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The painting is by the well-known Dutch artist Kees van Bohemen (1928-1985). This composition nr. 109 (1959, 90 x 70 cm, oil on canvas) has decorated W.R. van Zwet's office for the past 30 years and many of his colleagues from all corners of the world have become familiar with this work of art.

Mijnheer de Dekaan, Ladies and Gentlemen,

The highly valued presence of a large number of my colleagues from abroad makes it impractical to deliver this address in Dutch. I trust you will excuse me for speaking English.

Let me begin by telling you a story. It is about a child who didn't speak. At first the parents thought their baby was just a bit slow in learning and the family doctor told them not to worry. But when the child still didn't say anything at age three, a long line of medical specialists were consulted but in the end the conclusion was that there was no known cure for this and that the boy would never speak. Of course the parents were devastated, but they slowly got used to this unpleasant reality. But then, one day when he was ten years old and they were sitting down at dinner, the boy suddenly said: "The soup is cold". Of course his parents were overjoyed that he could speak after all, but his mother wanted to know why he never said anything before. "Well" said the boy "I had no complaints so far".

This story more or less describes my relationship with this university: I've had very few things to complain about. I had great fun as a student at Leiden. The only unsatisfactory thing I can remember was that they didn't teach statistics here, so I had to take courses with Van Dantzig at Amsterdam and get my PhD degree there. While working towards my PhD at the Mathematics Centre at Amsterdam, I taught a statistics course at Leiden. After I received my PhD with Jan Hemelrijk in 1964, I was appointed associate professor at Leiden six months later in 1965 and full professor in 1968. In those days there were no salary scales for a full professor. There was just one standard salary, independent of your field, age, experience, excellence or what have you. There were no such things as annual reports where you were supposed to write down what you were doing or not doing. In fact, it was taken for granted that you were probably doing something useful apart from teaching your classes, but nobody seemed terribly interested in knowing what that was. I do recall this gave me the distinct feeling that my career was over at age 34, but I've since come to realize that it was probably the closest thing to heaven on earth.

This lightning career of mine was of course not due to my excellence in statistics of which I still knew fairly little. There were other reasons. First of all, there were very few statisticians with a PhD degree at the time in the Netherlands. Second, Kloosterman, the head of the mathematics department at Leiden had a simple but effective strategy for hiring applied mathematicians. A pure mathematician himself, he realized that a mathematics department would not survive in the long run without paying attention to applied mathematics. On the other hand he took a rather dim view of applied mathematicians. To solve this problem he was inclined to pick former students who did well in his own courses on the assumption that they would at least have learned something before they deviated from the path of pure mathematics. So I always like to think that I became a professor of statistics because of my grades in an advanced course on number theory. Of course the fact that my friend and colleague Guus Zoutendijk had preceded me to Leiden may have had something to do with it too.

This may explain how I came here, but not why I stayed all those years. In fact, my eldest son who is a student of history discovered that at this moment I am the longest serving full professor in the University of Leiden. As a partial explanation I'll tell you another story. I already mentioned that after getting my PhD degree in July 1964 I accepted an associate professorship at Leiden starting January 1965. In the intervening months, however, I received an offer to spend a semester in the United States. In those days this was not as common as it is today and I decided that I should go. Unfortunately, both my visiting appointment in the US and the one at Leiden were supposed to start on January 1, 1965, and when they say January 1 in the United States they don't mean January 2. With some trepidation I spoke to Dr Hofstee the secretary of the university when I met him at a reception and asked him if I could have six months leave of absence starting on the day of my appointment at Leiden. That was not entirely usual in those days either. Dr Hofstee looked at me for a moment and said: "This university has been doing quite well without teaching statistics for almost 400 years. I don't think another six months will do too much harm". These memorable words set a pattern for my relationship with this university. The University of Leiden has consistently allowed me to spend time at other interesting institutions, mostly in the United States. Altogether I'd estimate I have spent 20% of my Leiden years elsewhere. The university's point of view has always been that these contacts are valuable to both the scientist and the university and I think they are right. For my part, I have tried to pull my weight in teaching and research, as well as in administrative jobs needed to keep things going. All in all, I believe the University of Leiden and I have been right for each other and I've never felt any strong urge to leave.

Enough said about my relationship with this university. By now, you've been sitting here long enough to notice the pros and cons of an ancient university for yourself. This hall is beautiful and impressive, but it is not terribly comfortable to sit on these closely packed benches for very long, especially if you happen to be tall. You are not likely to forget that this was once a nun's convent where suffering was an important virtue. Also, the use of any kind of visual aid in this room is frowned upon, so I can't show you nice pictures or even a small formula on a blackboard, which is a bit of a handicap for a mathematician. Luckily a microphone and electric light are among the recent inventions that are allowed in this hall.

As most of you will know, I am a mathematical statistician and I want to spend part of my time speaking about mathematical statistics. First a few words about applied mathematics in general. Applying mathematics means using mathematics - which is an abstract business - to build very concrete things like bridges, dams, ships, or airplanes; to organize complex tasks like telephone service, machine repair or replacement, or drug discovery and testing, etc. Let us pretend, for instance, that we have to design a dam. What do we want to achieve? We'd like to have a dam that can hold back a lot of water without collapsing and that preferably at low cost. From the laws of physics we can compute the forces that will be applied to the dam for any given amount of water and position and shape of the dam. Physics as well as our knowledge of materials tells us how to construct the dam so that it can withstand these forces up to a certain volume of water. Finally there is the capacity versus price

problem. In principle we can compute what a safe dam will cost that holds different amounts of water but the price tag goes up with the capacity and this dilemma has to be resolved by some decision-maker. What I'd like to get across at this point is that there is a huge amount of mathematics involved describing the relations between the many quantities of interest. All of this together is called a *mathematical model*. It tells us how to compute the pressure on the dam from lots of other quantities, what the construction of the dam should be to withstand this pressure, how this construction influences the cost, etc. Usually, certain parts of such a mathematical model are quite precise and reliable. Other parts will be rather crude and not very reliable at all. This is because there may be new physics involved or because we have neglected the influence of certain factors. The latter is unavoidable because we can't take everything into account if we ever want to get finished, but we hope that the factors we have neglected won't matter very much. If this is not true, our design can prove to be disastrously bad. Luckily there is something we can do about this. We can test whether our mathematical model is satisfactory by experimenting. Not with a real dam of course, but with a toy dam, a so-called scale model. If our mathematical model predicts that the dam will do fine but it collapses during an experiment, we'd better reexamine our mathematical model or we'll have very few jobs in future.

Now what do mathematical statisticians do? They build mathematical models that include uncertainty as an essential element and face the consequences of this. Let me explain. Suppose we wish to predict how an epidemic outbreak of a disease will develop. We would like to know how many people are going to catch the disease, how many work hours will be lost, how many people will die, etc. In order to answer these questions we again build a mathematical model. But now there are many uncertainties to take into account. Even if we know that an individual moves about in a population with a given percentage of infected people, we still can't say with certainty whether this individual will be infected and if so, how soon. But if we cannot decide who will infect whom, then we certainly cannot predict how the epidemic will develop in the precise sense of pointing out which people will be infected at any given moment. However, this is not really necessary because our questions are all anonymous in that we don't ask "which people?" but only "how many?". Statisticians deal with this type of problem by using the related concepts of randomness and probability. Even if we can't predict whether a certain person will be infected under certain circumstances, we may assume that getting infected is a random phenomenon and that there is a certain probability that this will happen in a given stretch of time. Now this probability may depend on a number of factors, such as the percentage infected in the population, the time the person has had to acquire immunity, etc. Our mathematical model will have to specify on what factors this probability depends and how. Of course there are many more things involved in our model such as the probabilities governing the length of the diseased period and the probability of death. Once the model is complete, we may still have to estimate certain quantities that play a role in the model but that are unknown to us, for instance the virulence of the disease.

On the basis of such a model we can now predict the course of the epidemic. In view of the many uncertainties, our predictions can of course not be of the kind:

exactly 2,500,000 people will be affected by the disease. All we can do is make approximate statements like: between 2,300,000 and 2,700,000 people will be affected. Moreover we have to add that there is a small probability, say 0.01, that even this approximate statement will be wrong. Thus the price we are paying for recognizing the presence of randomness is twofold: first of all we can't give an exact but only an approximate answer, and second, there is always a small probability that even this approximate answer is wrong. This is not a weakness of the statistical method. It is merely a result of the complexity of the problem. The strength of the statistical methodology is that it not only gives an approximate answer, but that it also expresses the degree of our uncertainty in terms of the probability that the answer will be wrong.

As in the case without randomness, it is possible to check the model by measuring the relevant quantities and seeing whether they are in agreement with the values predicted by the model. This is called a statistical test of the model and it will result in acceptance or rejection of the model with prescribed small probability of reaching the wrong conclusion.

Let me summarize this first course in mathematical statistics. Statisticians recognize that many phenomena exhibit an unpredictable variability. They believe that such phenomena are best described by a mathematical model that incorporates randomness as an essential element. Conclusions that can be reached on the basis of these models are generally approximate and may be wrong with a specified small probability. If the model is seriously wrong, however, then no valid conclusions can be drawn. It is possible to test the model on the basis of measurements of the relevant quantities and this should always be attempted. Alternatively one can of course rely on past good performance of a model, but this is a risky business at best.

Why am I telling you all this? I'm trying to explain that statistics is a powerful and indispensable element of the analysis of data. Of course, when using the wrong model you can arrive at seriously wrong conclusions. Still, almost any kind of modeling is better than no modeling at all. There are those who argue that many phenomena are so complicated that modeling is impossible anyhow, so why not use any method that produces "reasonable looking numbers" and "pretty pictures"? This is what I call the "why bother" attitude. In this computer age reasonable looking numbers and pretty pictures are a dime a dozen, so the market is being flooded by this type of information. Sometimes such ad-hoc methods may produce satisfactory results but just as often they won't and there is no guarantee one way or the other. Needless to say that this attitude usually goes hand in hand with a lack of statistical competence.

There is much more to be said about this but having explained the basic points, it is perhaps best to continue this discussion by providing a real-life example. On January 20 this year the daily newspaper Trouw published an interview with Dr de Kwaadsteniet a senior member of the scientific staff of RIVM, the national institute for health and environment in the Netherlands. RIVM is an institute funded by the Dutch government that is partly concerned with health studies and partly with

environmental studies. The interview concerned the environmental studies only and in particular the report entitled *Environmental balance-sheet: The Netherlands' en vironment explained* [1] that is published by RIVM annually. The report is mandated by law and is meant primarily for members of parliament and policy makers. It serves to underpin government policy with regard to the environment in the Netherlands and is funded by the Ministry responsible for environmental matters.

Dr de Kwaadsteniet claimed that RIVM is not primarily basing its conclusions on actual data, but on computer studies based on simple mathematical models that have often not been tested statistically. He also pointed out that hardly any indication is given of the accuracy of the results. He argued that this is misleading because it gives a false suggestion that the results are exact. In his own words: RIVM lives in an artificial world of its own creation, far removed from reality. The interview went on to relate the efforts of De Kwaadsteniet to convince his superiors until he finally decided to go public with his complaints about RIVM.

Let us note that environmental studies are subject to a great deal of randomness and thus any model in this area must include uncertainty as an essential element. Working with models that have not been subjected to statistical tests is precisely the sin we discussed earlier. Moreover, a shortage of actual measurements makes it very difficult if not impossible to test the model or provide realistic information about the accuracy of the results. Thus the criticism of De Kwaadsteniet is based on a coherent argument.

Of course this created quite a stir in the national press. Questions were asked in parliament and the appropriate parliamentary committee discussed the matter with the Minister responsible for environmental matters on February 11. The political discussion centered on the points of criticism mentioned above. Too much computation with insufficiently tested models, too few measurements and too little attention for uncertainties in the conclusion.

RIVM denied that there was anything wrong and at short notice produced a report entitled *Measuring, computing and uncertainties* [2]. I'm sorry to say this report is not very convincing. There is little indication of models being subjected to statistical tests. RIVM claims to have information about the accuracy of its results. Sometimes this information is said to be statistical but often it is based on expert opinion, which may mean almost anything. RIVM states that it has a selective attitude with regard to the reporting of uncertainty in its reports. Accuracy of estimates is discussed only if this might have important policy implications, and here we have to trust their judgement.

At the same time the Supervisory Committee of RIVM investigated the matter and reported on February 8 that the allegations in the media that RIVM would handle models and data carelessly are without foundation. The arguments for this conclusion were similar to the ones just mentioned. It is interesting to note that the committee feels that the models have been subjected to a satisfactory combination of various kinds of tests such as discussions with collaborating institutes and refereed

publications in the scientific literature. Of course this is not at all the kind of statistical test referred to earlier.

On the basis of this documentation the Minister assured the parliamentary committee that the data provided by RIVM constituted a sufficient basis for political decision making. The main point that the Minister made, however, is that he would like to see all uncertainties, both with regard to measurement error and model specification, explicitly mentioned in future. He expressed his satisfaction that RIVM has promised to pay attention to this. Parliament was apparently not entirely satisfied that the problems would go away, because on March 16 a motion was passed requesting that an independent quality evaluation be added to the annual *Environmental balance-sheet* report.

Is this a happy ending? Not quite yet. To all of these so-called expert opinions, let me add my own educated guess as a professional statistician about what is really going on here. Environmental research is perhaps one of the messiest topics in the sciences. Relatively little is known about many aspects of it and measurements are difficult and prone to large errors of many different kinds. Yet, the government decides that it wishes to formulate an environmental policy and it needs data to base this policy on. It funds a large research organization and charges it to produce these data according to a tight and rigid time schedule. The scientists of this research organization take their job seriously. They grasp at every set of data they can lay their hands on and that can provide any information at all about the problems they are facing. They are also willing to think of possible models, conduct experiments and measure whatever they can. They discuss matters with colleagues at similar institutions. Sometimes they have no choice at all because their model is prescribed by law or international agreement. But when all is said and done and time is running out, they realize full well that they can at best come up with estimates that are perhaps not unreasonable but can't pass the rigid requirements for scientifically sound research. This is not an environment where mathematical statistics will flower, because people don't like to be told that their results are unreliable. They do not realize that mathematical statistics has gone through a spectacular development in recent years and may actually be able to solve some - though not all - of their problems in a more satisfactory way. By that time, the institute will not house much expertise in mathematical statistics within its walls anyhow. This is typically the case with RIVM and the same is true for its Supervisory Committee. I'm quite willing to assume that this committee consists of people who are competent in their own field and I'm aware that at least one of the members has considerable experience in official statistics, but none of them are experts in mathematical statistics.

Now along comes someone – in this case Dr De Kwaadsteniet – who points out that the emperor's clothes are not quite in order. Naturally this is not a welcome message for the institute's leadership and since statistics is not really on their agenda any longer, they merely consider this as making trouble. This is what we call in Dutch a conflict between the *rekkelijken* en the *preciesen*, two religious groups, one of which took the bible less literally than the other. The problem with the rekkelijken (the elastic or flexible ones) is that they are liable to end up with the "why bother"

attitude that I described earlier: the phenomena we are studying are so complicated that modeling is impossible anyhow, so why not use any method that produces good looking numbers and pretty pictures? On the other hand the preciesen (the precise or dogmatic) are prone to fall into another trap, which is failing to realize that nothing is perfect in this world.

It is interesting to note that once the discussion became public, it was no discussion at all. De Kwaadsteniet accused RIVM of not testing their models and ignoring the accuracy question. His opponents did not provide a credible answer to this charge. As I have indicated, they simply denied that it is was true without advancing serious arguments against it. For the moment the only unbiased conclusion can be that the criticism leveled at RIVM's environmental programme still stands and that a closer investigation of these charges should be carried out.

I would, however, like to take a broad view of such an investigation. Its main purpose should not be finding out who was right and who was wrong in the past, but to look at the future and see what has to be done. At the request of the Minister, RIVM agreed to pay attention to all uncertainties, both with regard to measurement error and model specification. If this is to be done seriously it is going to be an enormous job of considerable mathematical sophistication. At present RIVM provides many estimates of unclear precision. What we don't want to happen is that these estimates will merely be supplemented by equally dubious claims about their precision. The investigation should produce clear recommendations on how to tackle the problem in a satisfactory manner.

It is difficult to see how such an investigation could be carried out by RIVM itself or be supervised by the Supervisory Committee of RIVM as presently constituted. This committee's opinion that there is nothing wrong with the present practices of RIVM is already on record. Moreover, the problem is about mathematical statistics so outside statistical expertise should be called in, both for the investigation itself and for its supervision.

Of course there is also an international angle to the problem. Duplicating work to be undertaken elsewhere should be avoided and if possible new methodology should not be restricted to this country. It so happens that a European Institute for Statistical Science funded in part by the Netherlands Ministry of Education, Culture and Science and Eindhoven University of Technology has just opened its doors. This institute named EURANDOM has an international staff. It is well connected with many other statistics centers worldwide and can call on the expertise of the world's outstanding experts in any area in statistics. It seems to me that EURANDOM could play a significant role in this investigation.

In order for such an investigation to achieve its purpose, it is of course necessary that RIVM should be willing to collaborate with outside experts in statistics. For this purpose, the colorful insults that have been traded between the warring parties are perhaps best forgotten.

Another point that came up in the discussion about this affair was the difficult position of a research institute like RIVM that is funded by the government to advise on politically sensitive issues. Such institutes are heavily dependent on the government as their main customer and may therefore be vulnerable to political pressure to produce results that this customer would like to see. In his discussion with the parliamentary committee the Minister asserted that neither he nor his predecessors have ever tried to influence the work at RIVM. However, this is part of a larger issue in the light of a book by Köbben and Tromp that appeared less than three weeks ago. In this book entitled *The Unwelcome Message* [3] they discuss 37 cases of attempts to influence the results of a scientific investigator by outside funding bodies or by the organization where the investigator in employed. The authors have 35 other cases on file. They feel that this practice is so widespread that the Netherlands Royal Academy of Sciences should appoint a highly reputable person to whom cases of undue influence could be reported. This seems a good idea.

At the end of this lecture I have also come to the end of my days at the University of Leiden. Because important things should be said early in any lecture, I already told you how much I enjoyed myself working here but also how much I valued the opportunities I was given to spend time elsewhere. One of the most enjoyable things of an academic career in a fully international subject like mathematics is that you end up with a group of friends that spans the globe. I'm truly happy to see some thirty of my colleagues from abroad present at this ceremony. They have taken the trouble to travel great distances from such places as Berkeley and Stanford in the West, Prague and Moscow in the East, Aarhus and Gøteborg in the North, Perth and Sydney in the South and so many places in between. Many of us have sat together on governing boards of scientific societies like the Institute of Mathematical Statistics, the American Statistical Association, the Bernoulli Society and the International Statistical Institute. Many of you have been with me on the editorial board of The Annals of Statistics and have been a great help and support for me in those hectic but enjoyable years. It's been a great pleasure to see all of you during the symposium we have enjoyed for the past week. I trust we'll keep meeting with some regularity in various and sundry places on earth.

In this connection I'm grateful to Fred Bakker, Mrs Bruins and my former graduate students Mathisca de Gunst, Chris Klaassen and Aad van der Vaart who put in so much work to organize the symposium during the past week. Fred and I have faced many storms together throughout the past 25 years or so and I'll miss the thrill of embarking with him on some scheme for what is perhaps best described as the improvement of the quality of life in mathematics. Quite a few of these schemes have actually worked over the years. Mrs Bruins is retiring the same day that I am but has been unable to use up the massive number of vacation days she still had coming because of the pressure of organizing the symposium. I bow my head in the face of such exemplary dedication. Working with my graduate students has been the greatest pleasure of my teaching career ever since I discovered the fun of starting students on a topic I wanted to learn something about myself. For me this worked well and I can only hope that some of my scientific children can say the same. I wish them all the best in their lives and their further scientific careers. My collega proximus Jaap

Fabius has been a great help in keeping my sometimes rather incomplete knowledge of probability theory up to par and also as a close personal friend for whom one has no secrets.

Apart from my former graduate students I collaborated with two people more intensively than with anyone else. Peter Bickel and I have collaborated for 27 years now and it's been a real pleasure all along. People are telling me that we are beginning to sound very similar and I do believe we are both a little different than we would have been if we had never met. I still think of Friedrich Götze as that brilliant young man though a quick computation shows that he can't be that young anymore. He has the solid German mathematics background which makes people unhappy in a mere Euclidean space, so from time to time Peter and I look out the window and say to each other: "There's Friedrich disappearing into Banach space". Friedrich has been wonderful to work with and will continue to do great things.

Apart from Berkeley where I spent much time as a visitor, I have fond memories of the University of North Carolina at Chapel Hill and Charles University in Prague. I'm grateful to Ross and Winsome Leadbetter who took so much trouble to make our life at Chapel Hill as pleasant as it always was. I'm very sorry that they can't be here today. Charles University has always meant a lot to me in the dark days in the past as well as in better times now and Marie Hu_ková is always welcome here. My thoughts also go to our colleagues in the former Soviet Union where the dark days have been followed by a new nightmare. I'm happy that Dimitri Chibisov, Ildar Ibragimov and Rafail Khasminskii are with us this week.

From time to time I've had something to do with university administration, in particular as dean of the school of natural sciences and mathematics and director of the Thomas Stieltjes Institute. I don't think I have any special talent for such things, but I did learn a lot from watching Guus Zoutendijk, a true master at this art. Many scientists believe that the university administration is the enemy but experience has taught me that this is false. Administrators are just as muddled about what to do next as anyone else. With few notorious exceptions, they have everyone's good fortune in mind even though things don't always work out that way. I strongly believe that common decency is an essential element of sensible university administration. I salute the past and present dean Kees Libbenga for putting this theory into practice. The same salute goes to Rien Kaashoek as chair of the Stieltjes Institute. Over the years I collaborated intensively on many administrative matters with Gerrit van Dijk, also a former dean and past and present chair of the mathematics department. I believe Gerrit and I buried the old war between pure and applied mathematics so effectively that it never even comes up in our discussions. I trust he'll guide the department well into the next century until the next generation can take over. Jan Coremans and Frans van der Touw never quite succeeded in teaching me the rudiments of financial management but they did have a great deal of patience with me.

For the past 15 years I have also been involved with the Leids Universiteits Fonds, a foundation devoted to furthering the aims of the University of Leiden. I would like to express my gratitude to the many people who have served with me on the

Scientific Grants Committee over the years and to Janneke Fruin, director of the foundation. I believe that our committee meetings gained the just reputation of being among the most pleasant and congenial gatherings in town. I can't remember that we ever had any problems finding members for this select committee.

I've had the extreme good fortune to have had only two secretaries in the past 27 years: Mrs Pieksma and Mrs Bruins whom I already mentioned. Both have helped me so well that it will be a harrowing experience for me to cope without their assistance.

Finally you will probably not be surprised to hear that I'm not completely stopping my activities next week. As any addict knows, it's difficult to kick a habit. I am now devoting some of my time to the new European Institute EURANDOM and I'd like to see this undertaking off to a good start.

Of course I realize that I have probably outlasted your patience by acknowledging far more people for their help and support than is usual on such occasions. This is probably because I have needed a lot of help and support. Of course I received most of that from my wife Lucie who firmly believes that all mathematicians are crazy and in my particular case tries to minimize the effect this has on the world at large.

In fact I could go on thanking people for quite a while and I'm painfully aware of the many people that I have slighted by not mentioning them. To them I can only apologize and point to the iron law that holds in any university the world over: you stop lecturing when your time is up.

Thank you for your attention.

Noten

1 Rijksinstituut voor Volksgezondheid en Milieu (1998). Milieubalans 98. Het Nederlandse milieu verklaard, Samson Tjeenk Willink b.v., Alphen aan den Rijn

2 Rijksinstituut voor Volksgezondheid en Milieu (1999) Meten, Rekenen en Onzekerheden. RIVM Rapport 408129005.

3 Köbben, A. en Tromp, H. (1999). De onwelkome boodschap of: Hoe de vrijheid van de wetenschap bedreigd wordt, Jan Mets.