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## Arthur Roger Thatcher's contributions to longevity research: A Reflexion

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Arthur Roger Thatcher, CB, died in London on February 13, 2010, at 83 years of age. He was actively engaged in demographic research until his death. One of his last papers, *The Compression of Deaths above the Mode*, is published in this volume of *Demographic Research* (Thatcher et al. 2010). Roger signed the copyright agreement for the paper on January 24, just a few weeks before his death. Another contribution will appear in a forthcoming monograph entitled *Supercentenarians* (Maier et al. 2010). In this note, we, the co-authors of his *Demographic Research* paper, will briefly review his remarkable research accomplishments.

Roger Thatcher was born in Birmingham in 1926. He worked for 26 years as a statistician in several national government offices. Later, he served as Registrar General for England and Wales, and was Director of the Office of Population Censuses and Survey (OPCS) from 1978 to 1986. A short description of his professional career up to his retirement can be found in *Population Trends* (1986).

He had a long-standing affinity for the history of actuarial sciences and statistics in England, taking particular interest in the early years of the Statistical Society of London, and helping to compile extracts from its 1830s *Proceedings* (see Boreham et al. 1988 and Rosenbaum 2001). He published a historical abstract (1971) of British labour-force statistics back to 1886. Thatcher was also a scientist with broad interests, publishing papers in a wide range of fields, such as archaeology, mathematics (number theory), and cosmology (1976, 1978 and 1982).

### 1. Old-age mortality and Kannisto-Thatcher Database

In order to review Roger Thatcher's major research accomplishment, we must start with the Cambridge Group project on the maximal length of life, in 1990. Peter Laslett, the co-founder of the Cambridge Group for the History of Population and Social Structure, and a fellow of Trinity College, Cambridge, launched the project with Roger Thatcher, Väinö Kannisto, and James Vaupel. Roger wrote in 2001, "In 1990 the Cambridge Group for the History of Population and Social Structure invited three interested researchers to collaborate informally in a project on the maximal length of life. They soon decided that a proper investigation would call examination of reliable data from as many countries as possible. Between them, and with funding from the Danish Research Councils and the U.S. National

Institute of Aging, they assembled and computerized all the published official statistics on death at ages 80 and over in 30 countries since 1960, or earlier in many cases” (2001).

In this project, Väinö Kannisto, a former United Nations Advisor on Demographic and Social Statistics, and Thatcher assembled detailed statistics on old-age mortality in many developed countries, carefully evaluated the quality of the data, and developed a comprehensive database on reliable estimates of old-age mortality. Thus the well-known Kannisto-Thatcher Database (K-T Database) was formed. The database was established at Odense University Medical School, Denmark, in 1992, as a component of the Odense Archive of Population Data on Aging. It is currently maintained by the Max Planck Institute for Demographic Research (MPIDR), Germany.<sup>4</sup>

Using the Kannisto-Thatcher Database, Väinö Kannisto, Roger Thatcher, and others studied trends of old-age mortality. This was a monumental study, showing that significant declines of oldest-old mortality had begun in the third quarter of the twentieth century in many developed countries. (Kannisto 1994; Kannisto, Lauristen, Thatcher and Vaupel 1994; Kannisto 1996; Vaupel 2002).

## 2. Centenarian studies

Roger Thatcher and Väinö Kannisto were the first researchers to thoroughly examine demographic data on centenarians. In a widely cited article published in 1980, James Fries argued that in England, there had been no detectable change in the number of people living longer than 100 years, or in the maximum age of persons dying in a given year, in spite of a great change in life expectancy at birth. His proposition became one of the main rationales used by biologists and medical scientists to argue that there must be a limit to human longevity: In typical arguments, the life expectancy was considered to be limited to approximately 85 years, and the maximum life span 100~110 years (Fries 1980; Cutler 1985; Walford 1983; Hayflick 1994).

However, in a paper in 1981, Thatcher demonstrated that “[e]ven after allowing for the overstatement of centenarians in the 1971 census” there had been a tremendous increase in the number and proportion of old people who survive to the age of 100 (Thatcher 1981). Then, in a paper focusing on the quality of data on centenarians, Kannisto noticed a rise over time in life expectancy at age 100 in 15 developed countries for which he had reliable data, though the rise was not uniform (Kannisto 1988). A few years later, Roger Thatcher completed his comprehensive study on trends in the number of centenarians in England and Wales and mortality at high ages (Thatcher 1992). These three papers exemplify the complementariness of Roger’s and Väinö’s works. Kannisto tended to incorporate reliable data from as many countries as possible to demonstrate some universal patterns of demographic changes, while Thatcher liked to conduct detailed, intensive analyses using British data.

Roger Thatcher was the first to clearly demonstrate the increase in the number of centenarians (1981, 1983, 1992, 1997, 1999a, 2001). This finding was extended to several developed countries by James Vaupel and Bernard Jeune in 1995, leading to a long series of works throughout the world (Robine and Saito 2009). Roger was also strongly interested in age validation and data on *supercentenarians*, i.e., people aged 110 years or older. Therefore, when a proposal to develop a new database focusing on supercentenarians was discussed,<sup>5</sup> Roger was most supportive of the new project. He organized a system for the Office for

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<sup>4</sup><http://www.demogr.mpg.de/?http://www.demogr.mpg.de/databases/ktdb/>

<sup>5</sup><http://www.supercentenarians.org/>

National Statistics (ONS) and the Government Actuary's Department (GAD) to report annually on deaths at age 110 years and above in England and Wales, with information on validation of their ages. The British contribution to the International Database on Longevity (IDL) is described by Roger Thatcher in the above-cited monograph (2010). His interest in supercentenarians and age validation was shared with Peter Laslett (Laslett 1999; Thatcher 1999b).

### 3. The logistic model of adult mortality

Roger Thatcher established the logistic model as the most suitable mathematical model for age patterns of human adult mortality. In the early nineteenth century, a British actuary, Benjamin Gompertz, found that age trajectories of human adult mortality could be approximated by the exponential function (Gompertz 1825). The Gompertz model and its modified version by Makeham (1867) were widely used as the standard models for adult mortality in humans, and then extended further to animal species in general.

However, data on mortality at high ages were not very reliable in those days, partly because age misreporting was not uncommon among the very old, and partly because a relatively small proportion of the population reached those ages. Several researchers felt that the limited, erratic data might suggest decelerations of the exponential increase at very old ages (Redington 1969), but the reliability of the apparent slowing-down remained questionable (Humphrey 1970).

The last decade of the twentieth century witnessed a breakthrough in research on adult mortality trajectories at the two front lines. In the emerging field of biodemography, James Vaupel and his collaborators conducted laboratory research on longevity of animals and revealed that the age-associated mortality increase slowed down considerably at old ages in a number of non-human species (Vaupel et al. 1998). In human demography, Väinö Kannisto and Roger Thatcher developed the Kannisto-Thatcher database and presented firm evidence on significant mortality deceleration at old ages.

These two series of research successfully documented the mortality deceleration at old ages in humans and a number of non-human animal species. Given that the Gompertz and Makeham models do not capture this important feature, the next key question was: what mathematical model should be adopted for age variations of adult mortality? In order to investigate this question, Roger Thatcher undertook a study to fit six different mathematical models to reliable data on oldest-old mortality (aged 80 and above) from 13 selected countries, covering the few recent decades. He assessed the comparative compatibility of those models to the data, and demonstrated that the logistic model was clearly the best, as it captured the mortality deceleration very well. A comprehensive monograph of this study was published by the Odense University Press (Thatcher et al. 1998). Thatcher then applied the same approach to some recent and historical mortality data (mainly from England and Wales) for a wider age range (ages 30 and over) and showed that the logistic equation fit those data very well also. His report was read on Wednesday, June 17th, 1998 at a meeting of the Royal Statistical Society and published in the society's journal (Thatcher 1999c). These two studies have established the logistic model as the best mathematical model of human adult mortality, replacing the widely used Gompertz model and Makeham model. For example, in the Human Mortality Database<sup>6</sup>, if detailed information was not available at any juncture, mortality in the open-ended age interval is then estimated based on a special version of the logistic model. These studies by Thatcher are undoubtedly a landmark in the history of human longevity research.

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<sup>6</sup><http://www.mortality.org/>

#### 4. M-Project: Thatcher's last work

Thatcher's last paper for scientific publication, *The Compression of Deaths above the Mode*, reflects the research interests and visions that he shared with Väinö Kannisto. In the final years of Kannisto's life, he served as a member of the IUSSP Committee on Longevity and Health, and also conducted a novel study on the compression of old age mortality, i.e., the tendency for deaths at very old ages to concentrate in a narrow age range (Kannisto 2000, 2001 and 2006). Initially, the shift of his focus on the study of old-age mortality from frequently used life table functions (i.e.  $q_x$ ,  $m_x$  and  $\mu_x$  functions) to other life table functions, i.e., the survivor function ( $l_x$ ) and the death distribution ( $d_x$ ), was perplexing. Kannisto revived the Lexis model of mortality (Lexis, 1878), focused on the modal age at death (denoted by  $M$ ), and developed a new measure of mortality compression,  $SD(M+)$ , which is the standard deviation of ages of deaths above the modal age. Kannisto's innovations inspired a PhD student (Cheung) and she extended his work to develop  $M$ -related indicators to examine the rectangularization of the survival curve and the limit of human longevity in her dissertation (2003), and convinced two other members (Robine and Horiuchi) of the IUSSP Committee that although the life expectancy had been the most widely used summary measure of longevity, the modal age and related measures provide powerful tools for demographic analysis of old-age mortality (Horiuchi 2003).

Roger Thatcher also became interested in this approach. The earlier collaboration between Cheung and Robine, lead to a series of publications since 2005 (Cheung et al. 2005, 2008, 2009; Cheung and Robine 2007) and developed into active communication among the four researchers in the interest of elaborating upon this approach. The group called this research collaboration the "M-Project" (It should also be noted that Vladimir Canudas-Romo (2008, 2010), working independently, made important contributions to the development and elaboration of the  $M$ -focused approach). Roger Thatcher found that the compression could be analyzed more clearly and systematically by applying the logistic model to this phenomenon. He led this study and first-authored the report, which became the last scientific paper that he published.

Since the inception of the  $M$ -Project in 2005, we had four meetings with Roger Thatcher in London between January 2005 and January 2008 to finalize the work, in addition to an extensive exchange of email. It was an honour to collaborate with so dedicated a scholar. His involvement in the  $M$ -Project, as his daughter, Ms. Sue Gammerman said, gave him great satisfaction. It pleased him to know that in his retirement he could still contribute to the world of science, and that his knowledge and experience could be of value to new colleagues in his field of research.

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