FROM STATISTICAL DEMOGRAPHY AND BAYESIAN MODELING TO LIVING LIFE TO THE FULLEST

Some reflections on research leading up to and following promotion to full professor by Leontine Alkema

Grootsch en meeslepend wil ik leven

from "De grijsaard en de jongeling", by H. Marsman, 1941.

In the Netherlands, a newly appointed full professor (hoogleraar) gives an inauguration speech in which they comment on the field and what they hope to contribute to this field in their new position. Inspired by this practice and speeches that I read, I decided to write this note with similar aims. A promotion, and in my case, the end of a sabbatical, seemed like a very good time to reflect on my work and field so far and how I plan to move forward. So… here we go…

STATISTICAL DEMOGRAPHY

The best thing about being a statistician, as per John Tukey's quote, is that you get to play in everybody else's backyard. I am a statistician by training and agree with that idea but applied it differently: I made my way into demography's backyard- and never left. The primary focus of my research to date has been the development of statistical models to assess demographic and population-level health trends and differentials in countries around the world. Ultimately, I hope that the insights from my research help to improve reproductive, maternal, and child health worldwide.

I consider my research to be at the intersection of statistics and demography. If I have to put my main contributions into a single field, I would pick statistical demography. My only reason for pausing briefly is that I think statistical demography as a scientific field is not necessarily all that well defined. On twitter I once had a 280-character go at it:

Statistical demography is formal (mathematical) demography extended to real populations and using data with measurement errors.

Building up a definition of statistical demography without a character constraint, it makes sense to start by defining statistical demography to refer to statistical science for the study of human populations. In turn, statistical science refers to the development and study of methods for collecting, analyzing, interpreting, and presenting empirical data. Statistical demography concerns statistical science to capture demographic processes and regularities, with such demographic "truths" at its core. Outcomes of interest are centered around population dynamics and characteristics, often aiming to provide insights related to population-level aggregates or life course perspectives.

My journey in statistical demography started at the University of Washington in 2004. When finishing up my MS in Applied mathematics/Statistics at TU Delft in the Netherlands, I wanted to use my statistics training to do "something good" in some yet-to-be-defined way. I applied to the University of Washington (UW) because of its PhD program in statistics with specialization in demography. I was told that "UW was a good place to go, just to watch out for the Bayesian in the basement". Little did I know at that point that that's exactly where I ended up and found a perfect match with my research interests. I received excellent training from faculty and peers in the Statistics and Biostatistics departments, the Center for Statistics in the Social Sciences, and the Center for Studies in Demography and Ecology. While the journey was a challenging one, thanks to the wonderful community at UW, and a year spent on a "PhD mini sabbatical" with the UN Population Division in New York and research centers in Kenya and South Africa, it was overwhelmingly an exciting period of growth and learning, and one that inspired much of the trajectory that followed.

MONITORING DEMOGRAPHIC INDICATORS IN DATA SPARSE SETTINGS USING BAYESIAN MODELS

My main research to date has focused on the development of statistical models for *monitoring and projecting demographic indicators* in low- and middle-income countries. Indicators include unmet need for contraceptives, abortion incidence, the maternal mortality ratio, and the under-five mortality rate[1]. Statistical models are needed for monitoring in settings where data alone are not sufficient. This occurs, for example, when data have not been collected, when data are subject to data quality issues in the form of bias or random measurement error, or when data are available that are *related to* the outcome of interest only, as opposed to measurements of the outcome of interest itself. In data-limited settings, statistical models are needed to fill in the blanks, to make the best out of available data, and to provide estimates of demographic indicators with an assessment of uncertainty.

In my research, together with an interdisciplinary group of students and collaborators, we have produced new insights in data limited setting via the development and use of *Bayesian statistical models*. Development of a Bayesian statistical model in this area typically focuses on specifying assumptions related to the indicator of interest and how data at hand relate to that outcome of interest. Motivated by real-world problems, we have spearheaded advances in both areas. Some of my favorite process models, that capture dynamics in outcomes of interest include (1) a demographic accounting model to estimate abortions and unplanned pregnancies (Bearak et al. (2020)), (2) mathematical descriptions to capture transition processes for contraceptive use (Alkema et al. (2013), Cahill et al. (2018)), the total fertility rate (Alkema et al. (2011)), and the son-preference driven inflation of the sex ratio at birth (Chao et al. (2021)), (3) a Bayesian cohort component projection model for estimating counts of women of reproductive age in data sparse settings (Alexander and Alkema (2022)), and (4) extensions of regression models to include temporal components and sparsity priors to better estimate maternal mortality and still birth rates (Alkema et al. (2017), Wang et al. (2020)). I was drawn into the area of dealing with data quality issues when working with data from birth histories, to work toward the improved use of such data to estimate child mortality (Alkema and New (2014)). Recent and ongoing research focuses on accounting for misclassification (for example, in self-reported contraceptive use and maternal cause of death, Peterson et al. (2022)) and the use of data that are collected routinely in administrative systems, for example in

[1] My website has an overview of key indicators and selected substantive findings.

the form of contraceptives supplied to clients (Cahill et al. (2022)). In my (biased) opinion, this line of research is very exciting because it pushes forward the field of statistical demography by introducing improved ways for data use and production of estimates.

My greatest motivation for doing research is that I hope that the insights from our work help to improve reproductive, maternal, and child health worldwide. To that end, I collaborate with various groups to try make available improved estimation methods and resulting estimates to diverse international audiences. It has been incredibly rewarding to help produce estimates of family planning indicators for all countries with the UN Pop Division, to improved use of data for estimating under-five mortality with UNICEF, to produce data-driven estimates of maternal mortality with WHO, country estimates of unintended pregnancies and abortions with Guttmacher Institute, and to collaborate with Track20 on the Family Planning Estimation tool (FPET), a tool that is used in-country to produce estimates for the FP2030 initiative.

BRINGING MODERN STATISTICAL TOOLS INTO ROUTINE PRACTICE TO INFORM MONITORING, EVALUATION, AND PROGRAM OR POLICY DEVELOPMENT AT THE NATIONAL AND LOCAL LEVEL

Looking forward, I aim to align my efforts in research, training, and service with the vision of bringing modern statistical tools into routine practice to inform monitoring, evaluation, and program or policy development at the national and local level. Moving towards the incorporation of modern statistical tools such as Bayesian models into daily routines requires changing the status quo on research and training in this area, and an increase of diversity of the communities involved. Below, I outline some specific goals aligned with that vision.

MAXIMIZING THE VALUE OF STATISTICAL MODELS FOR MONITORING DEMOGRAPHIC TRENDS, DIFFERENTIALS AND EQUITY

The use of model-based estimates in data-limited settings is a double-edged sword: On the one hand, model-based estimates can provide insights but on the other hand, model-based estimates may be based on assumptions that do not hold true or estimates may be subject to substantial levels of uncertainty, limiting their usefulness for action. It is worth noting that the increased focus on capturing within-country differentials compounds these issues: the interest in smaller subgroups brings about greater data needs and – when data availability does not match these needs – exacerbates the importance as well as the potential limitations of models.

To move forward, improvements in model development and communication of strengths and weaknesses of model-based estimates is an area of great importance. I believe that we, as a community of statistical modelers, have a key role to play here. Firstly, we need to move beyond our standard approach to presenting information regarding model-based estimates. Our work on quantifying the contribution of data to model-based estimates (Alkema et al, 2022) is one direction that I personally would like to build upon in this area. We also have a key role to play in the area of model development: to move beyond a field where modelers apply their favorite method to the indicator of interest, and possibly re-invent many wheels along the way, I see a need for general research to focus on systematizing model development, including testing and validation. We started along those lines with the proposal of a model class of temporal models for multiple populations (Susmann et al (2022)), aimed to help communication of model assumptions and highlight differences and similarities between existing models. Last but not least, we cannot (and should not aim to) pretend that model-based estimates have the final word in settings where additional data are needed to answer open questions. A more targeted approach to data collection, one that is informed by statistical models, could result in great gains in insights.

To maximize the value of statistical models for demographic monitoring, action is needed also to expand and diversify the community of modelers and users. While collaboration takes place within global communities, the majority of major modeling efforts are based on a set up where academics in the global north develop models and produce estimates. I hope to help increase diversity in our research communities, especially in the community of modelers and technical advisory groups. It seems to me that training of a more diverse group of individuals is key. The good news is that with the option of online training material in various forms, training is no longer limited to audiences that are geographically close. In the area of Bayesian modeling, impressive examples include courses by Aki Vehtari and Richard McElreath. I hope to contribute to this kind of initiative in the area of Bayesian modeling for demographic indicators, targeted at demographers in low- and middle-income countries. Finally, academic research agendas can be expanded to more explicitly consider demand for and usability of tools at the country level. I aim to do so in the context of subnational monitoring for family planning, as part of the FP2030 initiative.

IMPACT ASSESSMENT

In addition to "what's going on" monitoring type questions that I have focused on in my research to date, I am extending my research to also include questions of the "what if?" type. Examples of these types of questions are *"What is the impact of a family planning intervention program on outcomes of interest such as (un-)met need for contraceptives and fertility?", or "What is the impact of uptake of family planning methods on future birth rates?".* In terms of statistical science, these types of questions refer to causal inference- estimating impact and effect sizes. During my sabbatical in the past year, I have delved into this area with the goal to identify specific open questions regarding family planning that can be addressed with advances in causal inference methods. I see a lot of potential to use modern causal inference to better answer questions related to demographic impacts at a population level, taking account of population characteristics and life trajectories. I am looking forward to learning more and focus on the development of tools that can be used in local context.

DANKJEWEL (THANK YOU)!

I am delighted to have been promoted to Full Professor based on the research, training, and service that I love to do. I consider it a luxury to get the opportunity to work on exiting questions, both scientifically and substantively, with talented and driven individuals. I am immensely grateful to the many individuals and institutions that helped me along the way.

My academic journey in statistical demography would not have been possible without my graduate training at the University of Washington. I am forever grateful to my advisors Adrian Raftery and Sam Clark. I also thank other faculty in the Statistics department, the Center for Statistics in the Social Sciences, and the Center for Studies in Demography and Ecology for making UW be such a great place for statistical demography. A shout out to fellow students including Krista Gile, Amanda Cox, Larissa Stanberry, Marloes Maathuis, Jennifer Chunn, and Jeff Eaton; life in Padelford would have been a lot less bright without you.

My academic journey brought me from Seattle, with a brief but influential stop at Columbia University, to Singapore. There, in the Department of Statistics at the National University of Singapore, I was able to develop my research agenda in statistical demography with UNPD on family planning, with UN IGME on child mortality, and with the UN MMEIG on maternal mortality. I thank my former colleagues at the National University of

Singapore, in particular fellow Bayesian Alex Cook, for the support. I remember very fondly advising undergraduate students for their honor's theses or research during that period, in particular Jin You New, Fengqing Chao, and Sangqian Zhang. A big thanks to UN and WHO collaborators and fellow TAG members, including Patrick Gerland, Ann Biddlecom, Vladimira Kantorova, Ken Hill, Danzhen You, Lucia Hug, Doris Chou, Lale Say, Bela Ganatra, and others, I learned lots from all of you.

Since fall 2015, my happy academic home is at the department of Biostatistics and Epidemiology at the University of Massachusetts Amherst. I have the pleasure of working with a supportive group of colleague biostatisticians. Nick Reich and Raji Balasubramanian were particularly instrumental in supporting myself and others. Since joining Umass, I appreciate working with new-ish collaborators including Chi Hyun Lee and Jonathan Bearak. I continue to be impressed by the work of Avenir health colleagues, including John Stover, Emily Sonneveldt, and Kristin Bietsch, and look forward to continued discussion and collaboration. Last but all-but-least, sincere thanks go to past and current Alkema lab members at UMass Amherst: Niamh Cahill, Emily Peterson, Monica Alexander, Chuchu Wei, Zhengfan Wang, Herb Susmann, Greg Guranich, Elliot Yang, Fengqing Chao, Barbara Mottley, Jadey Wu, and Lucas Godoy Garraza. It's a pleasure working with all of you and I am excited about what the future will bring for each of you.

All throughout this journey, my parents were there for me and supported me, even if my plans did not quite fit their expectations and introduced many kilometers between us. Their first plane ride ever was to visit me in the US, they have made multiple trips across the Atlantic and to Asia since. No matter the destination or continent, they happily brought along drop, rookworst, and even gourmetstellen and beschuit met muisjes. Paatje en maatje, thank you for bearing with me and coming along for the ride as much as you did!

Seattle brought me not only love for statistical demography but moreover, it brought me love in the form of a wonderful man who was up for traveling the world together, trying to do good through academics, and starting a family. I did not expect to marry a person whose interests would include both ancient WHO reports about infectious disease outbreaks as well as building play structures from trees from our backyard but I'm sure glad that it worked out that way.

GROOTSCH EN MEESLEPEND WIL IK LEVEN

I would like to end by coming back to the quote that I started with: *Grootsch en meeslepend wil ik leven.* This quote is the start of a Dutch poem by Marsman, written in 1941, and literally translated means something like "I want to live in a grand and compelling way", or loosely taken, living life to the fullest. This sentence stuck with me since I first heard it in high school. To me, it speaks to trying to consciously make the most out of life, despite or within the constraints that it gives you. That's the route I took or tried to take, to align my life trajectory with my values and make the most out of it. When thinking about children and young adults worldwide, including my 5-year-old daughter, I truly want for all of them to live life to their fullest extent, however defined.

However, while the sentence and my liking and interpretation of it focuses on the individual's role in it, it is clear that so much of what our life trajectory looks like is directly influenced by external factors. What I'd like to commit to with my work going forward is to help others live their life to the fullest, in the little ways that I can, based on the opportunities given to me. In particular, I want to commit to advancing reproductive health and

rights for women and couples worldwide, such that they can live their lives to the fullest. With that in mind, I continue my academic journey with energy and passion.

Ik heb gezegd.

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