

By Rachel Ivie
 Stacy Guo

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Women Physicists Speak Again

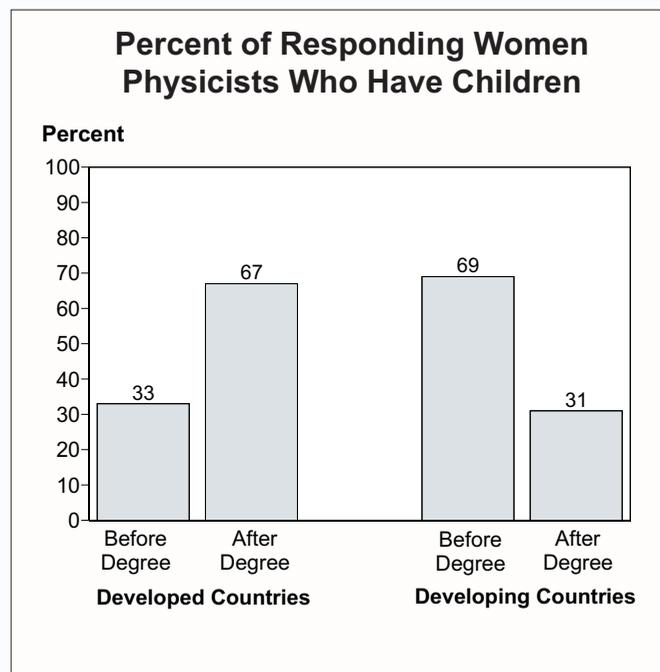
HIGHLIGHTS

More than 1350 women physicists from more than 70 countries responded to a survey designed to elicit information about their educational backgrounds, careers, the balance between work and family, and opinions about physics as a career (**Table 1**). The survey was conducted in conjunction with the Second International Conference of Women in Physics in 2005. The report includes data on degrees awarded to women in about twenty countries (**Appendix**).

Most responding women physicists said that they chose physics as a career early, primarily during secondary school (**Table 2**). Most women physicists reported receiving positive attention from physics professors as undergraduates (**Table 4**) and had either excellent or good relationships with their graduate advisors (**Table 6**).

During their education and careers, most responding women physicists reported that they relied on the support of at least one other person, along with their own determination, will power, and hard work (**Tables 5, 8 and 15**).

Women physicists from developing countries were more likely than those from developed countries to report that they have inadequate resources, including funding, equipment, and travel money (**Table 14**). Women from developing countries also had children earlier than women from developed countries (**Table 19**).



Although a majority of the responding women physicists said they would choose physics again, a majority also reported being discouraged about physics. Many spoke about negative interaction with colleagues, including many stories about discriminatory attitudes (**Table 17**). Eighty percent said that attitudes about women in science need improvement (**Table 18**).

The responding women physicists reported both positive and negative effects of marriage and children on their careers (**Table 20**).

In the first international survey of women in physics, women spoke a great deal about the effects of children and childcare demands on their careers. However, in this study, women were careful to point out that the main problem is that women in physics continue to face discrimination and negative attitudes.

In spite of the problems faced by these women physicists, most expressed excitement about physics and gratitude toward those who had encouraged them during their careers.

Across the world, women in physics have much in common. In almost all countries, women are largely underrepresented in physics. In the majority of countries for which we were able to obtain data from reliable statistical agencies, women earned no more than one-fifth of the PhDs in physics (**Appendix**). Many women physicists across the world also experience problems related to balancing the demands of a career in physics with the responsibilities of raising a family. In addition to these problems, there are the difficulties of dealing with discrimination, negative attitudes about women in physics, and workplace environments that are less than welcoming.

To obtain information about issues that are of concern to women physicists across the world, the Statistical Research Center of the American Institute of Physics conducted a web-based survey between May 9, 2005 and June 29, 2005. The survey topics included factors that influenced decisions to choose physics, experiences during the educational process and while working, opinions about physics, and demographic information. This study is a follow-up to a survey conducted by the Statistical

Research Center in 2002 in conjunction with the First IUPAP (International Union of Pure and Applied Physics) International Conference of Women in Physics.¹

E-mails were distributed to the mailing list for the Second IUPAP International Conference on Women in Physics, which was held in May 2005 in Rio de Janeiro, Brazil.² Those receiving the e-mail were asked to forward the survey link to others who might be interested. In the accompanying request, we emphasized that it was not necessary to attend the conference to answer the questionnaire. This approach proved effective, because although about 150 people attended the conference, we received replies from about 1600 physicists, including many students and some men. This report focuses on the responses of more than 1350 women physicists from more than 70 countries (**Table 1**). Physicists are quite mobile in the sense that it is not uncommon to live for a while in a different country while conducting research. For **Table 1**, women were included in the count for the country in which they are currently employed. In the case of students, women were counted with the country in which they went to high school, due to

Table 1. Number of Responding Women Physicists by Country, 2005

Continent/Country	Number	Continent/Country	Number
Africa		Europe	
Botswana	1	Albania	2
Canary Islands	1	Austria	12
Egypt	1	Belarus	6
Ghana	1	Belgium	9
Nigeria	8	Bulgaria	8
Senegal	2	Croatia	16
Somalia	1	Czech Republic	4
South Africa	3	Denmark	18
Tanzania	1	Estonia	2
Togo	1	Finland	3
Tunis	2	France	51
Asia		Germany	41
Bangladesh	1	Greece	3
Burma	1	Ireland	6
China	17	Italy	14
India	23	Latvia	4
Indonesia	4	Lithuania	11
Iran	2	Luxembourg	1
Israel	8	Netherlands	13
Japan	64	Norway	4
Malaysia	1	Poland	2
North Korea	3	Portugal	1
Pakistan	5	Romania	3
Singapore	1	Russia	9
South Korea	47	Serbia	1
Turkey	3	Slovakia	1
Australia/New Zealand		Slovenia	8
Australia	20	Spain	67
New Zealand	1	Sweden	20
North America		Switzerland	11
Canada	30	Ukraine	3
Cuba	1	United Kingdom	88
Dominica	1		
Mexico	42		
United States	511		
South America			
Argentina	40		
Brazil	44		
Chile	2		
Columbia	9		
Ecuador	1		
Peru	4		
Venezuela	3	Total	1353

the large number of physicists who attend school outside their home country, only to return to it after completing school. If a working female physicist did not report a country of employment, she was included in the country in which she attended high school.

More than 500 of the female respondents were from the US. To include all of these respondents would bias the results in favor of the US, and the situation for women in physics may well be different in the US than it is in other countries. In fact, we found that US women’s answers to some questions were different not only from women’s answers in developing countries, but also from women’s answers in other developed countries. To adjust for the large number of US respondents, we chose an arbitrary weight of 0.2 for each US respondent, and 1 for respondents from all other countries. Percentages in this report are calculated using these weights. This effectively reduces the percentage of US respondents in the group to about 10%.

Because this is not a representative, randomly drawn sample, our conclusions should be interpreted with caution and should not be generalized to all women physicists. Although our method of data collection means the results cannot be generalized, there is no list of physicists worldwide from which a sample could be drawn. Still, the survey results paint a picture of the situation of women in physics that could not be obtained any other way.

EARLY INFLUENCES

While rewarding, physics can be a difficult career for anyone, and may be particularly so for women. The importance of physicists’ early experiences in forming their careers cannot be underestimated. For many, physics captured their attention early, and it was something that they could not give up. To find out which experiences piqued women’s interest

in physics, we asked them several questions about the early influences on their decision to choose physics. We found that about 60% of women first thought of choosing physics as a career during secondary school (**Table 2**). This emphasizes, on an international scale, the influence of teachers early in a student’s career, where a good physics class often is the motivation for a subsequent career in physics.

Table 2. Timing of Career Choice for Responding Women Physicists

	Percent
Before secondary school (high school)	15
During secondary school	60
During undergraduate school	17
During graduate school	8

We also asked women to indicate what or who influenced their decision to choose physics. Respondents could choose more than one answer. About one-fourth said that their parents influenced them (**Table 3**), but 50% said that their teachers influenced them. This again underscores the importance of good science teaching during primary and secondary schooling. The most common answer however, was simply interest in the subject. In another question, many respondents reported a passion for physics that doubtless kept them going during difficult times.

Table 3. Influences on Career Choice for Responding Women Physicists

	Percent
Parents	24
Other family members	8
Teachers	50
Interest in subject	85
Other	9

* Respondents could choose more than one answer.

UNDERGRADUATE STUDIES

Most respondents (88%) reported that their first undergraduate degree was in physics.

Of those who did not obtain a physics undergraduate degree, the most common field was mathematics. A student's undergraduate experience is extremely important in forming a foundation for a career. An attentive professor or an engaging experiment can make all the difference in cementing a young physicist's interest in the subject. As **Table 4** shows, the majority of respondents reported that they had received positive attention from their physics professors while undergraduates. About one-third reported receiving attention that was neither positive nor negative, and less than 10% reported receiving negative attention or no attention at all. This suggests that positive attention from professors plays an important role in retaining women students. The surprising factor is the number of women who remained in physics despite receiving little support or attention from their professors.

We also asked respondents to describe who or what had been most supportive of them during undergraduate school. Respondents could choose two from a list including: a spouse, other family members, professors or mentors, other students, and their "own determination, will power, and hard work." Most respondents chose one other person but also said they relied on their own determination and hard work (**Table 5**). While the support of others is important for

	Percent
Positive	59
Negative	5
Neutral	32
No attention	4

Table 5. Sources of Support During Undergraduate Studies For Responding Women Physicists

	Percent
Only myself	7
Myself and one other person	64
Other people	29

women physicists in this study, most said that their own hard work was essential to their success.

GRADUATE EDUCATION

While undergraduate education lays the foundation for physicists' careers, it is graduate education that has perhaps the most influence. Eighty-five percent of the women responding to this survey reported that they have a graduate degree, and most of these have the PhD or its equivalent in their country. An equally large percentage, 86%, reported that their PhD or equivalent is in physics. Of those with other degrees, the most common field was astronomy.

The relationship with one's advisor has a profound influence not only on the graduate school experience, but also on the first few years after earning a degree. Graduate advisors can mentor (or not) their students through negotiating the first position after degree. Even after entering a career, former students may continue to collaborate with their advisors, ask them for career advice, and at the very least, for letters of recommendation. Since all these women are still "in physics," it is not surprising that most rated their relationship with their advisor as either "excellent" (37%) or "good" (41%, see **Table 6**). What is surprising is the number of women who reported poor relationships with their advisors, but still persisted in physics. This is testament, perhaps, to their own efforts, determination, and will power. During graduate school, students

Table 6. Ratings of Responding Women Physicists' Relationships with Their Graduate Advisors

	Percent
Excellent	37
Good	41
Fair	14
Poor	8

often can get started on their research careers by writing research papers and giving talks. Most of our respondents had these experiences in graduate school (**Table 7**), with the great majority giving talks or posters, and co-authoring papers. Half also said that they “wrote research papers on their own.”

Graduate school is difficult, and students often rely on others for support during this time. As in undergraduate school, women relied on at least one other person, but the majority also said that their “own determination, will power, and hard work” aided their success (**Table 8**). This pattern is similar to women’s undergraduate experiences, where many felt they needed to rely on their own strengths to make it through the trials of graduate school.

WOMEN’S CAREERS IN PHYSICS

Almost 30% of the respondents to this survey are currently full-time students. They have been excluded from the analysis of questions related to current employment, so that we can focus our attention on women who are

Table 7. Percent of Responding Women Physicists Who During Graduate School:

	Percent
Presented a poster or talk	85
Wrote an independent research paper	50
Co-authored a research paper	80

Table 8. Sources of Support During Graduate Studies for Responding Women Physicists

	Percent
Only myself	7
Myself and one other person	61
Other people	32

working in physics, rather than those who are preparing for a career in it. Women working in physics face many challenges, but also enjoy many successes. This section covers resources available, reasons for taking a job in physics, and awards and prizes, as well as other issues related to careers in physics. Working in physics can be different for women from developed countries than for women in developing countries, and some of these differences are discussed here. Women working in developing countries may face many challenges that women in developed countries do not, but there are some situations that women in developed countries face that women from developing countries do not.

Taking a postdoc is an important step for many physicists, and may be more important in developed countries than in less developed countries. For example, 60% of the respondents from developed countries had worked as postdocs, but only 50% of respondents from developing countries had postdocs (**Table 9**). There may be less opportunity to take a postdoc in developing countries; however, many physicists in developing countries may take postdocs in other countries. In addition, women in developing countries are more likely than women in developed countries to have traveled to another country to conduct research, although doing so is very common for all the respondents to this questionnaire. Our results show that 68% of our respondents from developing countries had traveled overseas to conduct research. On the other hand, 56% of women from developed countries had done so.

Table 9. Differences Between Women's Careers for Respondents From Developed and Developing Countries		
	Developing Countries(%)	Developed Countries(%)
Postdoc	50	60
Travel abroad for research	68	56
Unemployed more than 6 months	7	13

Another difference between women in developed and developing countries is that women in developed countries are more likely to report a period of unemployment lasting six months or more, although the percentage reporting this is relatively low in both types of countries (**Table 9**). The reasons for this period of unemployment are unknown, but it could be that women in developed countries are more likely to take extended time off to care for children or other family members. In the open-ended questions, it was usually women from developed countries who complained about the difficulty of finding jobs, like this physicist from Spain:

Difficult to get a job, [e]specially in my home place. ~Spain

The reasons that the women in this study gave for taking their current job are shown in **Table 10**. The most frequently mentioned reason for choosing a particular employer is location of the job, with about three-fourths of respondents

Table 10. Reasons Responding Women Physicists Took Their Current Job	
	Percent
Pay	37
Promotion opportunities	44
Research funding	48
Family	53
Employer's reputation	58
Research facilities	58
Collaboration	60
Location	73

*Respondents could choose more than one answer.

stating that this was one of the main reasons they took their current job. Unfortunately, the survey did not probe further, so we cannot give more detail about which characteristics of the location attracted them. More than half chose collaboration, research facilities, employer's reputation, and family as reasons for taking their current job. Less than half chose promotion opportunities and research funding. The least frequently mentioned reason was pay, at less than 40% of respondents. Although physicists can be well compensated, especially in developed countries, pay is not the primary reason women physicists are working for their current employers.

Women in physics work in all types of positions, including academia, private industry, government, and other types of employers. There are different reasons for taking jobs with each type of employer, as well as differences in the opportunities encountered in the course of a career. The respondents in our study are more likely to be working in academia than in other sectors of the economy (**Table 11**). About two-thirds work in academia, and another 15% work in government positions. The remainder work in industry or in other types of positions.

Table 11. Sectors of Employment for Responding Women Physicists	
	Percent
Academia	68
Government	15
Industry	7
Other	10

	Academics(%)	Non-Academics(%)
Pay	33	47
Funding	53	38
Family	56	46

The women in this study who work at academic jobs often took those jobs for different reasons than women who work outside of academia (**Table 12**). As expected, more women in non-academic jobs said that they took those jobs because of the pay, although not a majority said this. On the other hand, more women who took academic jobs said they took them because of the funding.

More women who took academic jobs said they did so because of family reasons, whereas fewer women in non-academic jobs said this was a reason for taking employment. It is difficult for us to know what about their family situations caused these women to choose academia. Some may have done so to be closer to a spouse or partner. Others may have chosen academia because they perceived it to be more adaptable to the schedule of a family. In some of the verbatim responses, women mentioned that they found academic jobs to be more flexible, allowing them to choose the hours that they work.

Needed to work flexibly, at a time when there were no formal opportunities - but academia makes this relatively easy. ~United Kingdom

There are other differences between women in academic and non-academic jobs. Women in academic jobs are more likely to have served on committees, both at their institution and externally (**Table 13**). Women in academia are more likely to state that they have been referees for research papers, served as editors of journals, and given invited talks at conferences. Finally, women in academia are more likely to say that they have received international or national fellowships, prizes, or awards. It seems that women working in academia may have more opportunity to make the connections that are needed for such prizes through their committee service, service to journals, and by presenting their work at scientific conferences.

As might be expected, women in developed countries have more access to resources than women in developing countries (**Table 14**). Women from developing countries were more likely to say that they do not have adequate funding for research, office space, lab space, equipment, travel money, and clerical support. In fact, on every measure of access to resources that we used, women in developing countries said they had less. One of the main sources of discouragement listed by women from developing countries is lack of resources, especially funding.

	Academics	Non-Academics
Served on organizing committee for a conference	56	41
Served on important committee at institute or company	51	38
Served on committee for grant agencies	26	16
Acted as reference for a research journal	61	41
Served as editor of a journal	17	9
Given a talk at a conference as an invited speaker	58	42
Received international or national prizes, fellowships or awards	43	24

	Developing Countries	Developed Countries
Funding	60	33
Office space	18	12
Lab space	29	15
Equipment	49	22
Travel money	63	32
Clerical support	49	39

Life was not easy some times, not only because of lack of funding but because of lack of a proper salary. ~Argentina

After my highest degree, I have no equipment and funding to continue my research ... in my country. I go to France in my old lab to do some research for about one or two months, but it is too short to do some things. ~Senegal

I am not given a single cent for traveling. It's very sad. ~Tanzania

Right now I have a collaborator in the US but no funding to support me. It is frustrating somehow. ~Nigeria

In both developed and developing countries, women physicists rely on others to support them. Almost all listed at least one other person as being most supportive of them during the early years of their careers (Table 15). However, most continue to rely not only on others, but also on their own determination, will power, and hard work.

	Percent
Only myself	5
Myself and one other person	58
Other people	37

One concern voiced by many women physicists is a sense of isolation. As a woman in a field of men, women physicists often feel out of place. Being able to discuss various issues with co-workers of either sex can help mediate this sense of isolation. We asked women physicists to indicate with how many co-workers they discuss various issues. While most women discuss their research with at least one other co-worker, the less directly related the issue is to research, the fewer women there are who will discuss it with a co-worker (Table 16). For example, 21% never discuss their personal lives with a co-worker, one-fourth never discuss the situation of women in science, and 28% never discuss their family obligations. Not surprisingly, 34% never discussed their salary with a co-worker.

	Percent
Research	6
Funding	12
Interaction with a supervisor	19
Situation of women in science	25
Personal life	21
Family obligations	28
Salary	34

OPINIONS ABOUT PHYSICS

According to the women respondents to this survey, perhaps nothing is so rewarding, yet so challenging, as a career in physics. Although the women who answered this survey overwhelmingly said they would choose physics again (86%), a majority (71%) also reported being discouraged by physics. Women listed

many reasons for choosing physics again, but the most commonly given answer was that physics is something that gives them a great deal of enjoyment.

I feel that physics chose me, not the other way around. I was born a physicist. ~Netherlands

Physics is to me what art is to the artist ... it is my passion. ~United States

Physics is in my mind and blood. ~Egypt

It is just such a pleasure to be able to work in order to understand nature. ~Portugal

It both fascinates and astonishes me. ~United Kingdom

Even women who said that they would choose physics again joined women who would not make the same choice in lamenting certain aspects of the field. They focused on three problem areas: the difficulty of finding employment, discrimination within the field, and the heavy workload.

Sexism is still important in experimental fundamental physics, and the theoretical field is completely closed to women, described as not enough clever or intelligent to [do] such research... this is really what men told me! ~France

It's hard, and harder for women. ~China

I am a physicist. I love this profession. It is not about money. I make money in my business, but I want to continue with research and satisfy myself with the profession I first loved passionately. I was greatly disappointed when I could not get a permanent job in physics... ~South Africa

I really enjoy working in the field, despite the travails of being a woman and under-appreciated and constantly doubting my own ability. Sometimes, I think that I might have shortchanged myself ... that being in a negative

environment isn't good for my soul. But gender bias is everywhere... where can one escape it? ~India

I love physics, and love teaching it. But the environment of "you must either be working or sleeping—and no sleeping"—is enough to kill the joy of any job, no matter how much you love it. ~United States

No job in physics, awful discrimination, I'm too tired to fight. ~Lithuania

Similarly, the majority of responding women physicists reported being discouraged at one time or another, and gave many different reasons for this feeling. **Table 17** shows the various reasons women who responded gave for being discouraged. More than half reported being discouraged because of interaction with their colleagues and because of funding. Frustration with these two areas is reflected in the verbatim comments of the respondents. When asked to comment on reasons they felt discouraged, responding women physicists focused on two areas: lack of funding and perceived discrimination on the part of men. Below are comments from women who felt discouraged by discrimination and negative attitudes:

	Percent
Research	49
Funding	52
Interaction with colleagues	55
Climate for women	43
Personal life	48
Family obligations	35

*Respondents could choose more than one answer.

Interaction with colleagues has been the most difficult. I have often felt that I am ignored or discounted when I attempt to initiate collaborations with men. ~United States

I had to change my clothing style—men were talking about me and my figure. ~Germany

I always have to justify why I as a woman have chosen physics. Men never get that question. ~Sweden

I have among other things been subjected to gender discrimination and harassment. Although I have been vindicated in my appeals against these, it has taken time and energy from my life and career, and a career in physics is not worth such hassle. ~India

After 15 years I can really say, there is one reason I felt discouraged: the gender discrimination, which appears in 1000 ways, and you don't know it is there, you think [it's] maybe my fault, but after 15 years I know what is my fault and what [is] not. ~Switzerland

It is difficult when you are, as I have been, the only woman in a conference. Or when people interrupt, or do not listen or even laugh at what you are saying, even if it is important. Or when advisors or mentors could not believe that I'd done the work myself. ~Spain

There was no incentive, even in front of the same work done by men, it was always the male contribution.... that was praised. Maybe I am tired. ~Italy

Some men think that women do not have [a] place in physics and it is difficult to fight those kind of men. ~Bulgaria

Women also expressed frustration with funding:

Funding issues are the main problem—more time is spent bidding for research work than actually doing science. ~United Kingdom

Funding? What's that? ~United States

Or with both funding and discrimination:

Sometimes chasing one more grant, or trying to do one more experiment with equipment that needs to be replaced, or trying to explain one more time why my colleagues' assessment of a female candidate is biased, seems like too much. ~United States

One source of discouragement that was mentioned by many women, but not included on our checklist in **Table 17**, was a feeling that they did not belong in physics—that they are “imposters” in the field.

I've just felt pretty stupid, although I'm quite sure I'm not. I also feel that what I'm doing isn't really important. ~United Kingdom

These days I often feel that I am not cut out for the high power working required in academia.... or anywhere else for that matter... Basically, I do not feel that I am a professional person and there is obviously not room for that. ~Netherlands

Sometimes I feel I don't know anything, that I am totally lost. I feel I am a fraud in physics and that everyone else is better than me. ~Brazil

I feel that (like many women) I have low self-confidence and often have felt that I am not good enough to be working in physics. This is still a problem even today, though when I think about it calmly I think I am as good as many of my colleagues, and better than some of them. ~India

The main reason [I've felt discouraged] is so often you are just made to feel like you shouldn't be there. You have to work twice as hard, do twice as much just to be considered half as qualified. ~Australia

I often felt [I was in] totally the wrong place, at different situations: comparing myself with really good people, trying to tell [others] about what I am doing in my private environment. ~Germany

Despite all evidence to the contrary (degrees and jobs from top institutions, fellowships, etc.), I never feel as qualified as its clear most of my male colleagues feel... Although I have never felt overt discrimination, the constancy of the male-dominated, aggressive environment wears on me. ~United States

Obviously, women with such close ties to the field have strong opinions about how to correct the flaws they see in it. In fact, almost all (91%) of the respondents felt that the situation for women in physics in their countries needs improvement. The percentages of women who felt that specific improvements could be made are listed in **Table 18**. Of the reasons that we provided for them, the majority of respondents agreed with each. Both respondents with children and those without agreed that several situations related to child care need improvement. More than half of the respondents said that daycare should be made more affordable, that availability of daycare should be improved, and that child care should be shared more equally between parents. Sixty-five percent of women with children agreed that travel should be easier for women with young children, but a smaller percentage (53%) of women without children agreed with this. This difference highlights the fact that those without first-hand experience, including many male scientists, may not realize the difficulty women caring for young children face when they need to travel for

	Percent
Daycare cost	55
Daycare availability	65
Travel with young children	58
Balance of child care in family	69
Discrimination	65
Attitude about women in physics	80

research or to a meeting or conference. Travel means making longer term care arrangements for children, and these arrangements are particularly difficult for mothers of infants.

Although women agreed that child care issues need improvement, they are more likely to say that negative attitudes about women need remediation. In fact, 80% of respondents agreed that societal attitudes about women in science need to be changed. Respondents also wrote in other ideas that we had not included in our checklist. The top three “other” suggestions for improving the situation of women in physics were: making work schedules more flexible, using role models and mentors to help younger women, and putting more women in leadership positions.

Increase flexibility [with regards to] work hours [and] the tenure clock. ~United States

[There are] very few role models in my immediate environment. I sometimes wondered if I was the only woman in this job and if I was a freak! ~Netherlands

Have women in highly visible positions of power. ~India

MARRIAGE AND CAREER

Marriage can change things a great deal for women scientists, and physicists are no exception. Sixty percent of the respondents are married, although more of the respondents from developing countries are married (67% in developing countries, compared with 58% in developed countries). Respondents from developing countries also married earlier in their careers than respondents from developed countries. In developed countries, 43% reported marrying for the first time after completing their final degree, whereas 80% of respondents from developing countries married for the first time while they were still students.

Two-thirds of all respondents said that their marriage affected their work. When asked if the effect was positive or negative, the responses were different for respondents in developed countries than for those in developing countries. Women in developed countries were much more likely to say that the effect of their marriage was positive (72%) than women from developing countries (58%). Women who felt that marriage positively affected their work mentioned repeatedly how supportive their husbands had been of their work. Many mentioned that they had married other scientists, particularly other physicists. Here are examples of how the women described the support of their husbands and partners:

I got someone who supported me and made me more secure about my own worth, someone to talk to after a “tough day at the office.” ~Denmark

My partner is a great physicist. He is the best thing that physics has given me. ~Spain

I married my best friend and my favorite collaborator. ~United States

My husband is extremely supportive. At times when I’ve had enough... he encourages me to stay on because I love the science. ~Australia

My husband is my great friend. He is [a] physicist, too. We discuss [our] results. ~Russia

Many women, however, reported problems that their marriage caused. Some were caused by the specific relationship, but others reported problems more related to societal expectations.

My husband hadn’t time and [didn’t] wish to help me. He didn’t take my independence and career very seriously, but [thought it was] secondary to his career. So I ran the house and did [it] all by myself. It was a disadvantage for my career. I felt it very much. ~Albania

I also enjoy family life and this does take time from one’s career work. I accepted becoming a medium quality researcher because that could fit in with the other side of my life. ~Denmark

My husband took the children to the doctor perhaps twice in 15 years. Somehow in his mind this works out to “equal” contribution... He comes home most days, plugs in his laptop, and continues working, and then once in a while complains about the house being messy. We have nearly equal positions and pay—but if I come home and continue work, then housework just doesn’t get done. If I come home and do housework, then I do not “produce” as much for work as he does. And he wonders why my career progress is slower than his... But I see more severe examples of this in other scientist-couple relationships. So I know I am better off than some others—in spite of my complaints. ~United States

Husbands are selfish things, even when they are not the main breadwinners. Being married and the main breadwinner is a double whammy of misery. ~United Kingdom

My husband wanted me to quit research, partly because he had a permanent job and did not want to move so that I could find a position, but also because he did not have the prospect of much more advancement in his career and he was very uncomfortable with me earning more than him. ~Australia

I believe my marriage was supportive. But the feeling that a woman should be many hours at home, taking care of her family was a pressure that I believe came not from my husband specifically but from society. ~Argentina

CHILDREN, FAMILY AND CAREER

The effect of children on a woman’s career is perhaps stronger even than the effect of marriage. Several studies in the United States have

documented these effects for mothers^{3,4} and women physicists with children are no exception. Forty-three percent of the respondents to this study have children, but among women older than 45, 79% have children. Many women physicists stated that they had decided not to have children:

We made the decision not to have children because [it is] not compatible with a career.
~Belgium

Women over 45 from developing countries are more likely (86%) to have children than women from developed countries, 73% of whom have children. Women in developed countries also tend to have their children at a later stage than women from developing countries. Two-thirds of women from developed countries had their first child after they received their final degree, but 69% of women from developing countries had their first child while they were students (**Table 19**). Not surprisingly, almost all respondents said that having children affected their work, and the percentage is higher for women in developed countries. Ninety-one percent of respondents from developed countries report that children affected their work, compared with 84% in developing countries. The reason for this difference is unclear, but could be related to the ability of women in developing countries to more easily rely on family members or to economically arrange for someone else to care for their children. In fact, women from developed countries were more likely than women from developing countries to say that daycare costs should be improved (58% in developed countries compared with 51% in

Table 19. Percent of Responding Women Physicists Who Have Children		
	Developed Countries	Developing Countries
Before final degree	33	69
After final degree	67	31

developing countries). As one Brazilian woman put it: *“I think that in my country, the main problem for women in science is not the family. We have maids.”*

Women who felt that children affected their work went on to describe these effects. Many spoke of the negative effects, including greater responsibilities at home that ultimately affected their productivity at work. Several also mentioned the perception that they were less committed to their work because they had children.

Having children very dramatically breaks any kind of equality at home. A larger burden in terms of child care and housework became a reality after children became a part of the family.
~Sweden

I was working in industry when my.... children were born and was definitely “mommy tracked.” I received fewer project lead opportunities and my rate of promotion slowed considerable even though I returned to work within 3 months of each child’s birth and I employed a nanny. ~United States

I felt many times very guilty for taking many hours at work. I believe that I decided not to travel much in order to compensate for this. But this is a drawback for science. ~Argentina

I can not stay at work as long as I would like. I divide my energy between work and children.
~Croatia

Children can affect the pace of women physicists’ careers. We asked respondents how quickly they thought their careers had progressed compared with their colleagues. The majority said that their careers had progressed at the same pace as or more quickly than their colleagues’ careers. However, more women with children said that

Table 20. Perception of Career Progress for Responding Women Physicists With and Without Children

Progressed	With Children(%)	Without Children(%)
More quickly	14	22
About the same	49	49
More slowly	37	29

their careers progressed more slowly (37%) than women without children (29%, see **Table 20**). This further illustrates the sometimes negative effects that children can have on women's careers.

However, women physicists also mentioned positive aspects of having children. Many said that having children made them more efficient and focused at work.

I had less time; therefore I became more efficient.
~Slovenia

Some mentioned both the positive and negative aspects of having children.

My children have greatly enriched my life, and made me think about physics in different ways. The stress of balancing childcare and work destroyed my marriage and my children's family.
~United States

I consider [the effect of children] positively. I am not very disciplined by nature. After the kid's delivery, I organized my life as in the army—severe control over every minute. I paid with a loss of my friends (no spare time!) and practically no personal life. ~Bulgaria

Family obliges us to control time. Perhaps we can learn to be more efficient, but frequently I feel I am not paying the attention my daughters deserve, neither [is] my research being done as deeply as it should. ~Portugal

Not only do some women physicists feel acutely the effects of children on their work, many are also responsible for the care of relatives other than children. In fact, 20% of the respondents to this study said that they were primarily responsible for the care of others. We did not ask respondents to elaborate on the effects of such responsibility on their work, but clearly this issue could be further explored in subsequent studies.

CONCLUSION

The more than 1350 women respondents to this questionnaire came from more than 70 countries, yet have many things in common. Most spoke passionately about their love of physics. While most spoke of family, friends, teachers, mentors, and colleagues as contributing a great deal to their successes, a significant number felt that their success was due also to their own persistence, determination, and hard work.

In spite of the similarities, issues are not the same for women physicists in developing countries as they are in developed countries. Women in developing countries spoke repeatedly of a lack of basic resources (funding, office space, lab space, equipment, travel money, and clerical support). Women in developed countries also found these issues (particularly funding) challenging, but the percentages who said they do not have enough resources for research are higher in the developing countries.

In the first survey of international women in physics,¹ women spoke frequently of the effects of children and childcare problems on their careers. Therefore, the questionnaire for this study included several items about these issues. In their concluding comments, however, women respondents to the second survey pointed out that childcare is not an issue only for women in physics, but is a general issue for all working women. Some pointed out that men also feel the

constraints that a career in physics puts on the family. Instead of focusing on childcare issues, these women felt that attention should be paid to the problems they felt were more specific to physics: discrimination and negative attitudes about women in science. Many continued to point out other issues that need attention.

While addressing childcare issues would probably help many women, I think that there are deeper problems with male attitudes and perceptions about women that may be deeply seeded and cultural or social in nature... I think that there is an underlying disrespect toward women in physics. ~United States

While these issues [child care and family] are important to both women and men in science, [there are] a plethora of other issues (e.g. climate, mentoring, available professional and skills development, and opportunities to collaborate). ~United States

Despite being a productive researcher, my career progression has been unsatisfactory so far. It is incorrect to assume that women's difficulties in establishing themselves in science are simply the result of family responsibilities. ~United Kingdom

Get people to discuss the real reasons behind discrimination: call a spade a spade and don't hide behind politically accepted causes like lack of childcare. Such are secondary factors, derivations of the main reason. The main reason is the mentality of seeing women as second-rate people. ~Netherlands

Many spoke quite eloquently about the need to end discrimination and change attitudes about women.

I would like women in physics to have the same rights as men. No extra rights, ... nor the lack of rights, but just the same rights regardless of sex. ~Poland

I think that we need the support of men to change the discrimination situation. They need to [be] aware of the problems. Without them we cannot succeed. The issue is that they do not want to talk about the subject because they are fine. Their wives have all the obligations of the family. Life for them is easy. ~Spain

I belong to [the] new generation of female physicists and I don't need to face the problems my predecessors had to face during their undergraduate or graduate years. Nevertheless my gender will always have some influence on my life via the behaviour of my colleagues or via the opinions of others. It is sometimes annoying to be treated first as a woman and after that as a physicist. ~Finland

There are a lot of stereotypes about women in India and the community is very male dominated. I have found that men get threatened by a woman who knows some things better than they do. ... It takes years before people take you seriously and a lot of willpower, which can suck the normalcy out of any human being! Being confident and aggressive is important, or one can get trodden upon easily. It's not a nice way to live. I fear that it will change my personality in a rather ugly way. ~India

Both women and men should be educated since childhood to [accept] the fact that a person is not smarter or more powerful BECAUSE he's a man or she's a woman. We should learn to treat gender in work-related issues as we treat, say, eye color. This will not come easy. ~Italy

In spite of women's frustration with discrimination and negative attitudes, there were many positive comments about physics as a career for women, including this one:

In the discussion on women in physics, the discussion has focused on the problems. These are important and should be discussed. But I

worry that women who might think of physics as a career are being discouraged by hearing only the negative side. I think physics is a great career for women to consider and I would like to see the positive aspects discussed also. Yes, there are struggles, but there are also wonderful aspects—let's not ignore these! ~United States

Among the more “wonderful aspects” are the passion many women feel for physics and the support of others who encourage them. Many respondents spoke quite fondly of men in their lives, especially their husbands, whom many felt were their biggest supporters. And in spite of the challenges faced by mothers, many women felt proud that they could provide good role models for their children. As this physicist from Russia

stated “I wanted to be a well-educated woman for my daughter[s].”

[My children] are the joy of my life. They make me strong enough to preserve my integrity and continue to love science as much as I loved it when I was a little girl, in spite [of] ... the injustice that I suffered. ~Argentina

And in spite of the problems women physicists encounter, most said they would do it all again, if only for the love of physics.

I think even if I tried not to choose physics, it would choose me. It is such a fascinating subject that no matter what other work I did, I would still want to learn about physics. ~United States

REFERENCES

1. R. Ivie, R. Czujko, K. Stowe, “Women Physicists Speak” in *Women in Physics: The IUPAP International Conference on Women in Physics*, edited by B. K. Hartline and D. Li, AIP Conference Proceedings 628, American Institute of Physics, Melville, NY, 2002, pp. 49-67.
2. The proceedings from the Second IUPAP International Conference on Women in Physics are available at <http://proceedings.aip.org/proceedings/confproceed/795.jsp>.
3. M. J. Budig and P. England, “The Wage Penalty for Motherhood” *American Sociological Review* **66**, 204-225 (2001).
4. S. Correll and S. Benard “Getting a Job: Is There a Motherhood Penalty” presented at 100th Meeting of the American Sociological Association, 2005.

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Appendix. Percent of Physics Bachelor's and PhD Degrees Awarded to Women in Selected Countries: 2-year Averages.

	% Bachelor's to women	Ave # of Bachelor's per year, both sexes	% PhDs to women	Avg # of PhDs per year, both sexes
Turkey	39	2,219	28	50
Greece	34	588	25	39
France	33	2,601	24	491
South Korea	30	2,189	10	125
Sweden	29	55	17	60
Latvia	26	12	20	3
Canada	23	503	13	118
Australia	21	182	20	100*
United Kingdom	21	1,755	18	415
Norway	21	72	20	28
USA	21	3,770	13	1,237
Taiwan	20	825	10	24
Slovenia	19	26	15	17
Estonia	18	20	10	5
Mexico	18	162		
Denmark	17	95	20	51
Japan	13	3,314	10	374
The Netherlands	12	206	12	68
Germany	9	2,173	10	1,570
Switzerland	9	206	9	109
Poland			13	182

21 Countries

* Include Master's degrees.

1998-99 data are presented for countries in blue. For all other countries, 1999-2000 data represented. To be included, countries had to provide appropriate data from reliable statistical agencies.

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