Contributions from the margins.
Dutch statisticians, actuaries and medical doctors and the methods of demography in the time of Wilhelm Lexis

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1. Introduction

The period 1860-1910 can be characterized as a period of transition wherein demography emerged from statistics as a separate field of interest. An international group of ‘great demographers’ like Lambert Adolphe Jacques Quételet (1796-1874), William Farr (1807-1883), Louis-Adolphe Bertillon (1821-1883) and his grandson Jacques Bertillon (1851-1922), Joseph Körösi (1844-1906), Anders Nicolas Kiear (1838-1919), Richard Böckh (1824-1907), Wilhelm Lexis (1837-1914) and Luigi Bodio (1840-1920) contributed to the development of demography and to the toolkit of methods and techniques of demographic analysis. As J. &. M. Dupâquier (1985: 393-394) put it: ‘At the end of the period (of the great demographers – dG/vP) the history of demography had become a collective enterprise of demographers, who were working either in an academic setting or as chiefs of statistical offices’. There are no statistician-demographers from the Netherlands figuring in the international setting of innovators of demographic methodology, although Dutch statisticians had important positions in statistical organisations, the International Statistical Institute ISI in particular. Dutch contributions to the development of the method and techniques of demographic analysis in that period were only marginal and came from the margin of the field.

In the first part of this paper the position of Dutch statistician-demographers in the above mentioned period of transition is discussed, starting from a study of the (limited) impact in the Netherlands of Lexis’ lasting contribution to demography in the form of the so called ‘Lexis diagram’. An analysis of the contents of some authoritative textbooks on the method of statistics, dating from the pre- World War II period and written by C. A. Verrijn Stuart and Van Zanten, is taken as a point of departure. These textbooks give a fair representation of the contemporary and specifically Dutch paradigm of statistics (and the application of the statistical method to demography). Therefore, in order to understand the nature of the reception of the Lexis diagram one needs to have some understanding of how statistics was looked upon by the main Dutch statisticians of that period.

Although 19th century statistics in the Netherlands was dominated by lawyers and economists, other fields of science also kept or developed a keen interest in demographic statistics. The contributions of the representatives of these fields of study do not easily find a place in the official history of statistics and demography as they were not often published within the main journals and statistical series. For that reason we direct our attention in the second part of the paper to two of these outsiders, the actuary David Samot and the medical doctor Johannes Zeeman. They can be considered as representatives of two scientific traditions which shared with demography their interest in the study of mortality but the value these disciplines attached to statistical analysis of death data had long been completely different. Continuing a tradition that dated from the 17th century, actuaries mainly studied life tables and other mortality statistics. In their attempts to extend the areas that could be covered by insurances, they also developed interest in questions of invalidity and incapacity for work. To calculate the probabilities they combined death and invalidity rates. Samot may have been the first to realise that this idea of a multiple decrement table might also be applied to the processes of nuptiality and mortality. The ideas for this combined nuptiality and mortality table were first mentioned in the 1870s.

Interest in statistics within Dutch medical science had strongly increased since the 1850s as a consequence of the growing role of the Hygienist movement. The contribution of medical doctors to the development of mortality measurement cannot be neglected. It is in particular the representatives of the English sanitary movement that played an important role (Eyler, 1980). Usually quite some time passed before their Dutch counterparts adopted the English innovations. A case in point is the role attached to the crude death rate and age standardisation. Zeeman suggested in 1888, three years before Körösy, a form of age standardisation to compare mortality rates between neighbourhoods, yet he seemed to have been not aware of the contributions made in this field by English colleagues some decades earlier.

2. Lexis' contribution to demography

For a good understanding of the contribution of Wilhelm Lexis (1837-1914) to demography J. and M. Dupâquier's *'Histoire de la démographie. La statistique de population des origins à 1914'* (Dupâquier, 1985) provides an excellent source. According to the Dupâquiers the academic Lexis belongs to the small group of great statisticians of the 19th century, together with his compatriot, the Prusian civil servant Richard Böckh (1824-1907). Lexis studied law and mathematics and natural sciences. He taught at the universities of Strasbourg (1872-1874), Dorpat (1874-1876), Freiburg-in-Breisgau (1876-1884), Breslau (1884-1887) and Göttingen successively. Lexis made contributions to the development of populations statistics and demography during a relatively short period of his professional career only, namely between 1875 and 1880. During his stay at Strasbourg University he started to specialize in matters of population. Here he published his introduction into the theory of population statistics ('*Einleitung in die Theorie der Bevölkerungsstatistik*'. Strassburg, 1875), wherein his famous diagram is presented. In 1876 follows a study on the quantitative relation between the sexes at birth *('Das Geslechtsverhältniss der Geborenen und die Wahrscheinlichkeitsrechnung'*, in: *Jahrbücher für National Ökonomie und Statistik*, 27, p. 209-245). In the years following he developed and elaborated his theory on the stability of statistical series *('Zur Theorie der Massenerscheinungen in der menschlichen Gesellschaft*', 1877; *'Über die Theorie der Stabilität statistischer Reihen'* in: *Jahrbücher für National Ökonomie und Statistik*, 32 , 1879). He demonstrated that the condition of homogeneity is rarely fulfilled in the universe of social mass phenomena; also that the underlying structure differs for different subsets of a (total) set because of specific conditions. Next, he studied the dispersion of observations around local averages, arriving, finally, at a characterization of the formula of corresponding distributions ('Sur les moyennes normales appliqués aux mouvements de la population' in: *Annales de démographie internationale*, 4,1880). Afterwards he focussed more and more on research in the field of economics and education. Apart from a few studies on the statistics of tuberculosis ('Zur Statistik der Tuberkulose', in: *Bulletin of the International Statistical Institute*, 313, 15-2, 1906, p. 20-28, and 'Bericht über die Statistik der Tuberkulose', *ibidem*, 18-1, 1909, p. 289-296) nothing original was published. Lexis satisfied himself with the (re)edition of former work. As an economist rather than a statistician he participated in the activities of the International Statistical Institute.

If the name of Wilhelm Lexis is still familiar among demographers at the beginning of the 21st century this is due to the work of the French demographer Roland Pressat (1961; 1966; 1969; 1973). Pressat's instructive application of Lexis diagram of 1875 was developed to make certain demographic calculations more transparent. In Pressat's application is "*…the working of three directions of consideration essential: Verticals relate to synchronic observation; horizontals relate to (people with) identical ages, and diagonals to people born at the same time. Of course, these three directions could have been chosen in a different way also. In the work of Lexis, whose name is connected to these kind of diagrams habitually, the verticals relate to people born at the same time and the diagonals (sloping downward with an inclination of 45°) to people living at the same time*".[1] (Yntema, 1977:51).

Lexis' geometrical representation of the renewal process of a population of 1875 did not emerge out of the blue, as becomes clear from concise overviews and discussions of the scientific ancestry of the Lexis (-Pressat) diagram as presented by Westergaard (1932) and after the second world war, among others, by Pressat, Godefroy (1974), Dupâquier (1985) and Vandeschrick (1992; 1994). From these overviews we learn that the introduction of the Lexis diagram is closely related to the study of mortality and particularly to attempts to make life table construction easier and with developments in the field of graphical representation of (demographic) phenomena, and more specifically the introduction of the stereogram (by Gustaf Zeuner in 1869).

In the Netherlands A. J. van Pesch started to advocate a generation approach to mortality (and life table) analysis from 1866 on, necessitating the double classification of deaths by age and year of birth (Westergaard, 1932:222). The double classification of deaths by age and year of birth had already been brought into practice in the statistics of the grand-duchy of Oldenburg in 1861 by K. Becker, followed by Prussia in 1864, the Netherlands in 1870 and Norway in 1872. The first to propose a double classification of the deaths in order to improve the calculation of mortality rates (probabilities of dying) in life tables, in 1869, was the German statistician G.F. Knapp. As the Dupâquier's (1985: 364) put it: *"Ici encore, la pratique avait précédé le progrès méthodologique" ('Practice has preceded methodological progress').* Knapp discerned various groups of deaths, first, persons belonging to the same generation, who died at a given age, second, persons of the same generation, dying within a certain space of time, and finally, persons who died at a given age in a certain space of time. The Dutch statistician M.M. von Baumhauer succeeded in convincing the 7th Congrès International de Statistique (The Hague, 1869) to accept a resolution on "*... la necessité d'indiquer dans les listes mortuaires non seulement l'âge, mais l'année de naissance des décédés*" (Von Baumhauer, 1869).

Although the theory of stereogrammes existed before and examples of drawings in perspective of what can be achieved in this way were given earlier,

[1] *"… te dien einde zijn zij door Pressat [1966, 1969] zeer instructief toegepast. Hierbij is het optreden van drie beschouwingsrichtingen essentieel: verticalen hebben betrekking op gelijktijdige waarneming; horizontalen op identieke leeftijden en diagonalen op gelijktijdig geborenen. Deze drie richtingen kunnen natuurlijk ook anders worden gekozen. Bij Lexis, wiens naam gewoonlijk aan dit soort diagrammen wordt verbonden, beantwoorden de verticalen aan gelijktijdig geborenen en de (45° naar beneden hellende) diagonalen aan de gelijktijdig levenden."* (Yntema, 1977: 51)

among others by Zeuner (1869) and Lexis (1875), the Italian engineer Luigi Perozzo should be credited for being the first to make two stereogrammes. By using Zeuner's instrument of stereometric representation it was easy to ascertain the different groups of deaths discerned by Knapp. Zeuner credited Becker for being the first to have done so in 1874 (Brackel, Vol. 1, 1970:43 f.n.1). Lexis followed a year later with a similar approach. According to Westergaard (1932:222) the advantage of the graphic representation advocated by Knapp and Zeuner, whether they made use of three dimensions, as did the latter, or only two, as Knapp has done, was not confined to these practical results. In fact it was easy to solve many problems concerning displacements within a population, particularly by the help of the continuous method, studying the movements in an infinitely small moment of time. In this way simple formulas of approximation could be derived. But it goes without saying that the geometric analysis can easily be replaced by algebraic methods, even though the former in many cases will be found more attractive.

Westergaard sees two other contributions, namely those of Lexis and Verwey, as worthy supplements to the proposals of Knapp and Zeuner. Verwey's approach was presented at the Royal Statistical Society in 1874. The program of Verwey's paper was *".. to find and express in function of time and space, the laws which regulate the quantitative and qualitative changes which populations undergo. Without apparently knowing the German contributions Verwey applies similar methods (with two dimensions) and continuous formulas"* (Westergaard, 1932:223). Vandeschrick (1992; 1994) focuses on the latter subject, namely the relation between the contributions of Lexis and Verwey, in particular. Although demographers currently use Pressat's version of the diagram, it continues to be known as the 'Lexis diagram'. In Vandeschrick's opinion it is not sure that Lexis was the first to present the version that is habitually attributed to him; Verwey and Becker can claim equal or even better paternity rights (Vandeschrick, 1994:302).

3. Dutch statisticians and the 'Lexis diagram'

What about the impact of Lexis' contributions to demography in the Netherlands? In order to find an answer to this question, two periods have to be distinguished: the periods prior to and after the publications of Roland Pressat on the graphic representation of demographic phenomena based on the 'Lexis diagram' in the 1960s. Limitations of time prevented us to make a thorough study of contemporary Dutch literature on demography and statistics with respect to the fields of Lexis' interests. Incidentally, one encounters references to Lexis, for instance in the reports to the Dutch government by the representatives of the Netherlands at the Sessions of the *International Statistical Institute (ISI)*, published as appendices in the *Nederlandsche Staatscourant* (Gazette of the Netherlands). So we find quite an extensive summary of Lexis' report on the statistics of tuberculosis, presented at the 11th Session of ISI in Copenhagen, covering a full page (Verrijn Stuart & Methorst, 1907). We have found another reference to Lexis in the contribution of the actuary A.O Holwerda to a *liber amicorum* presented at Verrijn Stuart in 1931, that runs as follows: 'Methods, like those of Lexis (in: *Abhandlungen zur Theorie der Bevölkerungs- und Moralstatistik*, Jena 1903) for research of the normality of an observed stochastic mass, which can be found in every manual on mathematical statistics, move towards the centre of interest'(Holwerda, 1931:131).[2] From Holwerda's reference we can conclude that Lexis' contributions to the field of mathematical statistics had become part of the body of knowledge of that field in the early 1930s.

For the purpose of this paper we have opted for a different approach, namely a study of the contents of the most influential textbooks on either (population) statistics and the population issue in the Netherlands. For a textbook can be expected to represent the state-of-the-art of a field of study (that is to say, within the framework of the definition of that field given by the author of the book). In that capacity a textbook can even be seen as representing the (construct) paradigm of a field of science (Masterman ,1970, 1974: 63-65).

3.1 The period prior to the 1960s

Two of the most authoritative textbooks on statistics in the Netherlands in the period prior to World War II are the textbooks on statistics by C.A. Verrijn Stuart and J. H. van Zanten. We have selected the editions of these textbooks published in the 1920s: Van Zanten on the statistical method (1927, first edition) and Verrijn Stuart's book on the statistical method and its application in the field of demography (1928; a revised edition of the 1910 issue). Both van Zanten and Verrijn Stuart belonged to the small group of Dutch top-statisticians of the inter war period. Both statisticians participated actively in the international community of statisticians, organised in the ISI. They stood on equal terms with the leading international statisticians, which they often encountered at the two-year sessions of ISI. Verrijn Stuart has been characterised as the first modern statistician of the Netherlands (De Vries, in: De Gans, 1999). Verrijn Stuart (1865-1948) had been the first director of the Netherlands Central Bureau of Statistics and a professor of political and theoretical economy at the universities of Delft, Groningen and Utrecht (and had taught statistics while being professor at the universities). Van Zanten (1874-1944) was during the greater part of the inter war period a director of the Amsterdam Bureau of Statistics and, apart from that function, a part time lecturer of statistics at the University of Amsterdam. Apart from these textbooks on statistics we have also taken a few textbooks on the population issue, published in the period between WWII and the 1960s: A. M. de Jong's introduction to the population issue (1946), Methorst and Sirks's (1948) and J. P. van Rooijen's (1995) studies of the population issue in the Netherlands. These books give a good overview of the state-of-the-art in thinking about the population problem and the underlying basis of demographic analysis in non-statistical textbooks of the post-war period. De Jong (1894-1969) was a former director of the *Nederlandse Bank* (National Bank of the Netherlands), an historian, an economist and a well-read demographer (Holtrop, 1969). He wrote his book (which was meant as a textbook for economy students) during the last years of the war, while being a private citizen (He had resigned from his directorship because he saw no longer possibilities to exert a positive influence on the policy of the bank during the

[2] *"Methoden als die van Lexis, waarbij men onderzoek doet naar de normaliteit van een waargenomen stochastische massa, die men thans in elk leerboek der mathematische statistiek aantreft, rukken aldus in het centrum der belangstelling".*

German occupation of the Netherlands). Methorst (1868-1955) was director of the Dutch Central Bureau of Statistics, vice-president of the IUSSP and honorary president of the International Statistical Institute. Van Rooijen was a professor of economy at the Calvinist Free University of Amsterdam.

From the books selected we can only draw one conclusion, namely that the impact of Lexis' contributions was very limited in the period under consideration and restricted to the textbooks on statistics. Van Zanten (1927:15) has only one single reference, in which Lexis is characterized as a representative of those statisticians, 'who attach a big part in statistics to mathematics and who give a scientific character to mathematical considerations and analysis of the results of statistical research'.[3] We come back to this later. In Verrijn Stuart's textbook we find references, in a footnote, to Lexis' *Abhandlungen zur Theorie der Bevölkerungs- und Moralstatistik* of 1903, with respect to the role of the man of science, who has to interpret figures, because statistical data cannot speak for themselves, and another reference to Lexis' opinion that there is no proof that the proportion of male births increases after a war (Verrijn Stuart, 1928: 8 and 270 respectively).

However, there is an interesting three pages long section devoted to the subject of stereogrammes (*ibidem*: 78-80). Stereogrammes are seen by Verrijn Stuart (1928:78) as '.. ingenious, and not unimportant, but because of the trouble and cost of the construction, not very practical, application of the notion of graphical statistics in three dimensions'[4]. It is not clear from Verrijn Stuart's text if he had any understanding of the potential use of the Lexis approach to demographic analysis. Presumably not; his focus of interest is once and foremost the 3-dimensional constructions of the kind made by the Swedish statistician F. Th. Berg and by Perozzo (discussed, among others, in Dupâquier, 1985: 286-387). Verrijn Stuart did not expect that the method of stereogramme-construction was going to be widely applied, and stressed the fact that the first and foremost graphical statistics are designed to clarify things. References to Verwey's contribution are completely missing in the textbooks of Verrijn Stuart and Van Zanten.

3.2 The 1960s and after

The situation changed after the publications of Pressat in the 1960s. Young Dutch demographers, like G.A.B Frinking of the Catholic University of Tilburg and K. de Jonge and H.A. de Gans of the University of Amsterdam participated in post graduate courses of the Demographic Institute of the University of Paris (IDUP/IDP). Back in the Netherlands they set up teaching programs in demographic analysis along the lines indicated in Pressat's textbook on demographic analysis. At the major Dutch universities generations of demography students are being acquainted with the ins and outs of the Lexis Diagram (but generally not with the statistician Wilhelm Lexis) by the intermediary of Pressat's textbook. As late as 1989 the Lexis configuration forms

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[3] *".. die aan de wiskunde een groote rol toekennen en aan de wiskundige beschouwing en ontleding der resultaten van statistisch onderzoek een wetenschappelijk karakter geven."*

[4] "*De stereogrammen ten slotte zijn een vernuftige, en niet onbelangrijke, doch wegens de groote moeite en kosten van de constructie weinig practische, toepassing van het denkbeeld der graphische statistiek in drie afmetingen*".

an essential aspect of a textbook on (municipal) population forecasting (De Gans, 1989).

The geometric representation approach began to permeate academic research too in the 1970s. At the University of Nijmegen Paul Brackel defended his PhD thesis on the risk of marriage and partner-choice, the analytical foundations of which are based on the Lexis approach (Brackel, 1970). As far as is known his dissertation is the first PhD thesis based on the age-period-cohort configuration after Verwey defended his PhD thesis at the faculty of mathematics of University of Utrecht in 1875. At the Catholic University of Tilburg, a few years later, Prof. J. Godefroy developed, without explicit reference to and apparently independently of Pressat, a transformed version of the Lexis scheme, building on Becker and Lexis (Godefroy, 1974). With respect to Verwey's contribution, one can only repeat that, apparently, it continued to be completely unknown, if the literature references of his compatriots of the 1970s and after are taken into consideration.

4. The attitude of Dutch statisticians to mathematical statistics at the turn of the 19th century.

At the turn of the 19th century differences between and within countries in the position of statistics as a science were considerable. Up to the middle of 19th century, two different fields of knowledge, both indicated with the name of 'statistics', were running side by side with few connections between them. These two fields only showed signs of coalescence in the second half of that century (Kendall, 1970). By that time the course of statistical science in the Netherlands and surrounding countries, England in particular, diverged, with consequences for the development of population studies in the next century.

The true ancestor of modern (mathematical) statistics is *political arithmetic*, not 17th century statistics, as one might expect. The last mentioned form of statistics, which was entirely concerned with the description of political states, was the forerunner of the genre of geographical and political works of reference that often contained immense amounts of interesting information, but were 'statistical' only in the sense of the *Staatenkunde* in German countries (Kendall, 1970; Stamhuis, 1989). Political arithmetic found a firm footing in the Netherlands in the 17th and 18th centuries, where its development benefited from the contributions of many outstanding people: the Mayor of Amsterdam, Johan Hudde and the gifted statesman and Grand Pensionary of Holland Johan de Witt in the 17th century; Nicolaas Struyk and Willem Kersseboom in de 18th century (Dupâquier, 1985).

In England, political arithmetic and public statistics coalesced in mathematical statistics, eventually giving birth to the *English school of mathematical statistics* which developed between 1880 and 1920. The journal *Biometrika*, founded by Karl Pearson in 1901, became its medium of communication (E.S. Pearson, 1967/1970). Through Yule's *Introduction to the theory of statistics* (1911) mathematical statistics began to be considered as a separate branch of science (Stamhuis, 1989).

In the Netherlands statistics had developed in its own distinctive way. Despite the rich Dutch tradition originating with Christiaan Huygens' inestimable contribution to probability calculus, mathematical statistics was almost unknown here until the 1840s

(Houwaart, 1991). But the nation continued to have excellent life table specialists in the 19th and early 20th century, men like Lobatto, Von Baumhauer, Van Pesch, Van Haaften. Lobatto, the only person to consider mathematics important in the development of statistics, took a solitary position in building on both the Anglo-Dutch tradition of political arithmetic and the French tradition of the calculus of probabilities. His attempts to evaluate statistical data with probability calculus found no further following after his death in 1866 (Stamhuis, 1989). If his line of thought was kept alive, it was not among the leading Dutch statisticians of the early decades of the 20th century such as Verrijn Stuart, Methorst and Van Zanten, but among actuaries in the world of life insurance. For a long period of time the scientific status of statistics in the Netherlands was neither determined by nor dependent on its mathematical content (Stamhuis, 1989; Stamhuis et. al., 1999). Initially, statistics and economics were closely related, both in the Netherlands and in England. Economists and statisticians sought to improve prosperity and built on quantitative statistical data. But the relationship evolved in different directions. In England, the Royal Statistical Society evolved into a truly scientific society with statistics as its main focus. Its Dutch counterpart, however, the Statistical Society, gave equal priority to both economics and statistics in the initial stages. In the end economics, not mathematics prevailed (Mooij, 1995). The scientific status of statistics in the Netherlands differed considerably from that in England and elsewhere. An overview of the prevailing opinions of statistics and its scientific status presented by Van Zanten (1927, p. 16) clarifies the Dutch position within the international field. Four categories of statisticians are distinguished.

First, the 'statistics is no science at all'- category. To this category belonged statisticians who thought of statistics as a method of research, and definitely not a science on its own account. Van Zanten reckoned C.A. Verrijn Stuart to be the main Dutch representative of this category. In the words of Verrijn Stuart himself: *'statistics is not a science but a form of methodical bookkeeping of phenomena of life that are liable to mass observation'* (Verrijn Stuart, 1910, p. 8). His textbook on statistics excludes the mathematical approach of statistics because it is an application of probability calculus, which belongs to the domain of mathematics, not statistics. Statisticians of the second category, mainly from German speaking countries, saw statistics as the quantitative description of mass observation in the form of tables (to be compared with the former *Staatenkunde*). In the third category were statisticians, among whom Van Zanten reckoned himself, who saw statistics as the doctrine of the statistical method (the method of mass research) and the science of statistics as the ordering of concepts, facts and theories regarding the observation of mass phenomena according to one system (Van Zanten, 1927). It was the task of statistics to provide official statistics that could be trusted. To the fourth category belonged statisticians who saw statistics as the mathematical science of mass observation. An increasing number of statisticians adhered to this category. They conferred on mathematics an important role in statistics. The adherents were of the opinion that statistics owed its scientific character to a mathematical way of thinking and to the mathematical analysis of the results of statistical research. The first propagators of the mathematical direction in statistics were, according to Van Zanten, statisticians like Lexis and Westergaard and—in the

Netherlands— Beaujon (1853-1890)[5]. They were followed by men like Edgeworth, Bowley and Yule in England; Liesse and March in France; Bortkiewicsz and Winkler in Germany and Austria; Mortara and Gini in Italy and Holwerda in the Netherlands (Van Zanten, 1927)[6]. Van Zanten's overview makes it clear that the school of mathematical statistics was not well represented among the leading Dutch statisticians at the turn of the 19th century. His overview helps to understand Verrijn Stuart's lack of interest in Lexis' 'stereogramme' and it explains also why the contribution of the Dutch mathematician Verwey got no footing in the Netherlands. That Westergaard depicted Verwey's contribution as not coming from the continent will not have been much help in the propagation of knowledge of the latter's contribution among his countrymen either (Westergaard, 1932: 223).

5. Contributions from the margins

During the period in which Lexis published his most important demographic studies, Dutch students of population directed their attention primarily on the study of demographic variables in their social and economic context rather than on the measurement and analysis of the components of population change. 'Population theory' was very narrowly defined as the study of the interaction between population growth and precocious marriages on one hand, and poverty, unemployment and economic growth on the other (Van Praag, 1980; Hogen Esch, 1980). More formal demographic studies were very rare. For most of the 19th century, statistical analysis of demographic phenomena in the Netherlands focussed on mortality; it was not until statisticians noted that a decline of fertility started to take place, shortly after 1880, that a more regular stream of statistical studies of fertility and nuptiality became visible.[7] As had been the case in the 18th-century, those who were or had been involved in life insurances played a prominent role in statistical studies of mortality: Lobatto, Von Baumhauer and Van Pesch are the most well-known among them. To a less-outstanding representative of the field- David Samot - we owe however a more innovative approach to the study of demographic changes.

As had been the case in England in the 1830s, progressive medical men in the Netherlands took up statistics in the middle of the nineteenth century. The numerical methods promised to provide the tool to advance medical knowledge and would make it possible to discover the principle of legislation and administration needed for social reform. Fruitful ways of applying numerical analysis to the health problems which interested the medical reformers were discovered by William Farr. It is from the 1850s on that his ideas started to have an influence on Dutch medical doctors. Although their work mostly consisted of simple applications of methods developed

[5] For an ample discussion of Beaujon's contributions and the Dutch attitude towards mathematical statistics, see also I.H. Stamhuis' paper *A contribution of a leading statistician at the end of the nineteenth century; Anthony Beaujon on nuptiality*, prepared for presentation at the workshop on *Lexis in Context*.

[6] Some of these men were to play an important part in the modernization of population forecasting methodology in the 1920s and in debate on methodology in the inter-war period. In the Netherlands Holwerda inspired the economist Wiebols, who made the first modern and, even from an international perspective, most elaborate and advanced demographic forecast (in 1925). Bowley was the originator of modern population forecasting in inter-war England (De Gans, 1999).

[7] Of course there are earlier interesting studies like those by Jansen on the sex ratio at birth, and those by Sandberg on nuptiality.

earlier in England, sometimes here too more innovative ideas were applied. We discuss here in particular a method to eliminate the age effects on mortality measures proposed by Johannes Zeeman.

5.1 An actuary on multiple-decrement tables

Although several of the founding fathers of the theory of life insurance were Dutch, the interest in the theoretical aspects of life tables and other mortality measures seemed to have weaned among Dutch mathematicians in the beginning of the nineteenth century (Lobatto, 1830). As a consequence, the Netherlands in this period lagged behind Germany and England in the development of the theory of life insurance. On the other hand, modern life insurance companies, that is companies that based their premiums on actuarial theory and not on 'experience' or 'tradition', developed earlier in the Netherlands than in Germany, Belgium or France. The first modern Dutch company was founded in 1807 (Stamhuis 1998). From 1830 on, several books were published in Dutch that were intended to make those involved in life insurance acquainted with the theory of life insurance. After 1860, the number of modern insurance companies increased quickly, and this tendency was even stronger after 1880. Modern insurance companies began to make use of highly educated advisors such as lawyers, medical doctors and mathematicians and actuaries (Van Gerwen, 1998).

After the middle of the nineteenth century, insurance companies directed their attention to an ever greater variety of contingencies of human life: not only death but also birth, marriage, sickness, unemployment, accidents and retirement. All actuarial work associated with the pricing of these products remained depended upon a proper analysis of observed mortality data. In evaluating these hazards, actuaries were carried more extensive into survival probabilities than usually was the case among statisticians or demographers. Because of life insurances and annuity applications, it was necessary to know the probability of survival to any future age from any present age separately for subclasses of the population and to enter into questions of ages at death for married pairs and other groupings of individuals. To allow for the evaluation of the chance that, if a married couple are at certain ages now, the husband will die first, and at a particular age, and the wife will survive him by a stated number of years, 'multi-life' probabilities were needed. Another necessary refinement, on which we will focus in particular, related to the use of multiple-decrement tables.

A multiple-decrement table is an adaptation of the life table to a population that is subject to attrition from an initial status not only by mortality but also by other factors. In the last three decades, numerous demographers have applied life table techniques to the analysis of cohorts in which there are two or more forms of exit from the initial cohort, one of which is mortality and the other some change in social or economic status (e.g. exit from the non-working population, exit from the single population or marriage). More complex tables which allowed successive transitions among living states, and hence increments into subsequently occupied states or re-entries into a state previously occupied have been developed since the mid-1960s. The first formal model of this type of multistate or multidimensional model seems to have been studied in the context of disability insurance in the beginning of the twentieth century (Du Pasquier, 1912; 1913: see Land and Rogers, 1982).

Early efforts by demographers to apply multiple-decrement tables without dealing with the question of re-entry focussed primarily on the analysis of marital patterns. According to Schoen and Nelson (1974), Depoid (1938) was the first to present life tables (for France) recognizing the marital statuses of single, once married, remarried, widowed and divorced, according to a methodology, which took into account attrition from death and marriage. Yet even earlier, at the session of the International Statistical Institute in Athens in 1936, Depoid (1936) presented a method for calculating a summary nuptiality measure, which was based on the joint application of a life table and a nuptiality table. Multiple decrement tables of married persons, recognizing both attrition by death and divorce, had not only been constructed by Depoid in 1938 (Depoid, 1938b), but already by Huber in 1913 (Huber, 1913). The Dupâquier's (1985, 375-377) argued correctly that Böckh (1886, 12-17) calculated already in the mid-1880s a table for the extinction of marriages. But he did more as he also tried 'die Ziffern der ersten Verheirathung in möglichst correcter Weise festzustellen'. Böckh argued that for such a calculation a life table for never-married women was a precondition. His final result was what he called a 'Abgangstafel', of the never-married within which attrition by death and by marriage could be distinguished. He also presented a remarriage table for widowed and divorced women. Böckh described rather detailed the way he estimated data on widowhood and divorce and on migration by marital status and age but equations making clear how the coefficients were calculated were not given. The summation of the attrition by marriage among the never-married showed according to Böckh the proportion of married women at each age (the 'Verehelichungstafel') and it is this measure which the Dupâquiers (1985, 377) considered to be the first use of the proportion ultimately single in the pure state. Böckh also presented an attrition table for 'Verheirathgewesener', that is for women in divorced or widowed state. Böckh stressed that the nuptiality tables could also be used for the calculation of the values of annuities and assurances that depended on marriage (*Aussteuerversicherung*). Premiums to be paid to guarantee the payment of an annuity or capital at the moment of marriage were also given.

Several years before Böckh, however, work had been done in the same context, that is that of 'marriage insurance',[8] in which a combined nuptiality / mortality table had been developed. This was due to an author, who was one of the few from the Netherlands who during the nineteenth century made a really innovative contribution to the development of mortality analysis: David Johannes Anthony Samot.

In the Dutch and international literature references to the work of Samot are hardly ever made. Samot was born on November 27, 1837 in Rotterdam, as the son of a clerk. After having started training as primary school teacher and watchmaker, he worked as editor of a journal devoted to dramatic art, as playwright, poet and critic (Bouwstoffen, 1897, 224-234). After the Nationale Levensverzekering Bank

[8] We use this notion as a literal translation of the Dutch 'huwelijksverzekering', the term that Samot used. The different kinds of marriage insurances had the objective to secure future payment, contingent upon the survival of a designated unmarried woman, of an annuity for the unmarried woman, a capital in case of death in unmarried state or a capital (endowment) in case a marriage was contracted.

(National Life Insurance Company) was founded in Rotterdam in 1863, Samot was hired as clerk, and one year later promoted to the function of correspondence clerk. He succeeded in acquainting himself with the theory of life insurance and kept the statistical data relating to the Bank's insurance policies. When the National Life Insurance Bank celebrated its tenth anniversary the management decided to publish a life table based on its experiences during the first decade. In 1875, this life table was finished, and a copy of the publication was sent to the London Institute of Actuaries. An English translation, by Dr. William Robertson, was published in the 'Journal of the Institute of Actuaries' in January 1876 and Samot was nominated as fellow of the Institute. Partly as a result of this, he attached much weight to English publications in the field of life insurance, but hardly took notice of French and German ones. Until his death on the 2nd of June 1887, Samot wrote a large number of articles on a variety of topics such as life insurance theory, pension schemes, and state control of insurance companies. He published two chapters for a planned *Handboek der Levensverzekeringswetenschap* (Manual on the theory of life insurance).

It is in Samot's work on marriage insurance starting in the 1870s that for the first time ideas were developed for the construction of a combined marriage and mortality – multi-decrement – table. The first references can be found in an article published in 1878 (Samot, 1878). This article was a reaction to several publications by Heym and Wiegand on invalidity pensions. Samot presented what he believed to be correct formulas for the calculation of the different probabilities that occur in the case of invalidity, namely:

> 'the probability of being alive and capable at the end of the year, the probability of being alive but incapable at the end of the year, the probability of first becoming incapable and then dying in the course of the year, and finally the probability of dying while capable in the course of the year'.

Samot concluded his article by saying that

> 'when we suppose that the equation (…) relates to a group of unmarried women, and assume b_x to be the number of women who leave the group of unmarried women because marrying, we have only to replace in the foregoing investigation, the expression *to become incapable* by the words *to marry* and to put for i_x some other symbol, such as m_x in order to have in my four formulas a means of calculating all the probabilities which can occur in the problem of marrying, when the probabilities of living at the end of the year and of marrying in the course of the year are known'.

Two years later in an article in *De Verzekeringsbode*,[9] Samot answered a question asked by one of the readers relating to the proportion of marriages still surviving after a marriage duration of fifty years. In his answer he stated that he had already several years earlier calculated a marriage table for women, the publication of which was still pending. After Samot's death, his daughter made these calculations and outcomes available to the management of the National Life Insurance Bank and several years afterwards they were edited by Van Dorsten, a mathematician working as scientific advisor of the Company. According to Van Dorsten, Samot started working on the marriage table soon after publication of his article in 1878 and completed the calculations in the spring of 1881 (Van Dorsten, 1898).

[9] *De Verzekeringsbode*, No. 9, November 29, 1884.

Samot's calculations had a practical purpose, namely the founding of a company specializing in selling marriage policies. In the manuscript which was edited by Van Dorsten, Samot had originally used his own notations for simple and more complex probabilities. However, when T.B. Sprague in 1879 held a lecture before the Institute of Actuaries on the construction of combined marriage and mortality tables (see below), a lecture which was published in the same year (Sprague, 1879), Samot adapted his notation to make it conform to the one used by Sprague.

Samot first calculated simple probabilities to marry for the first time (h_x), and to survive, independently of the marital state (p_x). These values were simply calculated respectively as the ratio between the number of first marriages during 1870 and the numbers of never-married women at the beginning of the year for each age, and as the ratio of the life table values ($l_{x+1} : l_x$,). The composite probabilities were calculated using the equations originally proposed when discussing the invalidity insurances and resulted in estimates of the following values:

- the probability of being alive and unmarried at the end of the year (p'_x):
  $p'_x = p_x - 0.5(1+ p_x)\, h_x$
- the probability to marry and being alive at the end of the year (h'_x):
  $h'_x = 0.5(1+ p_x)\, h_x$
- the probability of marrying and then dying in the course of the year (h''_x):
  $h''_x = 0.5(1- p_x)\, h_x$ and
- the probability of dying while being unmarried in the course of the year (c'_x):
  $c'_x = (1- p_x)\,(1-0.5h_x)$.

The simple and complex probabilities were used to calculated the combined life and marriage table. This table included the following columns:

- the number of living at each age x (l_x),
- the number of women living in an unmarried state at age x $(b\ l)_x$.:
  $(b\ l)_x = (b\ l)_{x-1} * p'_{x-1}$ (in which $(b\ l)_{16} = l_{16}$)
- the number of women living in married state at age x $(m\ l)_x$:
  $(m\ l)_x = (l)_x - (b\ l)_x$
- the number of women marrying during the year: $(b\ m)_x = (b\ l)_x * h_x)$
- the total number of women married before age x, whether still alive or not $\sum_{16}^{x-1} (b\ m)_x$
- the number of women died before age x in married state, including divorced and widowed women $(\sum_{16}^{x-1} (b\ m)_x) - (m\ l)_x$
- the number of women dying during the year in married state:
  $(m\ d)_x) = \sum_{16}^{x} (m\ d)_x) - \sum_{16}^{x-1} (m\ d)_x$ and finally
- the number of women dying during the year in unmarried state:
  $(b\ d)_x) = (b\ l)_x * c'_x$.

As was remarked above, at about the same time as Samot, Sprague (1879) proposed a combined marriage and life table, of which the marriage table was based on the experience of the British peers. Sprague referred in his article to the work done by Samot and confirms that the methods of calculation of the combined marriage and survival probabilities in general corresponded: 'The questions here considered as to the combination ov the probabilitys ov marriage and deth ar, to a great extent, the same as those considered by Mr. Samot in his paper *On the probabilitys which occur in the question of Invalidity*.' And later on, in discussing his formulas, he argued: 'These formulas ar identical with Mr. Samot's; and the reasoning by which I hav obtained them, altho very much shorter than his, seems quite as satisfactory'. The only objections Sprague had were that Samot assumed that mortality rates of unmarried and married people were identical.

5.2 Medical statistics and age-standardization

It was not only among those involved in life insurances that an interest in statistical analysis of mortality had developed early: a stimulus had also come from medical science. Yet although the collection of data on mortality by medical men started rather early, the Netherlands lagged far more behind the development in other countries as far as the analysis of this data is concerned: methods developed elsewhere were adopted after quite some time had passed and sometimes even methods were presented as new which had already found their place in the international literature for quite some time. A case in point is the use of age-standardization to eliminate the effects of differences in age composition between populations on their death rates.

Medical interest in analysis of mortality data was already present in the Netherlands from the middle of the nineteenth century on. During the second half of the 18th century, fatalism in the medical sciences gave way to a belief that pathogenic factors could be prevented or eliminated. Disease was no longer regarded as an individual but also as a collective phenomenon, influenced by natural and social causes. It was emphasized that each country and each district had its own peculiar diseases, depending on the condition and lifestyle of their inhabitants (Huisman, 1997, 71). In the Netherlands in particular, this medical geographic approach was popular due to the significant differences observed in health conditions in various parts of the country: the repeated outbreaks of fever in Zeeland were notorious; floods were known to cause epidemics; and in the early years drainage schemes were known to be extremely unhealthy (De Vooys, 1951, 2). By collecting as much data as possible on local mortality over as long a period as possible, and by making cross-regional comparisons, similarities and differences could be analyzed. Local descriptions of specific diseases could ultimately lead to the formulation of general disease theories and to universal knowledge (Huisman, 1997, 74-75).

The first move towards achieving this objective was made in the middle of the 18th century. In 1755, at the request of the medical professor Thomas Schwencke (1693-1767), the municipal council of The Hague established a system of death registration, containing details about the age and cause of death of the deceased (Van Nierop, 1919). Cause-of-death mortality data also began to be compiled in Alkmaar, Rotterdam, Amsterdam and several smaller towns.

At this stage, however, no statistical analyses were made of the many local data collected by doctors. Those involved had no clear idea about precisely how the empirical data should be used to formulate theories (Van Lieburg, 1991, 76). The lack of reliable population statistics, which made it practically impossible to calculate death rates in any form, also played a role: it was only in 1795 that the first nation-wide population census was held. The absence of quantitative analyses of death data was also related to the dominant disease theory. According to historical pathology, popular in the Netherlands until the 1850s, the essential features of diseases could be discovered by systematic comparison of the ways in which those diseases manifested themselves. The history of diseases displayed objective regularities that would ultimately increase the knowledge of the origins of diseases (Houwaart, 1993, 88-92). The late-eighteenth-century medical doctor was thus primarily a data collector (Van Lieburg, 1991, 76).

In the 1830s and 1840s, an increase in the number of smallpox cases, a deterioration in the general physical condition of the population in the wake of bad harvests and growing poverty, and above all the appearance of cholera in the 1830s and 1840s put the existing health-care provisions to a stringent test (Houwaart, 1993, 95-97). As was the case in other countries a few decades earlier, the answer to this scientific and political crisis in health care emerged from the ranks of the younger generation of medical practitioners, known as the sanitary reformers or hygienists. The hygienists' activities were closely interwoven with those of the medical profession as a whole and their ideas acquired a prominent position within the profession. Virtually all existing local medical associations had merged in 1849 in the Dutch Society for the Promotion of Medicine (*Nederlandsche Maatschappij tot bevordering der Geneeskunst, NMG)* which society, inspired by the hygienists, had also set up a Medical Statistical Committee. Despite their small numbers the hygienists exercised a great influence within the NMG.

The hygienists were actively involved in the improvement of public hygiene. They stressed the need for objective measurement of the health situation, and empirical research and statistics met this need. Immediately following the establishment of the Association for Statistical Studies (*Vereeniging voor de statistiek*) in 1857 prominent hygienists (Zeeman, Israëls, De Man and Ali Cohen) became members, with the particular aim of keeping abreast of advances in statistical knowledge. A great deal of the efforts of the hygienists was directed at the increase in the quantity of data on health and mortality, and at the standardization and increased dissemination of these data (Houwaart, 1993, 107-110). In the decades that followed, the hygienists were able to bring their statistical program into effect by building a national network consisting of local medical associations, local organizations for the improvement of public hygiene, and governmental authorities (Houwaart, 1993, 111-118).

From 1850 onwards, the hygienists fought incessantly for the creation of a governmental machinery for dealing with population statistics. After 1865 the hygienists attained prominent positions in the newly formed governmental bureaucracy in the area of public health. Many hygienists became staff member of the newly created State Health Inspectorate, became health inspectors or civil servants at the health councils or the municipal, provincial or national vital registration offices (Houwaart, 1993, 117-118). Whereas until around 1850 quantitative data on mortality were still very incomplete and reports on mortality from individual physicians consisted only of simple tables with absolute and relative figures intended to reflect the extent and severity of an epidemic and the number of people affected, only fifteen years later the hygienists had developed statistics with which, for many municipalities and provinces, mortality could be studied. This development was stimulated by concurrent changes in the organization of population statistics, such as the introduction in 1849 of the continuous System of Population Accounting, the population register. From that date on, continuous population registers were required in the Netherlands in every community making it possible to acquire information on the population at risk at all regional levels. This made it possible to relate numbers of deaths to the population size of each community.

After 1850, the hygienists published a considerable number of local studies of mortality. These studies made use of simple mortality measures, and complicated mathematical calculations were completely lacking. Following William Farr, the crude death rate or 'biometer' as he called it, was considered a thermometer value expressing the consequences of the local pathogenic, environmental and living conditions (Eyler, 1979, 68-74). Death rates made it possible to recognize at a glance the 'sick' areas of the country or the city and a comparison with mortality rates from other places showed the extent to which conditions were healthy or not, and this offered a clear perspective for improving health conditions (Houwaart, 1993a, 28-29).

Johannes Zeeman was by far the most well-known hygienist of the time working in the field of mortality research. Zeeman was a hygienist who played a very prominent role in many governmental statistical bodies. He was born in 1824 in Numansdorp, studied medicine at Leiden University and published his Ph.D. in 1847. After having worked as a resident in the Amsterdam *Buitengasthuis* Hospital he started a medical practice in Amsterdam which he continued until a few years before his death in 1905. In 1852 he became municipal health officer, in particular in charge of the care for skin diseases and syphilis patients (Houwaart, 1991, 271). Although Zeeman was also involved in the Dutch translation of Felix Niemeyer 's 'Lehrbuch der speciellen Pathologie und Therapie mit besonderer Ruecksicht auf Physiologie und pathologische Anatomie' (Berlin, 1858-1861) medical statistics had his special interest. From 1850 on he was one of the driving forces of the Medical Statistical Committee, set up by the Dutch Society for the promotion of Medicine. He published numerous articles on a variety of medical-statistical issues such as the height of conscripts, the mortality of prison-inmates, the health effects of child labor, the duration of life of medical doctors, the effect of the cholera epidemic of 1859, and the consequences of the reclamation of the Zuyderzee for the health conditions of adjoining regions. He made an important contribution to the first Atlas of mortality published in 1866 by the NMG in which for all Dutch municipalities death rates were published covering the period 1841-1860. He was also heavily involved in the second Atlas, relating to the period 1861-1874 and published in 1879. In both publications, extensive use was made of crude death rates to demonstrate the close link between local sanitary conditions and mortality.

In 1889 Zeeman published an extensive book review in which he suggested to use age standardization to eliminate the effects on death rates of differences in age structures of the populations. His review focussed on a study by the 'Vereeniging tot verbetering van den gezondheidstoestand in Den Haag' (Society for the improvement of Public Health in The Hague), published in 1889. Responsible for the writing of the report were the medical doctors L.J. Egeling (a distinguished hygienist too) and A.H. Pareau, both members of the Association for Statistical Studies. In this study crude mortality rates for the ten-year periods 1866-1874 and 1875-1884 were published for the 23 districts of the city of The Hague. Data on the age distribution for these geographical units were also available for census dates. Zeeman argued that several districts had during this period undergone such big changes in their population that it seemed risky to pass over these changes in judging the mortality levels. He considered it highly improbable that all age groups were in the same degree affected by these demographic changes, a circumstance which was important because of the fact that mortality varied enormously by age. ‘Given such differences, it is obvious to ask: are the differences in death rates between districts completely or partly a consequence of a higher proportion of infants and therefore only apparent?’ To take the differences in age composition between districts into account, Zeeman proposed to use indirect standardization by age (without calling it this way nor using any formulae). The proposed indirectly standardized mortality rate is the expected numbers of deaths that would have occurred in the index population (the district population with which the standard population of The Hague was compared) if it had experienced the age-specific death rates of the standard population (the population of The Hague that was used as reference in the comparison):

$$\frac{\Sigma(D_{ix}) - \Sigma(P_{ix} \cdot R_x)}{\Sigma(P_{ix} \cdot R_x)}$$

in which

P_{ix} = the number of persons at age x in the index population i, and
R_x = the death rate at age x for the standard population and
D_{ix} = the number of deaths at age x in the index population i.

This is the method which usually is applied when calculating indirectly standardized death rates: the only step that is missing is the multiplication of the resulting ratio between the observed and expected numbers of death with the observed death rate for the standard population to derive an adjusted death rate for each district. (Shryock and Siegel, 1975, 418-424).

When eight years later a second report on the mortality level of the districts of the Hague was published, dealing with the situation in the period 1885-1894 (the report was written by Pareau, J. Binnendijk and C.A. Verrijn Stuart and published in 1897: Vereeniging tot verbetering van den gezondheidstoestand, 1897, 50-51) the authors mentioned the fact that ‘nowadays, several methods are known to compare mortality figures in such a way, that the drawbacks of the differences in the age structure of the population, are almost completely removed’. The authors primarily referred to the ‘penetrating’ work of Zeeman, and argued that he ‘is entitled to the honour to have found before Körösi a mean to preclude the effect of the difference in age composition’. Nor Zeeman, nor the authors that he criticized were aware of the fact that a variety of methods to eliminate the effects of the age structure on mortality rates had been proposed by German and English statisticians at least a decade earlier. Only the method proposed by Körösi was mentioned, and applied by Pareau and his colleagues.

In the international literature, Joseph Körösi is usually mentioned as the first to have proposed a method of standardization (see for example Prinzing, 1906, 263; Thirring (1968, 447) mentions him as such along with Ogle and Koch). Körösi's contribution to the International Statistical Congress of Vienna in 1891 indeed clearly described the effect of the differences in age composition, in particular that of the youngest age group, on the CDR (Körösi, 1892). He wrote:

> 'Die Unpräcision der Mortalitäts-Coëfficienten rührt daher, dass derselbe uns eigentlich nur darüber Auskunft geben sollte, wie gross die Lebensgefährdung im Kreise einer Bevölkerung sei, derselbe aber durch die Art seiner Berechnung auch noch einen ganz anderen, für uns irrelevanten Umstand wiederspiegelt, nämlich ob die *Menge* der lebensschwachen oder lebensstarken Elemente in der einen Bevölkerung grösser oder kleiner, als in der andern sei'.

The question he wanted to answer was

> 'ob es denn nicht möglich wäre, *schon bei Berechnung des Coëfficienten zum Mindesten die wichtigsten Gruppen der Altersbesetzung zu berücksichtigen? – und ob sich die Sterbeziffer nicht derart feststellen liesse, um bie Vergleichung verschiedenartigster Bevölkerungen zugleich als internationalen Maass der Sterblichkeit zu dienen?'*

His solution was to calculate directly standardized death rates, called 'Internationalen Indexes': in this method, a standard population is selected and employed in deriving all the age-adjusted death rates in a set to be compared. It calls for computing the weighted average of the age-specific death rates in a given area, using as weights the age distribution of the standard population. The formula for direct standardization is:

$$\frac{\Sigma(R_{ix} \cdot P_x)}{\Sigma(P_x)}$$

in which

P_x = the number of persons at age x in the standard population, and
R_{ix} = the death rate at age x for the index population i.

As the standard population for the calculations Körösy proposed the population of Sweden, as this country had been the first to have adopted a population register.

In his contribution to the Chicago conference of the International Statistical Institute, Körösi (1895) came back to the issue, stressing how important it was to have a summary measure of the mortality experience of a country. In repeating his proposal to calculate a mortality index for which each age-specific death rate of a population is multiplied by the same proportion of a population in that age group, he described these as populations with a 'Standardbesetzung'.

Remarkably enough, at the same Vienna conference, a comparable proposal to use a standard population was made by the English physician and statistician and superintendent of statistics William Ogle (1827-1912). Körösi mentioned that only several years after the closing of the Vienna meeting, he became aware of the fact that Ogle had proposed and applied this idea of a standard population several years before the Vienna meeting. In a footnote he added that the director of the Statistical Office of Hamburg, Dr. Koch, also claimed that he already in 1883 had written on the use of a standard population. Koch's 'reduzierte Sterblichkeitsziffer' excluded however mortality in the first year of life.[10] Ogle's proposal was published in the Annual Report of the Registrar-General of Births, Deaths and Marriages in England and Wales for 1883 and also discussed in Newsholme's 'The elements of vital statistics', published in 1889. Given these claims, it is understandable that Thirring mentioned Körösi, Ogle and Koch in the same breath when discussing the introduction of the standardized death rates.[11]

Yet Körösi, Ogle or Koch were not the first to introduce age-standardized rates. The idea that the age composition of the population had an important effect on its crude mortality rate was known before these authors wrote their contributions. Yet it was an effect that was not well understood among the general public or in the medical profession. Already in the early 1840s, William Farr, according to Eyler (1980) inspired by the work of the British actuary Thomas Rowe Edmonds in the mid-1830s, appreciated the hazards of comparing crude mortality rates. In other countries as well proposals were made to make comparisons of crude mortality rates more trustworthy by eliminating the effects of differences in the age composition of populations. A proposal to eliminate the effects of age composition was made by Zülzer in 1878: he suggested to summarize the age-specific death rates and to divide them by the number of age groups, a method which of course equals direct standardization with a standard population of the same size in each age group.

Szulc (1929) argued how surprising it was that at the sessions of the International Statistical Institute in 1891 no one in the General Assembly or the Commissions made a reference to the standardization methods proposed by Harold Westergaard in his 1882 book 'Die Lehre von der Mortalität und Morbilität'. But according to Szulc, the idea of the method and its development are due to the statisticians of the General Statistical Office and N.A. Humpheys (1874) is the first to have written a thorough study of the standardization method.

Westergaard (1882, 29-30) had proposed a method of standardization which in fact was exactly the same as the one of Zeeman. In a situation in which the composition of the population by age is known but the numbers of deaths by age are not given, Westergaard suggested to apply a specific life table to that population. By multiplying the mortality rates of the life table with the numbers in each age group, summarizing them over the age range and comparing them with the observed numbers of deaths, a decision could be reached about the mortality level of the population in comparison with that of other populations.

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[10] Published in Statistik des Hamburgischen Staates, Heft 12, 1883, p. 44.

[11] In this second contribution, Körösi gave as a supplementary reason to use Sweden's population as the standard, the fact that Sweden as played such an important role in the history of mortality statistics and demographic research.

6. Conclusion

Remarkably enough, Lexis has left scientific traces in the Netherlands in particular after 1960 when his famous diagram found wide application among those doing research and teaching in formal demography. Yet, firm conclusions about the influence of Lexis on 19th-century Dutch demography could not be reached. To study in a more thorough way the reception of his ideas it would be necessary to make a more complete inventory of the literature of the time, focussing in particular on those scientific journals which were interested in the development of population, statistics, mortality, mathematics, life insurance etc. For example, we did not check whether reviews of Lexis' work were published in Dutch scientific journals such as *De Gids, De Economist*, the *Staatkundig en Staatshuishoudkundig Jaarboek, Tijdschrift voor Staathuishoudkunde en Statistiek, Nederlandsch Tijdschrift voor Geneeskunde* etc. One of the vehicles for international communication among statisticians and demographers in the nineteenth century was participation in the international conferences such as the International Statistical Conference (1853-1876), the Congrès de Démographie, the Congrès d'hygiène (1851-1882), the Congrès d'hygiène et de Démographie (1884-1891) and the sessions of the International Statistical Institute (1887-1913). Consultation of the reports to the Dutch government by the representatives of the Netherlands at these sessions as well as the more informal reviews from participants will better allow us to judge whether or not and how Lexis' publications were valued.

What we did learn from our study is that the formal study of demography in the Netherlands during the last quarter of the nineteenth century stood internationally at a very moderate level: the Netherlands only followed with a long lag time the (English) forerunners in medical statistics. The exception was the work done by Samot who can be considered as one of the first to have realized the usefulness of multiple decrement tables.

It also became clear from our study of English publications that among those working in the field of life insurance interest was not limited to the study of mortality. From the second half of the nineteenth century on, the statistical analysis of marriages and fertility had become the object of study of many students of life insurance (an overview is given by Van Dorsten (1898). In our opinion, the novelty of these contributions has not been evaluated correctly in the standard texts on the history of demography.

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