Kallenberg Symposium "Invariance, Symmetry, Exchangeability"

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Do you need mathematics in Public Health?

Klaus Krickeberg, 25th June 2013

I was very happy and greatly honoured when I received an invitation to the "Olav Kallenberg Symposium" in spite of having abandoned probability theory quite some time ago. However, as I wrote to Peter Jagers, I am still a bit nostalgic for the time when I worked in areas that are close to Olav's interests. To give you a concrete example, we were both dealing with conditions for certain random measures to be invariant in such and such sense; I did this for line processes.

In the year 1976 I published a book on point processes. It contained, in addition to standard material, some results that were new at that time and also little known topics like the entropy of point processes. It has not become widely known because it was written in Vietnamese. In 1976 modern Vietnamese mathematical terminology was still very young, in fact only four years old. It is true that some North Vietnamese mathematicians had already set up a Committee for creating this terminology in 1952. However they worked under difficult conditions, mostly in the jungle. The war against the French was still going on and the decisive battle of Dien Bien Phu was to take place only in 1954. Therefore it took the Committee twenty years to finish its work. In 1972 it published an excellent comprehensive English-Vietnamese Mathematical Dictionary that contained everything, from the most abstract to the most applied terms. It came just in time for me to prepare my course on point processes that I gave in summer 1974 in Hanoi and on which my book is based.

At that time the situation in Hanoi was still difficult. People were isolated but very curious about the development of science outside. During the six weeks that I spent in Hanoi several scientists from other fields of knowledge came to me and wanted to know something about mathematical methods in their area of work. First, there was the Minister of Higher Education, Tạ Quang Bửu, a mathematician who had studied in France before the Second World War and participated in the Bourbaki group. He was interested in everything. I still remember a discussion with him on the statistical bases of developing the use of wind power. Then people from the National Forest Institute inquired about modern methods for estimating yields of forest. As it happened I had been interested in the work of Bertil Matérn on spatial statistics with applications to yield forecasts; so I gave a talk on that in the Forest Institute. Next, people from agriculture arrived and asked question about varietal trials. This is classical statistics, analysis of variance and the like. Again it gave rise to a lecture of mine and exchanges of ideas.

Finally a high-school girl was presented to me. She had just won a second prize at the International Mathematics Olympiad. This is all the more

remarkable as she had gone to Secondary School in difficult conditions; Hanoi had still been bombed until 1972.

I lectured again to Vietnamese mathematicians in early 1978, this time on the statistical analysis of point processes, mostly for spatial processes but also about the Aalen approach to processes on the line. The General Statistical Office, which is the Vietnamese counterpart to Statistics Sweden, approached me then. They wanted a course on sample surveys, which I promised for later.

However, the most pressing demands came from the health sector. Already in summer 1974 the leader of Vietnamese medicine, Tôn Thất Tùng, appeared during a pause in my course. He had also studied in France and was before the First Vietnam War a famous liver surgeon. He organized the medical service of the Vietnamese army at Dien Bien Phu. After the war he became the Director of the Central Cancer Hospital in Hanoi. He wanted to know something about computer-aided diagnosis. That was still very new in 1974 and is of course more statistics than computer science; he had already understood that. Although a surgeon, Tùng had a marvellous intuitive feeling for epidemiology and its statistical methods. In 1978 he came again to me and inquired about clinical trials of treatments of liver cancer. This is clinical epidemiology and involves statistical analysis of survival times, the Cox model and all that. Above all he did the first epidemiologic study of the after-effects of the Orange Agent on children of exposed subjects. He showed me the draft of the resulting paper before publication and I had the honour of correcting a tiny error in calculation.

In early 1978, too, the second leading man of the Vietnamese health system approached me. It was the virologist Hoàng Thủy Nguyên who had studied in East Germany and was then the Director of the "National Institute of Hygiene and Epidemiology", or "Hygiene Institute" for short. This Institute is the former Pasteur Institute of Hanoi, and its work is prevention and control of infectious diseases. Nguyên inquired about mathematical methods in it. That is precisely the subject of my talk in the domain of infectious diseases. His seemingly innocent question became the root of a cooperation that is still strongly going on, 35 years later. It changed my scientific interests completely.

Already in summer of the same year 1978 I went again to Hanoi to work with the Hygiene Institute. I presented a memorandum on how mathematical work in the institute might be organized, which I had prepared in the mean time. Then in winter 1979 – 1980 I gave the course on sample survey methods at the General Statistical Office, probably the first course on that subject ever given in Vietnam. I profited from my presence in Hanoi to visit the Hygiene Institute once more and there something amazing happened. Nguyên presented to me four young people who had just graduated. He had created new positions for them in his institute. He called them the "Mathematics Group" of the Hygiene Institute and I was to train them further. The composition of this group was ideal: two physicians, one mathematician and a computer scientist. The latter was the only man in the group, by the way. The mathematician was none other than the former high-school girl who had

won a prize in a Mathematics Olympiad and whom I had met in 1974. In the mean time she had studied mathematics with emphasis on probability at the Moscow State University. She soon became the *de facto* leader of the Mathematics Group. We are still working together.

Now I rapidly got a grant from the French Ministry of Foreign Affairs for a programme over 10 years on mathematical methods in health in Vietnam. It started in 1981 and consisted of two parts:

– Seminars for Members of the Health System on all mathematical aspects of their work. They were taught by some French Colleagues and myself and took place in all institutes of the hygiene and epidemiology network, from Hanoi down to Ho Chi Minh-City.

– My work with the Mathematics Group. We dealt with concrete and urgent practical problems as they arose and at these occasions I pointed out to them the underlying general ideas, mainly from epidemiology.

What are these general ideas? Let me go back a bit and approach this question from another direction, namely from France instead of Vietnam. When I had written the memorandum for the Hygiene Institute in Hanoi in 1978 and thought about implementing a corresponding training and research programme I told myself: "First you have to learn that stuff yourself". Then I remembered my high school Latin, namely "*docendo discimus*", that is, "by teaching we learn". I was a professor at the University of Paris V at that time, and so I offered to my students of applied mathematics a course on "Epidemiology" in the wide sense, including clinical epidemiology and in particular clinical trials. It comprised 6 hours a week of theory and practise during the whole academic year. There was a lot of statistics in it but also for example discrete modelling in population genetics and modelling via differential equations of the evolution of epidemics, both deterministically and stochastically. As an example of a subject that necessitates particularly much mathematics let me mention vaccine trials.

I taught this course more than a dozen times until my retirement in 1998. It turned out that the students who had followed it successfully were very much sought after in the French health system. They readily found positions in big hospitals, health administrations and medical and public health research institutes.

But what is "Public Health"? It has existed since antiquity without a formal definition. Some countries developed it strongly from the middle of the 19th Century on under various names such as "Social Medicine". Attempts at defining the concept started some time in the 20th Century but the resulting definitions were long-winded, not very precise and not practical. For example the definition by WHO includes, as an indispensable component, a long list of applications. That is clearly absurd; just think of a definition of a "group" in mathematics that rests on a list of all applications of group theory. There is also, as part of the definition, a list of scientific fields that contribute to public health, which is just as absurd; incidentally, one of the most important ones, namely statistics, was forgotten. So I made up my own definition, which is more in a mathematical spirit. Here it is:

Public Health is the entirety of theoretical and practical activities that are related to health and deal with populations as a whole but not specifically with their individual members.

Let me now also recall the modern definition of "Epidemiology", which fortunately is clear and seems to be widely accepted nowadays:

Epidemiology is the science of the distribution of diseases and of similar health-related features in human populations and of the factors that influence such distributions.

This shows, in the first place, that epidemiology is to a large extent statistics, even fairly advanced mathematical statistics.

In the second place the two definitions imply that epidemiology is part of public health. It is in fact its backbone, and this is why my course in Paris was on epidemiology. Indeed, look at curricula in various Schools of Public Health all over the world. In addition to epidemiology, you will find courses on Environmental Health, Occupational Health, Nutrition and Health, Health Education, Health Management, Health Economy and may-be others. If you try to put any of these fields on a rigorous footing you find that it is largely based on epidemiology. Therefore, what you need in public health is, in the first place, mathematical statistics. In some countries such as the Scandinavian ones, France, the UK and others this is being clearly perceived and many mathematical statisticians are working in the health system. In others, for example in Germany and Vietnam, it is not yet being generally accepted.

Now let me return to my personal experiences. In 1983 the UNICEF-Office in Hanoi learned about the existence of our mathematics group. It was running a programme concerned with diarrhoea of small children and asked us for help in setting up an information system that was needed. So I became a UNICEF-advisor in Vietnam and Cambodia until 1987 for various topics in primary health care. It was a most interesting experience because it meant much fieldwork, that is, visits to village health stations and families. Often the staff of these little health stations had more understanding of epidemiologic and other public health matters than the officials in the health administrations and the UNICEF-experts.

In 1994 the German "Society for Technical Cooperation" (GTZ) hired me for its programme on family planning in Vietnam. There was again some non-trivial mathematical statistics in it, namely sample survey methods and demography. Finally I worked in 1999 and again in 2004 in the European-Vietnamese "Health Systems Development Programme"; my part was "Health Information Systems".

All of this practical work taught me that rigorous thinking following the ways of mathematics is of utmost importance, even in seemingly simple fieldwork. Let me give you an example. In 1999, while I was employed in the European-Vietnamese programme, the Vietnamese Ministry of Health asked WHO *against my advice* to design a new health information system to be called the "Health *Management* Information System"; management was buzz word at that time. The result was disastrous. A health information system is a

reporting system from lower health facilities to higher ones. It is based on registers in the lower entities such as village health stations and hospitals. WHO decided to put a large number of *separate* registers into these entities. This causes enormously much work to the health staff but there is also a more basic problem. You cannot study *relations* between variables that are recorded in separate registers.

Let me illustrate this by focussing on births, that is, deliveries in a given health station. According to the Health Management Information System the station has a register on *antenatal examinations*, another one on *deliveries*, still another one on the *development of the babies* during their first year of life, and one on their *vaccinations*. Now it would for example be very interesting to know whether the attendance of the mother at the antenatal examinations and the results of these examinations have any influence on the delivery and on the health of the mother and child afterwards; otherwise one could dispense with antenatal examinations. However, with separate registers you can obviously not know it.

Eleven years later, in 2010, I visited a small district hospital in Laos. Its director had had the common sense idea of putting all data pertaining to a given pregnancy *together* on a single sheet of paper, from conception on until the end of the first year of life of the child. Now relations of the type mentioned above could easily be studied by elementary statistical methods.

But why was I in Laos in 2010? After all, my story could have ended with my retirement from the University of Paris V in 1998 and the end of my assignment in the European-Vietnamese programme in 2004. However, in 2005 I went again to Vietnam, for the first time as a tourist, and I visited my old friend Hoàng Thủy Nguyên who had retired from the directorship of the Hygiene Institute. He told me that one of the smaller medical universities in the North-eastern region of Vietnam wanted help with the teaching of public health to its students. That was the beginning of another chapter of my story.

I started a programme, which in the course of time came to cover all Medical Universities or Faculties of Vietnam except the two big centres Hanoi and Ho Chi Minh-City. It is being funded by the German foundation "Else Kröner-Fresenius-Stiftung". In the present first phase it focuses on the teaching of public health to normal medical students during their 6 years of basic studies. In Vietnam this basic medical curriculum includes in fact courses on most topics of public health, which is very reasonable because physicians in the countryside or in small cities also have to do a lot of work in public health, for example managing a village health station, promoting health education, prevention including classical hygiene, and other tasks. That is excellent but unfortunately the *content* of these courses is as a rule incredibly bad.

What is worse is that the level of their teachers is often very low, too. The lecturers are used to reading to their students a given text word by word and never think about it. There are several reasons for that. Confucian traditions, overwork, but also the disastrous influence of international organizations, be they NGOs or not, are at the root of the poor working habits of the staff. Many lecturers do not even know the Vietnamese health system well

beyond their own little area of work. In addition I think that a lack of rigorous thinking and of a clear perception of the role of mathematics prevent any substantial improvement of the situation. There are almost no mathematicians working in the health system.

In the first phase of our programme we are therefore trying to widen the horizon of the lecturers and make them work more independently and more rigorously. We do it in two ways. Firstly, we run yearly workshops in Vietnam where we do not teach the participants any particular matter but have some of them present their own work. Above all, we discuss and work together on some topic, for example on the structure of a curriculum or on new teaching methods such as "population-side teaching". Excursions to small health facilities and rural families are always included.

Secondly, we write new texts on many topics together with Vietnamese lecturers. This is being done by a continuous exchange via e-mail. We always start with a critical analysis of the existing text. In the new text, examples, applications and case studies are mostly taken from the Vietnamese health system; foreign situations are being compared with the corresponding Vietnamese ones. All books are bilingual, the Vietnamese and the English version appearing in a single volume if possible. In order to accommodate all of these books and to make it clear that they form a coherent body of texts I have founded a book series in the Medical Publishing House of Hanoi; it is called "Basic Texts in Public Health". Until now, two books are finished:

– Epidemiology: Key to Prevention.

– Population Science and Public Health.

Exceptionally, the English and Vietnamese version of the book on epidemiology appear separately, not in one volume; the English version was published last year by Springer, New York in its series "Statistics in Biology and Health", which I had founded decades ago.

Two more books are far advanced:

– Health Education.

– Mathematics including statistics.

Others are being planned, in particular on environmental health, occupational health, and nutrition.

In these books the role of mathematics will of course be outlined clearly. The book on mathematics will not only provide methods applied in public health but also some of those used in clinical medicine. Thus it includes branches of mathematics needed for modelling phenomena in fields such as pharmacology, immunology, genetics and the evolution of epidemics. Hence you will find for example something on differential equations and on discrete analysis in addition to general basic concepts and to statistics.

When starting the programme we had included a Laotian component and one of our workshops took place in Vientiane in 2010 but for the time being this component is hibernating.

To conclude:

– Mathematics is needed in most parts of public health, starting from the most basic and indispensable elements of public health as taught to normal medical students.

– Rigorous and clear thinking along mathematical lines is indispensable to improving the teaching and the practice of public health.

– Mathematicians need to be employed in many places of the health system.

– Health authorities, university teachers and the medical and health profession at large need to have a clear perception of the role of mathematics in public health. This is to a large extent the case in several countries but not yet in Vietnam.