology advances, satisfaction is likely to increase."

Section B: Training and Skills Development

1. In your opinion, how adequately is your employer providing current training programs for AI and automation technologies? What aspects do you think need improvement?

A	"Currently, the company provides some channels for training, but these are quite basic. For more in-depth learning, individuals need to find resources on their own. The company has not yet found a clear direction and could offer more advanced courses and instruction."
B	"The company is still exploring; the training programs are not sufficient. Training plans are only made once they are confirmed necessary; right now, everyone is mostly figuring things out on their own with some very localized applications. However, in departments like customer service, the company has decided to eliminate positions and replace them with AI customer service."
C	"Currently, no training is provided. An improvement would be to help employees understand the benefits and importance of the technology and what it can bring. Raising awareness and familiarity with AI tools among employees is crucial."
D	"Mostly, it's self-learning, but the company does provide some AI-related online courses. There are no areas that need improvement in this aspect."
E	"Currently, no training is provided. Employee training does not currently cover AI-related topics; perhaps this could be included."

February 2026, Vol. 12, No. 1
ISSN 2163-758X

2. Have you sought additional training or learning resources outside of work to help you adapt to these changes? If so, what were they?

A	"No, I have been too busy."
B	"No additional structured training, but I do search for resources online."
C	"Somewhat, I regularly follow AI and technology news to stay informed about new developments. Understanding the trends helps reduce resistance and gives a better sense of control. It's how I know what skills or knowledge I might need to acquire."
D	"No, I only look for resources when a need arises during my work."
E	"No."

3. In your experience, what have been the most significant barriers to upskilling in AI and automation technologies? How do you think these can be overcome?

A	"The need to dedicate my own additional time; the company doesn't provide extra time for these activities, so learning has to be done by working overtime."
B	"I still don't know which skills are needed. For instance, I might want to know how to craft the most accurate prompts, but it's hard to find relevant examples for my work context online. Assistance from someone with expertise in the field would make technical progress more feasible."
C	"Lack of time, and the difficulties of using AI tools themselves. Also, it's not always clear whether the current tools are helpful for my work content. Without urgency, there's no motivation to improve skills related to AI usage."
D	"The difficulty sometimes lies in asking many times to get the answers I want. It requires continuous attempts to overcome this."

February 2026, Vol. 12, No. 1
ISSN 2163-758X

E	"The company needs to collect more data (repositories), allowing more customers to benefit from AI technology, reduce workloads, and increase work efficiency. Another issue is the uncertainty about which parts of the job, specifically the AI tools, should be applied."

Author Notes

Chia-Jung Wendy Chang is a senior double-majoring in English Language and Literature and Economics at Fu Jen Catholic University, New Taipei City, Taiwan. Her research interests include cross-cultural communication, the social impact of economics, and the applications of AI in education and society. She is preparing to pursue graduate studies in the United States in finance and analytics.

Yu-Chih Doris Shih, PhD, is an Associate Professor in the Department of English Language and Literature at Fu Jen Catholic University, New Taipei City, Taiwan. Her research interests are in the areas of English language and cultural learning with technologies, instructional design, multimedia education, and distance learning. In recent years, she has also done research studies on digital learning in other content areas, such as the pharmaceutical and medical areas.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The Great Drug Regulation Divide: How Resource Imbalance Is Strangling Global Health Equity

Wenhan Jiao, Wanyu Zhang, and Shanshan Kang

China Pharmaceutical University, Nanjing, China

Abstract

This study investigates the global disparity in the allocation of pharmaceutical regulatory resources, focusing on the significant gap between high-income and low-income countries in terms of regulatory capacity, drug quality, safety, and accessibility. It highlights how differences in resources directly impact the ability of low-income countries to ensure the safety and availability of medicines, with high-income countries benefiting from more robust regulatory systems. The research utilizes a mixed-methods approach, combining quantitative data analysis of regulatory budgets and staffing levels, alongside qualitative case studies of countries with data gaps, such as Haiti and Papua New Guinea. The study also includes a detailed case analysis of China—the world's second-largest pharmaceutical market—to explore how regulatory capacity differences manifest within a large, middle-to-high-income economy. The findings reveal that the regulatory divide not only constitutes a technical challenge but also represents a fundamental issue of global health equity and public health security. To address this divide, the study proposes solutions including strengthening international cooperation, enhancing regulatory capacity in low-income countries, and implementing digital tools to improve regulatory efficiency. The study concludes with policy recommendations and identifies future research avenues, emphasizing the need for standardized data collection, cross-country comparisons, and the development of regulatory frameworks that suit the unique needs of different countries.

Keywords: drug regulation, China, country income levels, pharmaceutical industry,

Introduction

As a special commodity, pharmaceuticals are directly related to human health and life. Effective drug regulation, a cornerstone of modern health systems, plays a core role as a gatekeeper for global public health. Its critical importance is manifested in several key areas. First, by implementing rigorous review, approval, inspection, and post-market surveillance, regulatory authorities ensure that medicines entering the market are safe, effective, and of controlled quality—a fundamental prerequisite for ensuring public medication safety (Ratanawijitrasin & Wondemagegnehu, 2002). Second, a robust

February 2026, Vol. 12, No. 1
ISSN 2163-758X

regulatory system can foster pharmaceutical innovation by providing a clear and predictable pathway to market for new drugs of genuine clinical value while eliminating ineffective or high-risk products, thereby optimizing the allocation of healthcare resources (Kaplan & Laing, 2005). Furthermore, authoritative regulation effectively combats the production and circulation of substandard and falsified (SF) medicines, safeguarding the integrity of the pharmaceutical market and public trust in the healthcare system (WHO, 2017). In an era of globalization, where drug research, development, production, and supply chains are increasingly international, a regulatory failure in any single country or region can pose a potential threat to global public health. Consequently, a strong, science-based, and independent drug regulatory system is not merely an expression of national sovereignty but also an indispensable contribution to global health security.

Despite the critical importance of effective drug regulation, a significant "regulatory divide" exists globally. This gap is most pronounced between high-income countries and low- and middle-income countries (LMICs) (Roth et al., 2018). On one hand, regulatory agencies in developed nations—such as the United States Food and Drug Administration (FDA), the European Medicines Agency (EMA), and Japan's Pharmaceuticals and Medical Devices Agency (PMDA)—possess mature legal frameworks, sufficient financial resources, abundant professional expertise, and advanced information systems. These capabilities enable them to implement stringent oversight across the entire lifecycle of a pharmaceutical product, from development to post-market surveillance.

On the other hand, the National Regulatory Authorities (NRAs) in many LMICs, particularly in sub-Saharan Africa and parts of Southeast Asia, perennially face a multitude of challenges. These include scarce resources, weak technical capacity, personnel shortages, inadequate legal and regulatory frameworks, and deficient governance structures (Franzen et al., 2017; Ndomondo-Sigonda & Ambali, 2011). Furthermore, for many of the least-resourced NRAs, a systematic absence of critical data—such as separately reported budgets and precise staffing numbers—is observed. This lack of transparency and systemic data gaps is itself a finding that reflects institutional fragility and systemic inequity. This profound disparity in regulatory capacity directly contributes to severe global health inequities.

The negative consequences of this divide are threefold. First, regions with weak regulatory oversight have become epicenters for substandard and falsified medicines. The World Health Organization (WHO) estimates that approximately one in ten medical products in LMICs is substandard or falsified, leading not only to treatment failure and increased antimicrobial resistance but also to a substantial number of patient deaths (WHO, 2017). Second, the divide delays access to innovative medicines and high-quality

February 2026, Vol. 12, No. 1
ISSN 2163-758X

generic drugs in these nations. The absence of efficient review capacities and registration pathways prevents many essential, life-saving treatments from being timely introduced to local markets, depriving patients of therapeutic opportunities available in high-income countries (Ahonkhai et al., 2016; Ahonkhai et al., 2016). Third, it undermines the collective global response to public health emergencies, such as the COVID-19 pandemic. During the crisis, disparities in regulatory capacity led to inequalities in the approval, distribution, and quality monitoring of vaccines and therapeutics, exacerbating the global health crisis .

In summary, the global regulatory divide is not merely a technical or resource-allocation issue; it is a profound problem of global health equity. It infringes upon the fundamental right of the most vulnerable populations to access safe and effective medicines and impedes the achievement of the United Nations' Sustainable Development Goal 3 (Ensure healthy lives and promote well-being for all at all ages). Therefore, a thorough analysis of the causes, current state, and impact of this divide, along with the exploration of effective strategies to bridge it, holds significant theoretical value and practical importance.

Methodology

This study adopts a mixed-methods approach to analyze the imbalance in global pharmaceutical regulatory resource allocation and its impact on public health. The data used in this study are primarily derived from publicly available government reports, documents published by international organizations, and macroeconomic data from the World Bank and the International Monetary Fund, ensuring the reliability and international comparability of the research.

The study utilizes multiple data sources. First, the study collects data on the annual budgets and staffing of national regulatory authorities (NRAs) across different countries, specifically focusing on "total expenditure" or "program-level budgets" disclosed in the official reports of these regulatory agencies, along with the funding structure (e.g., government appropriations, user fees). Additionally, the study uses the World Health Organization's (WHO) Global Benchmarking Tool (GBT) reports to ensure consistency and comparability in evaluation standards.

Two core indicators are selected to measure the regulatory resource allocation of national pharmaceutical authorities: annual budget and full-time equivalent (FTE) staff numbers. To account for population size differences across countries, this study employs the standardized indicator of "regulatory personnel per one million population." This approach allows for a fair comparison across countries, especially when the disparity in regulatory resources is substantial.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

For countries with missing data (e.g., Haiti and Papua New Guinea), this study follows the principle of "evidence first, conservative estimation." In cases of "data unavailable" or "budget not separately reported," the study treats these as significant findings and further analyzes the underlying systemic causes behind the missing data.

In addition to quantitative data analysis, the study incorporates qualitative analysis, particularly in exploring the institutional differences in pharmaceutical regulatory systems across countries of varying income levels. Through literature review and case studies, the research delves into the root causes of global pharmaceutical regulatory imbalances, including the disparities in regulatory capacity, legal frameworks, technological infrastructure, and staffing between high-income and low- and middle-income countries.

This study adopts the World Bank's income classification system, categorizing countries into four groups: high-income, upper-middle-income, lower-middle-income, and low-income. The study then analyzes the allocation of pharmaceutical regulatory resources in each group and evaluates the potential impact of these disparities on public health.

The safety of global pharmaceutical and medical products is highly dependent on the functional capacity of National Regulatory Authorities (NRAs). Globally, however, the capacity of these institutions exhibits a distinct and unbalanced pyramidal structure. At the apex of this pyramid are a small number of mature, well-resourced regulatory agencies. In contrast, the broad base is composed of a vast majority of authorities whose capacities are still at a foundational or developing stage, a reality that directly impacts medication safety for billions of people worldwide.

The WHO Global Benchmarking Tool (GBT) and Maturity Level Criteria

To scientifically evaluate the effectiveness and maturity of national regulatory systems, the World Health Organization (WHO) developed the Global Benchmarking Tool (GBT), the internationally recognized gold standard for assessment. Through a systematic evaluation of core regulatory functions, the GBT classifies a regulatory system into four Maturity Levels (ML), defined as follows (World Health Organization, 2021):

ML1 (Foundational Level): Some elements of a regulatory system exist.

ML2 (Developing Level): An evolving regulatory system that is not yet fully functioning or integrated.

ML3 (Stable, Well-Functioning, and Integrated Level): A stable, well-functioning, and integrated regulatory system is in place.For example, the World Health Organization

February 2026, Vol. 12, No. 1
ISSN 2163-758X

(WHO) has recognized China's vaccine regulatory authority as meeting Maturity Level 3 (ML3), positioning it as a capable regional regulatory authority(WHO, 2014).

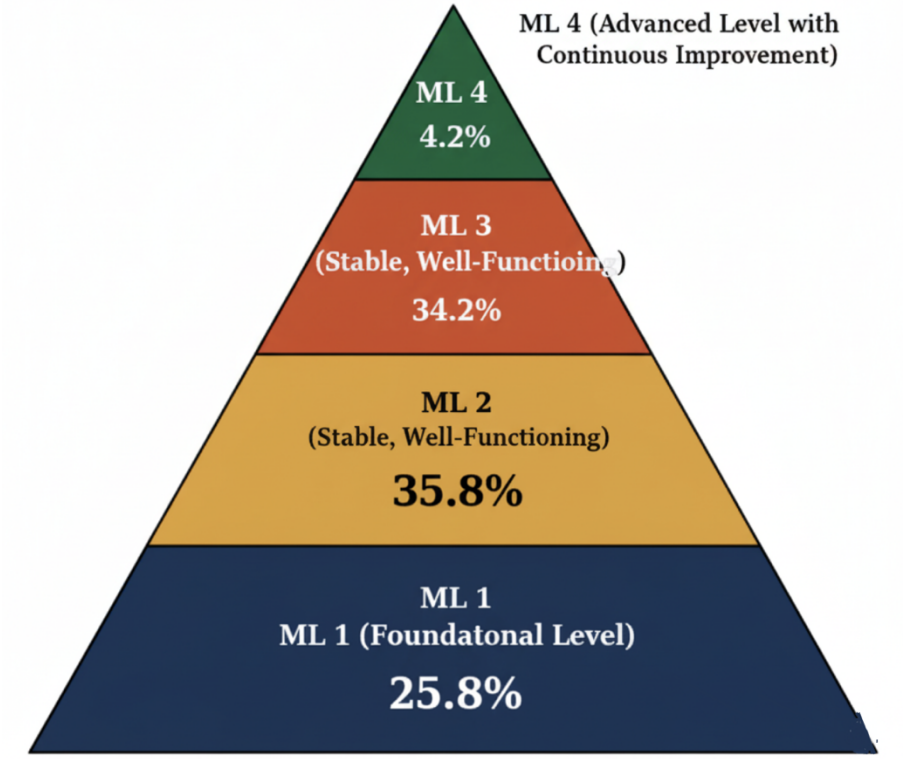
ML4 (Advanced Level with Continuous Improvement): The regulatory system is operating at an advanced level of performance and is continuously improving.

A national or regional regulatory authority must achieve at least ML3 to be considered capable of reliably ensuring the quality, safety, and efficacy of medical products in its market (World Health Organization, 2021).

The Current State of Global Regulatory Maturity Distribution

Periodic assessment reports from the WHO reveal the true landscape of global regulatory capacity. According to the most recent report submitted to the 77th World Health Assembly in May 2024, the distribution of capabilities among the 120 national drug regulatory authorities that had undergone a formal evaluation shows a pronounced bottom-heavy, top-narrow structure (World Health Organization, 2024).

Figure 1:
Distribution of Global NRA Maturity Levels



February 2026, Vol. 12, No. 1
ISSN 2163-758X

Analysis and Impact: The Public Health Crisis Behind the Data

The pyramidal structure revealed by these data is not merely a statistical representation; it is directly linked to global public health risks.

First, weak regulatory capacity is a direct cause of the proliferation of Substandard and Falsified (SF) medical products. In a seminal 2017 study, the WHO reported that approximately one in ten medical products in low- and middle-income countries is either substandard or falsified (World Health Organization, 2017). When a country's NRA is at ML1 or ML2, it often lacks the capacity to conduct effective market surveillance and product testing, creating opportunities for illicit actors to manufacture and distribute SF medicines.

Second, NRAs at the developing stage exhibit common deficiencies in critical regulatory functions. A 2018 study published in BMJ Global Health that assessed the regulatory capacity of 27 African nations found that, despite progress, significant gaps remained in several core areas, including clinical trial oversight, safety monitoring (pharmacovigilance), and post-market control (Roth et al., 2018). Many agencies lack the necessary processes, specialized personnel, and technical tools to effectively track adverse drug reactions after a product is marketed. This means potential safety risks cannot be promptly identified and addressed (Roth et al., 2018). Such functional deficits can render even authentic medicines harmful due to unmonitored risks.

Finally, achieving a mature level (ML3/ML4) is not only a reflection of technical competence but also a prerequisite for participating in global cooperation and ensuring a nation's population has access to advanced therapies. Regional international bodies, such as the Pan American Health Organization (PAHO), stipulate that a high maturity level is a precondition for an NRA to be designated as a "National Regulatory Authority of Regional Reference" (NRAr) (Pan American Health Organization, 2021). Only by meeting this standard can an authority's review decisions and inspection reports form the basis for regional or international recognition, thereby accelerating the market entry of new drugs, vaccines, and advanced medical technologies through "Reliance Pathways" (Pan American Health Organization, 2021). Conversely, NRAs that remain at the ML1/ML2 level cannot earn international trust for their review capacity, leading to longer waiting times and greater uncertainty for their citizens in accessing life-saving, innovative medicines from the global pipeline.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Comparative Analysis of Regulatory Resources by Income Level

To ensure objectivity and consistency in comparison, this report adopts the World Bank's FY2025 income classification standard, which divides global economies into four categories: High Income, Upper-Middle Income, Lower-Middle Income, and Low Income. In this study, two core indicators are selected to measure the regulatory resources of national pharmaceutical authorities: Annual Budget and Regulatory Personnel (FTE). The annual budget is primarily drawn from the "total annual expenditure" or "program-level budget" disclosed in regulatory agencies' official annual reports, with, whenever possible, details on the funding structure (e.g., government appropriations, user fees). Regulatory personnel are measured using the number of full-time equivalents (FTEs) reported in official annual or audit reports. To account for differences in population size across countries, this study employs the standardized indicator of "regulatory personnel per one million population." For countries with missing data (e.g., Haiti and Papua New Guinea), this study adheres to the principle of "evidence first, conservative estimation." Cases of "data unavailable" or "budget not separately reported" are treated as findings in themselves and are further analyzed for the underlying systemic causes.

Haiti and Papua New Guinea were selected not because they are the sole countries lacking data, but because they represent distinct, severe examples where the absence of quantitative metrics (budget and FTE staff) serves as a clear signal of underlying systemic weakness. Haiti epitomizes "institutional presence without functional capacity," where political instability and extreme resource scarcity prevent the agency from executing its mandate effectively. Papua New Guinea is illustrative of "institutional subordination," where regulatory functions are subsumed within the National Department of Health, with no budget transparency or institutional independence . Analyzing these two cases allows us to interpret the data gap itself as evidence of fragile governance and a fundamental crisis of capacity.

High-Income Countries

The United States Food and Drug Administration (FDA) represents the benchmark among high-income countries. In fiscal year 2023, the FDA's budget reached USD 8.4 billion, with more than 18,000 full-time employees. Standardized by population, this translates into approximately 54 regulatory staff per million people—arguably the global "ceiling" of regulatory resource allocation. Such abundant resources not only ensure comprehensive coverage of the large domestic market but also enable the FDA to set and influence global regulatory science standards. Furthermore, the significant share of user fees in its budget

February 2026, Vol. 12, No. 1
ISSN 2163-758X

reflects a mature “government–industry” funding model.

The European Medicines Agency (EMA) provides a contrasting example. Unlike a centralized “super NRA,” the EMA operates as a regional coordinating platform, with 982 employees in 2023. Its primary mandate lies in coordinating centralized review procedures and offering scientific guidance, while actual enforcement remains the responsibility of member states’ national competent authorities (NCAs). This illustrates two different modes of resource allocation in high-income contexts: the centralized national model represented by the FDA, and the distributed regional network model of the European Union. Although the latter is more fragmented, the combined resources of the EMA and national agencies also constitute a substantial investment in regulatory oversight.

Upper-Middle-Income Countries

Brazil’s National Health Surveillance Agency (ANVISA) exemplifies this category. In 2022, its budget amounted to approximately 2.7 billion Brazilian reais, with a workforce of around 2,000 staff. ANVISA’s centralized oversight spans multiple sectors—including pharmaceuticals, medical devices, food, and cosmetics—while its financing combines government appropriations and user fees. This reflects an effort by upper-middle-income countries to build comprehensive and independent regulatory systems capable of supporting their expanding pharmaceutical markets.

Turkey’s Medicines and Medical Devices Agency (TİTCK) had 961 employees at the end of 2023. Although smaller in size than ANVISA, TİTCK has actively aligned its regulatory practices with international standards, particularly in the field of clinical trial approvals. This demonstrates a “catch-up” trajectory, highlighting the ambition of upper-middle-income countries to modernize their systems rapidly.

Lower-Middle-Income Countries

The Food and Drugs Authority (FDA) of Ghana reported a budget in the range of several million USD in its 2020 annual report, with a staff size in the hundreds. Compared with high-income countries, this represents a stark quantitative gap. Despite limited resources, Ghana’s FDA has sought to expand organizational capacity and strengthen laboratory testing. Nevertheless, its staff density remains low after population standardization, directly constraining its regulatory reach and effectiveness.

Papua New Guinea (PNG) illustrates additional systemic weaknesses. Its regulatory

February 2026, Vol. 12, No. 1
ISSN 2163-758X

functions are embedded within the National Department of Health (NDoH), and no separate budget line is disclosed in the national accounts. This lack of transparency and institutional independence is itself symptomatic of fragile regulatory capacity. PNG's case highlights how the absence of data is itself a finding: opaque budgetary structures and institutional subordination are both causes and consequences of weak regulatory systems.

Low-Income Countries

The Rwanda FDA reported a budget of 4.16 billion Rwandan francs (equivalent to several million USD) in fiscal year 2020/21, with a budget execution rate of 96%. This example demonstrates that even in low-income contexts, it is possible to establish an independent agency with a formal budget. Nevertheless, the absolute volume of resources remains extremely limited, restricting the agency to core functions such as registration and approvals, while leaving little capacity for broader market surveillance or pharmacovigilance.

Haiti's Directorate of Pharmacy and Medicines/Medical Technology (DPM/MT) presents a more extreme case. While an agency formally exists within the Ministry of Health, no comparable data on budget or staffing are available. Information on its operations is instead derived largely from international organizations such as the Pan American Health Organization (PAHO). Haiti epitomizes an "institutional presence without functional capacity": although the agency exists in name, political instability and severe resource scarcity prevent it from carrying out its regulatory mandate effectively. In such cases, "data not available" must be explicitly reported as "not comparable," with institutional evidence used as a substitute for quantitative indicators.

Key Data Comparison

Income Group	Representative Country / Region	Agency	Year	Budget (Approx.)	Staff (Approx.)	Per Capita Staffing (per million people)	Data Source / Notes
High-	United States	FDA	FY2023	USD 8.4	18,000	~54	Official Budget Summary

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Income Group	Representative Country / Region	Agency	Year	Budget (Approx.)	Staff (Approx.)	Per Capita Staffing (per million people)	Data Source / Notes
Income				billion			
High-Income	European Union (Coordination Level)	EMA	2023	See Annual Report	982	N/A	EMA Annual Report (Not a national-level agency, not comparable)
Upper-Middle Income	Brazil	ANVISA	2022	BRL 2.7 billion	~2,000	~9.4	ANVISA Annual Report
Upper-Middle Income	Turkey	TİTCK	2023	Not uniformly disclosed	961	~11.2	Official Activity Report
Lower-Middle Income	Ghana	FDA	2020	Millions of USD	Hundreds	Low	FDA Ghana Annual Report
Lower-Middle Income	Papua New Guinea	NDoH	-	Budget not listed separately	Unknown	N/A	National Budget Volumes (Systemic absence)
Low-Income	Rwanda	FDA	FY20/21	RWF 4.16 billion	Unknown	Low	Rwanda FDA Annual Report
Low-Income	Haiti	DPM/MT	-	Data unavailable	Unknown	N/A	PAHO/GHS Index (Systemic absence)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

There is a gap of several orders of magnitude, from the "billion-dollar club" in high-income countries to the "million-dollar survival line" in low-income nations; the disparity in budget and personnel can be a hundredfold or even a thousandfold. This also reflects the value of transparency; whether a budget is listed separately and whether an annual report is publicly available are key indicators for measuring the maturity of a country's regulatory system. The data gap itself is a "soft underbelly" that limits the precision and effectiveness of international aid.

Policy differences severely impact the data retrieval for this report[13]. Therefore, it is recommended to promote the establishment of a simplified, internationally accepted template for NRA annual reports to encourage countries (especially low- and middle-income countries) to enhance transparency. The international community should prioritize "regulatory system strengthening" as a key area of public health assistance, with a focus on supporting human resource training and the construction of quality control infrastructure.

A direct and profound positive correlation exists between a nation's income level and its investment in pharmaceutical regulatory resources. This vast disparity in resource allocation directly affects the stability of the global pharmaceutical safety net. Bridging this gap requires not only the internal efforts of low- and middle-income countries but also a global collaborative framework to support the development of transparent, effective, and sustainable regulatory capacity.

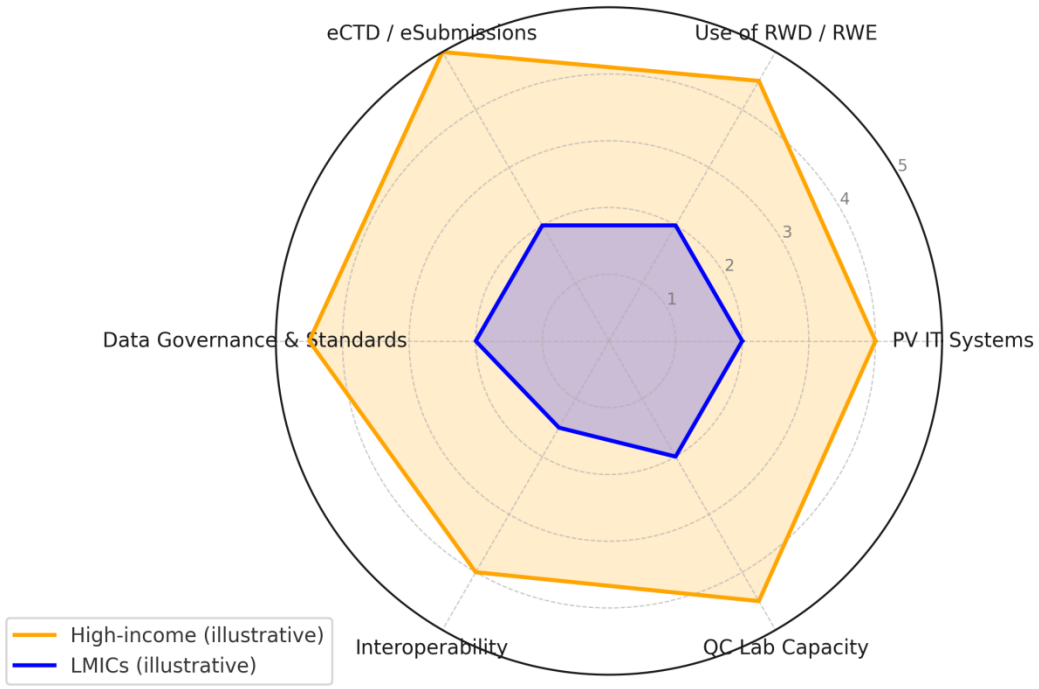
In the field of pharmaceutical regulation, generational differences in technological tools and infrastructure also constitute a major factor shaping the regulatory capacity of different countries. High-income economies generally adopt the internationally recognized electronic common technical document (eCTD) standard, enabling highly integrated electronic submission systems that facilitate cross-departmental and cross-agency data sharing and coordinated review. At the same time, these countries actively employ advanced tools such as real-world data (RWD) and real-world evidence (RWE) to support indication expansion, post-marketing reassessment, and risk management decision-making. For example, the U.S. Food and Drug Administration (FDA) has developed the Sentinel system, and the European Medicines Agency (EMA) has established the DARWIN EU platform, both of which strengthen the real-time and scientific basis of regulatory oversight throughout the entire life cycle of medicines.

By contrast, many low- and middle-income countries (LMICs) still rely on paper-based submissions, and their application documents often lack standardized formats. This results in inefficient reviews and delayed information transmission. Moreover, deficiencies

February 2026, Vol. 12, No. 1
ISSN 2163-758X

in laboratory quality control infrastructure significantly constrain their capacity for product testing, making it difficult to promptly detect and address market risks. In some countries, regulatory information systems remain underdeveloped, with data confined to paper records or fragmented Excel spreadsheets. Such limitations hinder the establishment of effective risk-warning mechanisms and evidence-based decision support.

To more clearly illustrate this disparity, the following “Tech & Infrastructure Readiness (Illustrative) for High-Income vs LMICs.” radar chart provides an explanatory assessment of regulatory capacity across six key dimensions, comparing high-income countries with LMICs.



Tech & Infrastructure Readiness (Illustrative) for High-Income vs LMICs.

Note. RWD = Real World Data; RWE = Real World Evidence; eCTD = electronic Common Technical Document; PV = Pharmacovigilance. Scores are illustrative (1–5 scale).

This figure evaluates six core competency domains: the application of real-world data and evidence (RWD/RWE), electronic common technical document and electronic submissions (eCTD/e-Submissions), data governance and standards, system

February 2026, Vol. 12, No. 1
ISSN 2163-758X

interoperability, quality control laboratory capacity (QC Lab Capacity), and pharmacovigilance information technology systems (PV IT Systems).

The figure clearly demonstrates that high-income countries (orange line) consistently achieve higher levels of maturity across all six dimensions, with scores approaching 4–5. This forms a full and outwardly expanded polygon, representing a comprehensive and robust technological and infrastructural system. By contrast, low- and middle-income countries (blue line) generally score lower, concentrated in the 2–3 range. Their polygon is visibly smaller and contracted, highlighting significant weaknesses across key domains. The most pronounced disparities occur in the application of RWD/RWE and electronic submissions (eCTD), which directly correspond to the previously noted reality that high-income countries have widely adopted RWE while LMICs continue to rely on paper-based submissions. Additionally, the low scores of LMICs in quality control laboratory capacity and system interoperability confirm their fragile infrastructure and the prevalence of data silos.

This technology- and infrastructure-based "digital divide" has dual implications. On the one hand, it delays the accessibility of innovative medicines in low- and middle-income countries. On the other, it creates risk exposures that facilitate the circulation of falsified and substandard medicines in the global market. Therefore, international capacity-building and aid initiatives should precisely target narrowing this divide. Policy priorities should include supporting LMICs in developing unified electronic submission platforms, strengthening the hardware and personnel capacities of quality control laboratories, and promoting the standardization and interoperability of regulatory information systems. Only through such targeted measures can the overall effectiveness and equity of the global pharmaceutical regulatory system be systematically enhanced.

The imbalance of regulatory resources is not merely a technical issue but also a critical challenge for the global public health system. Insufficient regulatory resources directly affect drug review and approval, post-marketing surveillance, and market inspections. Consequently, they reduce medicine accessibility, contribute to drug shortages, enable the proliferation of falsified medicines, and exacerbate antimicrobial resistance (AMR). Collectively, these issues pose severe threats to patients, national health systems, and global public health security.

Direct Impacts on Patients: Dual Threats to Life and Health

The absence of effective regulatory capacity manifests in two fundamental harms to patients: inaccessibility and insecurity.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

"Access Deficit" for Life-Saving Medicines

In resource-constrained regulatory systems, the drug review and approval processes are often inefficient and prolonged, which directly delays the introduction of innovative and urgent treatments into the market. For patients, this means that potentially beneficial therapies may be postponed indefinitely. Globally, the availability of essential medicines for children (EMC) between 2016–2020 was only 43.1%, far below ideal levels (WHO Model List of Essential Medicines for Children - 8th List, 2021, n.d.). This cold statistic hides behind it the countless children who lost their lives due to the inability to receive timely treatment, forming a serious "access deficit."

For example, in the late 1990s, highly active antiretroviral therapy (HAART, colloquially "cocktail therapy") became widespread in high-income regions, transforming HIV/AIDS from a fatal disease into a manageable chronic condition. However, in sub-Saharan Africa, where the epidemic was most severe, national regulatory authorities (NRAs) lacked the ability to independently review complex new drugs, resulting in significant approval backlogs. Moreover, patent and pricing issues delayed the widespread adoption of these life-saving therapies for years. During these years of "regulatory and access delay," millions of patients died due to their inability to access effective treatment . This has become a tragic global health lesson on the consequences of delayed medicine access.

"Secondary Harm" from Substandard and Falsified (SF) Medicines

A dysfunctional regulatory system cannot adequately monitor the post-market pharmaceutical supply, creating opportunities for the production and circulation of SF medical products. These medicines may contain insufficient active ingredients or harmful contaminants, leading to "secondary harm" rather than healing. In sub-Saharan Africa, approximately 19% of antimalarials have been confirmed to be falsified or substandard, directly correlating with increased treatment failure rates and deaths (Mengesha et al., 2024).

The proliferation of fake medicines not only deprives patients of recovery opportunities but also severely undermines public trust in the formal healthcare system. In 2008, Nigeria experienced a public health tragedy with the counterfeit teething syrup My Pikin, which contained diethylene glycol, a toxic industrial solvent. This resulted in the deaths of at least 84 infants due to acute renal failure (Fatal Poisoning among Young Children from Diethylene Glycol-Contaminated Acetaminophen --- Nigeria, 2008--2009, 2009). Subsequent investigations revealed significant regulatory gaps in GMP inspection and

February 2026, Vol. 12, No. 1
ISSN 2163-758X

post-market surveillance. This real event serves as stark evidence of how regulatory failure can lead directly to mass casualties.

Systemic Erosion of National Health Systems

The negative effects of the regulatory divide extend beyond individual patients and erode the very foundation of national health systems.

Unnecessary Increase in Medical Costs

Failures in regulation lead to therapeutic failure and adverse drug reactions, forcing patients to seek additional, more complex treatments or prolonged hospitalization. For health systems, this results in strained budgets and inefficient resource utilization. These avoidable costs impose an enormous burden on limited health insurance and national healthcare financing systems.

Loss of Public Trust

Frequent drug safety incidents gradually erode public trust in regulatory bodies, hospitals, and pharmacies. Once trust is broken, the consequences are disastrous: citizens may refuse to follow medical advice, decline vaccination, or turn to unregulated informal channels for medicines—further exacerbating health risks. A system that loses legitimacy faces increasing difficulty in implementing any public health policy.

Long-Term Threats to Global Health Security

In an interconnected world, a regulatory weakness in one country can become a global vulnerability.

Accelerating the Spread of Antimicrobial Resistance (AMR)

Poor regulatory oversight is a key driver of AMR: subtherapeutic doses in substandard antibiotics fail to eliminate pathogens, while weak governance over prescription and sales allows misuse. In the Greater Mekong Subregion (Cambodia, Laos, Myanmar, Thailand, Vietnam), widespread distribution of subpar antimalarials—often lacking effective doses—has significantly contributed to artemisinin resistance, threatening decades of global malaria control efforts.

Weakening Pandemic Response Capacity

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The COVID-19 pandemic demonstrated that efficient, agile regulatory systems are critical in public health emergencies, a step seen as crucial for global preparedness (Mukherjee & Goodman, 2023). During the COVID-19 pandemic, countries with strong regulatory capacities such as the U.S. FDA and EMA were able to conduct rolling reviews and authorize vaccines within weeks, establishing immunity barriers for their populations. In contrast, many lower-capacity countries struggled to independently assess the safety and efficacy of novel vaccines and therapeutics, relying on WHO's Emergency Use Listing or donations(Massard da Fonseca et al., 2024; Khadem Broojerdi et al., 2021). This "vaccine divide" not only exacerbated inequities in global pandemic control but also left room for viral mutation and spread

China’s Drug Regulatory Landscape

Building on the previous discussion of the global disparity in drug regulatory systems and the significant gaps between high-income and low- and middle-income countries, it is crucial to examine China’s unique position and efforts in bridging these regulatory divides. As the world’s second-largest pharmaceutical market, China faces distinct challenges as it navigates the growing complexities of globalized pharmaceutical supply chains. These challenges include aligning with international regulatory standards and ensuring the efficacy of its domestic regulatory system.

Internationalization of China’s Drug Regulatory System

With globalization intensifying, the pharmaceutical supply chain is becoming increasingly transnational and multifaceted. This trend has made it an inevitable necessity for China to internationalize its drug regulatory framework. Accelerating the alignment of China’s drug regulatory system with international standards not only enhances the scientific rigor and authority of its regulation but also serves as a critical strategic pathway for China to transition from being a major pharmaceutical manufacturing nation to an innovation-driven powerhouse.

Relevant policies have outlined clear expectations for the National Medical Products Administration (NMPA) in advancing its internationalization efforts. On one hand, China is committed to continuously translating and implementing globally accepted regulatory guidelines, particularly in the field of drug evaluation. This includes gradually aligning with the standards of the International Council for Harmonisation (ICH), which will enhance China’s clinical trial institutions' participation in international multi-center studies and promote the synchronized development and market launch of innovative medicines worldwide. On the other hand, China is accelerating its integration into

February 2026, Vol. 12, No. 1
ISSN 2163-758X

international pharmaceutical inspection cooperation mechanisms. By adhering to internationally recognized Good Manufacturing Practice (GMP) standards, China is expanding the scope of export certifications to cover all enterprises and products that meet regulatory requirements, providing institutional support for the global expansion of Chinese pharmaceuticals and medical devices (Wang, 2025).

Achievements of China's Drug Regulatory System

China has made significant strides in reforming and innovating its drug regulatory landscape. The advancements are largely evident in the following seven areas:

Upgraded Legal and Regulatory Framework

China has comprehensively upgraded its legal and regulatory framework, guided by an international perspective, problem-oriented thinking, and a commitment to scientific development. Key principles, such as risk management, full lifecycle control, scientific regulation, and social governance, have been established. The implementation of systems such as drug marketing authorization holders (MAHs) and professional inspectors reflects the modernization of China's regulatory law (Wang, 2025).

Reforms in Drug Review and Approval Processes

In response to growing demand for innovation, quality, efficiency, and capacity-building, China has deepened its reforms in drug review and approval. The introduction of systems like prioritized approval and conditional market entry has helped China approve 106 innovative drugs and 191 medical devices. To further support this, 426 technical guidance documents for drug evaluation and 529 for medical devices have been established, providing robust support for pharmaceutical R&D (Ma, 2023).

Contributions to the Global Pandemic Response

During the COVID-19 pandemic, the NMPA swiftly approved five COVID-19 vaccines under conditional approval and authorized 136 COVID-19 diagnostic kits. This rapid approval and regulatory oversight showcased the regulatory body's commitment to public health during a global crisis (Ma, 2023).

Traditional Chinese Medicine (TCM) Innovation

China has made notable progress in the registration and regulation of TCM, facilitating the international recognition of Chinese medicine standards. The approval of 22

February 2026, Vol. 12, No. 1
ISSN 2163-758X

innovative TCM drugs highlights the country's commitment to integrating traditional medicine into modern regulatory frameworks (Wang, 2025).

Strengthening Full Lifecycle Quality Control

China has also emphasized strengthening quality control over the full lifecycle of pharmaceutical products. With the country's vaccine regulatory system passing WHO evaluations, the overall drug inspection pass rate has increased to 99.4%, ensuring drug safety (Ma, 2023).

Building Regulatory Capacity

The establishment of regional evaluation and inspection centers in the Guangdong-Hong Kong-Macao Greater Bay Area and Yangtze River Delta has improved China's ability to handle large-scale evaluations. Furthermore, China has launched 19 regulatory science projects and established 117 key laboratories, accelerating the modernization of its regulatory system (Wang, 2025).

Enhancing International Cooperation

China has deepened its international regulatory cooperation, engaging with organizations like WHO, ICH, and the International Medical Device Regulators Forum (IMDRF). By becoming a member of these international bodies, China has expanded its regulatory reach and influence (Ma, 2023).

Regional Imbalances and Challenges

Despite the vertical clarity of the regulatory structure, there are significant horizontal disparities in resource allocation across different regions within China. According to a quantitative assessment study released in June 2025(Fu et al., 2025), China's pharmaceutical regulatory capacity varies considerably between regions due to differences in local economic development, resource investment, and policy enforcement. These imbalances manifest in several ways:

Economic Disparities

Developed regions such as the coastal provinces have greater financial resources, enabling them to invest more in regulatory infrastructure, personnel training, and technological advancements, which enhances regulatory efficiency. In contrast,

February 2026, Vol. 12, No. 1
ISSN 2163-758X

underdeveloped regions in the central and western parts of China face challenges such as limited funding, talent shortages, and outdated technology (Wang, 2025).

Talent Mobility Issues

Highly skilled professionals, including drug inspectors and evaluators, tend to migrate toward more developed areas like Beijing, Shanghai, and the Pearl River Delta, leaving the central and western regions with a shortage of qualified personnel. This has led to challenges in staffing and retention at the local level, affecting regulatory effectiveness.

Weakened Local Regulatory Bodies

At the municipal and county levels, regulatory bodies face staffing and funding shortages that prevent them from adequately fulfilling their responsibilities, impacting the breadth and depth of market supervision (Ma, 2023).

Globalization of China's Drug Regulation

China's increasing participation in international drug regulation highlights both the progress and the challenges of its regulatory system. China's regulatory framework is transitioning from a domestic focus to an internationally recognized system. However, there are several ongoing challenges:

Insufficient Global Outreach

Due to limited resources, China's international regulatory influence remains modest. Further strengthening of regulatory outreach and global partnerships is necessary (Wang, 2025).

Need for Regulatory Science Advancement

China must continue to expand its involvement in international regulatory science research to ensure that its regulatory cooperation remains robust and comprehensive (Ma, 2023).

Building a Qualified International Regulatory Workforce

China faces a shortage of highly skilled regulatory personnel capable of representing the country in international discussions and decision-making. This limits China's ability to fully engage in global regulatory governance (Ma, 2023).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Bridging the Regulatory Gap: Global Solutions and Future Perspectives

In the previous sections, we discussed the imbalance in pharmaceutical regulatory resources and its impact on drug accessibility and public health. Bridging this gap requires a multi-dimensional and systematic solution. This section will explore feasible paths to narrow the regulatory gap from three perspectives: reviewing existing international cooperation mechanisms, exploring future innovative pathways, and redefining the responsibilities of high-income countries.

Review of Existing International and Regional Cooperation Mechanisms

In recent years, the international community has implemented various cooperation mechanisms to address regulatory capacity challenges (Narsai et al., 2025). The core strategies include regulatory convergence, mutual recognition, and reliance, which aim to reduce redundant reviews and accelerate drug approval through unified standards and shared review data. These mechanisms are especially important for countries with limited regulatory resources.

For example, a study by Danks et al. (2023) demonstrated that the reliance review mechanism can effectively shorten drug approval timelines, particularly in resource-scarce countries. Additionally, Fonseca et al. (2024) noted that some middle-income countries temporarily address their regulatory gaps by borrowing decisions from mature regulatory agencies when they lack capital and human resources.

At the regional level, many African countries, such as Ghana, Nigeria, and Rwanda, have signed memoranda of understanding to deepen cooperation in drug approval, data sharing, and mutual recognition of evaluation reports. This collaboration helps share the regulatory burden and improves regional approval efficiency and consistency. The establishment of the African Medicines Agency (AMA) is aimed at promoting regulatory convergence and unified standards across Africa. Although AMA’s progress has been slow, once operational, it will significantly speed up the entry of new drugs and vaccines into the African market and provide crucial support in drug safety regulation and combating counterfeit drugs(Wairagkar et al., 2025).

Future Innovative Pathways and Regulatory Model Exploration

In addition to improving existing cooperation mechanisms, exploring innovative regulatory models is crucial for countries with limited resources to achieve accelerated capacity building. Digital regulatory mechanisms offer great potential to enhance efficiency. By utilizing big data, artificial intelligence, and remote monitoring

February 2026, Vol. 12, No. 1
ISSN 2163-758X

technologies, post-market surveillance of adverse events can be optimized, improving the accuracy of risk warnings. However, the promotion of digital health platforms also faces challenges such as lagging regulatory frameworks, insufficient infrastructure, and data standardization issues. To overcome these challenges, introducing "regulatory sandboxes" is recommended, as they allow for the testing and application of new data-driven tools in controlled environments, thus fostering the development of regulatory science.

The paradigm of capacity building needs to shift from traditional material aid to "empowerment-based" assistance, focusing on helping recipient countries build robust regulatory frameworks, information systems, and professional talent. Empowerment assistance should adopt a tiered support approach, providing differentiated support for countries at different levels of regulatory capacity, while including strict performance evaluation and feedback mechanisms to ensure the sustainability of projects and the efficient use of resources.

Another key innovative pathway is the establishment of resilient emergency regulatory mechanisms. During global public health emergencies, many countries lack the capacity to conduct rapid approvals and regulatory adjustments. Therefore, regulatory systems must be equipped with a dual-track mechanism, where emergency procedures are set up alongside standard processes, and cross-border emergency approval platforms should be established in advance. This would allow for rapid sharing of review data and mutual recognition of approvals, thereby saving valuable time for global public health during crises.

Redefining the Responsibility of High-Income Countries: From "Aid" to "Empowerment"

In global public health governance, the role of high-income countries (HICs) must fundamentally shift from "donors" to "empowerers." This means that high-income countries should not only provide financial support but also establish deep, long-term partnerships by sharing mature regulatory systems, standard templates, and information systems.

High-income countries should actively advocate for more equitable regulatory recognition and resource-sharing mechanisms on international platforms, such as the WHO and ICH, ensuring that resource-poor countries have a greater voice in the global regulatory framework. Furthermore, all empowerment projects should include transparent performance monitoring and accountability mechanisms to ensure the

February 2026, Vol. 12, No. 1
ISSN 2163-758X

effective use of resources. The ultimate goal is to establish a fair global benefit-sharing system, where middle- and low-income countries are no longer simply recipients of aid but become active participants and contributors to global public health governance.

Conclusion

This study analyzes the imbalance in the allocation of global pharmaceutical regulatory resources, highlighting the significant gap in regulatory capacities between high-income and low-income countries, particularly in terms of drug quality, safety, and accessibility. The research shows that the disparity in global pharmaceutical regulatory resources directly impacts the safety and accessibility of medicines in low-income countries. High-income countries, with their ample resources and well-established regulatory systems, are able to ensure drug quality and safety, whereas low-income countries, due to insufficient regulatory capacity, face issues such as poor drug quality, delayed market access, and public health risks.

The regulatory divide in pharmaceutical governance is not merely a technical issue; it is also a matter of global health equity and social justice, which affects global public health security. Bridging this divide requires a multi-dimensional approach, including strengthening international cooperation, advancing regulatory capacity building, and implementing digital regulatory tools.

The study finds that the disparity in the allocation of pharmaceutical regulatory resources directly affects the safety and accessibility of medicines in low-income countries. High-income countries can ensure drug quality and safety through sufficient resources and well-developed regulatory systems, while low-income countries face challenges due to inadequate regulatory capacity, limited resources, and delayed market access, leading to worsened drug quality issues and public health risks.

Furthermore, the regulatory divide is not only a technical issue but also a fundamental problem related to global health equity and public health safety, particularly in low-income countries, where drug quality problems are prevalent. Bridging this divide requires the implementation of a range of solutions, including strengthening international cooperation, advancing regulatory capacity in low-income countries, and introducing digital tools to improve regulatory efficiency.

Based on the findings of this study, we propose three key measures: First, strengthening international cooperation by promoting the unification of global pharmaceutical regulatory standards and adopting mutual recognition and reliance review mechanisms to accelerate drug market entry. Second, high-income countries

February 2026, Vol. 12, No. 1
ISSN 2163-758X

should support low-income countries in building modern pharmaceutical regulatory systems through technical assistance, capacity-building programs, and training. Finally, it is essential to promote digital regulation, encouraging low-income countries to adopt digital platforms to enhance regulatory efficiency, particularly in drug approval, market supervision, and drug safety monitoring.

Future Research Directions: This study faces data gaps and comparability issues, and future research could explore solutions to the challenges of cross-national data collection, promoting the establishment of standardized global pharmaceutical regulatory data collection practices to fill these gaps. Future research should also expand on case studies to explore the specific practices and successful experiences of pharmaceutical regulatory system development in different countries, with particular attention to the roles and contributions of low-income countries in global regulatory cooperation. Additionally, future research should focus on data standardization, improving the accuracy of cross-country comparisons, and fostering multi-level international cooperation to develop pharmaceutical regulatory frameworks tailored to the needs of each country, thereby optimizing the global allocation of pharmaceutical regulatory resources.

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Author Notes

Wenhan Jiao is an undergraduate student at the International Pharmaceutical Business School, China Pharmaceutical University, majoring in Pharmaceutical Administration. Her main areas of study focus on pharmaceutical regulation and global public health. During her studies, she has participated in introductory research related to the World Health

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Organization's Global Benchmarking Tool (GBT) and has maintained an interest in the allocation of regulatory resources across countries. Through coursework, she has gradually developed skills in literature review, data organization, and basic analytical methods. In addition to academic learning, she actively participates in academic activities and volunteer services to broaden her perspective and gain practical experience. Looking ahead, she hopes to continue her studies and further explore the connections between pharmaceutical policy and public health.

Wanyu Zhang is an undergraduate student majoring in International Trade at the International School of Pharmacy and Business, China Pharmaceutical University. Her academic interests center on pharmaceutical trade and global regulatory policy. Beyond classroom learning, she actively explores international pharmaceutical policy trends, such as comparing approval processes across countries and examining the distribution of pharmaceutical resources in cross-border trade. These explorations have provided her with a clearer understanding of the relationship between regulation and resource flows. In addition to academic studies, she values opportunities for international exchange, where she hopes to broaden her perspectives and gain practical experience. She is motivated to learn from diverse viewpoints, enhance her knowledge, and contribute actively in collaborative environments. Wanyu is enthusiastic about pursuing further studies and professional development in the pharmaceutical field.

Shanshan Kang is an Associate Professor of Economics and International Trade at the China Pharmaceutical University, School of International Pharmaceutical Business. With decades of experience in teaching Business English and cross-cultural communication, she has also served as a coordinator and instructor for the Global Partnership in Education. Prof. Kang's research focuses on treaties and conventions governing the international sale of goods, as well as regulations related to drug import and export. She has led and participated in multiple research projects, including a study on the regulatory system for market access of herbal medicines in the European Union. She has published several academic papers and acted as chief editor for a number of textbooks. Her recent publications include *FDA Current Good Manufacturing Practice (CGMP) for Medical Products in the United States* and *Compilation of FDA Guidelines on Current Good Manufacturing Practice for Medical Products.*

February 2026, Vol. 12, No. 1
ISSN 2163-758X

The Role of Algeria in African & Global Energy Markets: Challenges & Opportunities for Local Economic Development

Nourhane Lagreb and Maliha Bouayed Meziane

National Polytechnic School, Algiers, Algeria

Abstract

Last July during my internship at Schlumberger (SLB), an energy technology company, a local engineer told me: “When the diesel truck arrives to fix the generator, everyone hears it. But when solar panels do their job, no one notices because power flows without anyone noticing. That quiet reliability is how people realize real change has happened”. That is true because when it is that quiet, people realize that something has truly changed for the better! The clean energy not only solves problems but does so in a way that blends into daily life seamlessly and sustainably. When you first hear about Algeria’s energy sector, a vivid image comes to mind: the vast Sahara, its golden sand lying silently above, hiding underground reservoirs of oil and gas, while the sun shines over untapped solar fields stretching across the horizon. A professor from my school once joked: “Our wealth lies under the sand and above it!” referring to Algeria’s traditional oil and gas riches and its enormous solar potential, and this spontaneous remark captures the core challenge and promise facing Algeria today. This paper explores the paradox of immense energy wealth and lack of development, emphasizing on the impact of Algeria's energy sector on its local economic development, exposing the challenges and opportunities arising from its integration into the global energy landscape.

Keywords: Algeria, energy market, future scenarios.

Introduction

Algeria has long been one of Africa’s major hydrocarbon exporters after Nigeria (Cadi et al., 2025), with pipelines like the Maghreb-Europe and Trans-Mediterranean routes delivering natural gas to Europe (see Figure 1). On the other hand, the global shifts toward renewable energy and decarbonization mean Algeria must rethink its energy strategy. Its future role in African and global markets will be shaped by how it navigates these changes, and more importantly by how it translates them into jobs and industries, which would lead to local prosperity.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

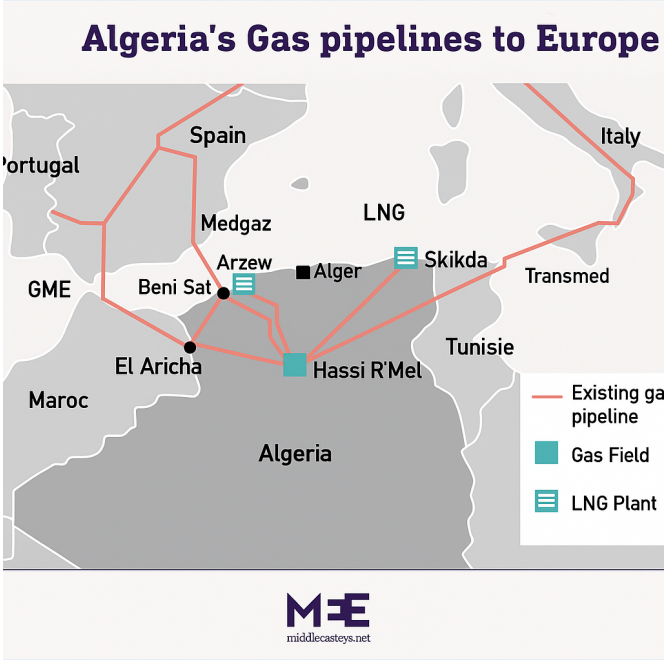

Figure 1: A map of major natural gas pipelines linking Algeria to Europe highlighting corridors like Maghreb, Europe and trans mediterranean (source: Middle east eye)

Historically about half of its gas output has been exported through pipelines like those shown above. This export capacity has given Algeria significant clout in world energy markets: hydrocarbons make up over 90% of its export revenues (Obeid, 2025) and nearly half of government revenue. The gas fields and major pipeline corridors are concentrated in the northern Saharan basins, mainly those of Hassi R'Mel and Berkine, while the renewable potential (especially the solar one) is strongest in the central and southern desert provinces. The map underscores how Algeria's gas reaches Spain, Italy, and beyond. Yet it also hints at a vulnerability: as Europe moves to diversify away from fossil fuels, Algeria's traditional markets may shrink.

To put it simply, the key question is whether Algeria will remain a hydrocarbon rentier, or become a regional renewable and hydrogen hub that spreads benefits more widely across the economy.

Background and Context

Geography and strategic position

Algeria, officially "the People's Democratic Republic of Algeria", is a country in the Maghreb region of North Africa. [Capital: Algiers] (Algeria - Wikipedia)

As the largest country in Africa by land area, Algeria spans from the Mediterranean coast in the north to the heart of the Sahara Desert in the south.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Figure 2: A map that shows where Algeria is located on the World Map. (Source: Ontheworldmap.com)

Historical evolution of the Energy Sector

Algeria's modern energy story begins in mid20th century with oil and gas discoveries (Encyclopaedia Britannica, n.d.). After independence, the government took control of the oil and gas industry and put it under the control of Sonatrach, which became the state's primary revenue engine (FundingUniverse, n.d.). Decades later Algeria developed pipelines linking its gas to Europe (Trans-Mediterranean, Maghreb-Europe, Medgaz), and built LNG and export infrastructure (U.S. Energy Information Administration [EIA], 2024). Hydrocarbons financed the state development and supported domestic energy consumption, that actually led to overdependence on this source. (EIA, 2024)

The 1990s in Algeria were marked by a violent civil conflict often called the "Black Decade." This internal war resulted in political instability after the cancellation of elections and had major effects on all sectors of the country, including energy. (Library of Congress, 2024)

Oil and gas infrastructure became targets of violence, forcing Sonatrach to increase security and leading many foreign companies to withdraw or pause investment (Lawler & Payne, 2013). This instability reduced exploration and development -key stages in the well lifecycle- thereby constraining growth in the sector. (Library of Congress, 2024)

February 2026, Vol. 12, No. 1
ISSN 2163-758X

As a result, the government began rethinking its energy strategy, eventually moving toward liberalization to attract foreign investment (Library of Congress, 2024). Despite the conflict, hydrocarbon exports remained vital to the economy, highlighting Algeria's dependence on energy revenues during the crisis. (EIA, 2024)

After the 2000s, global concerns began to be taken seriously (climate policy, European decarbonization ambitions, and increased competition) that pushed Algeria toward diversification (Underwood, 2025). In the 2010s and 2020s the government introduced renewable targets and most recently a National Hydrogen Strategy aiming to convert the excess of renewable energies into hydrogen exports. (Green Hydrogen Organisation, n.d.)

Yet, the existing government systems and financial support from local authorities made the transition slower. (Underwood, 2025).

Study Method

The study method I used in the making of this paper was a secondary research approach. The research was conducted by reading articles, reports by government and international agencies, as well as market reporting (press and trade).

The approach is qualitative-quantitative: I used descriptive statistics for figures and supplemented them by scenario discussions exploring alternative future developments and policy implications.

Results

Algeria's resource base and production

Below is a compact set of energy figures used in the paper (most recent available public estimates, 2022-2024 ranges). The numbers that I found online are approximate and referenced.

Indicator	Figure (approx.)	Source
Proven natural gas reserves	**~159 Tcf** (trillion cubic feet)	FrontierView
Annual gas production (recent)	**~58 - 100 bcm** range (billion cubic meters) [production & reported variation across 2021-2024]	Algeria gas exports
Share of electricity from gas	**~97%** (electricity largely gas-fired)	Algeria - Renewable Energy

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Renewable target	**15 - 22 GW** by **2030** / **27%** renewables by **2035** (government targets vary by source)	Algeria's Strategic Energy Vision
Hydrogen export ambition	**30 - 40 TWh/year** hydrogen exports by **2040**; **$8-10 billion** revenues target	Algeria | Green Hydrogen Organisation

Table 1: Algeria's key Energy figures (Referenced)

Key players

Sonatrach: the state-owned energy company (dominant in upstream, midstream, and export contracts). FrontierView

OPEC: Algeria has been a member of OPEC and participates in the organization's deliberations that shape oil market coordination (and also participates in OPEC+ arrangements). Organization of the Petroleum Exporting Countries

International partners: Italy (ENI), Spain (Medgaz/ENAGAS partners), Germany and other EU actors (renewables and hydrogen interest), China (manufacturing and financing), Gulf states (emerging partners in green hydrogen). Algeria's energy outlook appears dimmer in 2024 | FrontierView

Algeria's role in African and global markets

Algeria is one of Africa's top gas producers and has been a key supplier to Europe and one analysis even calls it "Africa's leading natural gas producer" (Obeid, 2025). Its network of pipelines (both undersea and overland) once gave it strong influence in the region (Wikimedia Commons, 2021). But things are changing because Europe is using less gas due to climate goals, competition from other gas exporters is growing, and pipeline issues like the Maghreb-Europe suspension add uncertainty (Montel News, 2024).

OPEC and oil market participation

Algeria is still active in OPEC and OPEC+ and takes part in decisions on oil production that impact global markets (OPEC, 2024). This helps Algeria keep some influence in diplomacy and energy markets, but it doesn't fix the country's deeper economic and development problems (Bouznit, 2022).

Export Fluctuations (oil & gas)

As I mentioned earlier, Algeria is a top African gas producer. The country continues to maintain substantial reserves that support exports to Europe and nearby regions.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

However, its gas production and exports have been unstable in recent years. Reports show that drops in output and exports occurred at various points in various years largely because of lower demand and maintenance work, such as the Medgaz pipeline maintenance in 2024. This shows that Algerian gas exports depend on both market conditions and technical factors. (Montel News, 2024; U.S. Department of Commerce, 2023).

Domestic consumption vs exports

Algeria's domestic gas use is rising due to industry and household needs. Since most electricity is made using gas, growing domestic demand means less gas is available for export if production doesn't increase. This creates a tradeoff between meeting local energy needs and earning money from exports (U.S. Department of Commerce, 2023). Recent reports show this has become a challenge, especially after 2020, as the government tries to balance both priorities (Cadi et al., 2025).

Renewables

Algeria's use of renewable energy is still very small, even though the country has set big goals for the 2030s. Plans include installing 15 to 22 GW of renewable power and reaching 27% of energy from renewables by 2035. However, progress is slow because of problems with funding and government systems (Chikhi et al., 2022; Climate Analytics, 2023). While the goals are serious and linked to future hydrogen projects, actual progress and installed capacity remain limited (Ghaoues & Kaouane, 2021).

CAP (MW)	Total renewable energies	Hydropower	Wind power	Solar energy
2012	253	228	-	25
2013	253	228	-	25
2014	264	228	10	26
2015	312	228	10	74
2016	482	228	10	244
2017	663	228	10	425
2018	686	228	10	448
2019	686	228	10	448
2020	686	228	10	448
2021	686	228	10	448

MW stands for Megawatt.

Table 2: Algeria's installed renewable energy / power-capacity mix (in MW) over 2012-2021. Data extracted from IRENA (International Renewable Energy Agency) (2022)

Emerging hydrogen and renewable export hub

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Algeria's National Hydrogen Strategy aims to start exporting green hydrogen to Europe, with goals of 30-40 TWh per year by 2040 and billions in expected revenue (GH2, 2024). Several partners, including EU countries such as Germany and Italy, as well as Gulf investors, are showing interest through agreements and project talks (Energy Capital Power, 2025). Thanks to its strong sunlight and large land area, Algeria has good potential to become a major player in green hydrogen (Zemri, 2024).

Challenges

Infrastructure gaps

Algeria needs major investment to upgrade key infrastructure like the power grid (long-distance electricity transmission from the desert) and also building hydrogen transport. While gas pipelines are in place, the electricity grid isn't ready for large-scale desert renewable projects without improvements (Chikhi et al., 2022; U.S. Department of Commerce, 2023). Problems like grid bottlenecks, weak connections, and aging gas systems are well known (Ghaoues & Kaouane, 2021).

Governance and institutional issues

Algeria's state-led system puts most decisions in the hands of the government, which can make rules and processes unclear. Studies show that policies are sometimes inconsistent or poorly carried out, sending mixed signals to foreign investors (Cadi et al., 2025; Chikhi et al., 2022). This slows down projects and makes private companies more cautious. Experts warn that without clear and stable rules, Algeria could miss out on foreign investment in renewables and hydrogen (Obeid, 2025).

Over-dependence on hydrocarbons and fiscal vulnerability

Algeria's economy still depends heavily on oil and gas prices and exports. These revenues have funded government spending for years, but slow progress in diversifying the economy could lead to financial problems if prices or demand drop (Bouznit, 2022). Experts warn that delays in the energy transition could leave assets unused and cause economic instability (Obeid, 2025).

Environmental and social issues

Fossil fuel extraction and gas flaring in Algeria harm the local environment (Bouznit, 2022). Government subsidies encourage people to use energy wastefully, which makes it harder to set fair prices for renewables (Cadi et al., 2025). Big energy projects also need community support but some face pushback especially in desert areas where nomadic or farming communities live (Energy Capital Power, 2025).

Opportunities for local development

Job creation and industrialization

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Big renewable energy and hydrogen projects can create many jobs in building and making equipment. If Algeria adds rules to use local workers and provides training, the job growth could be even bigger (Cadi et al., 2025; Energy Capital Power, 2025).

Renewable energy zones and Sahara solar

The Sahara has very strong sunlight and plenty of space. Special Renewable Energy Zones (REZs) could have large Photovoltaic (PV) and Concentrated Solar Power (CSP) solar plants, along with industrial areas for making electrolyzers and processing hydrogen (Climate Analytics, 2023). These zones could also include training centers and support local businesses (Ghaoues & Kaouane, 2021).

Photovoltaic (PV): Technology that converts sunlight into electricity using semiconductor materials.

Concentrated Solar Power (CSP): Technology that uses mirrors to focus sunlight onto a receiver, producing heat and generating electricity.

Skills transfer and Foreign Direct Investment

Bringing in foreign investment with technology sharing can help Algeria develop its own manufacturing and service skills (Chikhi et al., 2022). The country's talks with European and Gulf investors on hydrogen projects show good potential for local job creation, if everything is clearly agreed on (GH2, 2024).

the country holds exceptional solar resources and is positioning itself for future hydrogen projects, areas that Gulf states, especially those diversifying their energy portfolios, are actively exploring (GH2, 2024).

Discussions

This section interprets the results and provides scenario-based analysis.

Interpreting Algeria's current position

The results show a paradox: Algeria is highly resource-rich but institutionally constrained. While it remains a significant gas supplier, rising domestic demand and limited production growth narrow the export buffer. Renewables and hydrogen offer strong potential, but slow implementation and governance weaknesses hinder progress.

The issue is not resources but **institutional capability** and **investment climate**.

Future Scenarios (10–20 years)

I relied on Cadi et al.'s findings.

The paper by Cadi, Boukhatem, and Mokdad (2025) offers a clear and engaging look at Algeria's energy transition. Their work brings out several important themes, and reflecting

February 2026, Vol. 12, No. 1
ISSN 2163-758X

on these helps us better understand what's at stake and how policy efforts could respond to the challenges.

Now we can conceptualize three broad pathways for Algeria, each with distinct policy implications:

Scenario 1. Status Quo: Gradual Decline of Hydrocarbon Dominance

Limited reforms, hydrocarbons remain >85% of export revenues.

Gas exports stagnate as domestic consumption rises.

Renewable capacity grows slowly (< 5-7 GW by 2035).

Fiscal pressures intensify, new jobs are few, making social spending harder to sustain.

Policy implications:

Maintaining the current model risks fiscal instability and lost export opportunities as Europe decarbonizes without diversification, local development remains limited.

Scenario 2. Diversification and Energy Transition: Renewables + Hydrogen Expansion

Major grid upgrades attract international investors.

Renewable deployment surpasses 15–20 GW by 2035 as the government targeted.

Hydrogen hubs emerge in the central/southern Sahara, and local manufacturing of: solar panels, cables, electrolyzers, wind turbines, batteries, desalination components.

Job creation strengthens local economies in desert regions.

Policy implications:

Requires stable regulation, training programs, competitive power-purchase agreements (PPAs), alongside targeted incentives for local manufacturing and technology transfer to boost Algeria's renewable energy capacity, strengthening the country's long-term energy independence and industrial base. This scenario aligns best with sustainable development goals.

Scenario 3. Geopolitical Shifts: Africa-Centric and Global South Energy Partnerships

Europe reduces gas imports faster than expected.

Algeria pivots to African markets (e.g., West African pipelines, hydrogen exports to emerging Asian markets).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

China and Gulf states expand investment in renewables, grid modernization, hydrogen and Electric mobility.

Policy implications:

Algeria must adapt its diplomacy and infrastructure planning to non-European markets. This scenario balances risk but requires strong regional cooperation.

Comparing Scenarios (1, 2 and 3)

Scenario 1 is fiscally risky.

Scenario 2 generates the highest local development impact (jobs, value chains, industrialization, improved living standards).

Scenario 3 provides geopolitical resilience but depends on regional stability.

Policy Recommendations

Grounded in an understanding of Algeria's energy sector, I would like to support this paper with these recommendations aiming for sustainable growth:

Reform regulatory frameworks:

Publish clear renewable and hydrogen regulations to ensure stable PPAs.

Simplify investor procedures and adopt transparent permitting.

Upgrade infrastructure

Expand north-south transmission lines (grid) for solar integration.

Modernize gas infrastructure and develop hydrogen corridors.

Create standards to strengthen domestic industry involvement

Require local employment and training in large energy projects.

Support domestic manufacturing (PV panels, hydrogen components).

Strengthen education and vocational training

Create specialized renewable-energy institutes in desert regions.

Community integration

Ensure local benefit-sharing for communities in project areas.

Diversify export strategies

Develop energy diplomacy with African and Asian partners.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Conclusion

Algeria is at a turning point. Its oil and gas resources still give it a strong role in Africa and global markets, but its future depends on how it handles the energy transition. The key is to balance government finances with renewable investments, strengthen institutions to attract funding and make sure new industries benefit local people.

Algeria's goals for hydrogen and solar power are plausible and already gaining international interest (GH2, 2024; Energy Capital Power, 2025). But real success will depend more on good governance and involving local communities than just having natural resources (Obeid, 2025; Chikhi et al., 2022). If managed well, Algeria can move from relying on oil and gas to becoming a regional leader in clean energy with development that truly benefits its people.

And in this regard, we ask a very logical question, is energy transition an inevitable necessity for Algeria?

Well sticking with the current system is becoming too risky and unsustainable. The changes are already starting so the real question is not **whether** Algeria will transition but how **quickly** and how **effectively** it can do it to manage to be a role player in the Energy markets globally.

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February 2026, Vol. 12, No. 1
ISSN 2163-758X

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Author Notes

Nourhane Lagreb is a final-year Electrical Engineering student at National Polytechnic School of Algiers, specializing in renewable energy systems with a focus on hydrogen technology aiming to enhance energy efficiency and sustainability. After she got selected, she has participated at the 9th Global Issues Conference (GIC9) and presented "The Role of Algeria in African and Global Energy Markets: Challenges and Opportunities for Local Economic Development." Passionate about energy and particularly clean energy, Nourhane did many internships at SLB, Sonatrach, and the Center for Research in Renewable Energies (CDER). Outside her academic pursuits, she volunteers in scientific clubs and on campus.

Dr. Maliha Bouayed Meziane is an Associate Professor with a doctorate in Sociolinguistics. At Ecole Nationale Polytechnique, she teaches English for IT and heads the English & Virtual Education Center, where she runs international online classes to enhance cultural and language skills. Her research focuses on integrating digital tools into English language teaching.

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Cultivating Aloe Vera: An Economic and Environmental Asset in a Changing Climate

Saib Ibtissem, Zeggai Houaria, Nihad Abdelmalek, Nehar Benameur and Azzi Rachid

University of Abou Bekr Belkaid, Tlemcen, Algeria

Abstract

Aloe vera, a member of the Asphodelaceae family, is predominantly used for medicinal, pharmaceutical and cosmetic purposes, but its cultivation is now threatened by climate change. As global demand for this “green gold” keeps growing, extreme heat, unpredictable rainfall, and soil degradation threaten its sustainable expansion. This study examines the impact of climate change on *Aloe vera* production, while also evaluating its industrial consequences and exploring sustainable solutions. *Aloe vera* production is dominated by Mexico, which is the largest producer, and together with other major producers in the Americas, accounts for approximately 81% of the world's supply due to favorable climatic conditions. While nations such as India and China battle heat waves and unseasonal monsoons that reduce yield and quality of gel. The U.S. and Canada also rely on greenhouse technology to protect production from climate risk. Whereas Algeria, where this plant is known for its traditional use, shows potential as an untapped climate-resilient desert farming. As climate change triggers droughts and temperature fluctuations, the bioactive compounds are reduced in the *Aloe vera* resulting in altering the global supply chain that will affect pharmaceutical and cosmetic industries. The market analysis indicates an increasing demand, with the *Aloe vera* extract industry estimated at $2.99 billion by 2031. However, there are economic dangers associated with growing costs and unstable production. For these challenges, this study proposes sustainable alternatives like drought-resistant *Aloe vera* varieties, greenhouse farming, and advanced irrigation systems. Additionally, Algeria could use its vast desert regions to develop a climate-resilient *Aloe vera* industry.

Keywords: Algeria, *Aloe vera*, climate change, drought resistance, desert agriculture, greenhouse farming, sustainable solutions.

Introduction

Aloe vera L. (*syn*. *Aloe barbadensis Miller*), is a species from Asphodelaceae family, one of the most widely used medicinal plants, valued for its vast potential uses for the plant by the pharmaceutical, cosmetic, and nutraceutical industries. The gel or mucilage is greatly demanded due to its abundance in bioactive compounds such as polysaccharides, phenolic compounds and anthraquinones, and it was found to demonstrate promising wound-healing through antioxidant and anti-inflammatory activities (Eshun & He, 2004; Hamman, 2008). The *Aloe vera* global marketplace achieved USD 2.4 billion in 2019 and is expected to reach USD 3.2 billion by 2027, which demonstrates a fast-developing global marketplace (Majeed et al., 2024).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Yet, as demand continues to expand, cultivation of *Aloe vera* is under increasing threats from climatic fluctuations. Rising temperatures, frequent droughts, unpredictable rainfall, and soil erosion pose risks not only to plant productivity but also to the composition and quality of the bioactive compounds that define the plant's industrial value (Delatorre-Castillo et al., 2022; González-Delgado et al., 2023; Kumar et al., 2017). Mexico and the Americas are among the world's key producers; other regions like India and China are projected to become more susceptible not only to heat waves but also unseasonal monsoons (López-Cervantes et al., 2018; Singh et al., 2021). This has raised concern over supply chain security and sustainability of *Aloe vera* production.

Such declines in productivity have real-time implications for cosmetics and drug industries from which *Aloe vera* is an essential raw material. Rising production expenses, declining gel quality, and fluctuations in marketplace conditions in several nations are already changing international trade regimes (Liontakis & Tzouramani, 2016; Sadiq et al., 2022; Thakur et al., 2023). They highlight the importance of sustainable agribusiness practices.

Against this backdrop of growing international and industrial demand for *Aloe vera*, this review addresses key knowledge and production gaps. Most of the earlier research has focused on the pharmacological activity and phytochemical composition of the plant, in particular its acemannan content and antioxidant activity (Hamman, 2008; Kumar et al., 2019). However, there have been few studies specifically connecting climate variability and *Aloe vera* productivity and stability in bioactive compounds, thus generating very wide knowledge gaps.

Therefore, the present review attempts to analyze worldwide trends and geographical variations in *Aloe vera* production, to evaluate climate change effects on its productivity and growth, and to analyze the potential industrial and economic consequences of decreased production. Furthermore, it addresses sustainable measures to minimize climate-related risks, with particular emphasis on Algeria's potential as a future climate-resilient producer.

Global Aloe Vera Production and Regional Variations

Average annual *Aloe vera* production globally is calculated to be roughly 60,720,400 kg (Planetoscope, 2015), and global consumption was 60,720 tons in 2015 (~1.92 kg/s) (Planetoscope, 2015). Consumption continues to rise due to application in pharmaceuticals, cosmetics, and food industries. Table 1 summarizes the main producing regions, cultivated areas, and production challenges.

Table 1

Global Aloe vera production, cultivated area, and regional challenges

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Region	Country	Production (tons/year)	Area (ha)	Key Notes/Challenges
Americas	Mexico	158,000 (ActuLatino, 2021)	12,500	Semi-arid climate favorable; risks from recurrent droughts and heat waves above 35 °C
	United States	>32,000,000 (Forever Living, 2023)	>1,000	Industrial-scale, advanced processing; water shortages require greenhouse production
	Dominican Republic	Large-scale plantations (>2,000 ha) (Forever Living, 2023)	n/a	Export-oriented production
Asia	India	~100,000 (Interfresh, 2023)	50,000	Organic growth; vulnerable to unusual monsoons and heat waves
	China	~80,000 (Interfresh, 2023)	30,000	Concentrated in Yunnan, Guangdong, Fujian; humidity fosters fungal disease
	Thailand	~25,000 (Interfresh, 2023)	12,000	Warm, humid climate promotes growth but also fungal infections
Europe	Spain	~20,000 (Interfresh, 2023)	10,000	Canary Islands & Andalusia; niche, high-quality production
	Italy	n/a	160	Small-scale, focus on quality
Africa	Morocco	n/a (~120,000 ha) (ADA-ChababAgri, 2023)	120,000	Sidi Ifni ~30% production, mainly for cosmetics
	Algeria	n/a (author's estimate, based on climatic similarity with Mexico)	n/a	High potential in Sahara; limited by data, investment, and stress
	South Africa	15,000 (Interfresh, 2023)	8,000	Favorable warm climate; erratic rainfall reduces yield

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Region	Country	Production (tons/year)	Area (ha)	Key Notes/Challenges
Other	Canada	n/a	n/a	Greenhouse production only; small-scale, pharmaceutical-grade

Note. Data compiled from Planetoscope (2015), ActuLatino (2021), Aranda Cuevas et al. (2016), Interfresh (2023), Forever Living (2023), and ADA-ChababAgri (2023).

Regional Distribution

Americas. The Americas generate almost 81% of all *Aloe vera* grown in the world (ActuLatino, 2021).

Mexico. Leading producer with 12,500 ha under cultivation, yielding 158,000 tons/year. Main producing states are Veracruz, Yucatán, and Tamaulipas (4,250 ha) (ActuLatino, 2021). The semi-arid climate (18–35 °C) and sandy-calcareous soils favor growth, though recurrent droughts and heat waves above 35 °C pose risks (ActuLatino, 2021). In Yucatán specifically, 1,019 ha of plantations produced 3,944.06 tons in 2007 (Aranda Cuevas et al., 2016). Average yields reach 21–22 tons/ha (ActuLatino, 2021).

United States. Mainly in Texas and California, via industrial-scale production and advanced processing technology. Forever Living Products has >1,000 ha in Texas and produces >32 million kg *Aloe vera* annually (Forever Living, 2023). Water shortage determines greenhouse agriculture and precision irrigation.

Dominican Republic. Big plantations by Forever Living Products (larger than 2,000 ha), exporting (Forever Living, 2023).

Asia

India. Rapidly increasing organic *Aloe vera* production with ~100,000 tons from 50,000 ha. Unusual monsoons and strong heat waves (>40 °C) can reduce gel content in leaves and medicinal grade (Interfresh, 2023).

China. These yields ~80,000 tons from 30,000 ha, and it is highly concentrated in Yunnan, Guangdong, and Fujian. Both domestic and export use are rising, although high humidity fosters fungal disease and excess summer heat affects gel stability. Planting investments include controlled watering and heat tolerance (Interfresh, 2023).

Thailand. Produces ~25,000 tons from 12,000 ha, largely in central and north areas. The tropical environment with warm weather and high humidity promotes development but intensifies disease susceptibility to fungal infections (Interfresh, 2023).

Europe

Spain. Produces ~20,000 tons from 10,000 ha, largely in Canary Islands and Andalusia. Subtropical in Canary Islands and Mediterranean climate in Andalusia support niche, high-quality production (Interfresh, 2023).

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Italy. ~100 farm (160 ha), quality over large quantities (Interfresh, 2023).

Africa

Morocco: Over 120,000 ha, Sidi Ifni contributing about 30% production, mostly for cosmetics and spa exports (ADA-ChababAgri, 2023).

Algeria: Good prospects, especially in Sahara where climatic conditions and soils resemble Mexico. Underdeveloped production due to limited data, insufficient investment, and climatic stress. Greenhouses and sprinkler or drip irrigation can open industrial production prospects (author's estimate, on climatic similarity with Mexico).

South Africa: Estimated to produce ~15,000 tons from 8,000 ha, principally in Eastern Cape and KwaZulu-Natal. The climate is warmer than typically would be assumed but low rain fall creates variation in yields; however, sunny and/or warm provides good drainage and production potential (Interfresh, 2023).

Canada

Aloe vera is a subtropical and tropical species, and its large-scale cultivation is typically concentrated in warmer regions. While innovative uses of *Aloe vera*, such as its application as a scaffold in tissue engineering and food products, are being explored internationally, there is no evidence in the current literature of significant commercial *Aloe vera* farming or industrial-scale production in Canada (Gome et al., 2025). This suggests that, in Canada, *Aloe vera* is likely produced on a small scale, possibly in greenhouses or as specialty crops, rather than as a major agricultural commodity.

Table 2

Aloe vera research focus and production context in Canada.

Focus Area	Key Insights	Citations
Medicinal/Biomedical Use	Extensive research on health and therapeutic applications	Kumar et al., 2019; Gao et al., 2018; Sánchez et al., 2020
Agricultural Production	No direct evidence of large-scale production in Canada	Gome et al., 2025
Industrial Applications	Innovative uses in food and tissue engineering, not specific to Canada	Gome et al., 2025

Note. These papers were sourced and synthesized using Consensus, an AI-powered search engine for research. Try it at https://consensus.app

Climate Change Impacts on Growth and Phytochemistry

Physiological and Agronomic Effects

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Optimal Growth Conditions. *Aloe vera* prefers in warm conditions with humidity and temperatures between 20–38 °C. Growth is impaired below 20 °C, stops near 10 °C, and tissue harm occurs below 0 °C. Well-draining soils and moderate rainfall are preferred by the plant (Rodríguez-García et al., 2007).

Increased Temperatures (>40 °C). Reduce gel content and inhibit phytochemical compounds by directly lowering medicinal and phytochemical activity (Rodríguez-García et al., 2007).

Drought Stress. Limits the size of leaves, moisture levels, and polysaccharide production resulting in poorer gel quality and fewer antioxidant compounds (Rodríguez-García et al., 2007).

Desertification & Rainfall Irregularities. Defoliation, plus irregular rainfall patterns are impediments to phytochemical production and leaf renewal (González-Hernández et al., 2022).

Phytochemical Composition and Antioxidant Potential

Impact of Climate Zone. *Aloe vera* methanolic extracts from highland and semi-arid climatic zones consistently showed higher antioxidant activity and total phenolic content (TPC) than temperate climatic zones with tropical circumstances. This would suggest that stress effects are responsible for increased phytochemical synthesis, for example, phenols, flavonoids, saponins, alkaloids, and terpenes (Kumar et al., 2017).

Correlation of TPC to Antioxidant Activity. There were positive high relationships of TPC with good antioxidant activity in several assays (DPPH, metal chelating, hydrogen peroxide scavenging, reducing power and β-carotene-linoleic acid assay) (Kumar et al., 2017).

Mechanisms of Actions. Antioxidant activity serves to protect against oxidative stress due to free radical scavenging by reactive oxygen species (ROS), electron donation of free radicals, and metal chelation (Kumar et al., 2017).

Global Biodiversity and Distribution Risks

Habitat loss. MaxEnt modeling in Ethiopia indicates that suitable habitats for *Aloe vera* will shrink considerably from 2050–2070 with increased fragmentation (Hussein & Workeneh, 2021).

Major Climatic Variables. Reduced maximum monthly temperatures and less annual rainfall are most vital variables determining *Aloe vera* distribution (Hussein & Workeneh, 2021).

Regional Extinction Threat. If climate change intensifies, *Aloe vera* could suffer regional extinction in East Africa's vulnerable areas (Hussein & Workeneh, 2021).

Climate Role of Aloe Vera

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Aloe vera provides benefit to CO^2 absorption with ability to increase humidity in closed areas and outperformed many species (Rodríguez-García et al., 2007; Shishegaran et al., 2020).

Demonstrated ability to decrease CO^2 concentration by ~487 ppm across 8- hour cycles with little secondary release (Rodríguez-García et al., 2007; Shishegaran et al., 2020).

Therefore, *Aloe vera* shows to be both negatively impacted by climate change (stress and habitat loss) and utilized as remediation to offset climate change (carbon sequestration capacity).

Industrial and Economic Consequences of Declining Aloe Vera Yields:
Decreasing *Aloe vera* production has both short-run and longer-run implications for industrial markets that are dependent upon this produce—primarily cosmetics, pharmaceuticals, and nutritional supplements. Two interrelated themes are of highest relevance to understand: (a) market size and trend patterns regulating demand as well as price setting, and (b) economic risks involved whenever production becomes uncertain or becomes costlier.

Market Size and Trends

Global *Aloe vera* extract and finished-product demand has continued increasing during the last several years, influenced by rising interest in natural products. In 2019, *Aloe vera* leaf processors generated about USD 2.4 billion, projected to surpass USD 3.2 billion in the near future (Majeed et al., 2024). the most recently reported estimates of the global *Aloe vera* extract market value at USD 2.06 billion in 2023 and is projected to grow to USD 3.79 billion by 2030 (Grand View Research, 2023). Similarly, Mordor Intelligence (2023) stated that the *Aloe* extract market would reach USD 3.14 billion by 2025, growing at ~8.9% CAGR. An academic study reported the global market valuation of *Aloe* at USD 2.65 billion in 2023, and forecasts USD 2.86 billion in 2024 (Krupa et al., 2025). These forecasts emphasize the economic importance of maintaining a stable and quality-uniform raw material supply base for processors and end-product owners.

Risks of Unstable Production and Rising Costs

When *Aloe vera* is made intermittently—due to drought, heat, too much rain, or soil erosion—industries that depend on its face a number of associated risks:

Supply shortages and volatility. Unforeseen or lower yields lead to raw material deficits in certain regions or periods. These deficits increase prices in spot markets and force processors to find substitute suppliers or mix lots of varying quality. Field observations (Mittal, 2024; Thakur et al., 2023) demonstrate how rising input costs and falling yields reduce farmers' profit margins and decrease local supply guarantee.

Reduced quality and higher processing cost. Climate stresses do not only decrease the crop yield but also modify the chemical composition of the plant (e.g., phenolic composition or polysaccharide content). These changes lead to degraded gel quality as

February 2026, Vol. 12, No. 1
ISSN 2163-758X

well as pharmaceutically or high-end cosmetic product acceptability (Liontakis & Tzouramani, 2016).

Vulnerability in the value chain and concentration risks. Due to the fact that global *Aloe vera* supply is focused in some regions, regional climate shocks have disproportionate effects on global supply chains. Profitability and field studies (e.g., Saiyem, 2020; Mittal, 2024) shows that many farmers lack access to reliable storage, processing, and markets, making them vulnerable to both climate and market risks.

Socio-economic impacts. Fluctuating and declining agricultural revenues have spillover consequences into wider community effects—reduced farm investment and impaired total supply resilience. Local studies show that many farmers face limited margins and are challenged by structural constraints (e.g., costly inputs, limited availability of planting material, and lack of marketing infrastructure), which increase producers' and supply chains' vulnerability (Thakur et al., 2023; Mittal, 2024).

Table 3

Industrial and economic effects of reduced Aloe vera yields in selected regions.

Region / Country	Main Issue Reported	Industrial / Market Effect	Reference
India	Rising input costs and water scarcity reduce profitability at farm level	Lower supply reliability for processors; increased spot-market prices	Saiyem, 2020 ; Mittal, 2024
Mexico	Climate extremes (heat waves, drought) disrupt large-scale production	Volatility in gel exports; risk of global price shocks	Thakur et al., 2023
Greece (EU)	Climate-induced gel quality reduction (polysaccharides, phenolics)	Higher processing costs to meet cosmetic/pharma standards	Liontakis & Tzouramani, 2016
Global (Industry forecast)	Rising demand vs. unstable supply	Increased risk of concentration, vertical integration by large firms	Grand View Research, 2023; Fortune Business Insights, 2025

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Industry and Policy Implications

For businesses, declining yields justify investments in geographical diversification of supplies, traceability, and supplier support programs. Governments can reduce risks by subsidizing irrigation, greenhouse deployment, and processing plants. Certification systems such as organic or fair-trade and market differentiation (premium extracts vs commodity gel) can enhance resilience and sustainability of *Aloe vera* supply chains (Grand View Research, 2023; Liontakis & Tzouramani, 2016; Mordor Intelligence, 2023).

Sustainable Cultivation Strategies for Climate-Resilient Aloe Vera Production

To guarantee the long-term sustainability of production, a combination of climate-resilient agronomic techniques, innovative technologies, and socio-economic initiatives has to be adopted. Many of these methods were suggested and validated as a means of reducing the negative effects of climate change while enhancing yield, gel quality, and general resilience.

Genetic and Physiological Adaptability

Genomic studies discovered that *Aloe vera* possesses specific mechanisms of withstanding drought stress through CAM (Crassulacean Acid Metabolism) photosynthesis and high-level production of osmoprotectants (Jaiswal, 2021). These findings highlight the potential of developing better cultivars with high-levels of drought and salt tolerance through breeding and biotechnology techniques involving marker-assisted breeding and tissue culture techniques of mass-scale multiplication.

Water Management and Irrigation

Optimized irrigation is crucial for productivity. Recent studies have demonstrated that controlled deficit irrigation with optimum planting geometry significantly enhances water-use efficiency and yield (Singh 2021). Similarly, utilization of saline water during irrigation has produced a high volume of the material of bioactive compounds with a slight yield deterioration, revealing that *Aloe vera* may tolerate non-conventional water sources such as brackish water (Souguir, 2015).

Propagation and Agronomic Practices

Methods of propagation are paramount in obtaining bulk and sustainable production of *Aloe* (Cristiano, 2016) also highlighted sucker propagation, planting layout and distance, and land preparation, in initiating improved establishment and ultimate long-term productivity. Micropropagation and tissue culture are also effective alternatives towards obtaining standardized and pathogen-free planting materials, particularly during bulk production at a business level.

Controlled Environments and Protected Cultivation

February 2026, Vol. 12, No. 1
ISSN 2163-758X

Integration of controlled environments such as greenhouses can buffer *Aloe vera* from climatic fluctuations. Integration of photovoltaic systems at the time of greenhouse establishment has been elaborated upon by (Kavga, 2024) as raising energy efficiency besides offering good microclimatic conditions suitable for *Aloe* production. Inexpensive shading nets and hydroponic or semi-hydroponic systems could also offer alternatives under heat-stress or desert conditions, particularly among emerging producers such as Algeria.

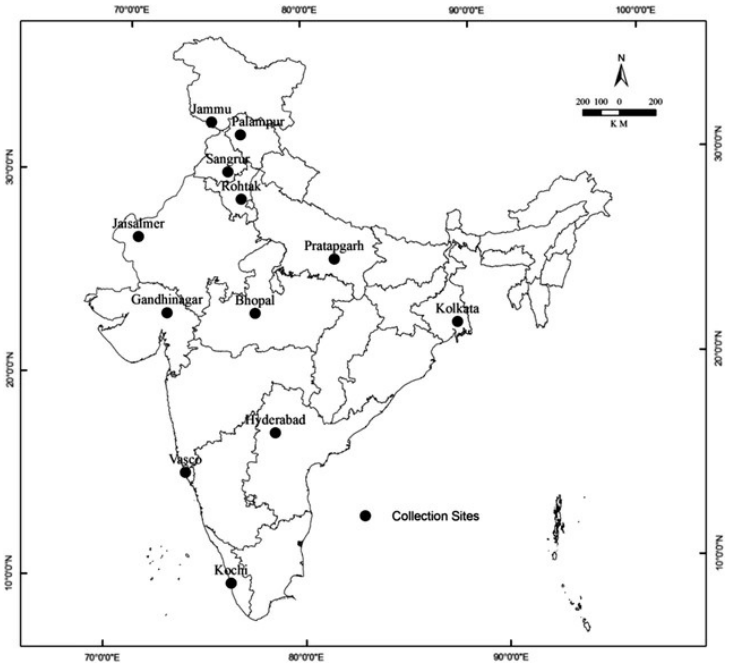
Socio-Economic and Policy Perspectives

Apart from agronomic practices, sustainable production of *Aloe vera* requires favorable socio-economic systems. Value-creating certification schemes such as organic or fair-trade labeling can improve *Aloe* commodities and promote responsible sourcing (Lee, 2025). Government initiatives toward promoting desert agriculture, particularly in North Africa, could improve the resilience of value chains and present new opportunities for rural livelihoods (Hssaisoune et al., 2020).

Integratively, sustainable *Aloe vera* cultivation requires genetic improvement, efficient use of water, innovative production systems, and socio-economic programs. Only with an integrated approach will future productivity under climatic changes as well as the sustainability of the cosmetic, pharmaceutical, and nutraceutical industries dependent upon this “green gold” also become secured (Cristiano, 2016; Jaiswal, 2021; Lee, 2025).

Figure 1

Showing different collection sites from 6 agro-climatic zones of India



February 2026, Vol. 12, No. 1
ISSN 2163-758X

Note. Adapted from Effect of climate change on phytochemical diversity, total phenolic content and in vitro antioxidant activity of *Aloe vera (L.) Burm.f*, by Yadav, P., Singh, A., & Kumar, R., 2017, Journal of Applied Research on Medicinal and Aromatic Plants, 5(3), 45–52.

Algeria as a Potential Climate-Resilient Producer

Algeria is characterized by semi-arid conditions with high temperatures and low, irregular rainfall, conditions not ideally suited for most native crops (Hssaisoune et al., 2020; Meddi et al., 2013). Therefore, *Aloe vera* emerges as a strategic and ideal crop due to its drought resilience and low watering requirements, making it naturally apt to flourish in Algerian conditions (Hamman, 2008; Surjushe et al., 2008). Recent studies in western Algeria confirm that *Aloe vera* performs well under semi-arid conditions, producing high gel yields (≈40.4%) with good quality and antimicrobial activity (Fedoul et al., 2022).

Availability of Marginal Land

Algeria contains extensive areas of marginal land that cannot compete with food crops for high-quality agricultural ground due to soil suitability or salinity. These lands present a guaranteed opportunity to cultivate *Aloe vera* without competing with staple crops, transforming underutilized resources into valuable economic potential (Fedoul et al., 2022).

Economic Opportunities

Aloe vera has the potential for increased economic activity because of escalating global interest in it, a result of its commercial applications and many value-added uses as a food, pharmaceutical, and cosmetic product (Fedoul et al., 2022; Liontakis & Tzouramani, 2016). Thus, Algeria stands to invest in developing small and medium-scale processing units with opportunities in domestic marketing and exporting to international markets. Moreover, successful greenhouse expansion in Biskra—enabled by government policy support and PNDA financing—illustrates that Algeria can leverage marginal and arid lands for profitable agribusiness ventures (Aidat et al., 2023).

Sustainable Practices for Long-Term Viability

For achieving the sustainability and survival of this business, it is critical to take intelligent choices based on modern methods (Aidat et al., 2023; Hu, 2020). They include water-efficient drip irrigation systems, promotion of agricultural cooperatives to build pools for joint use of resources, and promotion of scientific studies in the region for developing *Aloe vera* varieties best suited for Algeria's specific climatic conditions.

Aloe vera (*Aloe barbadensis Miller*) is cultivated in Algeria, particularly in regions such as Ghardaïa, where the plant is valued for its medicinal and biological properties. Studies of *Aloe vera* grown in Berriane (Ghardaïa) have demonstrated that the gel extract contains a variety of phytochemicals, including phenols, flavonoids, tannins, alkaloids, saponins,

February 2026, Vol. 12, No. 1
ISSN 2163-758X

and terpenoids, which contribute to its antioxidant and antimicrobial activities. These findings highlight the potential of locally produced *Aloe vera* as a source of natural bioactive compounds for therapeutic use and suggest that the plant is well-adapted to Algerian agro-climatic conditions. Ethnobotanical surveys in northeastern Algeria (Constantine and Mila) further confirm the traditional use of *Aloe* species, especially for treating skin diseases, reflecting both the cultural significance and the practical value of *Aloe vera* production in the country. The high fidelity level reported for *Aloe* sp. in these regions underscores its importance in local folk medicine and supports ongoing interest in its cultivation and utilization for health-related applications (Khane et al., 2022; Ouelbani et al., 2016).

Discussion

A Critical Perspective

The synthesis of findings across subsections suggests that *Aloe vera* is an exceptionally resilient plant when exposed to climate stress, through CAM photosynthesis and osmoprotectant production (Souguir, 2015). Although controlled environments using water-efficient cropping practices show promise (Mittal, 2024), the socio-economic and policy aspects remain underexplored. Most of the research has focused primarily on physiological and agronomic aspects with relatively few addressing long-term scaling or sustainability (Saiyem, 2020).

Regional Differences

Evidence from the literature demonstrates that there are pronounced regional differences in *Aloe vera* production practice and resilience. In India, controlled irrigation and optimized planting geometry significantly improved yields (Singh, 2021), while in Greece, climate-induced changes in gel phytochemistry required higher-priced processing adjustments (Liontakis & Tzouramani, 2016). Mexico, with its large-scale export orientation, remains highly exposed to price volatility during drought years (Pedroza-Sandoval et al., 2022). Algeria's semi-arid environments offer unique opportunity to produce *Aloe vera* with high value phytochemical characteristics (Fedoul et al., 2022). By contrast, tropical producers with higher rainfall would struggle to achieve high quality gel production. These differing regional challenges highlight localized contexts and strategies needed for sustainable production (Fedoul et al., 2022; Thakur et al., 2023; Surjushe et al., 2008).

Strengths and Weaknesses

The existing studies provide valuable evidence on *Aloe vera*'s physiological resilience and associated phytochemical diversity (Souguir, 2015), highlighting its potential contribution to carbon sequestration at scale. However, limitations remain, including the lack of long-term resilience assessments, insufficient socio-economic data from North Africa, and limited integration of biotechnology into practice (Jaiswal, 2021). Moreover, there is a lack of multi-disciplinary approaches (agronomy, economics and climate

February 2026, Vol. 12, No. 1
ISSN 2163-758X

modelling) that would enable enough collective knowledge in understanding *Aloe vera* as a crop (Saiyem, 2020).

Future Research Directions

Future research should prioritize biotechnology options including marker-assisted selection and tissue culture for drought- and salt-tolerant cultivars (Jaiswal, 2021). The study of controlled-environment systems will yield practical local enhancements, including greenhouse-photovoltaic systems, particularly in arid regions of North Africa (Hssaisoune et al., 2020). Socio-economic studies on cooperative models, certification systems, and equitable policy distribution could strengthen value-chain resilience (Saiyem, 2020). In conclusion, *Aloe vera* should not be viewed as one common plant but as one exciting agribusiness opportunity. It presents a practical model for climate-resilient agriculture that would greatly benefit Algeria's agricultural and economic security by transforming environmental constraints into authentic developmental opportunities (Aidat et al., 2023; Hssaisoune et al., 2020).

Conclusion

Aloe vera stands out as a unique crop that embodies both sensitivity and resilience in the face of climate stressors. Its ability to endure drought, coupled with its economic significance in the global bioproduct market, positions *Aloe vera* as a valuable asset for sustainable land management, particularly in regions like Algeria. This plant not only exemplifies how environmental challenges can be transformed into opportunities for economic and ecological resilience, but it also serves as a model for sustainable agriculture.

Aloe vera's adaptive mechanisms, including the increased production of bioactive compounds and its genetic traits that confer drought tolerance, enhance its survival under challenging conditions. These traits allow the plant to thrive despite the adverse effects of salinity and temperature extremes. However, it is essential to recognize that severe or combined stresses can still hinder its growth and photosynthesis, underscoring the crop's vulnerability amidst escalating climate pressures.

Ultimately, *Aloe vera* represents a promising pathway for developing resilient agricultural systems that can withstand climate variability while contributing to economic sustainability. Its cultivation could play a crucial role in promoting environmental stewardship and improving livelihoods in regions facing significant climate challenges.

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Author Notes

Saib Ibtissem is affiliated with the Department of Biology, Faculty of Natural Sciences, Life, Earth and Universe Sciences, University of Tlemcen, Algeria. She is a Master's

February 2026, Vol. 12, No. 1
ISSN 2163-758X

student in Applied Biochemistry at University of Tlemcen, Algeria – Faculty of Natural and Life Sciences, Department of Biology. Her current research focuses on medicinal plants, with particular emphasis on the biochemical characterization of Aloe vera and the impact of climate variability on its antioxidant and antimicrobial properties. Her work explores how environmental stress influences the stability of bioactive compounds, with the aim of contributing to sustainable industrial applications in the pharmaceutical, cosmetic, and food industry.

Zeggai Houaria is affiliated with the Department of Biology, Faculty of Natural Sciences, Life, Earth and Universe Sciences, University of Tlemcen, Algeria. She is a Master's student in Applied Biochemistry at the University of Tlemcen, Algeria – Faculty of Natural and Life Sciences, Department of Biology. Her research is centered on medicinal plants, with a focus on Aloe vera. She investigates how climate variability influences its biochemical composition, particularly its antioxidant and antimicrobial properties. Through this work, she aims to contribute to the sustainable development of Aloe vera applications in the pharmaceutical and cosmetic sectors.

Abdelmalek Nihad is affiliated with the Department of Biology, Faculty of Natural Sciences, Life, Earth and Universe Sciences, University of Tlemcen, Algeria. She is a Master's student in Applied Biochemistry at the University of Tlemcen, Algeria – Faculty of Natural and Life Sciences, Department of Biology. Her research explores the resilience of medicinal plants under environmental stress, with a specific focus on how climate variability alters the phytochemical profile and bioactivity of Aloe vera gel. She aims to contribute to developing sustainable sourcing strategies for the plant's valuable compounds in the cosmetic and pharmaceutical industries.

Azzi Rachid is affiliated with Laboratory of Antibiotics Antifungal Laboratory, Physical-Chemistry, Synthesis and Biological Activity, Department of Biology, Faculty of Natural Sciences, Life, Earth and Universe Sciences, University of Tlemcen, Algeria. He is a holder of a Doctorate in Biochemistry, he conducts his research in the field of medical biochemistry and medicinal plants, with a particular interest in bioactive molecules and their therapeutic applications. Currently Professor and Teacher-Researcher in biology, Biochemistry option, at University of Tlemcen. He leads Team 4 of Laboratory, which focuses on research into the biological activity of local flora. His scientific interests encompass biochemistry and medical biochemistry, with a particular focus on medicinal plants and bioactive molecules. His work is part of an interdisciplinary approach that combines chemical, biological, and pharmaceutical aspects to evaluate the therapeutic potential of natural compounds.

Nehar Benameur is affiliated with the Laboratory of Functional Agroecosystems and Agronomic Sector Technologies, Department of Biology, Faculty of Natural Sciences, Life, Earth and Universe Sciences, University of Tlemcen, Algeria. Associate professor actively involved in international research collaborations, including The Global environmental exchange program in partnership with East Carolina University (USA). His work focuses on environmental management and biological studies of water systems, with ongoing interests in aquatic ecosystems, database integration, and sustainable

February 2026, Vol. 12, No. 1
ISSN 2163-758X

environmental practices SDGs. Over 14 years of experience with companies, universities in teaching and researching topics related to natural resources, ecology, green skills, sustainability, and renewable energy. His mission is to educate the next generation on environmental sustainability and equip them with the knowledge and skills needed to build a more sustainable future.