



Women in Academia and Research: An Overview of the Challenges Toward Gender Equality in Colombia and How to Move Forward

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Throughout history and over the last years, women have strongly intended to play central roles in addressing major aspects of the world's most urgent problems such as global poverty, health, and climate change. Women have been in a continuous effort to promote health, educational, and environmental sustainability programs. In exchange, women are facing countless obstacles to ensure gender equality. Colombia has until recently been highly affected by decades of violent armed conflicts which had a huge impact on the general community of the country. Today, peace processes bring a new hope for the country, however, several social problems still persist. One of these problems is gender inequality that systematically hampers the ability of women to progress and develop their full potential. Colombia should be a country where men and women are treated equally and with justice. Instead women rights are still being continuously affected by violence, social exclusion, exploitation, and discrimination. Gender inequality creates a big barrier that needs to be overcome by women that want to effectively contribute to a so necessary development of Colombia. Science is not an exception on the field of gender-equality, being a great disparity between men and women present in the Colombian scientific community. In this review we discuss the hurdles that scientific women face in Colombia. Furthermore, and by learning from the experiences of some successful female Colombian scientists, we shed new lights on how women can overcome these challenges. We will also show how these female scientific leaders from different disciplines have combined efforts to build a better country with regards to science, education, technology, and innovation. Lastly, we propose new ways to reach gender equality in the scientific community. We hope that this review will motivate many young female scientists to invest in their careers, and ultimately help in the social development of Colombia.

Keywords: Colombia, gender equality, women, science, career

Scientific research does not know borders and brings together scientists with different backgrounds and areas of expertise (Tobin, 2017). The strategy that prevails amongst the scientific community is to work in a collaborative manner regardless of the characteristics of each individual contributor. In our opinion, is this fusion of all types of ideas and personal perspectives that creates novelty in science and helps on improving scientific paradigms. However, gender diversity is still limited across distinct scientific fields. According to the UNESCO Institute for Statistics (UIS), women

represent just 28.8% of the worldwide science researchers. In this review we will focus on the gender inequalities in Colombia where women only represent 37.8% of the countries' researchers (UNESCO Institute for Statistics, 2017).

Taking a deeper look into the different research fields in Colombia, it is a concern that women are considerably underrepresented in all disciplines with an exception for medical and health sciences where women account for the highest percentage of participation with 59.6%. The participation of women in natural sciences (28.2%), engineering and technology (18.4%), agricultural sciences (37.6%), social sciences (46.4%), and humanities and arts (27.1%) highlights the many challenges that women face in these areas (UNESCO Institute for Statistics, 2014). Political, economic and socio-cultural factors contribute to this gender disparity in science. In order to find solutions, we must aim for a deeper understanding of the factors that interfere with women's development following a scientific career.

THE 50 YEARS ARMED CONFLICT IN COLOMBIA

The armed conflict between the Colombian government and the Revolutionary Armed Forces of Colombia (FARC) with more than 50 years of duration was the oldest in western countries (BBC, 2016). This conflict has been tragic and devastating for Colombia, with over 260,000 people killed and more than 7 million displaced (Colombian National Information Network, 2017). On November 2016, a final peace agreement was signed (Alto Comisionado para la Paz, 2016), bringing a new wind that is already blowing in a country greatly affected by decades of war. The improvement of the living conditions, specially of rural communities highly vulnerable during the armed violence, and the boost of Colombian economy are some of the challenges that need to be urgently addressed during the post-conflict era we are living in (Pérez Correa and Pérez Martínez, 2002; Higuera and Ramírez, 2018). However, important these economic developments might be, we also expect that the peace will bring a renewed effort for gender equality in Colombia. As expressed by the United Nations Secretary-General Ban Ki-moon while attending the ceremony for the signing of the Colombian peace agreement "The agreements promise not only to stop the armed conflict, but to create the conditions for lasting peace based on equitable development, human rights and inclusion. These agreements envision a peace that values and ensures the participation of women, and a future in which there is room in politics for all, but no room in politics for violence" (UN Women Americas the Caribbean, 2016). Around four millions of women were victims of the armed conflict (Colombian National Information Network, 2017). Besides, more than 55% of the total internally displaced persons (IDPs) in Colombia were constituted by young girls and women (WCRWC, 2003). According to the 2000 UNDP Human Development Report, 60–70% of Colombian women have suffered from psychological, physical, or sexual violence (Amnesty International, 2004). Contributing to these numbers are the women which were victims of the

armed conflict, especially those internally displaced, as they are more vulnerable to sexual violence (Amnesty International, 2004).

The scientific community was also strongly affected by the Colombian armed conflict. For example, many different regions of the country were occupied by the armed group FARC, reason why it was impossible for some of the Colombian scientists to visit and preserve these unexplored areas rich of biodiversity (Brigida, 2016; Wade, 2016, 2018). Moreover, during the conflict, resources designated to science were really scarce. This is clearly highlighted by the UNESCO Institute for Statistics, which shows that in 2014 only 0.25% of Colombia's gross domestic product (GDP) was spent on research and development (R&D) (UNESCO Institute for Statistics, 2014). Most importantly, this violent conflict had severe implications on the psychological state not only of the victims but also, of the general Colombian population. Several risk factors affected people's quality of life and mental health, including the high number of homicides and kidnappings, the forced displacement and the damages caused by the antipersonnel mines (Franco et al., 2006). Studies from Bell et al. (2012) shows that the mental health of civilians experiencing conflict related violence in Colombia was associated to anxiety disorders. Moreover, risk factors such as suicide risk, depression, and aggression were also experienced by those civilians directly linked to the conflict but even more in those which did not have a direct experience but they were suffering from its derived effects (Bell et al., 2012).

The difficult peace agreement signed on 2016 should be the base to achieve a change on the Colombian society, removing all aspects associated to gender inequality including gender based-violence. The action of different government entities is required for the establishment of laws that can effectively ensure the respect for the continuously violated women's rights. Significant progress has been made by the Colombian government on the implementation of laws which aim to promote gender equality and to protect the rights of women (UN Women Americas and the Caribbean, 2013). For example, Law 1257 of 2008, Law of Gender equality (Ley de Igualdad de Género), Law 1448 of 2011, Law of Victims and Land Restitution (Ley de Víctimas y Restitución de Tierras), and the law 1719 of 2014 which guarantee access to justice for women sexually assaulted during the armed conflict (ABColumbia, 2013). All these laws previously mentioned show a huge progress on the protection of women's rights, however, their implementation has not been sufficiently effective (The Working Group to Monitor Compliance with Constitutional Court Auto 092 009 its Confidential Annexes, 2016). Gender equality in science is achieved when men's and women's work is run by the same rules, they are both able to develop their knowledge and research under the same conditions and they have the same opportunities to access high level job positions. In the world, and more specifically in Colombia, gender equality in science does not exist with many different challenges being faced particularly by women within the scientific community. Some of these obstacles will be discussed in the next sections of this article.

BREAKING DOWN SOCIAL STEREOTYPES

Gender roles or gender stereotypes can be defined as “socially and culturally defined prescriptions and beliefs about the behavior and emotions of men and women” (Anselmi and Law, 1998). Society is continuously expecting men and women to act and behave in certain ways according to already defined stereotypes (Eagly, 1987), harming both men’s and women’s development (Kahalon et al., 2018). Women’s identities get influenced by these damaging gender stereotypes limiting women’s personal ways of thinking, acting, and creating (Heilman, 2012).

Gender stereotypes are present from personality traits to academic choices (Heilman, 2012). The division of men’s and woman’s gender roles start at home, from an early age, when girls are offered to play with dolls and boys with racing trucks (Chick et al., 2002; Freeman, 2007). It does not help that the media are advertising the same idea to kids and their parents by producing adverts that promote these gender roles (Freeman, 2007). “Marketing worldwide, as in a globalized economy marketing ideas diffuse quickly, should be neutral and it should not reinforce gender stereotypes (Wood, 1994).” Parents must understand that different toys can help in the development of the cognitive skills of the kid (Blakemore and Centers, 2005). “Dolls are for girls and trucks for boys,” “this is a boy toy or a girl toy,” “you can’t play with that toy because you’re a boy/girl” are sentences that not only define kid choices and preferences, but that also influence the children’s way of thinking by following a certain behavioral pattern (Jadva et al., 2010; CNN, 2015). The use of pink princess dress costumes and toys related to make up, heels, baby dolls, kitchens, soft toys and flowers in the case of girls and blue clothes, dinosaurs, soldiers, toolkits, weapons, and balls in the case of boys implies that girls possess a soft character and are just designed to perform domestic work. Conversely, it suggests that boys can only perform activities that require strength or those relative to mechanics and engineering (Blakemore and Centers, 2005; Murnen et al., 2016).

Similar situation is encountered in schools with the existence of the negative stereotype that boys are better in math and science than girls (Spencer et al., 1999; Chatard et al., 2007; Kiefer and Sekaquaptewa, 2007). The Organization for Economic Co-operation and Development (OECD) coordinates the Program for International Student Assessment (PISA), which evaluates the performance of girls and boys with 15–16 years old in the subjects of science, reading, and mathematics. Moreover, PISA also assesses how the obtained results associate with demographic, social, economic, and educational variables (OECD, 2016a,b). In Colombia, 15–16 years old boys had, on average, a better performance in science and mathematics. In contrast, girls outperformed boys in reading. The above mentioned study associated these results to several causes including the socio-economic status of the students and the school infrastructures. Schools with better infrastructures or those schools offering extracurricular science activities have students which are expected to have higher scores in the corresponding subjects (OECD, 2016a,b). Besides these explanations, we want to question the direct role of the teachers in this type of results. Several studies have demonstrated that the gender gap observed in mathematics is associated to the teachers having lower

expectations for girls when compared to boys even when both have shown to be equally proficient in the subject (Fennema et al., 1990; Jussim and Eccles, 1992; Keller, 2001; Robinson-Cimpian et al., 2014; Lavy and Sand, 2015; Cimpian et al., 2016). These unjustified lower expectations generate a confidence decrease on girls that can be observed in their worse performance in these areas and that can greatly influence their future career choices. Both teachers and parents, must have a positive reinforcement in boys and girl’s decisions as they have a direct influence on their life choices.

Arriving to adulthood the scenario of discrimination remains. Colombian women working both inside and outside of Colombia, suffer from a virgin/whore dichotomy where women that choose to give importance to family life are seen as a failure at work and women that choose to focus on their work life are seen as selfish individuals with lack of family commitment. Constantly, female appearance, sexuality, and motherhood are confused with value, career engagement, and moral integrity, leading to a climate that often discourages women to effectively pursue their professional dreams.

ACADEMIC CAREER DISTINCTION FOR MEN AND WOMEN

It has been previously shown that for the moment young women decide to pursue an academic career, there is a clear distinction between the careers women pick based on gender beliefs (Correll, 2001). Women are thought to be less likely to enter Science, Technology, Engineering, and Mathematics careers because their aspirations are affected by gender stereotypes that state that only men are capable of pursuing math, science, and engineering careers (Hill et al., 2010; Wang and Degol, 2013). To analyse if this holds true for Colombian women, we interrogated data from the Labor Observatory for Education from the Colombian National Ministry of Education on the number of total graduates from higher education institutions divided by gender and degree type over two time periods (from 2001 to 2010 and from 2011 to 2014) (Labor Observatory for Education)¹. A summary of the data extracted from this governmental source can be seen in **Tables 1, 2**. Interestingly, according to the data analyzed, women graduated more than men in Colombia in the two time periods, constituting around 55% of graduates. Women also surpassed men in the majority of the research areas including, to our surprise, on mathematics and natural sciences (with women accounting for marginally more than 50% of the graduates on these areas on both analyzed periods). However, women’s underrepresentation was still observed in areas usually stereotypically defined as men areas as agronomy and veterinary (only 39% of women in the years 2001–2010 and 44% from 2011 to 2014) and in engineering, architecture and urbanism degrees (36 and 34% of women presence in the periods of 2001–2010 and 2011–2014, respectively; **Tables 1, 2**).

After analyzing the gender distribution of the total graduates, we were also interested in evaluating how women were

¹Labor Observatory for Education. *Colombian National Ministry of Education*. Available online at: <http://www.graduadoscolombia.edu.co/html/1732/w3-channel.html>

TABLE 1 | Percentage of total graduates from undergraduate and graduate programs at higher education institutions in Colombia, divided by gender and academic discipline for the time (2001–2010).

Academic discipline	Period 2001–2010					
	Total graduates %		Master %		Doctorate %	
	Men	Women	Men	Women	Men	Women
Agronomy and veterinary sciences	60.8	39.2	54.9	45.1	57.4	42.6
Medical and health sciences	28.4	71.6	37.0	63.0	47.3	52.7
Fine arts	47.2	52.8	56.3	43.7	0.0	0.0
Education sciences	32.4	67.6	41.6	58.4	54.2	45.8
Social and human sciences	46.9	53.1	52.2	47.8	67.9	32.1
Mathematics and natural sciences	46.0	54.0	54.8	45.2	65.8	34.2
Economy, administration, and accounting	39.8	60.2	61.7	38.3	75.0	25.0
Engineering, architecture, and urbanism	63.7	36.3	68.6	31.4	80.5	19.5
Total	45.5	54.5	55.2	44.8	66.4	33.6

Data was extracted from *The Labor Observatory for Education from the Colombian National Ministry of Education*.

TABLE 2 | Percentage of total graduates from undergraduate and graduate programs at higher education institutions in Colombia, divided by gender and academic discipline for the time (2011–2014).

Academic discipline	Period 2011–2014					
	Total graduates %		Master %		Doctorate %	
	Men	Women	Men	Women	Men	Women
Agronomy and veterinary sciences	56.3	43.7	56.0	44.0	59.1	40.9
Medical and health sciences	29.0	71.0	33.3	66.7	38.8	61.2
Fine arts	47.9	52.1	54.0	46.0	60.0	40.0
Education sciences	33.9	66.1	40.3	59.7	54.6	45.4
Social and human sciences	47.2	52.8	49.8	50.2	60.9	39.1
Mathematics and natural sciences	47.6	52.4	56.9	43.1	59.2	40.8
Economy, administration, and accounting	36.4	63.6	58.0	42.0	74.3	25.7
Engineering, architecture, and urbanism	65.7	34.3	68.0	32.0	73.9	26.1
Total	45.0	55.0	52.3	47.7	61.7	38.3

Data was extracted from *The Labor Observatory for Education from the Colombian National Ministry of Education*.

progressing in their studies. For that we specifically looked at the percentage of women that followed master and doctoral degree programs. In contrast to the undergraduate studies, women were underrepresented in the total of master (44.80% in 2001–2010 and 47.68% in 2011–2014) and doctoral studies (33.58% in 2001–2010 and 38.28% in 2011–2014; **Tables 1, 2**). This underrepresentation was observed in the majority of degree areas with the notable exception of medical sciences. In some areas this underrepresentation assumed worrying proportions as, for example, for doctorates in engineering, architecture and urbanism degrees where women accounted just for 20% (2001–2014) and 26% (2011–2014) of total degrees (**Tables 1, 2**). However, it is important to note that comparing the two periods of time evaluated, the overall situation is improving giving us hope that, while subtly, the situation could be changing (Labor Observatory for Education)¹.

JOB POSITIONS AND SALARIES

It is not only in education that gender differences exist. They remain across different job aspects as salary, place of work, employment conditions, leadership positions, among others. In general, statistics demonstrate the underrepresentation of Colombian women in research positions in academic institutions (38%), the public sector (37%), and the private sector (29%) (UNESCO Institute for Statistics, 2014). Importantly, the lower percentage of women participation is in the private sector where salaries are higher and working conditions are better and more stable (Pinker, 2009; Ohio State University News, 2016). This unequal situation persists in scientific leadership, due to the absence of women in high-ranking positions (Linehan and Scullion, 2008; Howe-Walsh and Turnbull, 2014). Work done by Gutiérrez (2012), shows that only 33.6% of scientific groups in Colombia are led by female researchers

(Gutiérrez, 2012). All this lower representation of women in research positions is then reflected in the amount of research publications, with several studies having found that in science men publish more than women (Xie and Shauman, 1998; Lee and Bozeman, 2005; Abramo et al., 2009; Rorstad and Aksnes, 2015). The situation becomes critical because, without female leaders, there is a clear lack of women mentors and role models. We believe that good women mentors are key to reach gender equality in Colombian science (Linehan and Scullion, 2008). Good mentor activities include helping the mentee in: career advancement; building confidence and motivation; trying to avoid negative labels and stereotypes; achieving critical thinking; becoming a new mentors (Wright and Wright, 1987; Anderson, 2005; Dworkin et al., 2012).

Women are not only less represented in research, but they also receive less payment. The persistent gender salary gap is clear in the information provided by the Labor Observatory for Education and the salaries received by recently graduated people in three different periods of time was taken to illustrate this point (Figure 1). The information obtained corresponds to the average salary by gender in the years of 2007, 2011, and 2016 for the graduated people in 2006, 2010, and 2015, respectively. It is observed that generally, the salaries are higher for the

people recently graduated from postgraduate programs when compared to those graduated from undergraduate programs, which is consistent with the corresponding increase in education level (Figure 1). However, what is worrying is that the average salary by gender for the 3 years analyzed is higher for men than for women with the only exception being observed in 2016, for the postgraduate program named technical professional specialization. Sadly, this type of results is recurrent in Colombia with a study performed by Cepeda Emiliani and Barón (2012), describing a salary gap based on gender. The authors in the paper attribute this gap to different degree subjects chosen by men and women (Cepeda Emiliani and Barón, 2012). In accordance with the mentioned authors our analysis observed differences in the salary gap based on area of degree (Tables 3, 4).

Data from the Labor Observatory for Education, shows that in 2016, for undergraduate programs, the highest gender pay gap is found in graduates from Medical and Health Sciences degrees at university (17.2%) and the lowest gender pay gap corresponds to the graduates from fine arts at professional technical level (-3.5%; Table 3). In the case of postgraduates programs, the highest gender pay gap is found in graduates from engineering, architecture, and urbanism degrees (37.6%) at technical level specialization. Contrastingly, the lowest pay

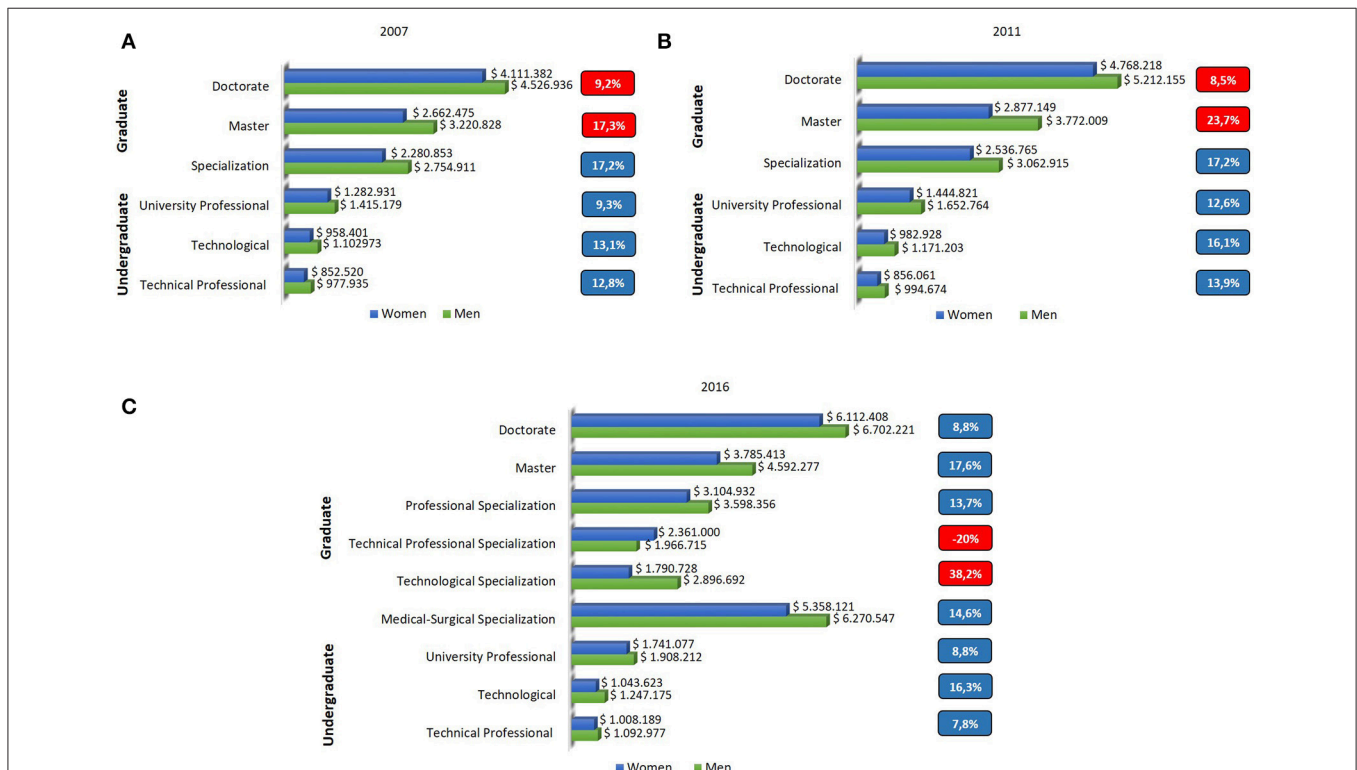


FIGURE 1 | (A) Average salaries in 2007 for graduates from undergraduate and postgraduate programs in 2006 from higher education institutions in Colombia, divided by gender. **(B)** Average salaries in 2011 for graduates from undergraduate and postgraduate programs in 2010 from higher education institutions in Colombia, divided by gender. **(C)** Average salaries in 2016 for graduates from undergraduate and postgraduate programs in 2015 from higher education institutions in Colombia, divided by gender. The percentage of salary gap is shown in the right panel of the graph for each year. The highest and the lowest percentage of salary gap are shown in red. Data was extracted from The Labor Observatory for Education from the Colombian National Ministry of Education.

TABLE 3 | Salaries in 2016 of graduates from undergraduate programs in 2015 at higher education institutions in Colombia, divided by gender and academic discipline.

Undergraduate-2016				
Level of education	Academic discipline	Men	Women	Salary gap (%)
Technical professional	Agronomy and veterinary sciences	\$845.134	\$781.159	7.6
	Fine arts	\$1.005.027	\$1.040.127	-3.5
	Education sciences	\$1.226.379	\$1.253.728	-2.2
	Medical and health sciences	\$1.053.026	\$1.018.333	3.3
	Social and human sciences	\$1.000.364	\$982.262	1.8
	Economy, administration, and accounting	\$1.037.429	\$991.439	4.4
	Engineering, architecture, and urbanism	\$1.184.409	\$1.048.399	11.5
	Mathematics and natural sciences	\$818.463	\$733.058	10.4
Technological	Agronomy and veterinary sciences	\$1.028.113	\$916.039	10.9
	Fine arts	\$1.153.669	\$1.035.303	10.3
	Education sciences	\$1.078.287	\$952.233	11.7
	Medical and health sciences	\$1.251.184	\$1.045.292	16.5
	Social and human sciences	\$1.107.237	\$985.324	11.0
	Economy, administration, and accounting	\$1.187.609	\$1.036.638	12.7
	Engineering, architecture, and urbanism	\$1.309.102	\$1.094.276	16.4
	Mathematics and natural sciences	\$1.253.969	\$1.094.255	12.7
University professional	Agronomy and veterinary sciences	\$1.387.784	\$1.260.356	9.2
	Fine arts	\$1.459.363	\$1.473.214	-0.9
	Education sciences	\$1.414.650	\$1.289.175	8.9
	Medical and health sciences	\$2.892.398	\$2.395.145	17.2
	Social and human sciences	\$2.070.437	\$1.826.973	11.8
	Economy, administration, and accounting	\$1.801.913	\$1.601.534	11.1
	Engineering, architecture, and urbanism	\$1.901.622	\$1.722.095	9.4
	Mathematics and natural sciences	\$1.865.435	\$1.903.405	-2.0

The percentage of salary gap was assigned for each academic discipline. Data was extracted from *The Labor Observatory for Education from the Colombian National Ministry of Education*.

gender gap corresponds to the same degree type (-19.3%) but at professional technical level specialization (Table 4). Nevertheless, independently of the possible causes and while acknowledging a noticeable reduction on the gender pay gap from 2011 to 2016, we consider that there are still big gender-based salary differences in Colombia that need to be mitigated with the utmost importance.

NEW PERSPECTIVES

The data compiled in this article depicts a scenario where gender discrimination is clearly hampering the progression of Colombian women in research careers. However, there are some lights in the end of the tunnel as we can see that the country has done some progress throughout the recent years. When we look into the total percentage of graduates from higher education institutions, we observe a higher percentage of women being graduated compared to men for the two examined periods (Labor Observatory for Education)¹. In the decade 1990-1999, the situation was similar, except in the year 1998, where the percentage of graduate men was slightly higher than the women's (51 and 49%, respectively; Wills, 2007). Thus, it is clear that for the last 30 years more women finish higher education

degrees than male peers in Colombia, so gender inequality is not observed here as women have been continuously motivated to follow their studies and pursue a higher education degree. However, something is hampering the complete development of women's potential in research as a gender gap is clearly observed in the percentage of women following master and doctoral studies (Tables 1, 2; Labor Observatory for Education)¹. Despite the persistence of this gap, the number of women researchers has slightly increased in the past years going from 34.7% in 1997 up to 37.3% in 2014 (UNESCO Institute for Statistics, 2014). Though remarkable, this observed progress in gender equality is clearly insufficient and focus needs to be put on supporting women on following postgraduate degrees in order to achieve a more equal research community in Colombia.

To start tackling this unbalanced situation, universities and research institutions must promote diversity and break the barriers of traditional gender roles. It has been shown that gender diversity in research teams can bring benefits and enhance scientific work (Nielsen et al., 2017). Also the schools and the parents, as mentioned previously, play a very important role in this situation. They both should promote the interest of girls in all different subjects to ensure that their future career decisions are based on their preferences. First of all, teachers should promote

TABLE 4 | Salaries in 2016 of graduates from postgraduate programs in 2015 at higher education institutions in Colombia, divided by gender and academic discipline.

Graduate-2016					
Level of education	Academic discipline	Men	Women	Salary gap (%)	
Medical-surgical specialization	Medical and health sciences	\$6.270.547	\$5.358.121	14.6	
	Technological specialization	Medical and health sciences	\$2.701.333	\$1.763.841	34.7
Technical professional specialization	Engineering, architecture and urbanism	\$2.955.300	\$1.844.500	37.6	
	Engineering, architecture and urbanism	\$1.978.613	\$2.361.000	-19.3	
University specialization	Agronomy and veterinary sciences	\$2.767.061	\$2.285.844	17.4	
	Fine arts	\$2.870.375	\$2.099.934	26.8	
	Education sciences	\$2.416.604	\$2.257.574	6.6	
	Medical and health sciences	\$3.154.197	\$2.755.135	12.7	
	Social and human sciences	\$3.839.818	\$3.480.515	9.4	
	Economy, administration, and accounting	\$3.765.406	\$3.149.034	16.4	
	Engineering, architecture, and urbanism	\$3.316.178	\$2.858.039	13.8	
	Mathematics and natural sciences	\$3.625.662	\$2.898.764	20.0	
	Master	Agronomy and veterinary sciences	\$3.400.344	\$2.937.331	29.6
		Fine arts	\$3.520.467	\$2.791.920	13.6
Education sciences		\$3.273.054	\$2.914.587	20.7	
Medical and health sciences		\$4.075.859	\$3.714.862	11.0	
Social and human sciences		\$4.728.179	\$4.176.613	8.9	
Economy, administration, and accounting		\$6.221.505	\$5.173.373	11.7	
Engineering, architecture, and urbanism		\$4.199.550	\$3.534.697	16.8	
Mathematics and natural sciences		\$3.428.819	\$3.030.705	15.8	
Doctorate		Agronomy and veterinary sciences	\$7.232.070	\$5.801.667	11.6
		Fine arts	\$4.706.389	\$5.484.000	19.8
	Education sciences	\$6.617.512	\$6.072.157	-16.5	
	Medical and health sciences	\$8.140.445	\$5.474.243	8.2	
	Social and human sciences	\$7.068.302	\$6.922.358	32.8	
	Economy, administration, and accounting	\$6.833.966	\$6.396.786	2.1	
	Engineering, architecture, and urbanism	\$6.446.110	\$6.642.784	6.4	
	Mathematics and natural sciences	\$6.058.592	\$5.257.364	-3.1	

The percentage of salary gap was assigned for each academic discipline. Data was extracted from *The Labor Observatory for Education from the Colombian National Ministry of Education*.

gender equality in their classrooms and have the same academic and behavior expectations from all students (Hill et al., 2010). Moreover, the parents should promote girl's scientific curiosity by engaging them in extracurricular activities involving STEM topics (Dasgupta and Stout, 2014). Once at the workplace the difficulties for scientific women continue. Work by Heilman et al. (2004), shows that women are disliked when they are successful in jobs that, based on gender stereotypes, are just for men. For this situation, the author encourages women to continue doing work with high levels of competence independently of the negative social responses (Heilman et al., 2004; Hill et al., 2010). Obviously, men and women have the self-confidence, aggressiveness and competitiveness required to reach top-level positions in science.

Besides these important but unstructured actions, there are, as well, other more global initiatives trying to reach gender equality. One example is the establishment of February 11th as The International Day of Women and Girls in Science by the resolution A/RES/70/212 from the United Nations General

Assembly (United Nations)² Colombian institutions should take advantage of these type of initiatives in order to perform the difficult but crucial task of raising awareness of gender bias across STEM fields (Moss-Racusin et al., 2014; Handley et al., 2015). Furthermore, these initiatives should try to increase the visibility of successful scientific women that would, by this increased visibility, become role models to stimulate girls to follow scientific careers (UNESCO, 2016). In this respect, it is really important to highlight the work of the Colombia Women Scientific Network (Red Colombiana de Mujeres Científicas) which promotes and stimulates the participation of Colombian women in science and technology. Similarly, but at the world level, it is important to mention the "L'Oréal-UNESCO for Women in Science International Awards program" which supports women in science and already recognized the work of

²United Nations. International Day of Women and Girls in Science 11 February. Available online at: <http://www.un.org/es/events/women-and-girls-in-science-day/>.

Colombian scientists. Lastly, it is crucial that once and for all the Colombian government adopts policies to protect women human's rights and to ensure gender equality in research and in all aspects of a women's life. Furthermore, better governmental policies should be deployed to help women in their work-life balance because they still tend to sacrifice their scientific careers for personal and family life (Huyer, 2015).

Similar to the governmental policies, funding grants are a really good option to ensure women's rights and could be allocated to different activities that promote gender equality such as: training women for the participation in peer review processes; training women for editing and publishing research papers; and increasing the awareness of women for the strategies for becoming research group leaders. It is also important for women to receive instruction in scientific communication skills and conflict management. Moreover, training regarding the management and control of emotions in the workplace is important as women should not allow these to interfere or have an impact in their performance and productivity at work. It is also relevant to mention that regardless of the efforts of women in trying to overcome gender discrimination, sometimes gender equality might not be achieved. In exchange, women keep working in a hostile work environment. For this reason, it is important to let women know that they can walk away from these work environments, as we believe, sometimes is the best option for their lives and scientific careers.

TESTIMONY FROM COLOMBIAN FEMALE SCIENTISTS

Despite the previously described gender inequality present in Colombia across different fields, we observe that there are countless striking Colombian women that are already successfully pushing the boundaries of scientific discovery. Thus, as an extremely valuable contribution to this article, we conducted a series of interviews to a group of Colombian female scientists and researchers working in a variety of research fields at high level research institutes in Colombia and worldwide. In these interviews they revealed not only their opinion about gender equality and women's empowerment in Colombia, but also how they tackled and keep tackling gender inequality in their careers. Most importantly, the voice of these outstanding interviewed women and their life stories will provide invaluable support to a great number of Colombian women currently struggling to overcome gender-based barriers in their career development. In the next section we compiled what we considered the most important points raised in their testimonies. However, we greatly recommend reading the full interviews (**Supplementary Material**) as, for the sake of brevity, many really interesting points were left out from our compilation. Here is the list of our interviewees:

Adriana Herrera-Barros. Ph.D. in Chemical Engineering. Universidad de Cartagena. Colombia.
Ana María Aldana. Ph.D. in Biological Sciences.

Angela Stella Camacho Beltrán. Ph.D. in Physics. Universidad de los Andes. Colombia.

Angela María Guzmán Hernández. Ph.D. in Physics. Universidad Nacional de Colombia. Colombia.

Angela Restrepo-Moreno. Ph.D. in Microbiology and Medical Micolgy. Corporación para Investigaciones Biológicas (CIB). Colombia.

Catalina Lopez Correa. Ph.D. in Human genetics. Genome British Columbia. Canadá.

Clemencia Gómez González. Ph.D. in Geological Sciences. Universidad Nacional de Colombia. Colombia.

Gloria Esperanza Duarte Huertas. Master Degree in Spanish Linguistics. Instituto Caro y Cuervo. Colombia.

Imelda Arana Sáenz. Master Degree in Sociology of Education. Master Degree in Women's Studies.

Maria Elena Arango Rave. Pediatric surgeon. Hospital San Vicente Fundación and Universidad de Antioquia. Colombia.

Myriam Jiménez Quenguan. Ph.D. in Philosophy. Universidad Santo Tomás. Colombia.

Sonia Del Carmen Jaramillo Villegas. Master Degree in Crop Physiology. Universidad Nacional de Colombia. Colombia.

An ethics approval for this research was not required as per institutional and national guidelines and regulations. All participants provided written informed consent for participation in this research and for the publication of the interview transcripts and their identifiable information.

Based on Your Personal Experience, Why Do You Think Colombian Women Are Underrepresented in Research Positions?

In this question we asked about the personal views of our interviewees on why Colombian women are underrepresented in research positions. The answers obtained depicted a diverse range of extremely interesting points. One of the researchers, namely Maria Elena Arango Rave, thinks that "there are less women in research positions due to their personal interests" as she considers that "there are the same opportunities for men and women" in the places where she has been conducting research. Similarly, Angela Restrepo-Moreno adds "I do not believe that presently women are underrepresented in research positions. I know of an important number of women that carry their research studies in the best Colombian universities and private laboratories of the country" but she also states that "It should be noted, however, that NO studies have been conducted to prove that the points I am making above have received confirmation, On the other hand, other aspects such as payment/salary levels do reflect an important difference between male and female employees." In contrast, the majority of the other interviewees consider that there is an underrepresentation of Colombian women in science and that this situation is due to more prejudicial reasons than personal preference.

Most of our interviewees observed that a male dominated culture, still present in Colombia, is one of the major causes for this above-mentioned underrepresentation. For instance, Imelda Arana Sáenz blames the "predominance in the country of patriarchal ideology and the androcentric order on which it

bases its political, economic, social and cultural organization” for this state of affairs. This “patriarchal ideology” was exemplified by Sonia Del Carmen Jaramillo Villegas that recalls her first job interview in September of 1978 that “was canceled on the pretext that the company did not hire women.” Also Gloria Esperanza Duarte Huertas shares these views by stating that “male chauvinism is a traditional attitude in Colombia” and that “people think that women do not have enough intellectual or academic qualities for working in research positions.” Importantly she adds that “some women are not sure their research abilities are on a par with those of men.” This statement touches on the importance of women’s confidence for their career development. Catalina Lopez Correa also agrees that confidence could be crucial for this problematic as she considers that “women in Colombia (and women in general) lack some of the self-confidence that most of the Colombian men have.”

Explanations for this low confidence of some Colombian women can be obtained from girl experiences during school years. Imelda Arana Sáenz considers that in Colombian schools prevails a “culture where masculine values still predominate, for which the students of basic and medium education are still oriented toward a life project with traditional female performance patterns: wives, mothers and caregivers.” Ana María Aldana also agrees by stating that in schools “girls are not encouraged to be good at sciences and when they are they will most likely feel out of place.”

Another explanation, recurrent amongst the answers obtained, for an underrepresentation of Colombian women in research positions is connected to familiar duties. For example, Ana Maria Aldana states that one of the causes for the disparity observed is the “idea that you have to choose between family and the academic work.” Imelda Arana Sáenz also shares this view. She considers that “women are still responsible for most of the family work and care tasks in all social spaces thereby reducing time and socio-emotional conditions for the performance of functions in the fields of science and technology.”

Another possible reason hampering Colombian women success in science is the existence of unfair job interviews. Adriana Herrera-Barros talks of a culture that still exists in Colombia where “power is passed from hand to hand and it is necessary to be closer to the president or the head of an organization to be able to continue with the leadership.” Finally, Imelda Arana Sáenz interestingly points out the lack of “public policies that favor the performance of women in non-traditional areas and the failure of the authorities and state institutions to comply with the constitutional mandates and the national regulations on the issue” as possible causes for the lack of gender equality on Colombian science that has been described here.

Have You Ever Personally Faced Gender Discrimination During Your Research Career? If So, How Did You Overcome These Discriminative Barriers?

Here we asked our interviewees to share their personal struggles with gender discrimination in their careers. Four of our interviewees expressed that they have never felt gender

discrimination. For example, Clemencia Gomez Gonzalez states that “as the first woman to be president of the Colombian Society of Geology. I have never limited myself working as a geologist for being a woman”. It is also important to highlight the personal experience from Angela Restrepo-Moreno, “I have considered myself as a “lucky” scientist from this point of view as I have suffered NO discrimination once the professor/researcher position was gained.” However, most of the women interviewed already felt directly or indirectly the weight of gender discrimination on research. For instance, Angela María Guzmán Hernández points to a felt “manifest disrespect” for her scientific ideas during her Ph.D. studies in Germany. She also considers that in Colombia “women are expected to maintain a low profile,” and that “men are supportive if women do not intend to reach the highest positions.” Thus, she affirms that a “woman needs to show permanently a much greater value than men to overcome the glass ceiling.” This “glass ceiling” is also felt by Imelda Arana Sáenz. In her field she observed that “ideas, opinions, proposals, and analyzes that women contribute, especially if they are oriented toward recognizing the gender inequalities prevailing in the education system, are unknown, ignored, and made invisible by the experts (men), who mostly hold the power of the word, of the publications and the designations for the exercise of power in that ground.” Similarly, Myriam Jiménez Quenguan, after dealing personally with specific episodes of gender discrimination, states that “it is usual for women to do triple the work of their male colleagues and to earn less; they almost always require more prominence, they seduce power and show that they are the best, it does not matter if they have to hire a woman to think and perform their tasks, because the merits are designed for them, this without mentioning that they have more time to investigate and also earn a better salary than them.” In addition, Angela Stella Camacho Beltrán expresses that “Although apparently, I was treated in equal conditions as my male colleagues, I only realized the discrimination after several years of being part of a research group.” Catalina Lopez Correa summarizes this hostile environment faced by women in academia and research by stating “I have to start from –20 whereas my white male counterparts start their jobs from 0.” Despite this obvious inequality of opportunities, our interviewees managed to continue their academic careers and reach high academic positions. Therefore, we were interested on knowing how they overcame these discriminative barriers.

According to the responses, our interviewees achieved their success by a combination of hard work, high personal confidence, strong personality and help from colleagues and collaborators. For example, Catalina Lopez Correa explains her success by: being a “dedicated and very hard-working individual”; working on her “personal confidence and self-awareness”; pushing herself “to take some professional risks (changing jobs, changing countries)”; and finally by finding “good female and male mentors” in her job positions. Similarly, Sonia Del Carmen Jaramillo Villegas considers “the support of mentors to be very important.” In her particular case, she found strong support from three male mentors to continue and successfully accomplished her master degree at CIAT (International Center for Tropical Agriculture, Colombia). This importance of mentors

is also exemplified by Angela Restrepo-Moreno, when she states that “Curiously, my position as Professor at the School of Medicine was supported by the important number of active male professionals such as Department Heads, Research Programs Directors and even by those in directive positions.” Sonia Del Carmen Jaramillo Villegas also believes that women “need a lot of persistence, and great doses of humility and discipline.” In the same way, Gloria Esperanza Duarte Huertas states that she “overcame these discriminative barriers working very hard on many research projects.” In brief, despite the inspirational stories securely present behind each of our interviewees success, it is saddening to observe the so uneven competition that women need to constantly face to fulfill their scientific dreams.

Which Actions Do You Envision to be Crucial in Order to Achieve Greater Participation of Women in Research? The Presence of Female Role Models and Mentors Can Have a Positive Impact in Women’s Participation. In Accordance to Your Experience as a Female Researcher, Do You Have Any Advice for the Colombian Women Who Are Struggling to Pursue a Career in Research or for Those Looking to Maximize Their Career Development?

It is clear at this stage that gender discrimination is hampering the participation of women in research. Thus, we asked our distinguished interviewees how this state of affairs can be altered. Not surprisingly, very interesting and important points emerged from the answers. Firstly, the answers made clear that a change in the way education works in Colombia is imperious. For example, Maria Elena Arango Rave considers that “it is important to motivate women in basic education, so they realize they can become researchers.” Ana María Aldana not only agrees with this point but also adds the importance of “teachers to learn about conscious and unconscious gender bias to give girls better support for the development of their research interest.”

Our interviewees also considered that role models can have a positive impact on women’s scientific careers. Angela María Guzmán Hernández considers that these role models could be delivered “through short workshops that allow real interaction” and using “advertisement to change the stereotype of a scientist as an isolated person and highlight their contribution to the society.” Importantly, Ana Maria Aldana adds that the role models “should also try to show that it is possible to have both: family and career.”

Another point arising from the answers was the need for women to help each other on their careers. Imelda Arana Sáenz defines this as “sisterhood (brotherhood among women)” that she considers that should be strengthened “in the field of scientific activity, with mutual support and work among peers.” In this aspect, Ángela Stella Camacho Beltrán highlights the importance of the Colombian Network of Female Scientists, from which she is president, on “several aspects such as motivation of young girls to science, women and education, politics of

science and technology with gender perspective and female entrepreneurship.” Clemencia Gómez González, also a member of the above-mentioned network, agrees on the importance of this type of association to “encourage the participation of young researchers.”

One possible role of this female scientific networking effort is to press governmental entities to ensure compliance with the law. The need for the equality laws to be respected in Colombia was referred by Imelda Arana Sáenz. In addition, other women suggest alterations or additions to the rules of research institutions that would promote gender equality in research. Angela María Guzmán Hernández, for example, suggests that grants should take into consideration child-bearing time and that teaching responsibilities should be reduced for women with newborns. Moreover, she adds that it is important “to instruct hiring and grant committees to ignore family-related gaps in CVs.” Importantly, Myriam Jiménez Quenguan suggests that there should be “more incentives for research on gender issues.” In fact, an increased understanding of the problem of gender equality is crucial for finding new ways to solve this problematic. This increased understanding could in turn, as suggested by Adriana Herrera-Barros, serve as a base used to press governmental institutions to create “special grant for projects” led by women.

In this question we also asked our notable interviewees for advice directed to Colombian scientific women currently struggling in their careers. All the answers were extremely inspiring with important messages of confidence and perseverance being mentioned repeatedly. However, due to space limitations, we cannot mention all the points raised by our interviewees. Thus, once again, we highly suggest the reading of the complete interviews (**Supplementary Material**). Nevertheless, we would like to mention the five truly inspirational points that Catalina Lopez Correa thinks to be “very important to ensure Colombian women succeed in a research career.” These are: “dream big”; “get the right education”; “work with passion”; “find a mentor”; and finally, “trust yourself.” We absolutely believe that these interviews and the examples of the fascinating careers of our interviewees will have an impact on the scientific careers of many Colombian women in the future.

CONCLUSION

With this study we successfully highlighted the underrepresentation of female researchers in Colombia. Using data from the UNESCO Institute for Statistics and the Labor Observatory for Education from the Colombian National Ministry of Education, we showed that there is a lower percentage of women across diverse research fields. Underrepresentation was also observed when analyzing the quantity of women following master and doctoral degrees. Additionally, we described the big gender salary gap that exists between men and women with identical education levels. Furthermore, in this work, we indicated several putative causes for this gender inequality, being one of them, for example, the stereotypical influence that women and men receive from

an early age at their homes and schools. Moreover, to better illustrate the unequal situation faced by Colombian women in the scientific community, we conducted a series of interviews to successful Colombian female researchers. By uniting the description of the current problematic situation in Colombia with the experiences of successful women, we believe that our article can be truly important on raising awareness of the gender inequality issues faced by Colombian female researchers. Hopefully this increased awareness will be reflected on attitude changes in the most diverse settings including homes, schools, higher education institutions and work companies. Moreover, this study is important because, as stated by Angela Restrepo-Moreno and Adriana Herrera-Barros, not many studies have embraced the task of describing the state of gender equality in the Colombian scientific community. Thus, and as mentioned by one of our interviewees, the information compiled in this work, could, in our opinion, be used to propose to governmental institutions the opening of specific grants for young female researchers either trying to build their own research group or for women following their postgraduate studies. Finally, and importantly we, with the precious help of the motivating testimonies of our successful interviewees, want with this work

to pass a message of perseverance to all the female Colombian researchers not only to keep fighting to succeed in their careers but also to actively encourage young women on pursuing their academic dreams.

AUTHOR CONTRIBUTIONS

Both authors have made a substantial, direct and intellectual contribution to the work and approved it for publication.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fspas.2018.00024/full#supplementary-material>

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