



Jane Menken

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On Becoming a Mathematical Demographer—And the Career in Problem-Focused Inquiry that Followed

Jane Menken

Institute of Behavioral Science and Department of Sociology, University of Colorado Boulder, Boulder, Colorado 80302, USA; email: menken@colorado.edu

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Abstract

I greatly appreciate this opportunity to reflect on my career. Looking back over five decades of involvement in demographic and sociological scholarship, I have tried to say a bit about my personal life and my work—from developing mathematical models of fertility early on, to applying lessons from those models to empirical work in the United States, Bangladesh, and elsewhere in the developing world, to involvement in evaluations of health and population interventions. Equally important to me have been the building of research capacity and involvement in program and policy development. So much remains for new generations of scholars to do, but my hope is that, in choosing their own directions, they—and sociology as a whole—will take as their mission examining issues of societal importance around the world.

INTRODUCTION

It all started at the Harvard School of Public Health (HSPH) with the simple question: Why did fertility differ dramatically in populations that did not practice deliberate fertility control? This was the puzzle that led me to mathematical demography and determined my lifelong research path.

I had gone to HSPH in 1960, right after graduating from the University of Pennsylvania with a degree in mathematics and with a strong sense that my interests lay in applications more closely connected to social issues rather than in pure mathematics. As a biostatistics master's degree student there, I was asked to work with a group of epidemiologists who were conducting an experiment in introducing family planning and improved medical care in a group of villages in India, the Khanna Study (Taylor 1997). In the Indian subcontinent, women who survived to the end of the reproductive span (say age 50) had, on average, just under 7 children. At the same time, I learned that Mindel Sheps, who later became my mentor and dear colleague and friend, was studying fertility among the Hutterites who, in the same reproductive span, averaged over a dozen children (Sheps 1965). So was born the driving question: Why, when societies practiced little in the way of deliberate family planning, did fertility differ so dramatically? And what, then, were the consequences of such differences for women and for populations?

Sheps, with Edward Perrin, had begun developing mathematical models to study fertility. I joined her project at Columbia University in 1966. The theoretical model we explicated takes an individual longitudinal—or family building—perspective based on an interacting set of social and biological determinants. It is orthogonal to the long tradition of formal demography of population growth, which takes group level characteristics as its building blocks: population rates of fertility, mortality, and in more recent approaches, migration (Bourgeois-Pichat 1971, Coale 1972, Keyfitz 1968, Rogers 1975). Instead, we built on both sociological and sociodemographic work on the components of fertility—but more about the specifics of this modeling effort later.

SOME PERSONAL BACKGROUND

Growing up in Philadelphia, I was a shy, tongue-tied, awkward kid. My childhood was colored by our family situation. Dad, a Russian Jewish immigrant, reached the United States in 1924 at age 13, after a difficult childhood of poverty, World War I, and the Russian Revolution. He brought with him the kidney disease that compromised his health for the rest of his life. For him, he said many times, life began when he arrived in Philadelphia. He was able to attend college intermittently and finally graduate, but in 1932, the best job he could get was as a truck driver for a dry-cleaning factory. Despite his chronic illness, he worked at this job and then added a small dry-cleaning store of his own. His patriotism evidenced itself in my life—as a child and preteen, I am sure we visited every historic site in Philadelphia and its surrounds. His positive example was one of courage and persistence. It also came in his support for my interests in mathematics. He never thought about sex differences in the brain. But he also firmly believed girls should not go to college and married women should not work outside the home. This stance, combined with his illness that at any time could bring total disability or death, made little sense to me. It forced me, early in high school, to think about women's roles in family and society in general and in my own life. I gradually realized I wanted not only to have a family and children but also to further my education and have a career that enabled me to use my intellect and support myself and my family. I am grateful to my father for his love, for his example of dealing with adversity, and for making me a feminist in the 1950s, well before the momentum of the movement in the 1960s.

Mom quietly supported my education. The Philadelphia inner city schools I attended were far from challenging, so I became a regular in the local library. One day when I was 10 or 11, I came

home and told her that the librarian refused to let me check out an adult book. Back she marched me. When the librarian said that the book was beyond my understanding, Mom asked her to pick out some paragraphs and let me tell her the meaning. That was the last time my choice of books was challenged. When my brother and I were cleaning out our family home after our parents died, I found a rubber-banded packet of my library cards (in those days, cards were stamped with the return due dates for the books) that Mom had saved. Her heart attack at age 40—when I was 15 and my brother, Marty Golubitsky, was 10—left her invalided for many years. Marty and I raised one another and that special bond continues to this day. Marty and his wife, Barbara Keyfitz, are mathematics professors, now at The Ohio State University.

My dreams would never have been realized without outside support, both financial and personal. A National Merit Scholarship enabled me to attend the University of Pennsylvania (Penn) while living at home. At Harvard, I had a National Institutes of Health (NIH) traineeship. My PhD studies in sociology and demography at Princeton University were supported by a Population Council fellowship. Unsurprisingly, I am a fervent supporter of efforts to create opportunities for the financially disadvantaged and to make higher education affordable.

I was fortunate to meet Matthew Menken, my first husband, at Penn. He went on to Harvard Medical School and I followed him to Boston. Matt and I divorced when our two children were teenagers and I remain grateful to him for our continued shared parenting. Ken (Yaakov) and Kate and their spouses are men and women of principle who are leading contributory lives of service. They are wonderful parents to their seven children and perfectly illustrate variation in childbearing—Ken and Tova Menken have six children and Kate Menken and Stephen Hanmer have one.

As a second-year medical student, Matt was required to take a biostatistics class. He asked the professor about opportunities for his then-fiancée (me), who was interested in statistics. It was my great good luck that Mindel Sheps was his professor. She invited us to her home, told me about HSPH, and introduced me to the chair of the Department of Biostatistics! Six years later, when we were considering a move to New York City, I learned that Mindel was also moving to Columbia University and wrote to her, asking for a job on her projects. And so began mentorship, collaboration, and deepest friendship.

Mindel's and my interests coincided; we thought in the same way about fertility and mathematical models. We spent three years together at Columbia and continued our work long-distance after leaving New York City. The experience of bouncing ideas across a table and then solving the mathematical problems we posed was exhilarating. We were able to live in a world of ideas based on the shared set of questions we wanted to answer and also a shared sense of humor—part of the acknowledgment in our book, *Mathematical Models of Conception and Birth*, reads “We wish that, like many other authors, we could acknowledge hours spent by our spouses in typing and checking the material. But Cecil Sheps and Matthew Menken did not read a page of technical matter. They were, however, unfailing in their interest and encouragement” (Sheps & Menken 1973, p. xxiii).

Mindel died of cancer at age 59 in 1973, before the publication of our book. In dedicating it to her, I wrote “She combined excellence in scholarship with warmth, integrity, a capacity to inspire close associates to explore their talents to the fullest, and a deep concern for social problems.” In a 1971 convocation address at the University of Manitoba, Mindel had suggested that

it would be well to approach all human problems with humility, with a strong sense of the limitations of our knowledge and of the existence of large areas of ignorance, and with readiness to admit the errors we may make. . . . The only hope of solving the problems of this planet lies in the application of scientific understanding and skills in the service of human dignity, freedom and welfare. Neither science nor high ideals can do the job alone. (Sheps & Menken 1973, p. v)

I have taken her words as the creed that guides my own work and life.

Charlie Westoff also played an important role in my career. As Matt and I readied to leave New York City in 1969, we looked for smaller towns with opportunities for a neurologist and a demographer. I planned to continue research with Mindel, who had moved to the University of North Carolina. I first met Charlie when we shared a panel at an annual meeting of the Population Association of America. I visited him to ask whether, if I were to move to Princeton, I could have access to the Office of Population Research (OPR) library while working at home. My recollection is that he looked at me and said “That’s the stupidest thing I ever heard. You’re coming here to *work*.” And that’s what I did.

I have been fortunate in all of the institutions in which I worked—HSPH, NIH, Columbia, Princeton, Penn, and now the University of Colorado Boulder (CU), in that order. NIH, Columbia, and Princeton all accepted part-time employment while my children were young. I knew I was following a risky path, but my disagreement with the philosophy of the women’s movement of the 1960s and 1970s was its emphasis primarily on women’s careers, with little attention to the needs of families and children. My mantra was and is: “I don’t want women to have men’s jobs [as traditionally defined]; I want people to have human jobs.” While enormous progress has been made in the more than 50 years since publication of *The Feminine Mystique* (Friedan 1963), much remains to be done to promote more symbiotic work-family relationships, whether or not family includes children.

Years before going to OPR, I had considered applying for the PhD program in statistics at Harvard, but I decided the time was not right. I had seen too many graduate students who were working on dissertations that were chores rather than passions. I did not yet know how to fit my own passions into a dissertation, so I decided to take a job as a better next step. After two years at OPR, I entered the Princeton sociology graduate program with a dissertation topic decided, having realized that no matter how good my research, my career choices were limited without a PhD. I returned to OPR in 1975, degree in hand, in a research position that allowed flexibility for me to be an active parent at a time when high-quality child care was even more difficult to find than it is today. By early 1980, I felt it was time to move to a full faculty position. With outside offers in prospect for me, Charlie Westoff, Ansley Coale, and then-chair of the Sociology Department Marvin Bressler persuaded the university to offer me a “target of opportunity” full professorship as the tenth tenured woman at Princeton.

OPR was an intellectually crackling place to be in the 1970s and 1980s. Ansley, Charlie, and Norm Ryder set the highest standards of research. Graduate students in those days included James Heckman, Doug Massey, John Knodel, Susan Watkins, James Trussell, Myron Gutmann, Hilary Page, and a list of others too long to give here. OPR was a center of the demographic world, with visitors coming through regularly and ongoing discussions on research and its relevance for policies and programs, and conviction that programs were better the greater the evidence base for their design and implementation. Collaborations with James Trussell and Susan Watkins, which continued over many years and a range of subjects, began during this period. Ansley and Charlie, then director and associate director of OPR, asked me to become assistant director. I discovered that I like research administration—meeting needs to establish and maintain an environment that fosters high-quality interdisciplinary research and mentoring.

My next position was equally fulfilling. Sam Preston and Frank Furstenberg enticed me to Penn in 1987, where I was director of the Population Studies Center for five years. A major attraction was Penn’s focus on African demography and on training young African scholars. In the mid-1990s, Etienne van de Walle claimed that more Africans with PhD training in population studies had received their degrees at Penn than all other institutions in the world combined. Sam and Frank, Etienne, Susan Watkins, Doug Massey, Phil Morgan, Doug Ewbank, Herb Smith,

Tukufu Zuberi, Irma Elo, Andy Foster, Jere Behrman—who could ask for a more talented and diverse group of population scientists than those at the Population Studies Center? The graduate students were also outstanding, and I continue to collaborate with Randall Kuhn, Sam Clark, Enid Schatz and Sangeetha Madhavan.

I was introduced to Richard Jessor in 1989 on my 50th birthday by Frank Furstenberg and his wife Nina Segre. It still amazes me that the love of one's life can show up at ages 50 and 65! His children and grandson are part of my family. Dick, who has been a CU faculty member since 1951, persuaded me to move from Penn to Boulder in 1997.

In 2001, I became Director of the CU Institute of Behavioral Science (IBS) and served in that position until becoming a research professor in 2015. Administration took much of my time for those 15 years; I am especially grateful to colleagues without whom my research during that time would have been impossible. IBS is an interdisciplinary social and behavioral science institute that attracts faculty and graduate students from all the social and behavioral sciences who work on problems of societal importance and carry out basic and translational research and outreach. Through the efforts of its outstanding faculty, IBS now has the National Institute of Child Health and Human Development–funded CU Population Center, the new US Census Bureau–associated Rocky Mountain Research Data Center, and the long-standing Natural Hazards Center. IBS-associated faculty who recently were or currently are Sociology Department professors include Del Elliott, Fred Pampel, Rick Rogers, Stefanie Mollborn, Jason Boardman, David Pyrooz, Ryan Masters, Lori Hunter, Lori Peek, Kathleen Tierney, Amanda Stevenson, and Sanyu Mojola. CU recognized our achievements and our potential for future research by funding the new IBS Building that opened in 2010.

RESEARCH INVOLVEMENTS

My research career began in 1966 with my collaboration with Mindel Sheps. Its focus was on developing theoretical foundations for understanding fertility and family building. We learned that plausible but quite different sets of basic building blocks led to near-indistinguishable fertility patterns. For this reason, while I continued to create mathematical models to address specific questions, my interests turned to methodology and population-based studies of the determinants of fertility. These interests, in turn, led to my work in Bangladesh. Bangladesh in the early 1970s was characterized not only by high fertility but also by the unusual situation that women had higher mortality than men, so that understanding the position of women and its impact on them and their society became part of my research agenda. Finally, and also because of my experience in Bangladesh, the latter part of my career has focused on evaluation of interventions intended to improve the lives of people in developing countries.

Theoretical Models of Family Building

When I first entered graduate school in 1960, the rapid rates of population growth in recent years were unprecedented and led to intense public policy concern. Arguments for policies to reduce growth go back, of course, to Malthus and notions that the world was going to run out of sustenance. The mid-twentieth century formulation went further—that population control would lead to social and economic benefits for countries and the world (Natl. Acad. Sci. 1971). Mortality decline was occurring nearly worldwide, so fertility, increasingly seen as the primary determinant of population growth and structure, became the policy focus. The view of fertility decline for the good of the world shared uneasy space with what I will call the Margaret Sanger view, which comes from concern for health and wellbeing of women and babies. Its claim was that health and

life chances of mothers and children would improve if there were better child health programs, increased intervals between births, and fewer children in a family. Becker combined these views to some extent in his quantity-quality tradeoff theory of the family: that having fewer children would permit greater investment in their quality, e.g., human capital, health, etc. (Becker 1981). A third view, aligned closely with the Margaret Sanger position, is one of reproductive rights and reproductive choice: that women and couples have the right to have children when and if they chose to do so (Cohen & Richards 1994). In some cases, population control was unfortunately associated with the eugenics movement and with coercion.

A somewhat startling gap in early population policy was failure to recognize that successful efforts to reduce mortality made reducing the growth rate more difficult. Fertility had to drop sufficiently to overcome any decline in mortality.

For Mindel and me, our professional work was firmly guided by a desire for scientific understanding. Implicit in our research was also the search for evidence that could inform public policy. In that regard, I served on the Guttmacher Institute Board of Directors for more than 15 years, beginning in the early 1980s. I shared fully its institutional values, which are “Commitment to rigor in . . . research and analysis and to publication of . . . findings, whatever the ramifications for policies and programs may be; prioritizing the needs of disadvantaged groups and addressing inequities in access to and use of information and services; addressing emerging questions to promote understanding and shape the public debate; collaborating with others to maximize the reach and impact of our research and analysis” (<https://www.guttmacher.org/about>).

In the 1960s, scientists in many fields were motivated to understand dynamics of population change. These dynamics, like most social processes, are difficult to study. There are no laboratory approaches; analyzing actual life situations, as in countries with intensive family planning programs, is difficult because of the inevitable presence of a large number of uncontrolled variables. Such realities account, at least in part, for interest in mathematical and simulation models as a way to investigate population dynamics. They also influenced my later empirical work in developing countries, work which has sought and implemented ways to measure fertility and its determinants and to address questions of whether, and how, reduced fertility indeed benefits individuals over their life course.

Mindel and my family building models followed the pioneering work of Henry (1972a,b), Vincent (1961), Perrin (Perrin & Sheps 1964), Potter (1963), Blake and Davis (Blake & Davis 1964, Davis & Blake 1956), Gini (1924), Pearl (1933), Dandekar (1955), Brass (1958), Tietze (1956), and others. In explaining human fertility and its variation, we, like others, assumed that social, economic, and psychological factors are the principal determinants, but they can only operate within biological structures and limitations.

Our models were based on a framework that included a few events of known importance and the intervals between them. The reproductive span is an interval that begins with the later of biological capacity to conceive (menarche) and initiation of sexual relations and ends with the earlier of sterility and cessation of sexual relations. Within that span, there are successive live births and the intervals between them. A birth is followed by a postpartum period that ends when both ovulation and sexual relations have resumed. Next, there is the interval to conception, often referred to as the waiting time to conception. This interval depends on fecundability, the monthly probability of conceiving. Next is a pregnancy interval that ends either with a live birth, stillbirth, or abortion (spontaneous or induced). In the case of a nonlive birth, there is another waiting time to conception and pregnancy period. There may be several of these waiting times until the live birth that ends the birth interval occurs. In most cases, both pregnancy and postpartum periods associated with a live birth are much longer than when pregnancy ends without a live birth.

Based on this framework, Mindel and I developed probability theory models using Markov renewal process theory and simulation models that allowed us to relax the strict assumptions we had to accept for the mathematical models (for example, fertility unchanging with age or over time). Conclusions—sometimes startling ones—that remain relevant today, both for basic understanding of family building and for family planning policy, follow from these models. They include:

- A highly effective contraceptive used by a fairly small proportion of women reduces birth rates more than a less effective contraceptive used by a much higher proportion of women (Sheps & Perrin 1963). So if one believes a highly effective contraception produces a better outcome for a contraceptive who wants to postpone pregnancy, then both individual and population goals are better served by access to highly effective contraception.
- Accidental pregnancies are common even when quite effective contraception is used. Even when fecundability is reduced to 0.0125, a monthly risk of just over 1 in 100, the probability of an accidental pregnancy is 40% within 5 years, 67% within 10 years, and 82% within 15 years. The reproductive health implications are clear: It is highly likely that during her lifetime, a woman will have to make the decision to either carry on with an unintended pregnancy or choose induced abortion. Because the risk of unintended pregnancy is so high, some will choose sterilization, feeling that that is the only sure pregnancy prevention method.
- Abortion alone is a poor way to control fertility. Abortions almost always are performed early in pregnancy and the subsequent postpartum period is very short. One abortion may only postpone the next birth by a short time. When induced abortion is the main means of fertility control, a woman may have many abortions over her lifetime. A much greater effect on births is achieved when abortion is a backup measure when contraception fails.
- Long postpartum periods serve as a substantial brake on fertility. Later empirical research demonstrated that breastfeeding practices are the major determinant of the length of this period (Howie & McNeilly 1982). Improved survival of breastfeeding infants can also lengthen this period.

An especially informative modeling study we undertook was to change one factor abruptly—in this case the induced abortion rate. The study was motivated by actual experience in Romania where induced abortion was the main means of fertility control until 1966. The government became concerned about low fertility and abruptly ended legal abortion. Six months later, the monthly birthrate shot up but then began to decline. We were able to show that the observed pattern was to be expected after a sudden shock like this. There would be no simple change in the birth rate but rather a series of fluctuations before a new constant birth rate was reached. This birth rate, while higher than the preexisting one, was not nearly as high as the one that initially resulted from the change in availability of abortion. Cohen (1974, p. 1046), in his review of our book, said these results “would warn effectively against believing that the early results of programs designed to affect the birth rate will be the same as the long-term results.”

We also studied selection effects. Some of the few existing studies of waiting time to conception showed monthly conception rates declining with time. We found that it was usually not possible to determine whether the cause was fecundability varying among women (heterogeneity) or fecundability truly declining for all women. With heterogeneity, there is a selection effect: The most fecund conceive sooner, leaving a less fecund pool of women to conceive the next month. Years later, Heckman & Walker (1990) delineated special cases in which heterogeneity could be distinguished from homogeneous declining fecundability.

With the publication of our book in 1973, I felt that we understood the roles that late biological maturation and late sexual initiation, early sterility and early end to sexual relations, contraception

that prolonged time to conception, increased frequency of spontaneous or induced abortion, and longer postpartum periods could play in reducing fertility. We had noted that populations could end up with very similar fertility patterns through quite different mechanisms. I decided a shift to empirical studies was my next step.

Along the way, however, there were several more modeling studies—of family structure with Susan Watkins and John Bongaarts (Watkins et al. 1987), of the effects of lengthening birth intervals through long-term breastfeeding with Randall Kuhn (Menken & Kuhn 1996), and of the effects of famine with Watkins and Cameron Campbell (Menken & Campbell 1992, Watkins & Menken 1985). I also want to note the pathbreaking work of Bongaarts, who based new and widely used measures of fertility determinants on models like ours (e.g., Bongaarts 1978).

Fertility Determinants and Reproductive Health

My first foray into empirical research was my doctoral dissertation on methods for estimating fecundability. I had no data of my own and no opportunity to carry out a study of my own design, but again, research generosity entered the picture. Henry Mosley and others had carried out a study in Matlab, Bangladesh, that collected detailed data on birth interval segments. Their paper is a classic (Chen et al. 1974). Henry shared their data with me and introduced me to the International Centre for Diarrhoeal Disease Research, Bangladesh (now icddr,b) and its Matlab Health and Demographic Surveillance System (HDSS). My main substantive dissertation finding is that the monthly probability of conception even in the absence of birth control was quite low, far lower than had previously been estimated or asserted for European historical populations. Causal mechanisms could not be addressed in this study, but both low frequency of intercourse and the effect of intense breastfeeding after ovulation had resumed have been suggested.

In 1975, James Trussell and I began a long collaboration on fertility determinants in the United States. We were among the first to study contraceptive effectiveness by applying life table approaches to survey data on monthly method use (Menken et al. 1979; Pratt et al. 1979; Vaughan et al. 1977, 1980). This approach yielded plausible estimates of effectiveness when a method was actually used by married couples. As might be expected, the most effective methods were those, like contraceptive pills and intrauterine devices (IUDs), that were applied furthest from intercourse itself. These ordinary use estimates were considerably lower than manufacturer estimates—the so-called laboratory or perfect use effectiveness. We were invited to a US Food and Drug Administration (FDA) Advisory Committee meeting in the 1980s where information to be included in packets of contraceptive pills and IUDs was discussed. We learned very quickly that researchers and activists may take very different stances on this issue. Our view was that ordinary use measures should be presented. A vocal set of activists argued that women should only be given information on outcomes under perfect use. Social science arguments that women and couples frequently are imperfect users failed to sway them in the least.

We were also deeply concerned with evaluating the impact of changes in reproductive health policy. So when the Hyde Amendment, passed in 1976, severely restricted use of federal funds for abortion, we, with the Guttmacher Institute, implemented a study of the impact of this restriction on women's ability to obtain legal abortions (Trussell et al. 1980). Federally funded abortions under Medicaid fell dramatically from 295,000 in fiscal 1977 to approximately 2,000 in 1978, but some states continued to subsidize abortions with nonfederal funds. We analyzed state abortion data and conducted surveys in abortion provider units in several states, including two that cut off abortion funding and others that did not. We concluded that approximately 20% of women who would have obtained abortions were unable to do so in 1978. The other 80% paid for abortions.

Because Medicaid funding was restricted to women on welfare in the states we studied, it is unlikely that these women had private insurance for abortion services. Our conclusions remain eerily relevant nearly 40 years later (Trussell et al. 1980, p. 130):

Americans are of many minds about abortions and about the desirability of using public funds to pay for them. It seems unlikely, however, that very many people can gain satisfaction from the effects of the Hyde amendment in [states we studied].

Those deeply opposed to abortion on religious or moral grounds who hoped that stopping federal and state funds for abortions would bring about dramatic decreases in these procedures must be disappointed. Most poor women in need of abortions managed to obtain them.

Those, on the other hand, who believe that abortion is a procedure which should be available as part of good medical care, and should not be discriminatorily deleted from the range of services offered to poor women under our system of publicly financed health care, will be angered that poor women are forced to dig into their exiguous welfare budgets to pay for a needed abortion. And they will be discouraged that a substantial number of indigent women were forced to bear unwanted children and that a few (no matter how few) were driven to risk their lives and health from self-induced or clandestine abortions. . . .

Those who believe that women should have the right to make their own conscientious decisions about abortion, but who do not support public funding of abortions, will be sobered at the realization that one can't have it both ways.

James and I were equally concerned with understanding infertility, especially at a time when women were increasingly postponing childbearing to later ages. In 1982, an incendiary editorial in the *New England Journal of Medicine*, based on an article in that issue, claimed that women's conception rates fell strikingly from their late twenties to early thirties (Schwartz & Mayaux 1982). It suggested that women who cared to have children would have to revise their plans and have children earlier if they were to have them at all (DeCherney & Berkowitz 1982). James, Ulla Larsen, and I turned to data on historical European populations in which late marriage was common (Flinn 1981, Hajnal 1965), as did Bongaarts (1982). We found that the decline in the proportions having at least one child was only 10% when women who married in their early thirties were compared with those who married in their early twenties. Sharp declines began only after age 35. The evidence was persuasive that biological infertility rises only moderately with age, at least until the late thirties and early forties (Menken 1985, Menken & Larsen 1986, Menken et al. 1986). Most evidence suggests that age-specific infertility has likely declined over time—people are healthier and have access to innovative medical technologies. Yet whether infertility is rising continues to be debated (Levine et al. 2017). What would I, if asked, tell my granddaughters? Let increased risk of infertility after age 35 be one, but only one, of the many factors you take into account as you plan your life course.

Health and Population Change in Bangladesh—The Matlab Studies

Henry Mosley's work, which introduced me to the Matlab HDSS, jump-started my long and continuing research on Bangladesh. Bangladesh, once described as the world's "basket case" by Henry Kissinger, who thought the country would need continual assistance after obtaining its independence from Pakistan, has seen astonishing change. Between 1970 and 2010, the infant mortality rate plummeted from 173/1,000 births to 37/1,000, the total fertility rate went from 6.9 children to 2.2, and girls' school enrollment rose from 34% to 93%. Changes like these and the existence

of the Matlab HDSS created an unusual opportunity for research on determinants of health and population change and the impact of health and social interventions on individuals and families.

The Matlab HDSS was launched in 1966 by icddr,b as part of a program to test cholera vaccines. Accurate measures of population at risk for the disease were essential. Basic demographic information (births, deaths, migrations, marriages, divorces) is collected through regular (at most bimonthly) visits to each household in a defined geographic area (Alam et al. 2017). Population censuses in 1966 and at 8–10 year intervals thereafter permit calculation of accurate measures of population size and structure at any point in time. In mid-2014, the population under surveillance was over 230,000. In 1978, icddr,b introduced the quasi-randomized Matlab Maternal and Child Health and Family Planning Program (MCH/FP) in approximately half the area; the other half serves as a comparison area that receives government services as provided nationally (Phillips et al. 1982). Data produced by this system are valuable for their accurate demographic measures over time and for vital statistics-based research. But their unique value is in enhancing more detailed longitudinal studies. They can provide the sampling frame for selection into the study, longitudinal information on community context, data collected prior to the study on respondents, and follow-up until migration or death. I refer to the HDSS as the skeleton that supports the bodies of specific studies.

Omar Rahman and I decided to initiate the Matlab Health and Sociodemographic Survey (MHSS) with the Matlab HDSS as our sampling frame. And so I entered the complex realm of survey design and implementation. MHSS1 took place in 1996–1997 (Rahman et al. 2001). MHSS2, in 2012–13, followed MHSS1 households. Omar, Randall Kuhn, Andrew Foster, Nizam Khan, and Abdur Razzaque led MHSS1, and Randall, Tania Barham, Andrew, and Razzaque led MHSS2. Elisabeth Root, Sajal Saha, Nobuko Mizoguchi, Gisella Kagy, Chris Jochem, Sveta Milosheva, and Patrick Turner were essential to the success of MHSS2. The team linked survey respondents and households to HDSS and other data on household members collected since 1974 (including MHSS1/2) and created the 35-year longitudinal Matlab Historical Record (MHR). Importantly, icddr,b has agreed to the release of the MHR as a public use data set.

MHSS2 was designed to ask whether the MCH/FP intervention positively affected the long-term life trajectories of women, children, and their families. In order to avoid selection bias, it was essential to minimize attrition of MHSS1 respondents. Indeed, we found that nearly 60% of males born shortly after the intervention began left Matlab before MHSS2 and would have been missed if MHSS2 included only Matlab residents. Migrant location methods developed by Kuhn and Barham that took advantage of near-universal cell phone availability were extraordinarily successful: More than 92% of those alive in each targeted age/sex group responded to our survey.

This is not the place for a full list of publications, but I mention a few studies of determinants of elder's survival (Kuhn et al. 2006, Rahman et al. 2004), childbearing and women's survival (Menken et al. 2003), arsenic exposure and health (Jochem et al. 2016), and long-term effects of exposure to famine (Kagy 2015). Early evaluations of the MCH/FP intervention show it was associated with higher cognitive functioning (Barham 2012), less outmigration (Barham & Kuhn 2014 title their paper "Staying for Benefits"), lower family size and increased consumption and child education (Foster & Milosheva 2015), and better labor market outcomes (Barham et al. 2016). We are working both on our own analyses and on preparing the MHR for release.

Health and Demographic Surveillance Systems in Low and Middle Income Countries

Influenced by my experience with the Matlab HDSS, I became interested in methods for obtaining population and health information worldwide. Periodic cross-sectional systems such as the

Demographic and Health Surveys provide valuable information but do not follow individuals; longitudinal studies such as the Health and Retirement Survey and the National Longitudinal Study of Adolescent to Adult Health are highly valued but struggle to measure the context in which respondents live. HDSS systems are somewhat of a hybrid in that cross-sectional studies can overlay a larger longitudinal structure. However, their coverage of only a small geographic area and outmigrant selection may make them less advantageous.

At least 30 European countries have national population registers that link administrative documents for an individual (birth, death, marriage, divorce, migration) to form longitudinal records (e.g., Poulain & Herm 2013). The US Census Bureau recently established a system of Federal Statistical Research Data Centers in which restricted-use information can be linked to generate longitudinal records.

Comparable national systems do not exist in low and middle income countries. However, as of 2017, 47 HDSS sites (including Matlab) in 18 countries comprised the INDEPTH network (<http://www.indepth-network.org/>). Together, they collect longitudinal information on health and life events of nearly four million people. I have worked with the University of the Witwatersrand (Wits) Agincourt HDSS in South Africa (Kahn et al. 2012) and with the African Population and Health Research Center (APHRC) Nairobi Urban HDSS, and I chaired the INDEPTH Scientific Advisory Committee for five years, 2002–2007. There are other data collection and analysis networks, e.g., the ALPHA (Analyzing Longitudinal Population-based HIV/AIDS data on Africa) network on HIV/AIDS in 10 sites, which includes some INDEPTH members (Reniers et al. 2016). I will focus on INDEPTH because of my association with the network and several member sites.

INDEPTH and its member sites seek to inform health and population policy by providing data through which pressing health and population needs can be identified and by providing settings for longitudinal research, especially related to interventions. I believe this promise has yet to be fully realized for several reasons. First, ongoing data collection is complicated and expensive, and few funders are willing to sustain essential core infrastructure. We in the United States need only refer to the difficulties of having a fully funded Census to recognize this issue. Second, place-based studies have been criticized as inadequately generalizable to other areas, even within the same country. INDEPTH is addressing this problem by sponsoring multi-site studies. Third, analysis of data has been slow. Owing to financial constraints, staffing tends to emphasize data collection. Few sites involve researchers with sufficient training in longitudinal data analysis and sufficient time dedicated to analysis. Unlike the Demographic and Health Surveys and the studies listed above, sites do not share data with the world research community to an extent that demonstrates their value convincingly and generates continuing support for them. To address these problems, INDEPTH sponsors short training courses and a repository for public use data, iShare (<http://www.indepth-ishare.org>). Its multisite studies now usually use a common data platform so that analyses can be carried out much more quickly. The website contains full descriptions of ongoing studies. And, finally, there is a more recent concern. As migration has increased, an HDSS population is increasingly limited to so-called stayers, who may be quite different in important ways from those who leave.

Despite their positive contributions, many HDSS sites are in financial straits and in danger of closing. A more general discussion in our scientific communities is needed on the contributions of this type of population laboratory and the extent to which they, as sources of accurate and timely demographic and health data and platforms for basic research and intervention studies, merit support in science policy and funding.

Evaluation of Health- and Population-Related Interventions

My work for the past several decades has been devoted to evaluation of population health interventions, not only in Bangladesh but also in South Africa, Honduras, and closer to home in Colorado. These projects are all interdisciplinary and go across institutions, as has become increasingly possible in our interconnected world. All are based on quasi-experimental designs that permit some degree of causal inference.

In South Africa, we are concerned with the extent of HIV/AIDS, the rollout of treatment, and impacts of HIV/AIDS on health and wellbeing of individuals and families. Our research is inextricably tied to capacity building for population research as well and is discussed below.

Honduras, like many countries, embarked on decentralization of health services with the goal of improving health outcomes. Decentralization, begun in 2005, was interrupted by a change of government, thus establishing a natural experiment: A set of *municipios* (comparable to US counties) was decentralized by 2011, and a comparison set remained under the Ministry of Health. A team of political scientists (Krister Andersson, Alan Zarychta, and Tara Grillos), geographers (Elisabeth Root), and sociologists/demographers (Jane Menken, Bertha Bermudez Tapia) is investigating health and health system impacts of this widely implemented but rarely evaluated intervention.

The Colorado Family Planning Initiative (CFPI), beginning in 2009, provided free or dramatically reduced-cost long-acting reversible contraceptive devices to Title X clinics in Colorado (but not surrounding states). Both fertility and abortion rates fell substantially in Colorado compared with surrounding states (Ricketts et al. 2014, Lindo & Packham 2017). CFPI thus presents a unique opportunity to assess long-term life course impacts of expanded access to these highly effective methods at a time when access to adequate data for this purpose has also improved dramatically. An interdisciplinary team of sociologists/demographers (Amanda Stevensen, Sara Yeatman, Stefanie Mollborn, Jane Menken) and an economist (Katie Genadek) is collaborating with the US Bureau of the Census. It will link American Community Survey and other administrative records to create data sets to investigate impacts on women's subsequent poverty status and economic stability. This project harks back to James Trussell's and my long-ago conclusion that contraceptives that free women from worry about accidental pregnancy are the most effective and may have the greatest impact on their life trajectories. In earlier work, however, causal analysis of the long-term impact of early parenthood was not possible (Furstenberg et al. 1981, McCarthy & Menken 1979, Trussell & Menken 1978).

CAPACITY BUILDING IN THE UNITED STATES AND THE DEVELOPING WORLD

In addition to my committed involvement in research over the decades, I have had an equivalent commitment to building research and training capacity at home and in the developing world.

Teaching and Mentoring

Even more than formal teaching, I love working directly with students, both undergraduate and graduate, and postdoctoral fellows, whether involving them in ongoing projects or on their own theses and later research. I am proud of the many who are professors and equally proud of those in nonacademic settings. At the risk of omission after these many decades, professors (some of whom have already retired) include Jim McCarthy, Doug Massey, Maxine Weinstein, Andrew Foster, Judy Seltzer, Zeng Yi, Sam Clark, Randall Kuhn, Irma Elo, the late Silvia Llera Lomeli, Omar Rahman, Jill Grigsby, Enid Schatz, Carrie Foote, Jane Miller, Patrick Heuveline, Andrew London, Sangeetha Madhavan, Nicole Angotti, Georges Reniers, and Christie Sennott.

Of those who followed nonacademic careers, Carolyn Makinson recently retired as director of the International Rescue Committee (IRC) UK. For her promotion of major new programs in refugee studies and her leadership of IRC, she was appointed to the Order of the British Empire, CBE. Alex Ezech served as director of the APHRC from 2001–2017 and led it to become a successful research and policy institution in sub-Saharan Africa. Eliya Msiyaphazi Zulu is the founding executive director of the African Institute for Development Policy. Others, including Barbara Mensch, Sajeda Amin, Laura Nyblade, Nizam Khan, Daniel Goodkind, Jill Williams, Casey Blalock, and Pradip Muhuri, went on to the Census Bureau, the Population Council, the Demographic and Health Surveys Program, and other organizations.

Institutional Collaborations

Working in Bangladesh, I became fully aware of the dearth of Bangladeshis who had the training needed to contribute to national development by analyzing policy-relevant data from and for their own country. I strongly dissent from the notion that people in the global south should collect data to be analyzed by people in the global north. To every extent possible, my colleagues and I have tried in our international research to be true collaborators with individuals and institutions.

By the late 1990s, several colleagues and I wanted to go beyond this approach. The Andrew W. Mellon Foundation under then–population officer Carolyn Makinson had recently decided to promote development of population studies in Africa and, in particular, in South Africa. Under apartheid, serious population studies programs did not exist. With Mellon support, IBS established the African Population Research and Training Center in 2001. In close collaboration with African institutions, our goals were to build the following: an international pool of talented social science researchers in the United States and in sub-Saharan Africa with the skills needed to address population issues, advanced international-level graduate training capacity in the subcontinent to serve needs of the region on a sustained basis, and strong collaborative research linkages with these institutions focused on crucial areas of population health and migration. We began by developing strong ties with Wits in Johannesburg, South Africa, and with the APHRC in Nairobi, Kenya. I served as a member of the APHRC Board of Directors for ten years, including three years as its chair. Our principles for creating institutional ties were, first, members at all levels of each institution must be involved and committed to the collaboration; second, collaboration had to be mutually beneficial to participants and all decisions made in collaboration, what a South African colleague termed mutuality; and third, training needed to include research experience through which students learn by doing research with established scholars.

With these principles in mind, we sought additional funding. The William and Flora Hewlett Foundation became our primary funder in 2005 and provided over 10 years of uninterrupted support. NIH was also a major funder through a grant from the Fogarty International Center for training in Africa of African graduate students and postdoctoral fellows. The National Institute on Aging provided infrastructure support to upgrade facilities at the Wits Agincourt research site in northeast South Africa and support for research emphasizing HIV/AIDS. I am grateful to Carolyn Makinson, Sara Seims, and the late Richard Suzman, who made this funding possible.

Under the leadership of Stephen Tollman and Kathleen Kahn, Wits decided to initiate graduate programs in population studies and demography in the School of Social Sciences and the School of Public Health. To address the dearth of people who could develop and teach in this new training effort, we established a 3-year postdoctoral program at CU in which fellows would spend two years at Wits, teaching and carrying out collaborative research, and then return to the United States for a year of intensive analysis and publication preparation before moving on. The plan succeeded beyond our greatest expectations. Fellows include Sam Clark, Enid Schatz, Sangeetha Madhavan,

Jill Williams, George Reniers, and Nicole Angotti; all but one are now faculty members at research universities. They contributed immensely to the development of thriving graduate programs in population studies at Wits. With encouragement (and sometimes financial support) from our team, several Wits staff members completed doctoral degrees. Our group and its graduates continue research collaborations with both Wits and APHRC (e.g., Clark et al. 2015, 2017; Gómez-Olivé et al. 2013; Madhavan et al. 2017; Mojola et al. 2015; Ralston et al. 2015; Schatz et al. 2012; Sennott et al. 2016).

Under this program, the Wits/Brown/Colorado/APHRC Colloquium on Population Issues met annually for a decade, rotating among institutions. Graduate students and postdoctoral fellows from each unit participated in the Colloquia and in short courses that were held in Johannesburg and Boulder. Partly through these meetings, APHRC and Wits conceived CARTA (the Consortium for Advanced Research Training in Africa). CARTA is a south-north collaboration based at APHRC that is working with eight universities and several African research institutions to develop “world class multidisciplinary research that impacts positively on public and population health” (<http://cartafrica.org/about-carta/>).

POLICY INVOLVEMENTS

As I indicated earlier, I have had a career-long commitment to furthering the application of research to inform public policy. The National Academy of Sciences, through its National Research Council (NRC), afforded me the opportunity to work as an invited volunteer on issues for which agencies, primarily of the federal government, requested advice. I was an NRC Committee or Panel member or chair continuously from 1978 to 2006 and sporadically since then. I benefitted as much as I gave to these enterprises. In particular, my research on African demography, HIV/AIDS, and aging in the developing world grew from to my participation in the Committee on Population and its predecessor Committee on Population and Demography, the Committee on National Statistics, and the Committee on AIDS Research and the Behavioral, Social, and Statistical Sciences. I also was a member of the Advisory Committee to the director of NIH for three years.

CONCLUDING THOUGHTS

In retrospect, I have been unusually fortunate to have had such a rewarding life in science—from where it all started, with a young student who discovered a problem of social significance that shaped the contours of her life, to theoretical models of fertility, to empirical studies and evaluations of interventions, to participation in capacity building and policy formulation. It has been both intellectually challenging and personally satisfying.

I am enormously grateful to the many students and colleagues—senior and junior, in the United States and around the world—with whom I have had the great good fortune to share this lifelong adventure. I hope that all the work over the years has made at least a small contribution to scientific understanding in the service of human welfare.

Now, as I approach the end of my eighth decade, I continue to have a full and fulfilling research agenda, but as I look to the future, I am well aware how much remains to be done. Therein lies the challenge for the young scholars who have taken the place of my generation. I wish for them the joy that social inquiry can bring.

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