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A conversation with Nancy Reid

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Abstract: Nancy Reid was born in September 1952 in Niagara Falls, Canada. She graduated from the University of Waterloo with a Bachelor in Mathematics and a Major in Statistics in 1974. She studied statistics at the University of British Columbia (UBC) where she obtained a Master's in Applied Mathematics in 1976, and at Stanford University where she graduated with a PhD in Statistics in 1979. After spending one year at Imperial College London visiting Sir David Cox, she joined UBC as an Assistant Professor in the Department of Mathematics, and in 1986 she moved to the University of Toronto as a faculty member in the Department of Statistics (now Statistical Sciences) where she has been ever since including serving as Chair between 1997 and 2002. At the time of writing, Nancy has authored over 100 papers and 5 books, including seminal developments in conditional inference, higher-order asymptotics, composite likelihood, and Bayesian inference. Her outstanding contributions to statistics have been recognized nationally and internationally with many awards, including the President's Award of the Committee of Presidents of Statistical Societies (COPSS), the Gold Medal awarded by the Statistical Society of Canada (SSC), and being elected Foreign Associate of the National Academy of Sciences. In 2017, the *International Statistical Review* published Nancy's conversation with Ana Maria Staicu [Staicu, A. M. (2017). Interview with Nancy Reid. *International Statistical Review*, 85(3), 381-403.], which had a biographical emphasis. Since then, Nancy has continued to support the discipline of statistics in important ways, such as by serving as Director of the Canadian Statistical Sciences Institute (CANSSI) (2015–2019) and Co-chair of the Institute of Mathematical Statistics' Committee on Ethics (2018–2020). Her research activity continues to be celebrated with important awards such as Fellowship of the Royal Society of London (2018), the inaugural Hollander Distinguished Lectureship at Florida State University (2020), the Distinguished Achievement Award (and Lectureship) from COPSS (2022), and the Guy Medal in Gold from the Royal Statistical Society (2022). In May 2022, the Department of Statistical Sciences at the University of Toronto, in collaboration with CANSSI and the SSC, organized a one-day conference, "Statistics at Its Best", in honour of Nancy's 70th birthday. This conversation took place in Toronto around the time of the event. Its focus is on Nancy's views on building a career in statistics, and the challenges and opportunities statisticians encounter within the rapidly evolving data science ecosystem.

Résumé: Nancy Reid est née en septembre 1952 à Niagara Falls, au Canada. Elle est diplômée de l'Université de Waterloo où elle a terminé un diplôme de premier cycle en mathématiques avec concentration en statistique en 1974. Elle a étudié la statistique à l'Université de la Colombie-Britannique (UBC) où elle a obtenu une maîtrise en mathématiques appliquées en 1976, et à l'Université Stanford où elle a obtenu un doctorat en statistique en 1979. Après avoir passé un an à l'Imperial College de Londres en visite chez Sir David Cox, elle a rejoint l'Université de la Colombie-Britannique à titre de professeure adjointe au Département de mathématiques et, en 1986, elle s'est jointe à l'Université de Toronto à titre de membre du

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corps professoral au Département de statistique (maintenant des sciences statistiques) où elle a occupé le poste de directeur du départment de 1997 à 2002. Au moment de la rédaction du présent article, Nancy a écrit plus de 100 articles et 5 livres, y compris des développements fondamentaux portant sur l'inférence conditionnelle, les approximation asymptotiques d'ordre élevé, la vraisemblance composite et l'inférence bayésienne. Ses contributions exceptionnelles à la statistique ont été reconnues à l'échelle nationale et internationale par de nombreux prix, y compris le prix du président du Comité des présidents des sociétés statistiques (COPSS), la médaille d'or de la Société statistique du Canada (SSC), et le statut d'élu associé étranger de l'Académie nationale des sciences. En 2017, la *Revue Internationale de Statistique* a publié la conversation de Nancy avec Ana Maria Staicu (Staicu, 2017), conversation qui avait davantage un accent biographique. Depuis, Nancy a continué d'appuyer considérablement la statistique, notamment en agissant à titre de directrice de l'Institut canadien des sciences statistiques (INCASS) (2015–2019) et de coprésidente du Comité d'éthique de l'Institut de la statistique mathématique (2018-2020). Son activité de recherche continue de lui valoir d'importantes distinctions telles que la bourse de la Royal Society of London (2018), la conférence inaugurale "Hollander Distiguished Lectureship" à l'Université d'état de Floride (2020), le prestigieux "Distinguished Achievement Award" (et la conférence) de la COPSS (2022), et la médaille Guy d'or de la Société royale de statistique (2022). En mai 2022, le Département des sciences statistiques de l'Université de Toronto, en collaboration avec l'INCASS et la SSC, a organisé une conférence d'une journée intitulée "Statistics at Its Best", en l'honneur du 70e anniversaire de Nancy. Cette conversation a eu lieu à Toronto au moment de l'événement. Elle souligne les points de vue de Nancy au sujet de la carrière en statistique, ainsi que les défis et opportunités auxquels les statisticiens sont confrontés dans l'écosystème des sciences des données en constante évolution.

1. STARTING IN STATISTICS

C & Y: How did you get into the field of statistics and which statistical problem first piqued your interest?

Reid: I got into statistics as an undergraduate at the University of Waterloo, which is somewhat unusual compared to many of my colleagues in the United States. Waterloo had an undergraduate statistics program even when I started there in 1970. I had started out in computer science because everyone thought that was the way of the future, and I did a lot of programming for which I had no talent at all, but I really enjoyed the statistics courses. The statistics faculty were very young and energetic and interested in both theory and applications. So there was a feeling that statistics was an exciting area. Some of our assignments were to actually fit models to data using a sort of typewriter terminal that ran a now-defunct, but intuitive, language called APL. You went to a special lab, wrote your little program, and got the regression results out and maybe some printed plots as well—I quite enjoyed that sort of fooling around with the data. An important event was the arrival of Jack Kalbfleisch to the faculty there in my fourth year. He offered a special topics course on biostatistics, which was my first indication that you could use statistics in public health and medicine, or in other words that statistics could be a service to society. Although this is perhaps obvious in retrospect, it was new to me, and really appealed to my interests at the time. So for all those reasons, I guess I got into statistics. If I hadn't gone into statistics, I might have majored in English! I took a lot of English literature courses and I liked to read, and to analyze literature and so on. But perhaps my closet choice of alternative profession is to have been a film critic.

C & Y: If you were 50 years younger, would you reconsider your choice of a career?

Reid: Oh my goodness, I have no idea how to answer this. It seems to me that there's never been a better time to go into statistics, even though it was also lots of fun 50 years ago.

C & Y: How was your graduate school experience different from what our students experience today?

Reid: Well, I did two stints of graduate school. I went to UBC for my master's which in those days was a two-year program with a thesis, in the mathematics department. There were two courses offered: statistics (taught by Philip Dawid, a very young professor who was visiting for a year) and probability. I remember being a bit dismayed when I saw the course catalogue, but there were other courses available through different departments, so there was enough to put together a program. This program was a great experience; there were very few graduate students in applied math and statistics, and the faculty were extremely welcoming. I remember the students almost immediately being invited to dinner with a group of faculty after the department seminar, for example. Of course, I needed to write a thesis, and I was very fortunate to work with Jim Zidek who suggested a great topic that I wouldn't have ever thought of myself. A surgeon gave a talk in the math department as he felt he needed some advice about the data he had collected on coronary bypass surgery. He felt there must be information hidden in this data, but he didn't know what to do with it. Jim handed me a deck of cards that was a program to fit a Cox proportional hazards model, which he had been given by Norman Breslow at the University of Washington, and said, "well, why don't you see what you can do?" Jim also encouraged me to consider going to Stanford for my PhD—I'm sure I would not have had the courage to apply without this support.

My graduate experience at Stanford was quite different again. Many of the incoming students didn't have a very broad statistics background, but they had a strong and rich background in science and liberal arts, and they were very quick studies. I had a lot of catching up to do on things like measure theory and abstract math, but I did find that I had built up a fair bit of statistical intuition that served me well. The program at Stanford was more course-based—we had two full years of very interesting courses, and the thesis was written in the last two years. Because I'd written a thesis already, I kind of knew what I was getting into, and was grateful to have had the master's experience at UBC.

C & Y: What advice do you wish you had been given when you were younger?

Reid: Well, probably, to relax a little bit. When I look back, especially at my time at Stanford, I found it fairly stressful and in later years I wondered why. After all, I was in a beautiful part of a country with world famous instructors and interesting students from everywhere, some of whom became lifelong friends. So why was I stressed? There was, I think, an undercurrent of competition that I wasn't prepared for, that's maybe a bit more American than Canadian, so I think I was not quite ready for that sort of friendly, but fierce, competition. Perhaps I'd tell my younger self, "Relax, you're going to manage. If not, this wasn't the right choice for you, and if you do, well, aren't you lucky!" But I'm not sure I give very good advice. So there you go.

C & Y: Current graduates with training in statistics have so many paths available to them: software development, data management and visualization, industry collaborations, etc. What advice would you give a young statistician to build a satisfying and long-lasting career?

Reid: Giving advice on careers is a tall order. I'm reminded that David Andrews always said he gave opinions, not advice. There are many interesting careers, as you noted, so in one sense the advice has to include finding something that you find interesting; don't assume that you must be on a particular path because you always thought that's what you wanted, or what your parents expected. But these decisions are so personal, I find it hard to give useful opinions, let alone advice. Now there are many opportunities to explore different paths, through internships, workshops, online events, and so on. I guess I would hope that having taken several theoretical and applied courses, you'd have a feeling for what you enjoy the most, and then try to figure out how to build a career in that. Of course, one problem is that academics are not the best people

to give advice about non-academic careers. But we can, for example, keep our own minds open about various careers and encourage our students to do the same.

C & Y: What advice would you give to new PhD students who are unable to decide research directions?

Reid: In terms of advice, or rather opinions, for students, I always give the same advice, which I think has served me well. Look at the journals. For example, start with, say two volumes of *Statistical Science* and two of the *Annual Reviews of Statistics and Its Application*. See what interests you, what title interests you, what discussion seems the most lively to you? When I did my first project analyzing the heart transplant data, I just loved sitting in the medical library, looking up unfamiliar words in the big medical dictionary on the table beside me. I'd been primed by the course in biostatistics at Waterloo, and really I went to Stanford to do biostatistics, although I ended up changing my field. If you find something that interests you, it's easier to keep at it for the long hours required.

C & Y: What challenges related to equity, diversity, and inclusion do students in statistics face as they are immersed in interdisciplinary and applied research?

Reid: The challenges for students are pretty hard for me to comment on; there are so many different aspects to this. Perhaps I would say to a student, if diversity is important to you, then just keep trying to put yourself in a situation where you find that diversity. It can be hard to speak up in a group, depending on the composition of the group and the leaders of the group. But if you need to have sharp elbows to have your voice heard, then unless you like having sharp elbows, that might not be the right group for you.

In my career, I was often the only woman in the room and it can be lonely. I got used to it, because there didn't seem to be many options, but it's not as nice as having more women in the room. One thing that helped me was to make sure to seek out women when I had opportunities, for example at conferences. So even if I was the only woman on seven hiring committees in a row at University of Toronto, when I went to Joint Statistical Meetings, I would go to women's talks, introduce myself to women in groups, and kind of look for "my people". On the personal level, I have enjoyed all my friendships in the department and in the discipline, and while I was dismayed at the difficulty in hiring more women faculty, and getting more women speakers at workshops and conferences, it wasn't a huge deal for me when I was younger. As I got older and saw the situation changing only very slowly, I became more outspoken about the lack of diversity. I'm using women as the example most relevant for me, but one could substitute any other under-represented group.

2. BUILDING A CAREER IN STATISTICS

C & Y: In terms of the evolution of our discipline, how do you see the shift of the focuses on research areas and student training?

Reid: One difficulty for training, which I think is well recognized, is that many students need to learn an application area in depth, as part of their studies. That takes time, so the programs have become longer, but it also means re-thinking the programs rather than simply adding to them. We have gradually changed a little bit, so that students have the space to fit this in, but it still seems to me a tall order for graduate students. I'm not sure we've mastered the interface very well yet. Another point is that part of the fun of statistics is its breadth of application, so I would feel a bit sad if our students graduated calling themselves a particular type of applied statistician, and didn't have the opportunity to change their mind as they went along in the discipline. So somehow we have to find the right balance between enabling students to make contributions,

for example, to genomics, but not making them feel that they necessarily need to continue working in genomic applications for their entire career, unless of course they want to, but then their career is in a slightly different discipline than what I think of as statistics. Maybe I'm old-fashioned.

C & Y: What is your take on the theory versus application debate?

Reid: Well, theory versus application is a long debate, but by way of measuring how things have changed, when I first came to Toronto to teach in 1986, there was a new course offered to fourth-year and graduate students called Applied Statistics, recently launched by David Andrews, and I welcomed the opportunity to teach it, using Cox and Snell's delightful book *Applied Statistics*, published in 1982. We still do have this course, but we have so many more applied courses. You can't possibly get anywhere close to the breadth of methodology and applications in one course. Well, you couldn't then either, but there has certainly been an explosion in the number of disciplines collecting and analyzing data, and in the amount of data we are able to gather.

C & Y: In the context of data science there seems to be increasing emphasis on interdisciplinary work. What is the role of theory in a data science team?

Reid: I guess my comments on the previous question apply here too. As you say, data science is very interdisciplinary, and it's not possible for a single researcher to be expert in the application area, in collecting and analyzing the data, in computational techniques, in presenting the results, and in developing new statistical theory or methods, as required. Of course, I think theory is very important for data science. But if you're going to do new work for any application area, you need a basis for the development of new techniques. It doesn't make sense for everyone to just keep trying things and see if they work, when we have a hundred years of understanding about how and why things work. I do wish our students had more time and more opportunities to work in large teams. But perhaps I'm reflecting poorly on the reality because I don't work in a data science team myself. I'm certainly open to discussions, and I like thinking about application areas, but it's not been an integral part of my research. So I may be a little out of touch with what students are doing now, but I think that a really interesting education would include mucking about with data, with the help of really talented computer science professionals and scientists, collecting the data, and still having the time to really go back to the foundations and think, "what is it we really want to do here? Do we have something in our arsenal that will help, and if we don't, what is next?"

C & Y: It has been said that "science is a social endeavour". How important is this element in developing a career?

Reid: The social element is important in different ways. For example, there's the social element of getting along with people: being able to engage with colleagues, to participate in meetings, and so on. We tend not to train our students in this, but hope they pick it up along the way. Perhaps the best training is to set a good example. A different aspect of the social endeavour is, again, working in teams. You need to be clear about what you are bringing to the table, and then present that in a way that is neither arrogant nor timid. You need to speak when you feel you have something to say, but understand that there are many people in the room who have different ways of looking at problems.

C & Y: In an interdisciplinary setting, what might be the obstacles for statisticians to find the right identity?

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Reid: I think statisticians can sometimes be a bit arrogant (I'm sure I've been guilty of this), thinking, "Oh gosh, these people really don't know what they're talking about. All they really need is the right formula for a standard error." And that might be true. Then as a social endeavour, it's your job to supply them with a standard error in a way that makes sense to them and that can advance their science. By opening that door, you may be bringing forward opportunities to do much more in the future. But finding the right team can be a slow process, with lot of luck involved. It's hard enough to find a collaborator in your area, with whom the chemistry is right. And finding congenial collaborators in other fields of science is also in large part serendipity. But being open to new ideas and opportunities that may arise when you least expect it is surely part of being lucky.

C & Y: What advice would you like to offer junior statisticians to build leadership skills in the discipline?

Reid: For building leadership skills, well, I have again some opinions. If you want to build leadership skills, then you need to look for opportunities to lead, and these opportunities come up in any number of settings. You can volunteer for a committee in your department, in a statistical society, or in another context altogether. You can talk to people in your department who are heading in that direction or have done already and ask them how they got started. You can go to workshops at the JSM about leadership. There's a whole book about women and leadership published by COPSS fairly recently. You learn leadership by doing.

C & Y: What topics in statistics are you following with interest?

Reid: I just follow my nose on topics in statistics. Just now I find it interesting to look at foundations, and to look at high-dimensional inference, and I find it interesting to follow from a distance aspects of machine learning that require statistical thinking. I've always enjoyed finding items in the news that involve statistical thinking, well or poorly done. But I'm afraid I'm going to bail on answering that question properly.

3. THE FUTURE OF STATISTICS

C & Y: The interest for data science (DS) is at a historically unparalleled high. If we are to match the demand for qualified data scientists, we need to define what level of training is needed and get more of our students at that level. What elements in the educational process slow us down?

Reid: In our department at the University of Toronto, for example—and I'm guessing it's not that different in other undergraduate and master's level programs—I think we're falling down on the art of communication, understanding concepts, and being able to explain these to a non-specialist. I had many students this year in the mathematical statistics course, to my surprise, reporting that as the p-value was less than 0.05 we should reject the null hypothesis, although in the applied statistics course I taught I don't think I would see that in a report, because I rant about it so much. So why did they say that in my mathematical statistics course? Perhaps I forgot to rant enough, but I think there might be a disconnect in their thinking. That when you "do math stats", there are rules that have been developed according to theorems, and one reports the rules, whereas when you "do applied stats", there's more room for interpretation. So I think somehow the courses need to be better integrated. Students in applied courses need to really understand what theory was used to develop that p-value, and students in the theoretical courses need to be able to think, "how am I going to use this in applications? And how am I going to explain this to a layperson? How can I explain it in a way that resonates?" I think we have the skills to teach it,

but it involves a lot of intensive work, and we simply don't seem to have the manpower for this, given the size of our classes.

C & Y: Computer science and statistics are fundamental to DS. What would you say to those who are worried about statistics losing its core values in the future?

Reid: Well, my first thought is that I'm not worried about losing our core values at all. Although I know there are, in some quarters, worries that computer science, or some other field, could sideline statistics in the world of data science. In a way, I think statistics has been worrying about this forever. Data used to be small, but it was big if you had to do everything by hand. And then one could handle datasets a little bit bigger if you had a hand calculator, and maybe two or three assistants helping you with that. And so on, as computers improved, our demands grew with them—the size of the data being always just a little bit bigger than what one could handle. But the key concepts of uncertainty and variability are always there. How could they vanish? How could we not have to think about the uncertainty in our statements about what we found in some set of data? Now, perhaps people will say, "well, that's exactly what's happening in fields of machine learning and artificial intelligence (AI)", where the output is a set of classifications, often very good ones. For example, this interview was transcribed using software presumably built on machine learning, and it's both convenient and remarkably accurate. I have no idea what theoretical properties go into the algorithm, and this is essentially irrelevant. There is a set of problems for which black-box methods provide very helpful, innovative, and interesting solutions. But there are many other problems for which they don't. And I think recognizing the dichotomy between those classes of problems underlies current interests for explainable, or fair, or ethical, uses of AI and machine learning. For a great many problems it's imperative to explain why you're getting the predictions you're getting and whether the predictions you're getting are going to be valid in other contexts. And for that we need basic concepts in statistics: Statistics 202, 302, and 3002. So I can't imagine that there's not going to be a need and a place for the core concepts of statistical methods and statistical theory, as long as we have data.

C & Y: If you have to shout out, what actions do we need to take as a whole of the statistical community to make our discipline thrive?

Reid: I do have a strong opinion on that. We statisticians are much too critical of each other in interdisciplinary settings. This has been driving me crazy for years, especially as science and statistics have become more interdisciplinary. We've talked a lot about that in this interview, that data science research is very interdisciplinary. The more that is the case, the more often we find ourselves in a competition, or a comparison, with various disciplines. If we don't support each other, why would anyone support us? In these settings our skeptical nature is harming us, and if we don't get on top of it, I think we won't live up to our potential. So if you're asked to write a letter for someone, remember what your mother told you—if you can't say something good about someone, don't say anything at all. It doesn't help to point out the weaknesses in someone's approach when the other disciplines' representatives are consistently praising the genius of their colleagues. It's fine to have a healthy debate amongst statisticians—we're trained to be skeptical and this often has a place. We should have a healthy debate about whether such-and-such procedure is really going to work as well as the proponents claim, or whether this-or-that principle of inference is really as crucial as our colleague thinks it is. But this discussion should not colour how we describe our science in a milieu that involves scientists from a host of other disciplines. We do not need to share the opinion that some applicant for a job, promotion, prize, award, grant, would be a better statistician if they did what we think they should. That is just shooting ourselves in the foot and it drives me crazy. So if there's one thing we could do, it is to stick up for each other all the time in every

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setting. I would be very grateful if we all wrote more positive things about each other and about our discipline and about what we bring to the table, and did much less careful parsing around the nuance of every bit of praise. Let it go. Sing their praises. Let it go, please. Thank you.

C & Y: This is a perfect note to end on. Thank you, Nancy, for taking the time to chat with us.

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