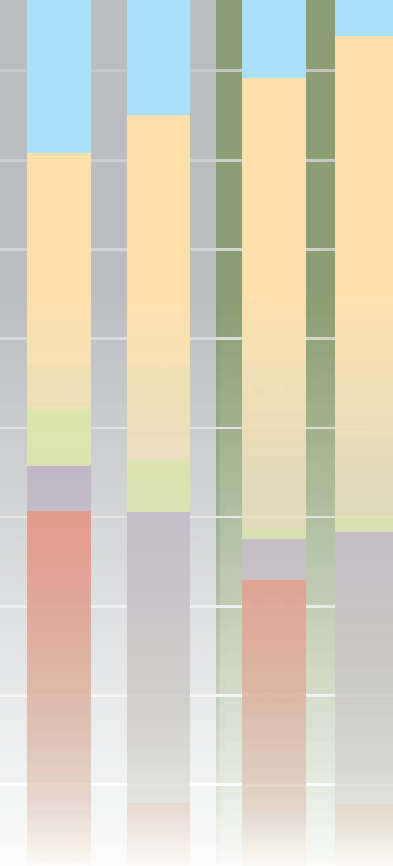


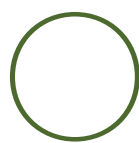


Women in physics: *A tale of limits*

Rachel Ivie and Casey Langer Tesfaye

A newly completed survey of 15 000 physicists worldwide reveals that women physicists still do not have equal access to the career-advancing resources and opportunities enjoyed by their male colleagues.

Rachel Ivie (rivie@aip.org) is the associate director of and **Casey Langer Tesfaye** is a technical research analyst at the Statistical Research Center of the American Institute of Physics in College Park, Maryland.

 If all the sciences in the US, physics continues to have the lowest representation of women. Currently, women earn just 21% of bachelor's degrees and 17% of PhDs in the field.

Discourse about women in physics often centers on representation, and the unspoken assumption seems to be that if the representation of women were to increase to some higher level, all would be well. However, the focus on representation obscures important issues and ignores the day-to-day experiences of women physicists.

In fact, women physicists could be the majority in some hypothetical future yet still in their careers experience problems that stem from often unconscious bias. After all, science, and especially physical science, is seen by many cultures as a primarily male domain. But do women actually experience problems in their day-to-day work as physicists? Do they have equal access to opportunities and resources? If not, how does that inequity affect their careers? If harmful, sex-based differences of access exist, then those of us who care about the situation of women in physics need to come up with a solution that encompasses more than just increasing female representation.

A survey of surveys

The first IUPAP International Conference on Women in Physics was held in Paris in 2002, under the auspices of the Working Group on Women in Physics of the International Union of Pure and Applied Physics. Three years later the IUPAP organized a second conference in Rio de Janeiro

(see *PHYSICS TODAY*, May 2002, page 24, and August 2005, page 29); the most recent conference was held in 2011. Before they convened, the first two conferences had sponsored surveys to ascertain working relationships in graduate school and beyond, access to opportunities and resources, and the effects of those variables on women's careers. But the surveys also probed the effects of another important variable: family obligations.

The goal of the first two IUPAP surveys was to describe common problems that women physicists worldwide face in their work and studies. More than 1000 women from more than 50 countries replied to each of the surveys. Still, the questionnaires were sent only to women, and respondents were obliged to answer in English. During the third IUPAP International Conference on Women in Physics, held in Seoul, South Korea, in 2008, the IUPAP Working Group on Women in Physics decided to expand the scope of the surveys. The third survey, the Global Survey of Physicists, was sent to men as well as women, to document the differences between their experiences. Moreover, the working group decided to offer it in eight languages. With support from the Henry Luce Foundation, the survey was translated into Arabic, Chinese, French, German, Japanese, Russian, and Spanish.¹

Physicists had one year to respond—from October 2009 to October 2010. By the end of that period, 15 000 physicists from 130 countries had sent in answers. Part of the reason for the huge increase in respondents was the participation of men. But the help of physics societies in distributing the surveys and the translation into seven languages

no doubt also contributed to the increase. Some 3000 women responded to the survey, representing 22% of the total and a significant increase over the number answering the first two women-only surveys.

All three of the IUPAP surveys were conducted by the Statistical Research Center of the American Institute of Physics (AIP). In this article we report on the third survey.² About 75% of the responses came from countries with a very high human development index (HDI), a measure devised by the United Nations Development Programme that takes into account such things as life expectancy at birth, income, and educational attainment.³ In our analysis, we will distinguish between those countries and countries with HDIs other than very high. Interesting differences exist between those two groups. But the results we will present concerning women in physics are independent of development level.

Resources and responsibilities

It makes sense that if a scientist is without access to resources needed to conduct research and disseminate results, his or her career will stall. Scientists need many things, including access to graduate students or employees to assist with research, clerical support, research funding, and travel money. Until the global survey, no study had documented whether such resources are distributed equitably to women and men in physics. Professional opportunities—for example, giving an invited talk at a conference—are also essential for a scientist's career advancement. The survey explicitly asked about such experiences, to establish whether they are equally available to women and men.

Armed with the survey results, we examined how family responsibilities impact women's careers in physics. The importance of familial obligations may surprise some readers, but the cultural expectation that women will take on most of the child care and household responsibilities should not be overlooked. Indeed, many researchers have documented how the results of cultural expectations vis-à-vis marriage and family affect the broad class of US women faculty members. For example, one well-cited study finds, among other things, that

mothers are 29% less likely to enter tenure-track positions than otherwise comparable women without children.⁴ Furthermore, women who are full professors are much less likely to be married with children than are male full professors. Will the link between family obligation and career hold for physicists, and will it hold in other countries?

To address access to essential resources, the global survey asked respondents if they had enough of the following to do their research: funding, office space, lab space, equipment, travel money, clerical support, and employees or students. Table 1 gives the percentages of yes answers. Even a quick glance at the table reveals that in both the very highly developed and less developed countries, women are less likely than men to report that they have adequate access to key resources.

The women who answered the survey tended to be younger than the men. Could that age disparity account for the difference in resources? After all, younger scientists might be expected to have fewer resources. If women work in different types of jobs, that difference, too, could explain away the sex difference. A more sophisticated statistical analysis, however, reveals that the sex-based difference in access holds regardless of age or HDI and regardless of whether the employment was at a university, government, private-sector corporation, or other entity. Indeed, except as otherwise stated, all the sex-based differences we report in this article hold up even after we control for age, HDI, and employment sector.

Table 2 illustrates the percentages of women and men who reported participating in a variety of experiences, many of which would serve to advance almost any scientist's career. The results reveal at least a nominal sex difference for all cases, with women less likely to have the experience than men. However, when we checked to make sure that the sex difference held across different ages, sectors of employment, and HDI, we found that for four of the experiences, variations were better explained by age, HDI, or type of job than by gender. Those experiences were advising undergraduates, serving on either of two kinds of committee, and attending a conference abroad. Under no circumstances were women more likely than men to have any of the opportunities listed in the table.

Family affairs

Across cultures, women generally have the primary responsibility for taking care of home and children.⁵ The Industrial Revolution may have liberated women from the drudgery of household chores, but women still spend more time on them than do men.⁶ Perhaps more significant—at least for those in the academic world—is that studies of the careers of faculty members across all disciplines⁴ and AIP's analyses of the first two global surveys of women physicists document the effects of children on women's careers.⁷ So we turn again to the subject of family responsibilities and examine whether their effects are different for women and men.

When asked about which partner is responsible for the majority of housework, the respondents to the global survey gave answers that are consistent

Table 1. Percentage of respondents with access to key resources.

	Less developed countries		Very highly developed countries	
	Women	Men	Women	Men
Funding	34	51	52	60
Office space	64	74	72	77
Lab space	42	47	46	52
Equipment	42	49	58	64
Travel money	31	47	57	64
Clerical support	22	38	30	43
Employees or students	42	53	33	43

Table 2. Percentage of respondents with career-advancing experiences.*

	Less developed countries		Very highly developed countries	
	Women	Men	Women	Men
Gave a talk at a conference as an invited speaker	51	67	58	73
Served on committees for grant agencies	22	37	26	36
Conducted research abroad	54	71	61	69
Acted as a boss or manager	38	53	46	61
Served as editor of a journal	16	24	11	19
Advised graduate students	63	77	58	70
Served on thesis or dissertation committees (not as an adviser)	52	66	37	52
Attended a conference abroad	75	81	83	87
Served on important committees at your institute or company	50	62	48	60
Served on an organizing committee for a conference in your field	48	59	48	55
Advised undergraduate students	82	84	69	74

*Rather than being a result of gender, the sex-based differences evident in this table could, in principle, be explained by such variables as age, level of a country's development, or type of job. We checked for those three possibilities and found that for the four items highlighted in red, the male–female discrepancy was better explained by age, human development index, or employment differences. For all the other items, however, sex difference provided an appropriate explanation.

with cultural expectations and previous time-use studies: Although many report that chores are shared equally, women are more likely than men to report that they do more of the housework than their spouses or partners. That result holds even if we limit the responses to households in which both partners are employed, as shown in figure 1, or if we consider only households in which the woman makes more than her partner.

Our data also show that male physicists are more likely to be married to someone who either does not work outside the home or who earns less than they do, and they are less likely to be married to a spouse with a high level of education. Those findings, too, are consistent with cultural expectations—it is more acceptable for men to marry someone of lower earning power.

Taken together, the survey results indicate that if family responsibilities do affect physicists' careers, they are more likely to affect women than men. Why? Because when push comes to shove and somebody needs to care for a sick child or family member, it makes economic sense for the partner who makes less money to take on that responsibility. And for most men, that partner is someone else.

Career progress

The Global Survey of Physicists revealed sex-based differences in resources, professional opportunities, and family responsibilities. Our analysis showed, as might be expected, that physicists with relatively poor access to key resources and career-advancing opportunities reported that their careers progressed more slowly than those of their colleagues with better access.

Family responsibilities, especially parenting, have multiple and sometimes unexpected effects on the careers of physicists. Those filling out the survey were asked how their work or careers changed

when they became parents. By an almost two-to-one margin, women were more likely than men to say that becoming a parent significantly affected their work in various ways. Women were most likely to report changing their schedules, spending less time at work, and becoming more efficient. Those findings echo results from the first two IUPAP surveys, in which women physicists reported that having children forced them to become more efficient because they had to leave their laboratory or office in time to pick up young children from child care.

The survey also asked respondents whether their employers had assigned less challenging work to them when they became parents. The majority of physicists did not report a change. Still, women were more likely than men to report being given less challenging work, and the difference was statistically significant.

For many, parenting means career changes, but does parenting slow overall career progress? And if so, are men and women affected differently? AIP's analysis of the two earlier surveys showed that when women compared themselves with others who had completed their final degrees at about the same time, women with children were more likely to report relatively slow career progress.⁷ The third global survey allows us to see if the effect of children on a physicist's career is different for women and men. Figure 2 gives the survey results and shows that women with children are the group most likely to report that their careers progressed more slowly than those of their colleagues.

The group least likely to report that their careers stalled was men with children. That result may come as a surprise. It is consistent, however, with the findings of University of California researchers Mary Ann Mason and Marc Goulden, who reported that across the board, male faculty members with children are the most likely to achieve tenure.⁴

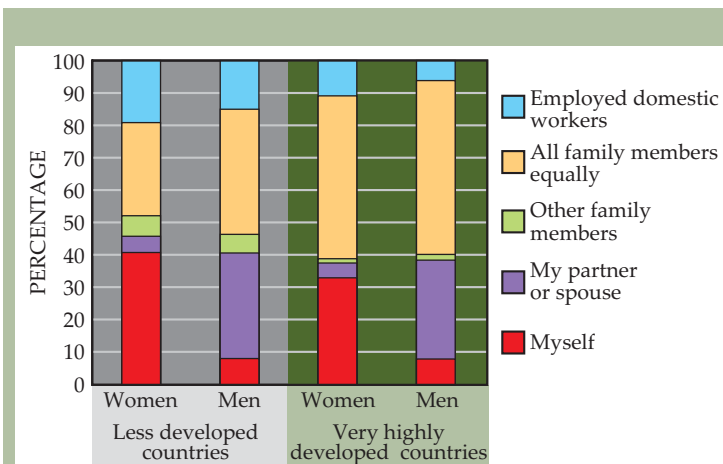


Figure 1. The majority of housework is more likely to be done by women than by men. The results shown here were derived from the responses to a global survey conducted by the American Institute of Physics and filled out by almost 15 000 physicists. To generate this graph we disregarded the responses of those physicists whose spouse or partner was not employed. The disproportionate burden of housework on women holds independent of level of development of the respondent's country.

Mason and Goulden's criterion of achieving tenure is more objective than the subjective responses to the global survey. But the subjective testimony we used holds across all countries and types of employment sectors.

Children have a demonstrated effect on career progress. Conversely, it is likely that career choices influence how people think and act when family life is at issue. The two earlier, women-only surveys suggest that some women, particularly more senior

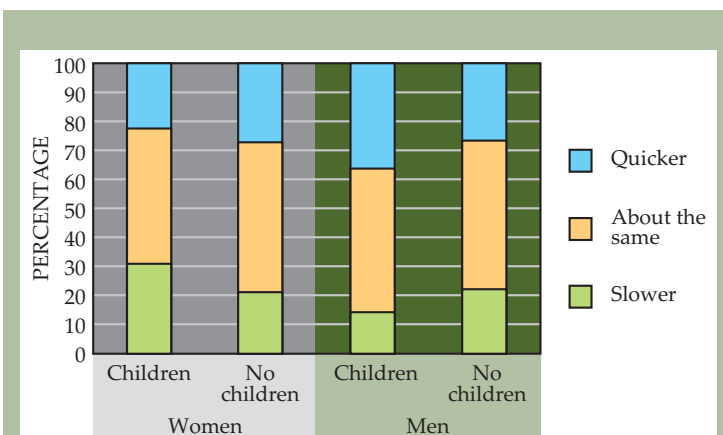


Figure 2. Having children tends to slow the career progress of women physicists but not that of their male counterparts. To generate the data that produced this graph, a global survey analyzed responses from some 15 000 physicists to compare their career progress with that of their colleagues.

women, deliberately chose not to marry or not to have children so that they could focus on physics. So for the third survey, we asked respondents about how their careers affected their decisions about marriage and children. Again, consistent with cultural expectations, women were more likely than men to say that their careers affected decisions about family life.

Testimony reflects reality

The global survey follows a body of work that has examined the importance to career success of access to resources and opportunities. The survey found that women are less likely than men to report access to various resources and opportunities that would be helpful in advancing a scientific career. It also confirmed, consistent with cultural norms, that men are more likely than women to have a spouse who will shoulder the burden of housework. We noted the cultural expectation that women are responsible for child care and documented survey results showing that parenting affects the careers of women more than it does the careers of men.

Admittedly, our results are derived from the testimony of survey respondents, and it is conceivable that the sex differences we have found exist not because women are treated differently but because they differ from men in their expectations about work. However, the results reported here will come as no surprise to the researchers who have already found that resources, opportunities, and family responsibilities affect women's careers.^{4,6} We believe the results reflect an underlying reality of disadvantage—not differing work expectations—and that all the sex-based differences documented here adversely affect the careers of women physicists.

The low representation of women in physics is a problem the community needs to address, but the community also needs to address inequities in access to resources and opportunities. Cultural expectations about home and family also inhibit the progress of women physicists; those, of course, are much more difficult to change. Nonetheless, we look forward to a future in which science truly means science for all.

References

1. The survey, in all eight languages, is available at <http://www.aipsurveys.org/global>.
2. For additional detail, see R. Ivie, C. Tesfaye, "The Global Survey of Physicists: A collaborative effort illuminates the situation of women in physics," <http://www.aip.org/statistics/trends/highlite/women/global.pdf>.
3. For more on the human development index, including country rankings, see <http://hdr.undp.org/en/statistics>.
4. M. A. Mason, M. Goulden, "Marriage and baby blues: Re-defining gender equity," <http://ucfamilyedge.berkeley.edu/marriagebabyblues.pdf>.
5. J. Baxter, *Sociology* **34**, 609 (2000); J. A. Batalova, P. N. Cohen, *J. Marriage Fam.* **64**, 743 (2002); M. Fuwa, *Am. Sociol. Rev.* **69**, 751 (2004).
6. J. L. Hook, *Am. Sociol. Rev.* **71**, 639 (2006).
7. R. Ivie, R. Czujko, K. Stowe, *Women Physicists Speak: The 2001 International Study of Women in Physics*, <http://www.aip.org/statistics/trends/reports/iupap.pdf>; R. Ivie, S. Guo, *Women Physicists Speak Again*, <http://www.aip.org/statistics/trends/reports/iupap05.pdf>. ■