

A Conversation with Raymond J. Carroll

Xihong Lin and Nilanjan Chatterjee

Abstract. Raymond J. Carroll is Distinguished Professor of Statistics, Nutrition and Toxicology at Texas A& M University, USA. He has made fundamental contributions to numerous statistical and health science areas, including measurement error models, data transformation and weighting in regression, nonparametric and semiparametric regression, longitudinal data analysis, and statistical methods and applications in nutrition, epidemiology and molecular biology. Carroll has received many distinguished honors. Some highlights are the 1988 Presidents' Award of the Committee of Presidents' of Statistical Societies (COPSS), the 2002 COPSS Fisher Lectureship Award, American Statistical Association and Institute of Mathematical Statistics fellows. He was the first statistician given a Method to Extend Research in Time (MERIT) Award from the US National Cancer Institute. Carroll has provided outstanding professional services, including editor of Biometrics, the Journal of the American Statistical Association (Theory and Methods), and founding chair of the Biostatistical Methods and Research Design study section of the US National Institutes of Health. Carroll is an inspirational and successful teacher and mentor. He has won a College of Science Teaching Award from Texas A&M University, and has trained over 45 Ph.D. students. He has also been an outstanding mentor and supporter to many junior researchers in the statistical community, including the two authors of this article. In this interview, Carroll talks about his career, including his passion for mentoring junior researchers, and offers some helpful advice.

Key words and phrases: Epidemiology, longitudinal data analysis, measurement error, nonparametric and semiparametric regression, nutrition, transformation.

1. INTRODUCTION

The interview was conducted at the Johns Hopkins School of Public Health, Baltimore, Maryland, on October 22, 2019 (Fig. 1).

2. FAMILY BACKGROUND, CHILDHOOD AND TEEN YEARS

Lin: Ray, it is an honor to chat with you about your life and career. You have been so influential to many of us. Let's start with your family. You were born in a military family, and your father was a successful military lawyer. Can you tell us a little bit about your parents?

Xihong Lin is Professor of Biostatistics at Harvard T.H. Chan School of Public Health and Professor of Statistics at Harvard University, Boston, Massachusetts 02115, USA (e-mail: xlin@hsph.harvard.edu). Nilanjan Chatterjee is Bloomberg Distinguished Professor of Biostatistics and Genetic Epidemiology at Johns Hopkins School of Public Health, Baltimore, Maryland 21205, USA (e-mail: nchatte2@jhu.edu).

Carroll: Thank you very much for doing this interview. I know it's a lot of work on you guys' parts, and I want to thank Matt Wand, who initiated this. My parents were Irish Catholics from Brooklyn, New York. My father joined the military directly after the attack on Pearl Harbor. He became what is called a judge advocate general, and stayed in the Air Force for over 30 years. My mother was very Irish Catholic and did not take any guff from anybody. She was a lovely person, and everybody loved her, including her family. But when somebody attacked one of the kids in the family, they were in for a very hard time.

Lin: Can you tell us a little bit about your childhood and teenage years and your siblings?

Carroll: I was born in Yokohama, Japan (Fig. 2). At age 3, we moved for a year to Nagoya, Japan. Then we moved when I was 4 to Virginia, USA, where my dad worked at the Pentagon. When I was a teenager, I spent 2 years in Germany, two and a half years in Wichita Falls, Texas, and then three years in Omaha. My mother found the moves very, very stressful. I just liked traveling, and going to new



FIG. 1. Raymond Carroll (left), Xihong Lin (middle), and Nilanjan Chatterjee (right), had lunch at a Baltimore restaurant after the interview on October 22, 2019.

places. I sometimes took buses around Germany when I was 12 years old. I still like traveling a lot.

There were five of kids in my family (Fig. 3). I was the oldest of the five. We have family reunions every year. We get together at sporadic times during the year. Most of my siblings are in the Texas area, and one is in Cincinnati.

Lin: How did you develop a passion for math?

Carroll: I did not. I wanted to be a lawyer, like my grandfather, my uncle, my father, follow in people's foot-

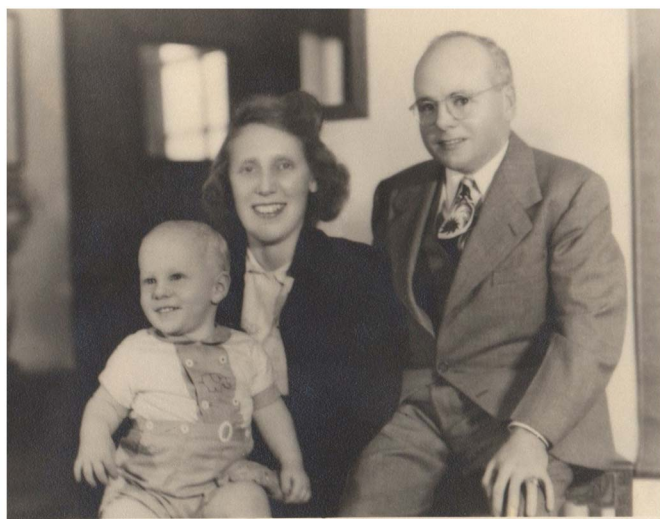


FIG. 2. Raymond Carroll at 18 months, with parents Regina and Norman, US Air Force base, Yokohama, Japan, late 1950.



FIG. 3. Raymond Carroll (second from the left) with siblings, at the Connemara National Park, Ireland, 2011.

steps who you love. I was good at math, and I took great pleasure in it, but it was no passion at all. I did have some pretty good math teachers, and so that always helps. In high school in particular, I had excellent math teachers. They had accelerated, for the time, math classes, nothing like nowadays.

3. COLLEGE AND GRADUATE SCHOOL YEARS

Chatterjee: Ray, I want to start by saying again what an honor it is to interview you. Can you tell us a little bit about your undergraduate years?

Carroll: At the time, money was a little tight in the family, because they did not pay military people very well. I had a summer job mowing lawns on a golf club for a year. It was a really good pay. Then I had two years as a substitute mailman. I used the money I made to pay for my college. I loved going to University of Texas (UT) at Austin. The education was superb. I had lots of friends, and UT won the national football championship in my junior year.

Chatterjee: Did you choose math as your major? What were your initial thoughts on what you would do with that major?

Carroll: Well, I had no intention to become a mathematician or a statistician when I started. As I said, I thought I would be a lawyer. But I had a great calculus teacher in my first year, and I switched major. I did not start thinking about what I was going to do till my senior year at UT, in 1970–1971. The Vietnam War was raging. My draft lottery number was 61. I was going to go into the military. I decided to go to graduate school. I had to make a decision between math and stat. At the time, the University of Texas did not have any statisticians in the math department. I took probability from an educational psychology professor, and sort of theoretical statistics from a visiting assistant professor. They were very good teachers. What I liked about the statistics part was uncertainty, and it played into my skills, since I can do algebra. So I picked to go to graduate school in statistics.

Chatterjee: Let's talk about your postgraduate years. You went to the Department of Statistics at Purdue University for your graduate study. So how did you choose Purdue?

Carroll: Well, one of the things is that there were no statisticians at UT then. I did not have anybody to talk to. I went up to Southern Methodist University in the spring break of my junior year. There was a guy there, and his office was open. So I asked him if I could talk to him about where I should go to graduate school in statistics. It turned out to be Don Owen. The American Statistical Association (ASA) now has an award called the Don Owen Award. Don worked with me for about two hours. The Purdue graduates all graduated in four years from the time of entrance. The North Carolina graduates, well, it was mostly five to six. He said, if I were you, I would go to Purdue and get your Ph.D. earlier. That seemed to me pretty good advice, so that was what I did. I always thought grateful to Don Owen for being willing to interrupt himself for somebody he didn't know, who was not from his university, but just knocked on his door.

Chatterjee: Can you tell us more about your graduate school years? How you chose your dissertation problems?

Carroll: I didn't know enough about what was hot. My major professor was Shanti Gupta. He was the head of the department and a wonderful man. He had also had a good record of getting his students jobs, which mattered to me. Shanti did ranking and selection, which is not much in favor these days.

He would have us over for dinner. The department had a policy then of inviting graduate students to the receptions for various speakers. Nobody ever went, but I got this invitation. Being a military kid, you just accept the invitation. All the professors were really nice to me. Then after that, everybody started coming. George Casella came the next year. We just had a wonderful time going and eating at a professor's house and having some drinks.

Chatterjee: What was your interactions with your Ph.D. supervisor like?

Carroll: I did talk to him a lot, because he wanted to know what I was doing. But I said to him I wanted to write my own thesis. It may not be any good, but it would be mine. He said, OK. As long as it's on ranking and selection, I'll let you go on your way. It worked out well. I was the only student in my first year class who didn't have a master's degree. So it was a little rough at the start. My office mate, Steve Furman, who ended up at Bell Labs, really helped me. Because of my math background, I was able to do the qualifying exams after the first year. I am the son, nephew and grandson of lawyers. So I read the rules. It turned out that once you'd passed your qualifying exam, you did not have to take hardly any more courses. I never took a course in linear models. I graduated in three years, which I am still pretty proud of.

Chatterjee: You have made landmark and influential contributions in multiple areas of statistics, including data transformation, nonparametric and semiparametric regression, and measurement error, just to name a few. How had your graduate training prepared you in these subjects?

Carroll: Well, the one thing that I am deeply appreciative of Professor Gupta is he let me do what I wanted to do. I learned about kernel density estimation and kernel regression in the early days. I spent a lot of time in the math library, which was on a different floor in the same building. I would go on Saturdays and just see which new journals came in. So that really helped. The whole milieu of the stat department at Purdue at the time was really good for people who wanted to be independent.

4. YEARS AT THE UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL, MEASUREMENT ERROR, AND NONPARAMETRIC AND SEMIPARAMETRIC REGRESSION

Lin: You started your academic career as assistant professor at the University of North Carolina (UNC) at Chapel Hill. Can you describe how the life of an assistant professor at that time differed from now, and in what way it has changed?

Carroll: Some things are universal in academia: tenure and worries about tenure, and worries about whether people will write nice letters for you, plus the excitement of doing research. But the real difference, to me, is the emphasis on money now. It was simple to get three months' summer support at that time. Not now! That is a big change. The other part of the big change is that if you do not have enough funding now, you are not going to get tenure. The most welcome change is that we are not all men anymore in stat departments. The influx of women has changed things a lot, and I think made it a better place to be. Writing papers and teaching classes is the same thing. Technology changed for the better. I do not have to use IBM Fortran cards. On the other hand, I did not have to do email either.

Lin: David Ruppert and you have been long-term collaborators and have jointly made several influential contributions. Did you meet David at Chapel Hill? How did two of you meet and develop friendship and long-term collaboration?

Carroll: I went to UNC at 1974. David came to UNC in 1977 and was my next-door office mate. I was changing myself, because I was kind of bored with proving theorems, which is not a very good thing to do three years after your Ph.D. I had a great experience of a well-known marine scientist named Dirk Frankenberg, who came one day to the department. I was the only one around. There we go. A famous marine scientist comes in and talks to the 26-year-old. He asked me a question that really changed my



FIG. 4. *Raymond Carroll (left) and David Ruppert (right), Yellowstone Canyon, 2004. Photo by Rick Rossi.*

professional life. That was, how many shrimp are we going to catch in the Pamlico Sound this coming year? That is a simple question. But the data were pretty sparse. They came to me in handwritten note cards on salinity, water temperature, harvests, and catches. There were eight years of data. I was tasked with getting a projection. I have never had a course in linear models. It is a really dangerous thing to let loose somebody my age at the time, who did not have any actual real knowledge of how to do statistics. I worked hard and spent a good three months analyzing the data and had a wonderful time. At the end, I went to Dirk and said, it is going to be the best year ever. The technical report I wrote is on my web site. Dirk said, are you sure? I do not know nowadays how many 26-year-old statisticians who would say, as I did, yes, I am absolutely positive. It was only because I did not know anything about regression when I said that. The upshot was that the model predicted extremely well, blind luck.

The Fisheries Department of the State of North Carolina started calling it the Fisheries Department Model of Shrimp Catches. They kept using it for years. It did pretty well. But we all know about now when you get covariates that are not in the support of the original model space, things can go wrong. Finally, a few years later, the prediction was one of the extremes. It was completely wrong. At that point, they decided to call it the University of North Carolina Fisheries Model. That was a great experience. I loved doing it.

Ruppert showed up just as I had finished the predictions. Dirk came back to us saying, well, we want to know how to manage this fishery called the menhaden, which was an endangered fishery. Our wives were out finishing their Ph.D.s. We had nothing else to do. We started working together. I still remember the first paper. The first time we started talking about it seriously was about trimmed least squares. At the time, there was a push to take regression residuals and trim 5% or so of the highest ab-

solute residuals. We just sat down on the blackboard one day and wrote out the theory of doing that. We did not get it all done on the first day, of course. But we got it done. That was fun. So we started working together. We have written 45 papers and 3 books. We are close personal friends (Fig. 4). The nice thing about it is besides that we are compatible, he had better technical skills than me. We have exactly opposite personalities. It has been a lifelong friendship that worked out great.

Lin: That's a wonderful story. You have made very influential contributions to nonparametric and semiparametric regression. Did you start this area of research at Chapel Hill?

Carroll: I started nonparametric stuff in graduate school in my thesis, about estimating sequentially the density function at an unknown point, like the mode. These semiparametric problems started coming up. In particular, the problem of variance functions appealed to me, because in the shrimp study, there was severe heteroscedasticity. So I estimated least squares with a nonparametrically estimated variance function. It just came naturally. Later on, we worked on more sophisticated problems like partially linear models, where there is a parametric component and a nonparametric component. So it really was a natural progression from my graduate school days. I could never have done it though without David Ruppert.

Lin: You were among the first who worked on statistical methods for measurement error in 1980s. You have made fundamental and landmark contributions to shape this. At that time, very few people worked on this problem. How did you become interested in this problem?

Carroll: I was in my office on a sabbatical with the National Heart, Lung, and Blood Institute (NHLBI) in 1981. All the statisticians at NHLBI were on a retreat. Rob Abbott walked into my office and said, I have a referee's report. I need help to answer the question on what the effect of measurement error on logistic and probit regression was. So that was when I started. Certainly it was fun, because it was the first time I'd ever been asked a question that I could solve and which I did not think had any literature. It turned out there was some literature, but that did not matter. You could not go to Google to find it out at the time. There is a lot of measurement error in cardiovascular diseases. So I started writing papers on measurement error models, and then eventually on deconvolution. I had a student, Len Stefanski, now very famous, who wanted to work on that topic. Spending a year and a half at National Institute of Health was really useful, because they had lots of data, lots of data problems. I had another friend, Mitch Gail, who was there at the same time in the National Cancer Institute (Fig. 5). They had problems about measurement error in all sorts of contexts. So, within the environment I was in, it came naturally to start thinking about the measurement error problem.

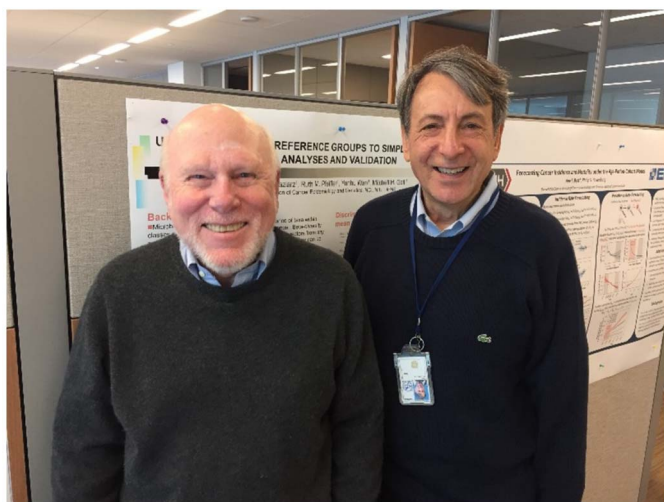


FIG. 5. Raymond Carroll (left) and Mitch Gail (right), National Cancer Institute, 2019.

5. YEARS AT THE TEXAS A&M UNIVERSITY AND NUTRITIONAL RESEARCH

Lin: Let's talk about your Texas A&M years. When did you move to Texas A&M? Can you say a few words about the move?

Carroll: I moved in 1987. I was unhappy at North Carolina. The only reason I stayed at North Carolina was because David was there. In about 1985, he started looking for jobs. I made a choice that I wanted to go back to Texas, because my family and my wife Marcia's family are from Texas. My mother was still alive at the time. My father died the year before. I wanted to help my mother. It seemed like a really natural thing to do. I knew the people at Texas A&M and liked them. They had an opening for a full professor. I figured if I went there, I could probably negotiate something that would allow me to spend time with my mother and more time with Marcia, who was in Bethesda, Maryland.

Lin: What was your research focus after you moved to Texas A&M?

Carroll: I have done a lot of work on measurement error, and a lot of semiparametric things. Of course, functional data analysis was just being discovered about then. I happily want to acknowledge Joanne Lupton, Nancy Turner, and Robb Chapkin at Texas A&M, who are nutritionists (Fig. 6), and they introduced me to nutrition problems for the basic biology of nutrition and cancer and not dietary measurement error.

By that time I was tenured and at least reasonably successful. So I did not feel any need to do anything in particular. I did whatever came to mind at the time. Not a very good style of doing research, but it does work for me.

Lin: You are a University Distinguished Professor of Statistics, Nutrition, and Toxicology. How did you become interested in nutrition and toxicology?



FIG. 6. Raymond Carroll (middle) with (from left) Naisyin Wang (now at the Department of Statistics, the University of Michigan) and nutritionists Robb Chapkin, Joanne Lupton and Nancy Turner in Carroll's office, 2004.

Carroll: I became interested in toxicology because of Doug Simpson, one of my and David's students, who was working on toxicology. The nutrition story is a little funnier. They were putting together a big center grant for toxicology and nutrition. They had a reception, and they were all toxicologists. So I was the only statistician there. I did not know who to talk to. Sitting over in the corner I saw this woman, Nancy Turner. I went up to her and said, what do you do? Because she obviously was not a toxicologist. She said nutrition and cancer. On the spot, she started explaining to me what she did having to do with colonic crypts, and damage and repair mechanisms in cells in the crypts. She did such a good job of explaining it, I realized it was a functional data analysis problem. But it was a very unusual one. We started writing papers together. My student, Jeff Morris, who is now at the University of Pennsylvania, wrote his thesis on those kinds of problems. They were wonderful problems, where you could actually get biology people interested in what you were doing. I have about 20 papers with that group of biologists, a number of them in good stat journals. It was a wonderful, long-term relationship. I spent a lot of time in their labs, talking to them. It is just a lot of fun.

6. REFLECTIONS ON THE AWARDS

Chatterjee: Now we'll talk a little bit about the prestigious awards you have received. You were awarded the COPSS Presidents' Award in 1988. How did you feel when you heard the news? Can you say a little about your statistical contributions that were recognized by the committee?

Carroll: It was my last year of being eligible for the COPSS Award. I had not heard anything until the middle of June. The Joint Statistical Meetings (JSM) that year

was in New Orleans. I got called up by the committee chair who asked, are you going to the JSM this year? I said, no. He says, well, I think you might want to come. That's when I learned that I had won the COPSS Presidents' Award. I was very excited. What did they recognize me for is hard to know, because I do not know. I never saw the nomination. There also was a little bit of a "who's left?" part, because of the people my age, one of them was Jeff Wu. He got it the year before I did. Jim Berger was basically my age, and he got it two years before. Peter Hall won it the year after I did.

Chatterjee: You wrote a beautiful essay in the COPSS 50th Anniversary Volume on personal reflections on the COPSS Presidents' Award (Carroll, 2014). Can you say a few words about this essay?

Carroll: Yes. We were all asked to write something. Some people wrote technical papers. I was giving a lot of advice to various people, either professors or students and postdocs. I have given talks about how to write a paper and how to write a grant proposal. Some of those things are on my web site. I thought, why not write about that, what helped me become somewhat successful? One of them was to have great collaborators. When you have collaborators like David Ruppert, Mitch Gail, Len Stefanski and many, many others, it really makes it easier. Another one was to get lucky, and that's the Dirk Frankenberg story about fish and the Nancy Turner story about biological basis of nutrition and cancer. I was in very good mood then so I wrote a happy paper. Since they were not going to reject what I wrote, it was fun.

Chatterjee: You were also selected for the 2002 COPSS Fisher Lecture Awards. You are among a very few statisticians who received both of these awards. What did you present at your lecture? What were some of the main messages that you wanted to convey to the audience?

Carroll: The title of the talk was "Variances Are Not Always Nuisance Parameters" (Carroll, 2014). I have been on this kick for 40 years, about how variances and structure of variances is important in statistics. It is really overlooked, although much more emphasis now is paid on quantile regression, which is a very good thing. I gave a talk about where variances have a role, other than just as a nuisance parameter in a t-test. If you win the Fisher Award, you get to write a paper in a journal of one of the participating associations. I choose *Biometrics*, for which I had just been the editor. I love variability. I think that is the whole thing that distinguishes us from other people is we believe in variability. I like to think I intrinsically understand it and do not consider it an enemy but quite a friend.

Chatterjee: So you're the first statistician who received the National Cancer Institute (NCI) Method to Extend Research in Time (MERIT) Award. Can you tell us a little bit about that?

Carroll: The NIH MERIT Awards are basically 10-year grant awards. There's a little evaluation after five years that is pro forma. The rule was to even be considered, you had to have three grant cycles where your proposal got a score in the lowest 5%. I had some great scores, but I had one which was at the 5.1 percentile. The program officer was able to talk to the appropriate division head and convince them to round the 5.1% down to 5%. The program officer was a nutritionist. She really liked both my work on nutrition and my collaboration with her many colleagues in nutrition there. It was great not have to write a grant for 10 years.

Chatterjee: How have these various distinguished awards shaped your career and research?

Carroll: Well, the research, not so much. But my career, it gave me great visibility. I have given over 400 talks in my life. I have never given a talk since 1991 that the introduction does not mention the COPSS Presidents' Award. That is not me. That is just the flavor of the award. If they want to do two, they do the Fisher Award. That sort of visibility is very good for one's career. I sort of expected to have a chance at the Fisher Award. But I never thought I would get the COPSS Award.

Chatterjee: Other than these very well-recognized awards, can you tell us a little bit about whether there have been some moments in your life where you have felt extremely honored?

Carroll: I really love them all, because they're all special for one reason or another. I won the Snedecor Award for a paper with Bruce Lindsay and my good friend Kathryn Roeder, the Wilcoxon Award with David, the Noether Senior Award, the Mitchell Award, the Sacks Award, and the Don Owen Award, which given how influential he was in my choice of graduate school, was a really nice thing to have won. I also won an interesting award from Texas A&M University. It was for promoting diversity. The award was given to me in 1996. Diversity was not that big a thing back then. I discovered a program in the National Cancer Institute's grant program that if you had an NIH-NCI grant, and there were two or more years remaining, you could get a supplement. I supported three very good Hispanic students through their graduate school years so that they did not have to worry about finances, and a few postdocs. They have all been successful.

7. COLLABORATIONS WITH NATIONAL CANCER INSTITUTE COLLEAGUES

Chatterjee: You already mentioned that some of your work started when you were a visiting scientist at NIH. I myself met you when I was at NIH. Throughout your career, you have been collaborating with various biostatistics and epidemiology groups at NIH. How was that experience? How did that shape your career?

Carroll: I love the NIH. As a statistician, it is nirvana. It is an unbelievably rich environment for statisticians to be in. I did two years at NHLBI. A few years later, I went to the National Cancer Institute. Mitch Gail invited me. I spent a couple of years there. The sheer overwhelming nature of the number of people working on things that I liked was really something. I have had lunch with Mitch Gail many, many times in my life, and usually at the same place. It is really a neat place to work with people. I have worked with many people who are not Mitch Gail at the NCI, including you!

Chatterjee: Could you tell us a little bit more about your relationship with Mitch, for example, the working relationship and the friendship?

Carroll: Mitch is the kind of guy who is really friendly, and everybody knows him as a kind person. If he gets into a problem, and he thinks it is important, he will just go after it. He has a remarkable ability to identify important public health problems and push them through to a solution. I have never written a paper with Mitch that didn't get accepted in the first journal, I think. Of course, he is famous for the Gail Model of Breast Cancer Risk. I was there when he was writing that model but not involved. I could see how hard he was working at it.

Chatterjee: Can you tell us about the collaboration with others at NCI?

Carroll: Besides the Rob Abbott story of 1981, I've worked very closely with a biostatistics group in a different division of the NCI from Mitch's Division of Cancer Epidemiology and Genetics. I also work with people in Division of Cancer Prevention, headed by Victor Kipnis. I have worked with Victor and two of his colleagues, Doug Midthune and Kevin Dodd on a many problems. In Mitch's division, I also have worked with other people there, Ruth Pfeiffer and Josh Sampson. So there is a lot of power at the NIH in statistics.

8. REFLECTIONS ON METHODOLOGICAL RESEARCH AND TIME WITH PETER HALL

Lin: Can you tell us a little bit about your "aha" moments in your statistical research?

Carroll: I call them flash days. My first one was during the qualifying exam as a graduate student. That was a convenient time to have a flash day! They came a lot faster and more often when I was younger, but they still sometimes come. I have to work, but at one point I just sometimes get it, know how to solve the problem, and do that.

Lin: You have worked on many different areas throughout your career. Can you tell us how you pick and prioritize your problems, and what motivates you to get into certain areas?

Carroll: Well, this is not my strength. It is very haphazard. Whoever comes and talks to me, if they have what



FIG. 7. Raymond Carroll (left) and Peter Hall (right), circa 2012. Photo courtesy of Jeannie Hall.

sounds like an interesting problem, and it sounds I can maybe help solve it, then that becomes a priority. It is both a strength, because I am curious, and not a strength, because I go all over the place without a real theme.

Lin: You and Peter Hall had a long-term collaboration and friendship. Can you tell us about it?

Carroll: It was a tragedy when he died. I visited him about 18 times in Australia and spent good parts of the American summer in Australia (Fig. 7). We got along extremely well, right from the start. Of course, Peter, with his astonishing math ability, brought something to the collaboration, ha ha. I like to think I brought something, too. In fact, in his Statistical Science interview, he says some nice things about how we brought different things to the table in my applied focus. Our very best paper was on density deconvolution, which appeared in JASA.

I met him in 1985 at UNC. I then visited him in 1987 in Canberra. We worked hard, six days per week. He would go out on Saturdays taking photographs, trains in particular, and he published photos in train magazines. He would be beside the railway tracks in his Subaru Outback. He would just go as fast as he could to get ahead of the train. We kept following the trains. These little dirt roads were not really very safe. I learned everything I know about photography from him. He had some very good camera lenses, but he also had a great eye for what is the right way to set up a picture. I learned from him that it is not how to hit a button, but how to frame the picture in such a way that you get your story across. Jeannie Hall, Peter's wife, was kind enough to give you one of her pictures of me. He took lots of pictures. They are really great pictures, but he took very few pictures of people, which I thought was interesting. She discovered one which is a great technical picture (Fig. 8). It's just a picture of me on



FIG. 8. *Raymond Carroll on railroad tracks near Canberra, 1987. Photo by Peter Hall, courtesy of Jeannie Hall. In full screen, even the shoe laces are in perfect focus.*

some railroad tracks clowning around, but it is so well focused that you can see the color of my shoelaces. I loved working with him. We talked about airplanes and cats. He was an airplane buff, as well as railroad buff. I am a cat person. Recently, Jeannie sent me two photos Peter took, and they are now in pride of place in our Washington State home.

9. REFLECTIONS ON COLLABORATIVE RESEARCH

Lin: You started as a mathematical statistician. You have made substantial contributions to many applied statistical areas and their applications, for example, in nutrition, toxicology, bioinformatics, just to name a few. How and when did you successfully make this transition? How have you trained your mentees in conducting collaborating research?

Carroll: I started making the transition in 1976, when Dirk Frankenberg came into my office. I wanted to do methods research. It is more fun if you have an application that you are thinking about in advance. It really fits my personality that you can have fun doing some math stuff, but it also actually matters in various contexts. I think this has been really my real theme, if I have ever had a theme. I like them to have some deep basis somewhere in some field that is easy to understand. I used to say, I want to do something I can explain to my mother. In my current life, nutrition is my favorite application. That has a lot to do both with my colleagues at the NCI and my experience at A&M on the biological basis of nutrition and cancer.

Lin: Can you tell us some of your favorite collaborative stories?

Carroll: There are many of them. A nice project I worked on was with people at the National Cancer Institute (NCI) on estimating the distribution of usual intakes of foods and nutrients in US. It was using the US National Health and Nutrition Examination Survey (NHANES) data. My statistics collaborators were Victor

Kipnis, Doug Midthune, Keven Dodd and Janet Tooze. The original estimates based on a single 24-hour recall estimated that—and I am going to have my numbers a little bit off here. But the standard analysis estimated that $\approx 38\%$ of kids in US in that wave of the NHANES had abysmally bad diets. My nutritionists thought it was a gross overestimate. The really neat thing about that is you can show it is a gross overestimate in a trivial simulation. It is a multivariate problem, half of the variables being episodically consumed. So they are zero or some positive number, and then substantial measurement error, due to day-to-day variability.

I tried to do that, like a dumb Bayesian, which I am, and I could never get the MCMC to converge. I realized that there was one technical peculiarity of the data and variables. One variable, for example, was how much did you eat of whole fruits? The other was, how much did you eat of total fruits? Now, if you have some whole fruit, you automatically qualify for total fruit. So with probability 1, if you consume a whole fruit, then you consume total fruit. That screws up all the MCMC. I just thought, why not call it fruit juices and whole fruits, and whole grains and non-whole grains? All of a sudden, the program started running. It is now used in nutritional surveillance in many different places. My estimate was that 8%, not 38% of kids had an abysmal diet. That major change is important!

Lin: You have collaborated with many people, both statisticians and non-statisticians. Can you tell us a little bit about the key factors to make such collaboration successful?

Carroll: Well, I at least am a pretty friendly person. I never really thought about what are the key factors. First of all, it helps if you are not both experts in a particular thing, so that both people bring some contributions. I like to work with smart people. I actually have a pretty good filter on people who just want me to run t-tests versus people who actually want to have a long-term collaboration. That is the applied side. In the statistical side, well, I know what problems appeal to me. So I think you have to work with smart people whose expertise you respect. Sometimes they have greater expertise than you do. Off my experience over the last 15 years it is usually your collaborators who have better expertise in something that is important for the project than I do.

Lin: What do you think about applied research as a statistician?

Carroll: It is a good thing. I do not do it as a living. I think the exposure to smart people doing applied things, or scientifically interesting things, is important. It is something that helps advance your thinking in terms of what are interesting problems. You learn to listen to people as to what they wanted. To write a good collaborative research paper is just as hard as writing a good statistics paper.

10. TRAINING, MENTORING AND PROFESSIONAL SERVICES

Chatterjee: Let's talk about training and mentoring. It is stunning that you have trained 48 Ph.D. students in your career. Many of them have become distinguished statisticians. Just to name a few: Len Stefanski, Marie Davidian, Jeff Morris, and Veera Baladandayuthapani. Can you tell us a little bit about your students, and your interactions with them?

Carroll: I have been lucky to have mentored many great Ph.D. students, including those four. Really, if they want to work, they will work. If they do not want to work, you cannot help them.

Chatterjee: What is your training philosophy when you train Ph.D. students?

Carroll: I try and make them independent. I try and get them so at the point they graduate, the last thing they want to hear from is me.

Chatterjee: You have been very generous also mentoring junior statisticians who are not your students or trainees directly. Both Xihong and myself have benefited from your mentoring in our early careers. There are other people we know, like Richard Samworth, Naisyin Wang, Bani Mallick are among others. Can you tell us a little bit more about this aspect of your mentoring? What has been your experience? What would you tell other people, like mid-level or senior people, so they can benefit? How can they mentor junior statisticians?

Carroll: Thank you. That's nice. I have this philosophy, from my mother and father, that you should help people if you can. I have written letters for many people: Peter and I once had a competition as to who would write the most tenure reviews, but he was so fast and in demand it was not a competition. You watch your friends go from very junior statisticians, like you two, to become famous. One of you is already in the National Academy of Medicine. That is pretty rewarding. Everyone should do it.

Chatterjee: Thank you for all the mentoring you have done to us and other junior people. Let's talk about your other contributions to the profession. You were the chair of the Department of Statistics at Texas A&M in your late 30 s. What was your experience being a chair?

Carroll: It was very hard. I would never be a chair again. That was an exceptional time. I was brought to Texas A&M by the dean, the chemist John Fackler. I think I did OK. It is very hard to maintain your research program and maintain yourself as a good department head and good leader, especially these days.

Chatterjee: In your view, is there a right time when people should consider taking administrative responsibilities? If they do, how to balance the administrative responsibility and research?

Carroll: I was 38 when I started as a department head. I was like President George H. W. Bush: neither of us has much of a vision thing.

11. RESEARCH AND PROFESSIONAL SKILL DEVELOPMENT

Lin: What do you think your most important contributions are? What led you to these?

Carroll: I go and look at my vita. I love a lot of my papers. I never thought about I want it to be called a major contribution, because I realized very quickly it is a way to make sure you don't write any papers. I will tell a story. I wrote a paper with Margaret Wu that came out in 1988 in *Biometrics* (Wu and Carroll, 1988). Margaret was at NHLBI. We talked about a paper when I was there during 1981 to 1984. A few years later, she said, you know, we really ought to work on this paper. It was one of these things— it now has a term, where you combine longitudinal data with time to event data, called joint modeling. The paper was really not very sophisticated, but it was pretty. The method really worked, and that was good. I just thought of it as a throwaway paper. It has hundreds of citations! I have never been very good at deciding what was important, a priori. I have had many papers I loved and thought were possibly important and they get rejected without review.

Lin: We know communication skills and writing skills are extremely important. How can junior researcher enhance their communication and writing skills?

Carroll: Well, I think I'm a pretty good writer, but too spare. I also won a teaching award, which was amazing. What it is that I see sometimes with people who are not communicating well is that they really do not care that they are not communicating well. I try to remember that the audience does not care about the technical details. They want to know what is the problem, how it fits in. So I try and give a talk so my mother could understand it. It really takes an effort. It's not something that comes naturally to anyone. The same thing with students. David Ruppert taught me a saying: Never try and teach a pig how to sing, because it wastes your time and annoys the pig. He was talking about teaching undergraduate non-math students. You can't make them mathematicians. They are not mathematicians and never will be. So why even bother trying? It does waste your time, and it does annoy the pig.

Lin: How to deal with rejection, obstacles, and failures?

Carroll: As you two know, my first six papers were rejected. Some were not very nice rejections. One editor said, you should leave academia, you obviously do not have any talent for it. Well, of course, that is a lunkhead. But you are going to get papers rejected. I am very proud to be the co-author of Peter Hall on the first paper that he got rejected. That is a lifetime achievement award. What I have learned is rejections occur because readers do not get the point of the paper, because the point of it was not clear.



FIG. 9. Raymond Carroll with wife Marcia Ory, on vacation in Lizard Island, Australia, 2004.

12. WIFE MARCIA ORY

Lin: Let's talk about your wife, Marcia Ory. You have been married to Marcia for over 50 years. Marcia is a Regents and University Distinguished Professor at A&M. She has developed great friendships with many of your statistical friends, including us, over years.

Carroll: She's a real expert in gerontology and healthy aging over the life course (Fig. 9). Her work and her projects are amazing. She is just now (2023) returning from a project work in Lviv Ukraine, this being inspired by the awful, immoral invasion by Russia.

13. SPARE TIME AND HOBBIES

Chatterjee: Let's talk about something other than statistics. How do you spend your spare time, starting with your hobbies? You are a very avid traveler. Tell us some of your travel stories.

Carroll: While I have hobbies, these days my major one is fishing.



FIG. 10. Fly fishing the Big Hole River with Rick Rossi and David Ruppert, Montana, 2005. Photo by David Ruppert.

I have been all around the world trout fishing—South Africa, Spain, Chile, the United States, Canada. My friend Rick Rossi taught me how to fly fish. Everybody is going to these big trophy streams. Not me! There is a place called Tenderfoot Creek, just north of White Sulphur Springs, Montana, where you can, after a major hike, catch 100 fish a day (Fig. 10). I have now started going to a lodge located at northern Saskatchewan in Canada, where I enjoy fishing for northern pike. At Hatchet Lake Lodge I once caught a 46-inch northern pike, all catch and release.

Chatterjee: We are coming to the end of the interview. We would give you a chance, if you have something more to add that we have not covered.

Carroll: No, I think we have covered plenty. Thank you.

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