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# Math-gender stereotypes in Chile: Identification of associated factors across youth and adults

*Estereotipos de género en matemáticas en Chile: Identificación de factores asociados en jóvenes y adultos*

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## ABSTRACT

Math-gender stereotypes that associate math more with males than females are a contributing factor to the underrepresentation of women in STEM fields. Given the pronounced gender disparities in math achievements in Chile, this study investigates these stereotypes within the Chilean context, examining their incidence and associated factors in two distinct age groups: adults and youth. Participants included adults (n = 5,038) and youth (n = 846) from the Encuesta Nacional de Percepción Social de la Ciencia, Tecnología, Conocimiento e Innovación study. Information on math-gender stereotypes, sociodemographics, and science perceptions were collected via participants' reports. Logistic regression analyses using sampling weights were conducted in the two groups. Adults exhibited significantly higher levels of math-gender stereotypes compared to youth. Both groups shared factors associated with the probability of endorsing stereotypes (educational level, socioeconomic status, perception towards science). Conversely, sex emerged as a significant predictor for youth but not for adults. Findings suggest that math-gender stereotypes persist at different age groups in Chile, albeit with varying degrees. Socioeconomic disparities and the value towards science emerged as significant precursors across all groups.

**KEYWORDS:**
*math-gender stereotypes; socioeconomic disparities; youth; adults; Chile*

**PALABRAS CLAVE:**
*estereotipos de género en matemáticas; disparidades socioeconómicas; jóvenes; adultos; Chile*

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## RESUMEN

Los estereotipos de género en matemáticas que las asocian más al género masculino que al femenino son un factor que contribuye a la subrepresentación de las mujeres en STEM. Dadas las brechas de rendimiento en matemáticas por género en Chile, este estudio investiga esos estereotipos en el contexto chileno, examinando su incidencia y factores asociados en dos grupos de edad distintos: adultos y jóvenes. Los(as) participantes incluyeron adultos (n = 5,038) y jóvenes (n = 846) del estudio Encuesta Nacional de Percepción Social de la Ciencia, Tecnología, Conocimiento e Innovación. Se recopiló información sobre los estereotipos de género en matemáticas, los datos sociodemográficos y las percepciones sobre la ciencia a través de informes de quienes participaron. Asimismo, se realizaron análisis de regresión logística utilizando factores de expansión en los dos grupos. Resultados: Las personas adultas exhibieron estereotipos de género en matemáticas significativamente más altos en comparación con las jóvenes. Ambos grupos compartieron factores asociados con la probabilidad de adherirse a estos estereotipos (nivel educativo, estatus socioeconómico y percepción de la ciencia). Sin embargo, el sexo emergió como un predictor significativo para las personas jóvenes, pero no para las adultas. Los hallazgos sugieren que los estereotipos de género asociados a las matemáticas persisten en diferentes grupos de edad en Chile, aunque en diferentes grados. Las disparidades socioeconómicas y el valor hacia la ciencia surgieron como factores precursores significativos en todos los grupos.

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## INTRODUCTION

The development of science is crucial for the progress of nations and the well-being of societies. Scientific and technological advancements drive economic growth, enhance healthcare, and address global challenges (Adenle et al., 2023). However, despite the recognised importance of science, participation in scientific fields is not equally distributed across different demographics. Women, in particular, are significantly underrepresented in science and related fields, collectively known as STEM (Science, Technology, Engineering, and Mathematics) (National Science Foundation, 2021). This underrepresentation not only reflects a loss of potential talent but also perpetuates existing gender inequalities in the workforce and society at large. Therefore, understanding the factors contributing to these gender gaps is important for developing effective strategies that promote inclusivity and diversity.

Numerous hypotheses have been formulated to elucidate this representation disparity, emphasising the pivotal roles of gender bias and social beliefs (Master, 2021; Wegemer & Eccles, 2019). Societal expectations and stereotypes about gender-related abilities possess the capacity to shape vocational inclinations from an early developmental stage (Dunlap & Barth, 2019; Wegemer & Eccles, 2019). For instance, traditional gender stereotypes often align women with nurturing and prosocial skills, while men are associated with analytical and technical competencies (Eagly & Wood, 2012). A particularly influential belief contributing to early gender disparities is the math-gender stereotypes. These stereotypes assert that males inherently possess greater mathematical abilities than females, who are perceived as having reduced capabilities or interest in this domain (Starr & Simpkins, 2021; Starr et al., 2022). Nonetheless, extensive research indicates that gender disparities in math abilities are actually modest and subject to age-related and cultural variations (for a recent comprehensive review, see Casey & Ganley, 2021).

Despite substantial evidence challenging the validity of math-gender stereotypes, these beliefs persist and have been recently identified among parents (Chaffee & Plante, 2022; Starr et al., 2022), teachers (Dersch et al., 2022), and children (King et al., 2021), suggesting a formative influence from a young age. For example, studies have shown that educators often provide unequal support and opportunities in math, typically favouring male students (McKellar et al., 2019; Ober et al., 2021). Moreover, it has been observed that parents are more likely to discourage girls than boys from engaging in math activities at home (Silinskas & Kikas, 2019). However, while studies have extensively documented these stereotypes among adults (Casad et al., 2017) and children (Miller et al., 2018), their incidence among youth has been less explored. Addressing this gap is crucial, given that this age group is at a pivotal stage in making educational and career decisions that such biases can influence. Thus, a deeper understanding of math-gender stereotypes in youth could provide important insights for improving gender representation in STEM.

Current research indicates that math-gender stereotypes are prevalent not only among adults but also within younger populations, albeit with distinct patterns of expression (Hand et al., 2017; Starr & Simpkins, 2021; Morrissey et al., 2019). Starr and Simpkins (2021) documented a significant increase in traditional gender stereotypes among U.S. adolescents, with the perception of math as a predominantly male domain progressively strengthening from 9th to 11th grade. Additionally, they found that parents were three times more likely to attribute superior math and science abilities to males rather than females, and these beliefs strongly correlated with the stereotypes held by their children. These math-gender stereotypes not only shaped adolescents' self-concept in math and science but also influenced their career expectations in STEM fields. Similarly, a study conducted by Morrissey and colleagues (2019) in Canada found that adults reported more typical math-gender stereotypes on self-report measures than adolescents, suggesting that these stereotypes are not as relevant to youth as they are to adults. Nevertheless, despite the significant insights provided by these studies, comprehensive research that conducts coordinated analyses of these stereotypes among both youth and adults at the population level remains scarce. Such research is needed to determine how these perceptions vary across different age groups and to identify potentially distinct factors associated with their prevalence in each demographic.

### Factors Associated with Gender Stereotypes

Several studies have suggested that sociodemographic factors beyond age significantly influence the perception and reinforcement of gender stereotypes related to math. Regarding gender, research involving children indicates that boys typically exhibit stronger math and science gender biases (Woods et al., 2022). However, this tendency appears to diminish in adulthood, with evidence suggesting that adult men generally hold weaker math and science stereotypes compared to women (Nosek & Smyth, 2011). Socioeconomic status (SES) also plays a critical role, as higher SES and educational levels (often used as proxy for SES), are related to a decreased likelihood of endorsing traditional gender roles, which may extend to math-gender stereotypes (Marks et al., 2009). Additionally, occupational status can also influence gender stereotypes. For instance, women in STEM disciplines tend to exhibit fewer gender/STEM stereotypes compared to women in female-dominated fields and men in STEM, likely due to their direct engagement with counter-stereotypical role models (Dunlap & Barth, 2019).

Moreover, in addition to sociodemographic antecedents, positive perceptions of the social relevance of science significantly impact gender stereotypes, particularly in STEM fields. Positive perceptions of science promote critical reflection on the association between science and gender, thereby fostering more

[1] Note: In this study, the term 'gender' is used when referring to stereotypes and beliefs as related to established theory. The term 'sex' is employed to describe our predictors and participants in accordance with the study's characteristics. The dataset utilised binary response options (male/female) with no information available regarding gender identification. As a result, the research group decided to use 'sex' henceforth for our study variables.

Moreover, in addition to sociodemographic antecedents, positive perceptions of the social relevance of science significantly impact gender stereotypes, particularly in STEM fields. Positive perceptions of science promote critical reflection on the association between science and gender, thereby fostering more equitable representation in traditionally male-dominated disciplines (Truffa, 2012). For example, research indicates that these perceptions positively predict female students' intentions to pursue STEM paths, while male students are not similarly influenced (Kyte & Riegle-Crumb, 2017). Additionally, women in science fields with a strong scientific identity and a higher value towards science exhibit weaker gender stereotypes (Smyth & Nosek, 2015). These findings collectively suggest that positive perceptions of the value of science, particularly among females, may contribute to reducing gender stereotypes in STEM fields. However, no research to our knowledge has directly explored individuals' perceptions of science on math-gender stereotypes, which could open new pathways for reducing these biases.

### The Case of Chile

Chile presents a compelling context for examining math-gender stereotypes, particularly due to its pronounced gender performance gap in mathematics. In the PISA (OECD's Programme for International Student Assessment) math assessment, Chile is one of only six countries where the gender disparity in math performance, favouring boys over girls, exceeds 20 points (Organisation for Economic Cooperation and Development [OECD], 2015; 2021). This trend is mirrored in Chile's standardised national school achievement test (Sistema de Medición de la Calidad de la Educación [SIMCE], 2023). The most recent iterations of this assessment, conducted in 2022 and 2023, on fourth and tenth-grade students reveal an important shift: the math gender gap, traditionally observed among older students but absent in recent years, has reemerged and now extends to fourth-grade students. Additionally, these national representative evaluations reaffirm the well-documented socioeconomic disparity in math achievement, favouring male students from high SES backgrounds (Agencia de Calidad de la Educación, 2023).

Local studies highlight that Chilean children exhibit math-gender stereotypes from an early age (del Río & Strasser, 2013; del Río et al., 2016; 2019), with a notable association to sociodemographic factors such as SES, as these stereotypes are more pronounced among children from lower socioeconomic backgrounds (del Río et al., 2016; Su et al., 2023). Furthermore, within the Chilean context, math-gender stereotypes also permeate parental and teacher perspectives (del Río et al., 2016; Espinoza & Taut, 2016), demonstrating their pervasive presence across multiple dimensions of the educational landscape. Consequently, it is necessary to better understand how these stereotypes manifest in Chile at the population level and the associated factors that may influence their expression. Such findings can inform targeted interventions and educational policies to address and mitigate the impact of these stereotypes, potentially reducing the pronounced gender performance gap and the underrepresentation of women in STEM areas.

### The Present Study

Research exploring math-gender stereotypes in different age groups (i.e., youth, adults) is needed to enlarge our understanding of factors and barriers contributing to math gender gaps throughout different life stages. This knowledge can facilitate the development of targeted interventions and policies that address the particular needs of diverse age groups, thereby promoting inclusivity and diversity in math and science domains. Furthermore, there is a particular need to explore these math-gender stereotypes in countries presenting pronounced gender gaps in math performance, such as Chile. Therefore, the current study had two aims. First, to examine math-gender stereotypes in Chilean youth and adults to enhance knowledge around potential differing presentations between these two groups according to sociodemographic characteristics and personal beliefs associated with the importance of math and science. Second, to identify if sociodemographic features and perceptions towards the role of science increase the probability of presenting math-gender stereotypes in Chilean youth and adults. This is the first study to our knowledge that simultaneously addresses these two aims using coordinated analyses with two different age groups.

Supported by previous studies (del Río et al., 2019; 2021; Espinoza & Taut, 2016; 2020), it was expected that Chilean youth and adults would report math-gender stereotypes. Additionally, Chilean adults would report more math-gender stereotypes than youth (Hand et al., 2017; Starr & Simpkins, 2021; Morrissey et al., 2019). Regarding associated factors, it is anticipated that youth and adults from lower SES backgrounds, with lower educational attainments, who are currently not working, and who have a poor perception of the value of science would present more math-gender stereotypes (del Río et al., 2016; Dunlap & Barth, 2019; Su et al., 2023). However, since gender has shown mixed findings concerning age, no specific predictions were made for this antecedent. The present study was pre-registered in the Open Science Framework[2].

## METHODS

### Data Source and Participants

Data for the current study were derived from a Chilean open access dataset: *Encuesta Nacional de Percepción Social de la Ciencia, Tecnología, Conocimiento e Innovación* (ENPSC; National Survey of Social Perception of Science, Technology, Knowledge, and Innovation; https://observa.minciencia.gob.cl/encuesta/encuesta-nacional-de-percepcion-social-de-la-ctci).
This study is a nationally representative cross-sectional survey conducted at three different time points (i.e., 2015, 2018, and 2022) among a random sample of Chileans aged 15 years and older. For our study, we exclusively utilised data from the third time point (N = 8,344) due to the absence of gender-related questions in the first time point and limited sociodemographic

[2] https://osf.io/dxhz9/?view_only=842e318c917048788ffe6f37c78f49d3

data in the second time point. To differentiate between adults ($n$ = 7,207) and youth ($n$ = 1,137), we employed the guidelines set by the World Health Organization (2024), classifying 'Youth' as individuals aged 15 to 24 years. This segmentation is also supported by developmental and social considerations. Youth represents a transitional period characterised by significant milestones such as educational development, entry into the labour market, and the consolidation of social identity. In contrast, the adult category, though broader, encompasses a stage where many of these transitions have been completed, and individual trajectories tend to stabilise (Baltes & Smith, 2004). This approach aligns with existing studies (Arnett, 2000) that recognise the distinct developmental and social contexts of these groups, thereby justifying the use of differentiated age ranges tailored to the research aims. From these groups, we included participants who responded with either agreement (i.e., agree, strongly agree) or disagreement (i.e., strongly disagree, disagree) to the math-gender stereotypes question of the study, excluding cases with neutral responses (i.e., neither agree nor disagree). As a result, the final ENPSC sample comprised 5,038 adults and 846 youth, representing 69.9% and 74.4% of the originally recruited sample, respectively. A comparison between the included and excluded samples revealed significant differences across several sociodemographic variables, including sex ($\chi^2(1) = 5.4909$, $p = .019$), educational level ($\chi^2(3) = 133.2033$, $p \leq .000$), employment status ($\chi^2(1) = 12.3465$, $p \leq .000$), area of residence ($\chi^2(1) = 9.2673$, $p = .002$), and SES ($\chi^2(4) = 30.5243$, $p \leq .000$). Therefore, to account for data attrition after implementing the inclusion criteria, sampling weights (estimated according to the probability of selecting the sample) were applied to the analytical sample. Weights were used to enhance the generalisability of the results by aligning the sample distributions with population characteristics. For more comprehensive information on ENPSC recruitment, data collection, and sampling weights, refer to the report by Subsecretaría de Ciencia, Tecnología, Conocimiento e Innovación (2023). Table 1 provides details regarding the sample characteristics of each included group. Ethical approval for the ENPSC study was obtained from the Ministerio de Ciencia, Tecnología, Conocimiento e Innovación de Chile (Ministry of Science, Technology, Knowledge, and Innovation of Chile). All included study participants contributed voluntarily, with consent collected before data collection in both datasets.

**Table 1**

*Sociodemographic characteristic of adults, youth, and children*

| Adults | *n (%)* | Youth | *n (%)* |
|---|---|---|---|
| **Sex** | | **Sex** | |
| Men | 2,058 (40.9) | Men | 373 (44.1) |
| Women | 2980 (59.2) | Women | 473 (55.9) |
| **Age** | | **Age** | |
| 25-34 years | 1218 (24.2) | 15-19 years | 304 (35.9) |
| 35-44 years | 1018 (20.2) | 20-24 years | 542 (64.1) |
| 45-54 years | 985 (19.6) | **Educational level** | |
| 55-64 years | 900 (17.9) | Primary | 59 (7.0) |
| 65-74 years | 629 (12.5) | Secondary | 465 (55.0) |
| ≥ 75 years | 288 (5.7) | Vocational training | 125 (14.8) |
| **Educational level** | | University training | 197 (23.3) |
| Primary | 815 (16.2) | **Employment status** | |
| Secondary | 2,394 (47.5) | Unemployed | 489 (57.8) |
| Vocational training | 746 (14.8) | Employed | 357 (42.2) |
| University training | 1,083 (21.5) | **Area of residence** | |
| **Employment status** | | Urban | 699 (82.6) |
| Unemployed | 2,038 (40.5) | Rural | 147 (17.4) |
| Employed | 3,000 (59.6) | **SES - quintile** | |
| **Area of residence** | | First | 261 (30.9) |
| Urban | 4,102 (81.4) | Second | 216 (25.5) |
| Rural | 936 (18.6) | Third | 110 (13.0) |
| **SES - quintile** | | Fourth | 105 (12.4) |
| First | 976 (19.4) | Fifth | 154 (18.2) |
| Second | 1,675 (33.3) | **Perception towards the role of science Q1** | |
| Third | 716 (14.2) | Nothing | 27 (3.2) |
| Fourth | 739 (14.7) | Little bit | 122 (14.4) |
| Fifth | 931 (18.5) | Something | 320 (37.8) |
| **Perception towards the role of science Q1** | | A lot | 377 (44.6) |
| Nothing | 202 (4.0) | **Perception towards the role of science Q2** | |
| Little bit | 964 (19.1) | No benefits | 19 (2.3) |
| Something | 1,724 (34.2) | Few benefits | 99 (11.7) |
| A lot | 2,148 (42.6) | Lots of benefits | 287 (33.9) |
| **Perception towards the role of science Q2** | | Many benefits | 441 (52.1) |
| No benefits | 166 (3.3) | **Perception towards the role of science Q3** | |
| Few benefits | 761 (15.1) | Strongly agree | 273 (32.3) |
| Lots of benefits | 1,604 (31.8) | Agree | 241 (28.5) |
| Many benefits | 2507 (49.8) | Neither agree nor disagree | 158 (18.7) |
| **Perception towards the role of science Q3** | | Disagree | 80 (9.5) |
| Strongly agree | 1,839 (36.5) | Strongly disagree | 94 (11.1) |
| Agree | 1,520 (30.2) | | |
| Neither agree nor disagree | 837 (16.6) | | |
| Disagree | 425 (8.4) | | |
| Strongly disagree | 417 (8.3) | | |

*Note. Adult dataset N = 5,038; Youth dataset N = 846. Perception towards the role of science Q1 = 'How much has science, technology, knowledge, and innovation contributed to the development of Chile in the last two years?'; Perception towards the role of science Q2 = 'Understanding benefit as the positive consequences produced by an event. How many benefits will the development of science and technology bring to our world in the next 20 years?'; Perception towards the role of science Q3 = 'How much do you agree or disagree with the following statement: we depend too much on science and not enough on Faith'*

## MEASURES

### Outcome: Gender Stereotypes

Participants' math-gender stereotypes were assessed using the statement: 'Girls have less ability in mathematical skills than the rest of the students'. Responses were recorded on a five-point Likert scale, ranging from 1 *(strongly disagree)* to 5 *(strongly agree)*, with higher scores indicating stronger endorsement of math-gender stereotypes. For analysis purposes, responses were dichotomised into *'agree'* (combining *'agree'* and *'strongly agree'*) and *'disagree'* (combining *'disagree'* and *'strongly disagree'*), while neutral responses *('neither agree nor disagree')* were excluded.

### Sociodemographic Antecedents

Participants provided information on the following sociodemographic variables: sex (male/female), age (categorised into groups: 25-34, 35-44, 45-54, 55-64, 65-74, and ≥ 75 years old), highest educational level attained (primary, secondary, vocational training, university training), employment status (employed, unemployed; for young people who were pursuing higher education, they were considered unemployed as long as they did not have a paid job at the time of the survey), and area of residence (urban/rural). SES was determined using per capita income quintiles provided by ENPSC, with lower quintiles indicating lower SES.

### Perception Towards the Role of Science

Participants' perception towards the role of science was assessed using three questions: (i) 'How much has science, technology, knowledge, and innovation contributed to the development of Chile in the last two years?' *(nothing, little bit, something, a lot)*, (ii) 'How many benefits will the development of science and technology bring to our world in the next 20 years?' *(no benefits, few benefits, some benefits, many benefits)*, and (iii) 'How much do you agree or disagree with the following statement: 'we depend too much on science and not enough on Faith' *(strongly agree, agree, neither agree nor disagree, disagree, strongly disagree)*. Higher scores on these questions indicate more value on the role of science.

### Data Analyses

A post hoc power analysis was first conducted using G*Power 3.1 (Faul et al., 2007). By specifying a two-tailed test, a small effect size (OR <1.5) (Chen et al., 2010), and an alpha of .05, results showed that the groups' sample sizes were satisfactory to test the study hypotheses (statistical power > 0.9). Youth' and adults' frequencies of math-gender stereotypes (i.e., agree or disagree) were initially examined concerning sociodemographic antecedents and perceptions towards the role of science. Bivariate comparative analyses were conducted to explore differences between sociodemographic and perception towards science antecedents and participants' agreement or disagreement with the math-gender stereotypes statement. Additionally, differences in math-gender stereotypes between adults and youth were assessed using a $\chi^2$ test. Subsequently, logistic regression models were employed to identify predictors of math-gender stereotypes. This analysis was conducted in two stages. First, separate models were estimated for youth and adults to explore how predictors behave within each subgroup. Second, a joint logistic regression model was applied to the entire sample, including a dichotomous variable to indicate whether an individual belongs to the youth or adult group. This approach facilitated direct comparison of predictors across groups and addressed potential issues arising from smaller sample sizes within subgroups. Only statistically significant variables from the bivariate level were included in the multivariable models, adhering to the principle of parsimony. However, the variable sex was retained in the multivariable model despite the significant level at the bivariate model due to its theoretical relevance in the Chilean context. All logistic regression models were conducted using sampling weights to enhance result generalisability. The term significant is used hereafter to denote statistical significance. All data analyses were performed using Stata V.17 software.

## RESULTS

### Youth's Math-gender Stereotypes

In the total youth sample, a substantial proportion of participants (81.9%; $n$ = 701) disagreed with the statement 'Girls have less ability in mathematical skills than the rest of the students', while a smaller fraction (17.1%; $n$ = 145) agreed with it. Significant differences were observed between youth who agreed and disagreed with the math-gender stereotypes statement concerning several sociodemographic factors (e.g., sex, educational level, SES) and their perception towards the role of science (e.g., the extent of science, technology, knowledge, and innovation's contribution to Chile's development in the past two years, and the balance between reliance on science and Faith). Conversely, no significant differences were found regarding age, employment status, area of residence, and beliefs about the potential benefits of science and technology in the next 20 years. Detailed frequencies and comparative analyses are provided in Table 2.

A multivariable logistic regression model, comprising five predictors, was conducted to examine the associations between these factors and math-gender stereotypes in youth (Wald $\chi^2$ (5) = 52.63, $p \leq .001$). In line with the results from the bivariate analyses, sex, educational level, SES, and two perception statements towards the role of science were observed to be significantly associated with math-gender stereotypes. More precisely, youth with higher educational achievements, more advantaged socioeconomic backgrounds, who perceive that science, technology, knowledge, and innovation have significantly contributed to Chile's development in the last two years and disagree with the notion that society depends too much on science and not enough on Faith, are less likely to endorse math-gender stereotypes. On the other hand, men are more likely to express agreement with math-gender stereotypes during this age range (see Table 3).

**Table 2**
*Bivariate antecedents gender beliefs – Youth*

| | ***Girls have less ability in mathematic skills than the rest of the students*** | | |
|---|---|---|---|
| | **Disagree *n* (%)** | **Agree *n* (%)** | **$\chi^2$ *(p)*** |
| **Sex** | | | **4.92 (.027)** |
| Men | 297 (79.6) | 76 (20.4) | |
| Women | 404 (85.4) | 69 (14.6) | |
| **Age** | | | 3.54 (.060) |
| 15-19 years | 242 (79.6) | 62 (20.4) | |
| 20-24 years | 459 (84.7) | 83 (15.3) | |
| **Educational level** | | | **19.47 (≤.001)** |
| Primary | 47 (79.7) | 12 (20.3) | |
| Secondary | 367 (78.9) | 98 (21.1) | |
| Vocational training | 104 (83.2) | 21 (16.8) | |
| University training | 183 (93.4) | 13 (6.6) | |
| **Employment status** | | | 0.27 (.603) |
| Unemployed | 408 (83.4) | 81 (16.6) | |
| Employed | 293 (82.1) | 64 (17.9) | |
| **Area of residence** | | | 0.46 (.499) |
| Urban | 582 (83.3) | 117 (16.7) | |
| Rural | 119 (81.0) | 28 (19.1) | |
| **SES - quintile** | | | **12.95 (.012)** |
| First | 204 (78.2) | 57 (21.8) | |
| Second | 190 (88.0) | 26 (12.0) | |
| Third | 87 (79.1) | 23 (20.9) | |
| Fourth | 84 (80.0) | 21 (20.0) | |
| Fifth | 136 (88.3) | 18 (11.7) | |
| **Perception towards the role of science Q1** | | | **20.07 (≤.001)** |
| Nothing | 15 (55.6) | 12 (44.4) | |
| Little bit | 97 (79.5) | 25 (20.5) | |
| Something | 261 (81.6) | 59 (18.4) | |
| A lot | 328 (87.0) | 49 (13.0) | |
| **Perception towards the role of science Q2** | | | 7.77 (.051) |
| No benefits | 13 (68.4) | 6 (31.6) | |
| Few benefits | 75 (75.8) | 24 (24.2) | |
| Lots of benefits | 238 (82.9) | 49 (17.1) | |
| Many benefits | 375 (85.0) | 66 (15.0) | |
| **Perception towards the role of science Q3** | | | **18.80 (.001)** |
| Strongly agree | 226 (82.8) | 47 (17.2) | |
| Agree | 183 (75.9) | 58 (24.1) | |
| Neither agree nor disagree | 133 (84.2) | 25 (15.8) | |
| Disagree | 70 (87.5) | 10 (12.5) | |
| Strongly disagree | 89 (94.7) | 5 (5.3) | |

*Note. N = 846; Perception towards the role of science Q1 = 'How much has science, technology, knowledge, and innovation contributed to the development of Chile in the last two years?'; Perception towards the role of science Q2 = 'Understanding benefit as the positive consequences produced by an event. How many benefits will the development of science and technology bring to our world in the next 20 years?'; Perception towards the role of science Q3 = 'How much do you agree or disagree with the following statement: we depend too much on science and not enough on Faith'; Significant differences are highlighted in bold.*

**Table 3**
*Logistic regression gender beliefs - Youth*

| | | | **95% CI for OR** | |
|---|---|---|---|---|
| **Predictors** | **OR (SE)** | ***p*** | **Lower** | **Higher** |
| **Constant** | 21.877 (17.164) | ≤.001 | 4.701 | 101.814 |
| **Sex (men)** | 2.479 (0.697) | .001 | 1.429 | 4.301 |
| **Educational level** | 0.663 (0.105) | .010 | 0.487 | 0.905 |
| **SES - quintile** | 0.672 (0.074) | ≤.001 | 0.542 | 0.834 |
| **Perception towards the role of science Q1** | 0.472 (0.084) | ≤.001 | 0.334 | 0.668 |
| **Perception towards the role of science Q3** | 0.618 (0.064) | ≤.001 | 0.505 | 0.756 |
| **Model** | Wald $\chi^2$ | df | p | Pseudo $R^2$ |
| | 52.63 | 5 | ≤.001 | .161 |

*Note. N = 846; OR = Odds Ratio; SE = Standard Error; 95 % CI for OR = 95 % Confidence Interval for Odds Ratio.*

### Adults' Math-gender Stereotypes

Within the adult sample, most participants (76.4%; $n$ = 3,851) disagreed with the statement 'Girls have less ability in mathematical skills than the rest of the students', while 23.6% ($n$ = 1,187) agreed with it. Furthermore, significant differences emerged between adults who agreed and disagreed with the math-gender stereotype statement across several sociodemographic factors (i.e., age, educational level, employment status, SES) and perception towards the role of science (i.e., how much has science, technology, knowledge, and innovation contributed to the development of Chile in the last two years?; how many benefits will the development of science and technology bring to our world in the next 20 years?; we depend too much on science and not enough on Faith). However, no significant differences were found concerning sex and area of residence antecedents. Table 4 presents detailed frequencies of math-gender stereotypes and comparative analyses based on sociodemographic factors and perceptions towards the role of science.

A multivariable logistic regression model, comprising eight predictors, was employed to examine the associations between these factors —including sex— and math-gender stereotypes in adults (Wald $\chi^2$ (8) = 154.79, $p \leq .001$). Consistent with the findings from the bivariate analyses, educational level, SES, and two perception statements towards the role of science were found to be significantly associated with math-gender stereotypes. Specifically, adults with higher educational levels, more advantaged socioeconomic backgrounds, who endorsed the idea that science, technology, knowledge, and innovation have made substantial contributions to Chile's development in the last two years, and disagreed with the idea that we depend too much on science and not enough on Faith, exhibited a reduced likelihood of endorsing math-gender stereotypes (see Table 5).

**Table 4**

*Bivariate antecedents gender beliefs – Adults*

| | ***Girls have less ability in mathematic skills than the rest of the students*** | | |
|---|---|---|---|
| | **Disagree *n* (%)** | **Agree *n* (%)** | **$\chi^2$ *(p)*** |
| **Sex** | | | 2.39 (.122) |
| Men | 1,596 (77.6) | 462 (22.5) | |
| Women | 2,255 (75.7) | 725 (24.3) | |
| **Age** | | | **59.20 (≤.001)** |
| 25-34 years | 1,001 (82.2) | 217 (17.8) | |
| 35-44 years | 817 (80.3) | 201 (19.7) | |
| 45-54 years | 705 (71.6) | 280 (28.4) | |
| 55-64 years | 674 (74.90) | 226 (25.1) | |
| 65-74 years | 455 (72.3) | 174 (27.7) | |
| ≥ 75 years | 199 (69.1) | 89 (30.9) | |
| **Educational level** | | | **163.02 (≤.001)** |
| Primary | 525 (64.4) | 290 (35.6) | |
| Secondary | 1,777 (74.2) | 617 (25.8) | |
| Vocational training | 590 (79.1) | 156 (20.9) | |
| University training | 959 (88.6) | 124 (11.5) | |
| **Employment status** | | | **27.01 (≤.001)** |
| Unemployed | 1,481 (72.7) | 557 (27.3) | |
| Employed | 2,370 (79.0) | 630 (21.0) | |
| **Area of residence** | | | 0.65 (.419) |
| Urban | 3,145 (76.7) | 957 (23.3) | |
| Rural | 706 (75.4) | 230 (24.6) | |
| **SES - quintile** | | | **139.67 (≤.001)** |
| First | 630 (64.6) | 346 (35.5) | |
| Second | 1,376 (82.2) | 299 (17.9) | |
| Third | 513 (71.7) | 203 (28.4) | |
| Fourth | 558 (75.5) | 181 (24.5) | |
| Fifth | 774 (83.1) | 157 (16.9) | |
| **Perception towards the role of science Q1** | | | **79.07 (≤.001)** |
| Nothing | 136 (67.3) | 66 (32.7) | |
| Little bit | 702 (72.8) | 262 (27.2) | |
| Something | 1,241 (72.0) | 483 (28.0) | |
| A lot | 1,772 (82.5) | 376 (17.5) | |
| **Perception towards the role of science Q2** | | | **95.41 (≤.001)** |
| No benefits | 105 (63.3) | 61 (36.8) | |
| Few benefits | 507 (66.6) | 254 (33.4) | |
| Lots of benefits | 1,196 (74.6) | 408 (25.4) | |
| Many benefits | 2,043 (81.5) | 464 (18.5) | |
| **Perception towards the role of science Q3** | | | **80.84 (≤.001)** |
| Strongly agree | 1,410 (76.7) | 429 (23.3) | |
| Agree | 1,068 (70.3) | 452 (29.7) | |
| Neither agree nor disagree | 657 (78.5) | 180 (21.5) | |
| Disagree | 340 (80.0) | 85 (20.0) | |
| Strongly disagree | 376 (90.2) | 41 (9.8) | |

*Note. N = 5,038; Perception towards the role of science Q1 = 'How much has science, technology, knowledge, and innovation contributed to the development of Chile in the last two years?'; Perception towards the role of science Q2 = 'Understanding benefit as the positive consequences produced by an event. How many benefits will the development of science and technology bring to our world in the next 20 years?'; Perception towards the role of science Q3 = 'How much do you agree or disagree with the following statement: we depend too much on science and not enough on Faith'; Significant differences are highlighted in bold.*

**Table 5**
*Logistic regression gender beliefs - Adults*

| | | | 95% CI for OR | |
|---|---|---|---|---|
| **Predictors** | **OR (SE)** | ***p*** | **Lower** | **Higher** |
| **Constant** | 4.10 (1.344) | ≤.001 | 2.157 | 7.797 |
| **Sex (men)** | 0.945 (0.104) | .609 | 0.762 | 1.173 |
| **Age** | 1.054 (0.038) | .138 | 0.983 | 1.131 |
| **Educational level** | 0.666 (0.039) | ≤.001 | 0.593 | 0.747 |
| **Employment status (employed)** | 0.871 (0.097) | .217 | 0.700 | 1.084 |
| **SES - quintile** | 0.824 (0.036) | ≤.001 | 0.757 | 0.896 |
| **Perception towards the role of science Q1** | 0.821 (0.050) | .001 | 0.728 | 0.926 |
| **Perception towards the role of science Q2** | 0.909 (0.060) | .147 | 0.799 | 1.034 |
| **Perception towards the role of science Q3** | 0.840 (0.037) | ≤.001 | 0.770 | 0.916 |
| **Model** | Wald $\chi^2$ | df | p | Pseudo $R^2$ |
| | 154.79 | 8 | ≤.001 | .075 |

*Note. N = 5,037; OR = Odds Ratio; SE = Standard Error; 95% CI for OR = 95% Confidence Interval for Odds Ratio.*

### Joint Model of adults' and Youth' Math-gender Stereotypes

Compared to youth, adults displayed significantly higher rates of math-gender stereotypes ($\chi^2 = 20.78$, $p \leq .001$). A multivariable logistic regression model was applied to the entire sample, including eight predictors, one of which was a dichotomous variable indicating whether an individual belonged to the youth or adult group. This approach facilitated direct comparison of predictors across groups in relation to math-gender stereotypes (Wald $\chi^2$ (8) = 204.03, p ≤ .001). Consistent with the findings from the separate logistic regression models, educational level, SES, and two perception statements regarding the role of science were found to be significantly associated with math-gender stereotypes. Additionally, the dichotomous variable distinguishing age groups was also significantly associated with math-gender stereotypes. Specifically, participants with higher educational levels, more advantaged socioeconomic backgrounds, those who endorsed the belief that science, technology, knowledge, and innovation have made substantial contributions to Chile's development in the last two years, and those who disagreed with the idea that society depends too much on science and not enough on Faith, exhibited a reduced likelihood of endorsing math-gender stereotypes. Conversely, adults are more likely to express agreement with math-gender stereotypes (see Table 6).

**Table 6**
*Logistic regression gender beliefs – Joint adults and youth model*

| | | | 95% CI for OR | |
|---|---|---|---|---|
| **Predictors** | **OR (SE)** | ***p*** | **Lower** | **Higher** |
| **Constant** | 4.052 (1.288) | ≤.001 | 2.172 | 7.556 |
| **Age group (adults)** | 1.576 (0.234) | .002 | 1.178 | 2.109 |
| **Sex (men)** | 1.111 (0.116) | .315 | 0.905 | 1.364 |
| **Educational level** | 0.663 (0.035) | ≤.001 | 0.598 | 0.734 |
| **Employment status (employed)** | 0.828 (0.086) | .071 | 0.675 | 1.016 |
| **SES - quintile** | 0.801 (0.032) | ≤.001 | 0.741 | 0.867 |
| **Perception towards the role of science Q1** | 0.771 (0.045) | ≤.001 | 0.687 | 0.865 |
| **Perception towards the role of science Q2** | 0.918 (0.057) | .167 | 0.813 | 1.036 |
| **Perception towards the role of science Q3** | 0.804 (0.033) | ≤.001 | 0.742 | 0.871 |
| **Model** | Wald $\chi^2$ | df | p | Pseudo $R^2$ |
| | 204.03 | 8 | ≤.001 | .082 |

*Note. N = 5,037; OR = Odds Ratio; SE = Standard Error; 95 % CI for OR = 95 % Confidence Interval for Odds Ratio.*

## DISCUSSION

The current study provides several contributions to the field of math-gender stereotypes. Specifically, the study extends previous research by (i) examining two different age groups, including youth and adults; (ii) identifying incidence rates of math-gender stereotypes (iii) and associated sociodemographic and perceptions towards the role of science factors; (iv) by using a large nationally representative dataset from Chile, a population with large gender gaps in math performance. Therefore, findings offer new insights into understanding math-gender stereotypes across different age groups and shed light on factors associated with math gender disparities. Research and practical implications are discussed next.

First, our results demonstrate that while most youth and adult respondents do not endorse the statement *'Girls have less ability in mathematical skills than the rest of the students'*, an important percentage does, which aligns with our study hypothesis (del Río et al., 2019, 2021; Espinoza & Taut, 2016, 2020; Hand et al., 2017; Starr & Simpkins et al., 2021). Among adults, 23.6% agree with this statement, and a slightly smaller percentage of young individuals also endorse it (17.1%),

comprising around 20% of the population holding math-gender stereotypes that undermine the mathematical abilities of girls. This finding is noteworthy, considering that the question was a direct self-report query susceptible to social desirability bias. Nevertheless, a significant distinction emerges between the responses of youth and adults, with a lower percentage of young individuals endorsing these stereotypes. This discrepancy could be attributed to the stronger inclination of young people towards gender egalitarian beliefs (Scarborough et al., 2019), which leads to their reduced tendency to support gender-based stereotypes. For example, in Chile and other countries, feminist movements since 2018 have emphasised the importance of transcending gender social norms and stereotypes that restrict the expression of both women and men. Young people, particularly female higher education students, have been the main protagonists of these movements (Silva-Tapia & Fernández Ossandón, 2022). This result aligns with our hypothesis and the findings of two studies conducted among adults and adolescents in North America (Morrissey et al., 2019; Starr & Simpkins, 2021). Thus, it suggests that adults' higher endorsement of math-gender stereotypes may be a global trend.

Regarding socio demographic antecedents related to the likelihood of agreeing with math-gender stereotypes, both adults and youth share certain similarities. More precisely, individuals from both age groups with higher educational attainment and more advantaged socioeconomic backgrounds are less likely to endorse math-gender stereotypes. Our findings align with previous research in Chile and other countries, showing that adults and youth from lower SES tend to hold more math-gender stereotypes (del Río et al., 2016; Su et al., 2023). Additionally, considering that educational level and SES can overlap in Chile, given that individuals facing greater economic vulnerability often attain lower academic levels (Valenzuela et al., 2014), it was not surprising that those with higher educational levels were less likely to agree with math-gender stereotypes.

Furthermore, regarding beliefs about the importance of science, the study's findings also reveal similarities between adults and youth. Specifically, a consistent pattern emerges: the greater the importance placed on the role of science, the lower the likelihood of agreeing with math-gender stereotypes, observed across both adult and young populations. This finding aligns with previous research suggesting that positive perceptions of the social relevance of science may contribute to reducing gender stereotypes in STEM fields and extends this effect to math-gender stereotypes specifically (Kyte & Riegle-Crumb, 2017; Smyth & Nosek, 2015). This effect could be explained by the fact that science promotes critical reflection, potentially encouraging individuals to consider evidence that refutes math-gender stereotypes (Kyte & Riegle-Crumb, 2017; Truffa, 2012). Therefore, future studies should continue exploring attitudes toward science and science capital when exploring math-gender stereotypes, and the intersection with sociodemographic factors across different age groups.

Despite shared sociodemographic characteristics and perceptions towards science, a noteworthy distinction emerged between adults and youth in this study. Specifically, sex was a significant predictor for youth but not for adults. Moreover, when youth and adults were analysed jointly, sex was not a significant predictor. Young males exhibited a 147.9% higher probability of endorsing math-gender stereotypes compared to young females. This finding aligns with previous research suggesting that the influence of sex on gender-stereotypes diminishes in adulthood (Nosek & Smyth, 2011; Woods et al., 2022). Additionally, it is consistent with findings from a prior Chilean study involving higher education students, which revealed that male students were more likely to adhere to gender stereotypes in various areas of knowledge, including STEM fields, than their female counterparts (Espinoza & Albornoz, 2023). Therefore, these results emphasise that while young individuals might exhibit a greater inclination towards gender-egalitarian beliefs (Scarborough et al., 2019) and demonstrate lower incidence rates of math-gender stereotypes, gender-related beliefs remain linked to the sex of youth, a characteristic unique to this age group. Future research with a longitudinal focus should continue exploring this notable difference to determine whether it is due to cohort effects (i.e., different social and cultural trends experienced throughout their lives) or developmental effects (i.e., being at different stages of development).

In summary, the study findings underscore that youth and adults have some similar predictors associated with math-gender stereotypes (i.e., educational levels, SES, perception towards science). Socioeconomic disadvantages emerge as prominent antecedents across groups for the endorsement of math-gender stereotypes. This is particularly concerning in the Chilean context since lower SES has been associated with lower educational levels, poorer access to educational resources, and worse math academic achievement. Therefore, it is suggested to continue exploring individuals who face more social disadvantages in order to promote equal opportunities for the development of math and STEM trajectories. Additionally, young individuals exhibit a distinct characteristic not observed in adults (i.e., sex), highlighting the importance of individually investigating predictors for each age group. These groups can differ not only in their presentation (e.g., incidence rates) but also in the underlying factors that contribute to them. Overall, the results contribute to a better understanding of the extent to which math-gender stereotypes persist within the Chilean population, with a novel effort to understand math-gender stereotypes across different ages characterised by diverse features.

**Strengths and Limitations**

The present study has several strengths, including using a large representative study from Chile, a country characterised by prominent gender gaps in math performance. Moreover, this study used a novel approach of using two different age groups to explore math-gender stereotypes, furthering our understanding of incidence rates of these stereotypes and the common and unique factors associated with each group.

Nonetheless, certain limitations warrant consideration. First, the assessment of adult and youth math-gender stereotypes relied solely on a single self-reported question. This approach might not represent the full spectrum of stereotypes experienced within these cohorts. However, the ENPSC dataset only included two questions related to gender beliefs. The other question *('in Chile, women have the same possibilities of becoming researchers as other genders')* did not exclusively evaluate math-gender stereotypes. Additionally, the phrasing of this potential question proved

ambiguous, potentially leading to interpretational challenges. It could be interpreted as either an acknowledgement of structural barriers impacting gender-based opportunities or a belief in varying skill levels among genders when pursuing research careers. Consequently, the decision was made to retain the usage of a single question to gauge math-gender stereotypes. Future iterations of the ENPSC dataset could incorporate a more comprehensive array of questions exploring math and science-gender stereotypes within diverse contexts (e.g., educational settings, interactions at home, ability, interests and motivation, and professional prospects). Associated with this limitation, the employed question adopted a direct self-report format susceptible to social desirability bias. Hence, results might obscure a larger percentage of participants who agree with math-gender stereotypes. Additionally, since the variable was dichotomised, the variability of responses may have been limited. Thus, future research could expand upon these findings by incorporating alternative methodologies to counteract social desirability bias, such as employing broader measurement techniques (such as questionnaires using vignettes) or adopting mixed-methods approaches to better capture nuanced stereotypes. Thirdly, the attrition rate after the stereotype variable was dichotomised could have impacted the representativeness of the sample. Therefore, sampling weights were employed to adjust the distribution, aligning it more closely with population characteristics and enhancing the generalisability of the results. Finally, the study utilised different sample sizes for the youth and adult groups, with a significantly smaller number representing young people. Nevertheless, both groups exhibited sufficient statistical power to evaluate the study hypotheses.

### Practice Implications

Notwithstanding the limitations and acknowledging the strengths of this study, the findings have important practical implications, especially for the development of educational initiatives and public policies aimed at promoting gender equality and the appreciation of math and science from an early age. First, the results indicate a higher adherence to gender stereotypes among adults than young people. Consequently, it is relevant to implement initiatives that target these stereotypes early in development. Public policies should focus on using mass media to dispel the belief in differential abilities between boys and girls, emphasising the adverse effects of math-gender stereotypes on children's learning and development, as well as on society as a whole. These initiatives could play an important role in shaping gender-neutral perceptions of ability, helping to foster a more equitable educational environment.

Additionally, considering the associations between positive perceptions of the role of science and math-gender stereotypes in adults and youth, public policies should increase the visibility of scientific advances and their benefits to the broader public, transferring knowledge in an accessible form for the entire population. These initiatives should feature equal gender representation and could be tailored to different age groups to promote engaging and relevant content to diverse people. Given that math-gender stereotypes become more prevalent with age, it is crucial to prompt these initiatives early in development to prevent the emergence of these beliefs, with a particular focus on boys and young males.

Furthermore, these findings emphasise the importance of education, in general and scientific domains, as a potential mechanism for reducing math-gender stereotypes. Promoting high-quality, and non-sexist math and science education for both girls and boys becomes highly relevant in this context. Consequently, it is essential to encourage pedagogical practices in schools that offer equal learning opportunities in math and science and set learning expectations without gender bias. For example, integrating a gender perspective into teacher training programs —both initial and continuous— would ensure that future generations of educators are better equipped to promote a non-sexist approach to teaching, particularly in math and science. This is especially important in countries like Chile, where sexist beliefs and pedagogical practices are still prevalent in secondary and higher education (Espinoza & Albornoz, 2023; Espinoza & Taut, 2016). Therefore, emphasising initiatives that specifically incorporate a gender perspective into math and science teaching is important for addressing the substantial gender disparities in math (Leder, 2019). Considering the impact of SES on adherence to math-gender stereotypes, these efforts are particularly vital for individuals from lower SES backgrounds. Policies that target these groups could help bridge educational gaps and ensure that gender equality initiatives reach those most affected by educational inequalities.

## CONCLUSION

Math-gender stereotypes are widely recognised as a contributing factor to the global underrepresentation of women in STEM fields. Given the pronounced gender disparities in math performance in Chile, this study investigated math-gender stereotypes across two age groups: youth and adults. We also examined factors associated with their incidence, including sociodemographic characteristics and perceptions regarding the value of science. Findings reveal the presence of math-gender stereotypes in adults and youth, albeit with varying degrees (adults exhibited higher levels than youth). In terms of associated factors, the value towards science and socioeconomic disadvantages emerged as prominent precursors across groups. Therefore, it is recommended to further explore individuals facing economic disadvantages to promote a more equitable participation of men and women in math. Additionally, sex differences, especially in younger stages, suggest the need for tailored efforts to reduce math-gender stereotypes. Study implications suggest strengthening the gender perspective in education, particularly within the realm of math and scientific subjects.

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