REVIEW

Streets of Paris, sunflower seeds, and Nobel prizes. Reflections on the quantitative paradigm of public health

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Quantitative methods are central to public health and public health research. The historical roots and philosophical foundations of this predilection for the quantitative, however, are little known and seldom discussed.

be found on the city plan, namely Poisson, one of Lagrange's students (fig 1). Regrettably, his street is only a small one, nor has Poisson—unlike his master—been “pantheonised”, as the French would say.

Modern day public health researchers are, for the most part, unaware that the origins of the application of quantitative methods in public health lie in France. Most historical treatises in the field of public health fail to look beyond the Anglo-Saxon nose of the author, and ascribe the roots of these methods to English pioneers, such as Farr and Chadwick, who in the third and fourth decades of the 19th century published their famed quantitative analyses of the poor health conditions in the major cities of England. Both, however, were building on the work of French researchers in the 1820s, such as Villermé. We know that Farr studied in Paris under Pierre Louis, who laid the foundation for the “numerical method” in medicine. Chadwick quotes extensively from the work of his French predecessors, for example when dealing with the need for public responsibility in sanitation issues and the necessity of laying sewerage systems.³

The idea that sanitation was not merely a private matter, but rather an issue for the public authorities had emerged shortly before and during the French Revolution. This notion reflects something of the rabid Enlightenment way of thinking that also produced the guillotine—a scientifically efficient method to cut opponents down to size. The very same way of thinking led to numerous drastic reform proposals in public health, which, while amounting to very little during those chaotic years, would none the less later give rise to the foundation of the first public health institutions in Europe. France was also the first to have a public health journal: the *Annales d'Hygiène Publique*, which for the first time appeared in 1829, and still exists, albeit without an impact factor.⁴

This brief historical detour provides some insight into the backgrounds of how the quantitative approach came to be used in public health issues. Application of the numerical method in health issues was an innovation that arose at the teaching hospitals of Paris in the early 19th century; it was used to systematise patient observations. It merged careful observation with mathematical reasoning, and can be seen as an attempt to reconcile “rationalism” with “empiricism”. It applied Cartesian principles: the

THE STREETS OF PARIS

Situated at the highest point of the “rive gauche” in Paris is the Panthéon, an edifice built in the classical style that forms the final resting place of the heroic sons of France. Inside the building, under a central dome some 60 metres high, is a copy of Foucault's pendulum. This is a small but heavy weight on a long steel cable that leisurely swings back and forth, and if one watches long enough, it can be seen that the pendulum appears to be rotating very slowly. “Appears” to be rotating, because it is in fact the floor under the pendulum that is turning—rotating with the earth, while the pendulum continues to swing in exactly the same direction. This is a brilliant demonstration of the rotating movement of the earth, used by Foucault to provide its first scientific proof in 1851. Or, in slightly different words: while the motion of the earth occurs on a scale that does not affect our perception of movement, it is clearly visualised by means of Foucault's pendulum on a few square metres of marble floor.¹

Under the floor is the crypt of the Panthéon, accommodating the vaults of important French statesmen, philosophers, and writers, as well as those of a number of men of science, the latter dating mainly from the end of the 18th and the first half of the 19th century. Among these are a remarkable number of mathematicians, including Lagrange, Condorcet, and Monge. Thanks to Lagrange, renowned for the publication of the first systematic theory of functions, we are able to formulate regression equations. Condorcet became famous for his work on the probability of majority decisions, after which he himself literally fell victim to such a majority decision during the French revolution. Monge is the founder of modern geometry.²

A street has been named after each of these men in Paris, as well. More precisely, there are over 100 streets in Paris named after mathematicians. Next to the three aforementioned names, that of a figure well known to epidemiologists and public health researchers generally can also

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that can be reduced to mathematical formulas, can therefore be simulated on the computer, and are based on the fact that living nature utilises the laws of lifeless nature that have for so much longer been described in mathematical terms. Astronomy, optics, geography are all inconceivable without mathematics, nor would Foucault have ever been able to devise his experiment with the pendulum without the mathematics of circle and gravity.

It becomes even more fascinating when the partly biological, partly social processes determining the health of populations are also found to conform to simple mathematical formulas. The application of the numerical method in public health often does not go beyond a little addition, subtraction, division, and multiplication. However, the rare moments that we detect patterns that can be described by a mathematical formula fill us with a sense of being close to a deep truth. There are many examples: from the pattern of the spreading of infection to the rise and fall of the ischaemic heart disease epidemic, and from seasonal variation in disease rates to the rise in mortality rates with age.¹⁰

This last example is one of the best—the regularity in the increase in mortality rates with age indicates that even life and death are governed by the elegant laws of mathematics. It was a contemporary of Lagrange, Condorcet, and Monge, called Gompertz who formulated a “law of mortality”. Benjamin Gompertz was an actuary of Dutch descent who applied mathematical principles to life assurance while working in London. He discovered that, at least from around the age of 20, the risk of dying doubled with every eight years lived. He described this phenomenon in a simple formula and discovered that the same formula not only applied to Britain, but to other countries as well.¹¹ Even today, the doubling of risk in eight years still holds, even though the basic mortality rate has fallen strongly because of the higher level of prosperity, public health measures, and improvements in health care.¹²

Gompertz was convinced that this formula contained a fundamental truth about life and death, but was unable to unravel this. Later, other researchers found exponentially increasing mortality figures with age for other species as well, although different lengths of time in which the risk doubles apply. The mortality figures are lowest for any species around the age of sexual maturity, and subsequently increase faster with age the shorter the reproductive period. What is the deeper truth behind this? According to those who have studied the phenomenon, the message contained in this pristine pattern is that we die because we are finished with sex, and that external life is solely attainable via reproduction.¹³ Probably, just like the mathematical model behind sunflower seeds, it is all a matter of efficient utilisation of space, energy or both.

THE IRONY OF NOBEL PRIZES

Public health goes beyond the experience of beauty and the consoling thought: the knowledge we acquire using our quantitative methods must be applied in practice. However, it is at this point that we run up against an extremely annoying problem: many people cannot understand our figures, and even when they can, they refuse to act accordingly.

Innumeracy takes many forms, and the causes are likely to be complex.¹⁴ It is not always merely a question of not being able to do arithmetic, although that may also play a part. The difficulty of understanding why, if you add 50% to something and then subtract 50%, you do not end up with the same number you started out with, is not necessarily caused by dumbness. Arithmetical operations that are more complicated than simple addition or subtraction just do not correspond with the operations that we apply in reasoning and deliberation. This is caused by the fact that the latter consist

of words, which we tend to subject to “linguistic” rather than mathematical operations.

Another difficulty is that it is hard for most people to imagine very big and very small numbers. And these are what we use most in public health: we talk about large numbers of cases of disease and about small risks, but most people have no mental image of the numbers concerned. Almost no one can summon a concrete image of numbers that are larger than 1000 or smaller than one hundredth,¹⁴ and it is therefore hardly surprising that our message does not always find a fertile reception. In that sense, we lack a tangible example of the kind provided by the pendulum of Foucault, which can demonstrate a movement on cosmic scale on the ground beneath our feet.

And then the calculation and interpretation of risks: despite 200 years of probability calculation, very little of this has penetrated the everyday thinking of the population at large. For many people, the reality of the 80 year old smoking grandfather looms far larger than the calculations of probability made by epidemiologists about the health risks of certain dietary habits or environmental factors. Hence smokers may well have a fear of flying, and doctors may be of the opinion that the negative effects of a drug trial do not apply to their patients. This is the world in which public health experts must peddle their wares: telling people that they should not smoke and eat a more nutritious diet, telling policymakers that the breast cancer screening programme should definitely be continued or not, and that the cholesterol guideline is wrong, all the while keeping a cool head and awaiting the latest refinement in the calculation that can make all the difference...

That gap between the straightforwardness of infallible mathematics and the apparent twists and turns in the reasoning of those of mere flesh and blood is not only sadly

Figure 3 Daniel Kahneman, winner of the 2002 Nobel prize for economics.

persistent, it has even given rise to new areas of research. It is undeniably clever of us researchers first to invent the concept of risk, and then, on discovering that people are slow to pick up on this, to ensure additional years of work under the flag of the new concept of “risk perception”. It is therefore ironic that a Nobel prize can be won for research into the numerical ignorance of ordinary people, as in Kahneman’s case in 2002 (fig 3).¹⁵ He demonstrated in a number of rightly famous studies that people find small risks and big numbers very difficult and that they are extremely inconsistent when it comes to weighing advantages against disadvantages: the probability of a loss is weighed much more heavily than an equally large probability of an equally large benefit, which makes behavioural choices regarding health and disease appear irrational.¹⁶

BY WAY OF CONCLUSION

Trust in quantitative methods is part of the “paradigm” of public health,¹⁷ and some of the most resounding successes achieved by public health may be directly attributed to meticulous counting and calculating. One example that immediately leaps to mind is that of the paradigmatic John Snow, who tracked down the contaminated water pump in Broad Street by counting cholera patients in the streets of London. This predilection for the quantitative is, on the face of it, perfectly understandable, because how could we ever draw any kind of conclusions about population health without counting and calculating the number of individuals who are ill?

There is more to it than that alone, however, as the above paradoxes illustrate. The French origins of this quantitative approach have their roots in philosophical ideas to which few modern day practitioners of the quantitative method subscribe in undiluted form, but that still influence their interpretative preferences. The aesthetic ideal that partly drives the search for simplicity in quantitative analysis leads us to far more basic principles than we had ever expected or might have been searching for. And, time and again, all our knowledge, acquired through counting and calculating and applied for the greater good of the public, runs up against a wall of

numerical ignorance the study of which can earn one a Nobel prize—but that ultimately sets binding constraints on the application of the results of public health research.

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