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Cohort Life Tables from Life Courses for the Municipality of Modena (Italy): New Data and New Analyses

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Abstract

The method used to construct cohort life tables starting from individual lives, which was shown to be valid in relation to small villages is also applicable to urban realities, albeit with prudence. Whenever it is necessary to select a sample, it is certainly expedient to stratify it on the basis of month of birth, after which the results may be considered reliable if the percentage of dates of death sourced is around 90%, and especially when numerous "last dates known to be alive" are available.

The results also appear to be reliable in those cases in which the percentage of dates of death is lower, but it is good practice to ensure this by backing them up with those obtained by replacing the estimates based on the sample with other estimates based on data which may be sourced from the scientific literature.

With more particular regard to the evolution of mortality in Modena district, it may be affirmed that this started to decline with the generations born at the end of the Nineteenth century, and therefore mainly in relation to improvements in public and private hygiene. During the Twentieth century, the industrialisation of the area appears to have had different consequences for males and females: the increase in life expectancy proved to be rather slower for the former.

Keywords: Life table, life course, city.

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Introduction

Life tables describe the survival of a cohort of individuals belonging to the same population. For surviving individuals, their life expectancy, namely the number of years which, on average, they may expect to live, may be calculated at any moment.

Two main types of mortality tables are constructed: "cohort life tables" and "period life tables". The former describes the survival of a cohort of individuals born in the same calendar year; the latter describes the survival of a hypothetical birth cohort, the members of which should experience, in the course of their lives, the mortality conditions found in a particular year.

The "period life tables" are constructed starting from the probability of death at the various ages. It is therefore more appropriate to construct them with regard to large-scale populations, but this makes it difficult to relate the changes which are found in life expectancy with the appearance or disappearance of specific habits or agents. Moreover, from the point of view of the researcher, they present difficulties in interpretation connected with the fact of not referring to real cohorts, but rather to fictitious cohorts. If one wishes to relate the changes which occur in the life expectancy of historical populations with the changes to the environment in which they lived,[1] it is more appropriate to construct "cohort life tables", and do this starting from the reconstruction of the lives of the individuals, rather than, as is the custom with regard to large-scale populations, a calculation of the probability of death by single year of age and single calendar year.[2]

This is what was attempted in 1994 in Serravalle di Bibbiena, a mountain hamlet in the "Casentino" area (in the Province of Arezzo), for generations born between 1870 and 1914. The results obtained through name-reconstruction techniques were more than satisfactory. An integrated analysis of ecclesiastical and civil-archive sources enabled the dates of death to be traced (or to ascertain that the person was still living) for 88.8% of the individuals. For the missing data, reasonable estimates, based on archive documents, could be made (Zavattaro & Nicolini, 1988; Nicolini & Iammarino, 2013).

[1] Nearly all causes of death result from an interaction between an individual's genetic make-up and the environmental (biophysical and cultural) agents that he or she is exposed to.

[2] Cohort life tables can be also constructed using projections of future mortality rates and nowadays they are used extensively in actuarial science, demography, biology and epidemiology.

For several years now, an attempt has been ongoing to construct cohort life tables from life courses for the municipality of Modena (Nicolini, 2013a). The aim is to construct cohort life tables starting from the lives of people born in defined calendar years, not in relation to a mountain village (where it is easier to link the information regarding the same individual) but rather in relation to a medium-sized Italian city. Also in this case the outcome is satisfactory.[3] The earlier results were published three years ago (Nicolini, 2013a; 2013b): something which appears particularly significant is the increase in the juvenile survival which occurred before the substantial improvements in diet and medicine occurred in that area.

The purpose of this work is to integrate, using new data sources, the life tables described in the earlier publications and to verify the validity of the method through further processing.

The Municipality of Modena

Modena district, located in the Po Plain, currently has a population of approximately two hundred thousand people. Lying at the centre of an area characterised by thriving agriculture and the presence of major industries, it is one of the most wealthy districts in Italy (Figure 1).

From 1598 to 1859 it was the capital city of the "Estense Duchy" and, mid-way through the Nineteenth century, was composed of 65,321 people. Of these, 22,664 were "workers, day labourers and servants", 19,008 "peasants", 7,358 "artisans", 2,984 "shopkeepers", 2,371 "soldiers", 2,211 "beggars", 771 "clergymen", 573 "clerks" and 475 were "persons from the professions and the liberal arts". In addition to the 2,651 "civic houses", there were 1,927 "farmhouses", thirty mills, two paper mills, plus a spinning and a tanning factory (Roncaglia, 1849-50).

With Italian Unity, the boundaries of the Municipality changed, with the resulting loss of around ten thousand people, the majority of these being residents in the countryside. This notwithstanding, Modena remained primarily a rural centre, in which the only factories present were the wineries and meat-processing plants. It was only with the start of the Twentieth century that some ironworks and a few chemical companies were established: however, until the end of the twenty-year fascist interlude (1922-1945), the

[3] Making life tables from life courses for medium-sized cities (instead of villages) is very challenging because of the difficulty in finding data about an individual among the data concerning many people. Such operation resembles "to look for a needle in a haystack" or, rather, "to look for an ant in a haystack", because the ant, unlike the needle, can migrate.

area remained only slightly affected by industrialisation, regaining its importance only after the Second World War due to impressive industrial development (Silingardi & Barbieri, 1994).

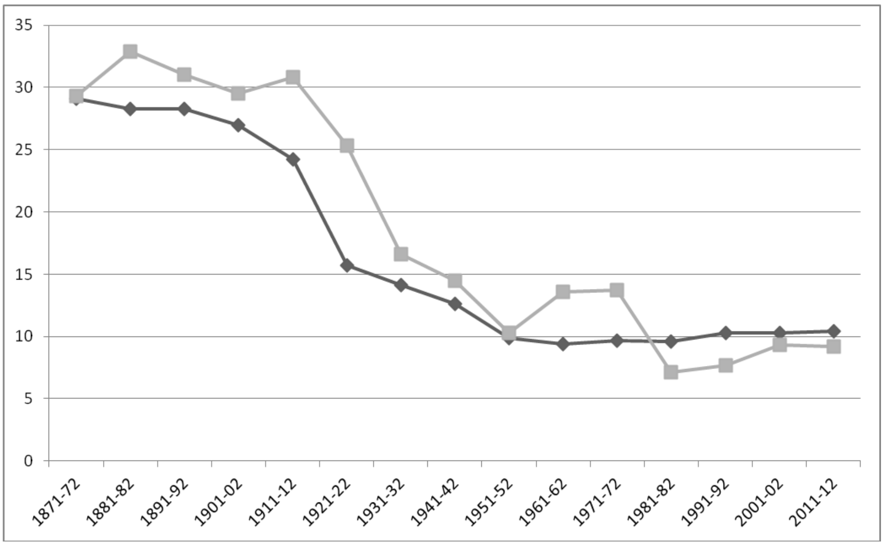
FIGURE 1. Northern Italy. In the red ellipse: the Po Plain. MO = Modena; CO = Comacchio; SE = Serravalle di Bibbiena.

Figure 2 shows the decrease in mortality and birth rates observed over time: the decline in mortality began in the Nineteenth century and became clear between 1910 and 1920; the decline in fertility followed it.[4] Around 1950

[4] These results are similar to the results obtained in Serravalle di Bibbiena (Zavattaro & Nicolini, 1988) and highlight the scarce effect of the damages caused by

the "demographic transition" was completed. Concerning this topic it is important to point out that before 1940 Modena was not equipped with an aqueduct and an efficient city sewer system (Bulgarelli, 2015).

FIGURE 2. Modena: Temporal trend of mortality rates (in black) and birth rates (in gray).



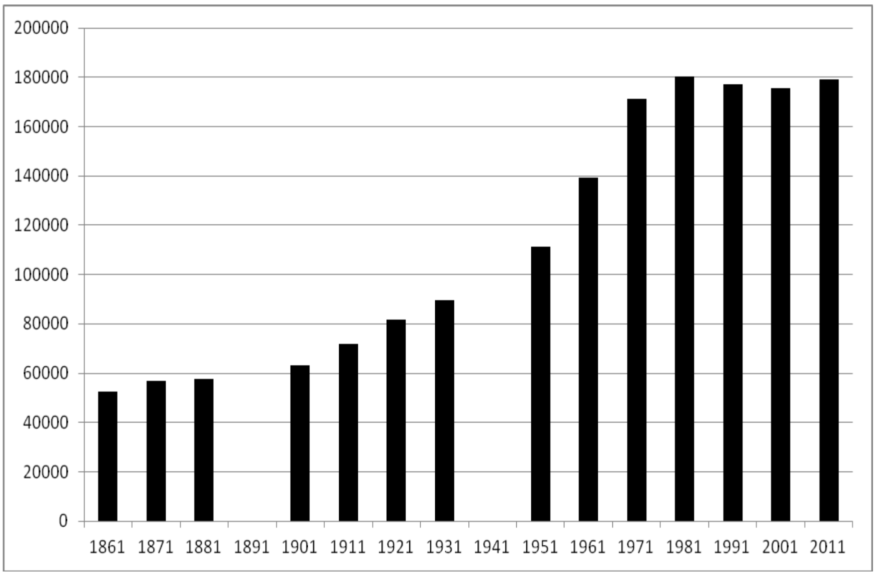
Source:
http://www.comune.modena.it/serviziostatistica/pubblicazioni/annuari/annuario2013/demografia2013/demo_tav2013.shtml
The rates referred to 1871-72, 1881-82 and 1891-92 are our estimates based on public registers.

Between 1951 and 1981 the population employed in the secondary sector increased from 19,482 to 34,748 individuals.[5] The economic growth caused remarkable immigration from the countryside and the resident population increased amounting to 180,314 in 1981 (Figure 3). In particular, because of immigration, the population growth rate of Modena increased to 16.1‰ in 1951-1981 up from 8.4‰ in 1871-1951.

the First World War to the demographic development. Before 1940, as a matter of fact, the decline in mortality was governed principally by the decrease in the infant and juvenile mortality (Bellettini, 1987).

[5] 14,064 males and 5,418 females in 1951 (Istat, 1954); 23,745 males and 11,003 females in 1981 (Istat, 1983).

FIGURE 3. Modena: resident population (1861-2011).



Source:
http://www.comune.modena.it/serviziostatistica/pubblicazioni/annuari/annuario2013/demografia2013/demo_tav2013.shtml

Cohort life tables are under construction for its geographical area: those integrated and analysed here refer to births in the years 1870, 1890 and 1905 (the choice of this date rather than 1910 is due to the fact that the records of births in 1910 were not yet available for consultation).

Sources and Methods

The method used to construct the tables is fully integrated in the classical demographic tradition. As a result, the same life table functions present in those constructed on the basis of death probabilities are obtained, the only difference being that they were calculated starting from the length of life of individuals belonging to an initial list, rather than as is the norm, from the relationship between deaths reported and the resident population to which they can relate.

The composition of the initial list was defined by working on the public register records and including live births in the district's geographical area (therefore also children of individuals not resident in the district), including the foundlings handed over to the foundling hospitals of Modena and brought up under their control.[6] In addition, a stratified sample based on the month of birth was opted for, in order to take the seasonality of infant deaths into account (Breschi & Livi Bacci, 1986; Breschi, Mazzoni, Melis & Pozzi, 2007).

For construction of the tables, use was made mainly of data gleaned from civil and military sources (public registers, military service lists and service books). Until three years ago, when the tables integrated and analysed here were published, the information taken from civil sources contained in the Municipal Historical Archives and the State Archives of Modena pertained to birth certificates of the years 1870, 1890 and 1905 (often accompanied by annotations regarding dates of marriage and dates of death), marriage certificates (the complete series of which was consultable only up to 1910) and deaths which occurred from 1870 to 1915. The information taken from military sources contained in the State Archives relate instead to conscripts belonging to the born in 1870 and 1890: the military service lists are available for all of them, and for those born in 1890 also the service books. To make the reconstruction more complete, all deaths reported in the "Gazzetta dell'Emilia" in the "Public Register" section from 1916 to 1940 were also consulted.[7]

In 2014 it was also possible to consult the civil records of deaths occurring from 1916 to 1920, and at the State Archives of Modena the "Rolls of Foundlings" from 1870 to 1906.

The sample used in the research consists of a total of 600 individuals. 100 males and 100 females were selected for each of the three generations considered. The individuals for whom the date of death was traced total 139 in relation to births in 1870 (133 in Nicolini, 2013b), 141 for births in 1890 (136 in Nicolini, 2013b) and 178 for births in 1905. It was then attempted to link each of the remaining individuals with a "last date" when they were known to be living i.e. the date of the most recent certificate from which they proved to be living[8].

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[6] This way emigrants were considered members of the population, immigrants instead were left out of the calculations. This is important, particularly when we are studying populations affected by considerable infant mortality: immigrants in fact, during the first year of their life, were not exposed to the environmental (biophysical and cultural) agents characteristic of Modena; emigrants instead were exposed to such agents, and then left their homeland because of them. Also the foundlings, during the first month of their life, were exposed to the environmental agents characteristic of Modena; soon afterwards were usually entrusted to rural families.

[7] The "Gazzetta dell'Emilia" was the daily newspaper published in Modena.

[8] The improvement obtained utilizing new archive documents (11 new dates of death) may appear negligible, but also the new information regarding "last dates" must be considered.

In this way three lists were obtained (one for each generation studied), containing for each individual his/her gender, name, surname, father's name, date of birth, date of death (or last date known to be living), and father's profession (at the time of the child's birth). In cases when the date of death was traced, the individual's age at death was obtained by subtracting the deceased's year of birth from the year of death, whereas for all deaths during the first year of life an age at death of 0.2 years was attributed without distinction.[9] In all cases where a date of death was not available, the age at death was estimated by calculating the mean age of death of individuals of the same gender and generation who died at an older age than that of the individual in question's last date known to be living. Finally, those for whom no information subsequent to the date of birth is available, were attributed the mean age at death of individuals of the same gender and generation.

Having assigned to each individual an age at death (real or estimated), the following were then calculated: survivors at subsequent birthdays (l_x), probabilities of death (q_x), years lived (L_x) in the different age classes, reverse cumulative series of years lived (T_x) and lastly, life expectancy (e_x).

To attempt to verify the reliability of the results obtained in this way (called into question by the low percentage of dates of death traced for the first two generations), all life table functions of the tables were then recalculated by doing what - consistent with the spirit of the method used (that of not adjusting the data with information from outside the sample) - had been abstained from. Namely, the estimates based on gathered data were replaced with estimates based on the life tables for Italy supplied by the National Institute of Statistics (www.istat.it). Since in the latter case they were period life tables, care was taken to attribute to each individual the life expectancy related to the age and calendar year corresponding to the most recent document stating that the individual was living.

Results and Discussion

The results obtained are summarised in Tables 1, 2, 5 and 6. As shown in Table 1 and 2, the inclusion of new data has not substantially altered the picture presented by Nicolini (2013b): from the 1870 generation to the 1890 generation, life expectancy at birth rose from 33 to 41 years for males and from 36 to 38 for females, evidencing a decrease in mortality in the first years of life which cannot be easily attributed to medical progress (still inadequate

[9] The effects of these simplifications on the calculation of life expectancy at birth are negligible (Nicolini, 2013b).

and especially insufficiently applied) or improved diet, as it is well-known that the last decade of the Nineteenth century - during which those born in 1890 spent their childhood - was the darkest period in recent Italian economic history (Istat, 1958; Luzzatto, 1968; Zamagni, 1993).

TABLE 1. Modena: evolution of life expectancy at different ages (new results based on archive documents).

	Males			Females		
	1870	1890	1905	1870	1890	1905
e_0	32.8	41.0	40.8	36.6	37.8	53.5
e_1	42.6	55.1	52.0	45.5	46.2	66.7
e_{10}	47.6	52.6	54.2	44.6	49.9	64.1
e_{50}	19.1	22.7	19.9	22.4	23.3	26.1
e_{70}	7.7	6.3	6.9	9.3	7.4	13.8

TABLE 2. Modena: probability of death during the early years of life (new results based on archive documents).

Cohort	1870	1890	1905
1000q first month	115 (116)*	120 (120)	120 (121)
1000q first year	235 (235)	235 (236)	220 (220)
1000q first five years	370 (371)	325 (325)	315 (316)

* In brackets the values recalculated considering a sex ratio at birth of 106 boys per 100 girls.

Significant rises are also observed in life expectancy at age one year, which increased from 43 to 55 years for males (whereas it remained almost unchanged for females), and in life expectancy at age ten years, which increased from 48 to 53 years for males and from 45 to 50 years for females; on the contrary there were no improvements in life expectancy at adult ages, which remained essentially constant. These considerations (concerning the transition from the 1870 generation to the 1890 generation) are consistent with the considerations we can make with regard to Serravalle di Bibbiena (Nicolini & Iammarino, 2013) and Comacchio,[10] where cohort life tables were

[10] Comacchio is a municipality located in the Po Plain just south of the present mouth of the Po river. The most important resources of its population, during the last centuries, were the fish farming and the salt ponds. With respect to the effects of diet, in this municipality, as is the case in Modena (Nicolini, 2013b), there were not, during

constructed starting from the reconstruction of the lives of 1,207 individuals (Tables 3 and 4).[11]

TABLE 3. Comacchio: evolution of life expectancy at different ages.

	Males			Females		
	1870	1890	1905	1870	1890	1905
e_0	27.7	41.9	55.7	29.1	45.2	62.8
e_1	38.3	55.4	64.2	39.4	55.3	68.4
e_{10}	38.8	57.9	59.8	47.6	58.4	62.2
e_{50}	20.2	24.9	23.3	26.7	25.5	27.5
e_{70}	10.3	8.4	9.1	8.6	9.6	13.1

Source: Nicolini, Franchi (2015).

TABLE 4. Comacchio: probability of death during the early years of life.

Cohort	1870	1890	1905
1000q first month	119	111	56
1000q first year	288	228	121
1000q first five years	445	350	161

Source: Nicolini, Franchi (2015).

In other words, the increase in life expectancy observed in Modena from the 1870 generation to the 1890 generation was caused, as expected, by the decline in mortality in the first years of life. According to McKeown (1976) such decline cannot be attributed to medical progress, but also its explication based on improved diet is difficult to support: it probably was in relation to improvements in public or private hygiene (Nicolini, 2013b). With respect to this topic it should be highlighted that before 1940 Modena was not equipped

the Nineteenth century, significant differences in life expectancy between sons of workers and sons of the well-to-do people (Nicolini & Franchi, 2015). An almost complete absence of socio-economic differentials in infant and child mortality was highlighted also in Sardinia (Breschi, Esposito, Mazzoni & Pozzi, 2012) and in Spain (Reher & Sanz-Gimeno, 2004).

[11] Significant rises which cannot be easily attributed to medical progress or improved diet were observed also in Spain (De las Heras Salord & Porras Gallo, 2010). With respect to medical progress, in the Netherlands "during the Nineteenth and early Twentieth century" the "children of doctors did not have better survival prospects than children in comparable or even those from lower social classes" (Van Poppel, 2004: 207).

with an aqueduct and an efficient city sewer system and in 1951 only 17,869 habitations (out of a total of 27,157) were provided with water by aqueduct (Istat, 1954).[12] As regards the illiteracy, often related to bed hygiene habits, it affected 43.6% of the males and 52.7% of the females in 1871, 28.6% of the males and 35.3% of the females in 1901, 3.6% of the males and 5.5% of the females in 1951. (Ministero di Agricoltura, Industria e Commercio, 1875, 1902; Istat, 1954).[13]

The data relative to the subsequent generation are more difficult to interpret: for males, life expectancy remained almost constant between the 1890 and the 1905 generation, while for females it increased very significantly, especially with regard to young females. This gender difference could be explained by the small sample size used which, by chance, may not be sufficiently representative of the population studied. However, it should not be excluded that starting from the 1905 generation, that female longevity which characterised the entire Twentieth century in industrialising countries and still persists today, though lessened (Alter, Manfredini & Nystedt, 2004), had begun to show itself clearly.[14]

A remarkable gender difference in the improvements in life expectancy is evident also in Comacchio (Table 3), but in this case the value of e_0 increased from 42 to 56 years for males and from 45 to 63 years for females. In Modena, instead, during the same time interval, the value of e_0 for males seems to remain constant. The significant contribution of males to the industrialisation of the studied area, that took place during the Twentieth century, may explain such marked gender-differences in the development of life-expectancy.

With respect to this topic it should be noted that Carlo Nava (1978), after a research regarding the mortality caused by cancers from 1942 to 1976 and referred to the municipality of Modena, wrote: «The mortality caused by tumours increased by 120% in the resident population and by 164% in the present population, during the considered period; (...). Males are more affected

[12] A similar situation was observed in Comacchio (Nicolini & Franchi, 2015). In Mykonos (Greece) "the decline of infant mortality does not seem to have been associated with the introduction of public health measures, since even at the time of the decline water supplies remained poor, and systems of excrement-removal rudimentary, for the majority of the population" (Hionidou, 1997: 170).

[13] Data calculated considering only the population over 6 years of age.

[14] The causes of the gender-differences in the development of life-expectancy are generally attributed to: - genetic factors (feminine biological superiority, pointed out by the decrease in the number of females died in childbirth); - differences in habits (e.g. nicotinism); - differences in gender-roles. (Pinnelli & Mancini, 1997; Caselli, 2007).

than females by the mortality caused by tumours that hits more and more elderly people».[15]

The situation remains essentially unchanged when the data obtained are replaced with the data recalculated using the estimates based on the life tables for Italy supplied by Istat (Tables 5 and 6).[16]

TABLE 5. Modena 1870: old results (Nicolini, 2013b), new results based on archive documents and results Obtained Using New Estimations.

	Males			Females		
	Old	New	OUNE	Old	New	OUNE
e_0	33.8	32.8	34.1	36.2	36.3	38.0
e_1	44.0	42.6	44.4	45.3	45.5	47.6
e_{10}	47.6	47.6	50.0	44.3	44.6	47.1
e_{50}	20.6	19.1	18.9	23.9	22.4	21.5
e_{70}	7.1	7.7	7.6	9.6	9.3	10.7

TABLE 6. Modena 1890: old results (Nicolini, 2013b), new results based on archive documents and results Obtained Using New Estimations.

	Males			Females		
	Old	New	OUNE	Old	New	OUNE
e_0	42.1	41.0	40.7	38.2	37.8	38.7
e_1	54.3	55.1	54.7	45.5	46.2	47.4
e_{10}	51.4	52.6	52.2	48.5	49.9	51.4
e_{50}	22.7	22.7	21.6	23.5	23.3	21.0
e_{70}	6.3	6.3	6.9	7.4	7.4	9.4

The increase in life expectancy at birth which occurred from the 1870 generation to the 1890 generation is still observable, whereas no improvements are registered for adult ages.

Moving from the 1890 generation to the 1905 generation, life expectancy at birth remained identical for males whereas it rose significantly for females. This gender difference is also evident when considering life expectancies at adult ages.

The main purpose of this study was to evaluate the agreement degree between:

[15] Also nowadays, in Modena, cancers mainly concern males.

[16] The differences between "Old" and "New" results shown in the tables are explained by the use of new dates of death and new "last dates".

1) the life expectancy calculated using, in all cases where a date of death was not available, the age at death estimated by calculating the mean age of death of individuals of the same gender and generation who died at an older age than that of the individual in question's last date known to be living ("New" in tables 5 and 6);

2) the life expectancy calculated using, in all cases where a date of death was not available, the estimation based on the life tables for Italy supplied by the National Institute of Statistics ("OUNE" in tables 5 and 6).

Such differences range between 0.3 and 1.7 for e_0, 0.4 and 2.1 for e_1, 0.4 and 2.5 for e_{10}, 0.2 and 2.3 for e_{50}, 0.1 and 2.0 for e_{70} and are negligible considering that the life tables utilized for the new estimations relate to all Italy.

Finally, some comparisons can be made using data provided by other authors. According to Del Panta & Scalone (2002), in the first half of the Nineteenth century life expectancy at birth fluctuated, in the "Estense Duchy", between 30 and 40 years (values consistent with the results reported for 1870 in the Cohort life tables from life courses). In 1992 the life expectancy at birth, reported in the most ancient period life tables published by the National Institute of Statistics and referred to the entire province[17] of Modena, results 74.2 for males and 81.2 for females, showing remarkable gender-differences.

Conclusions

The method used to construct cohort life tables starting from individual lives, which was shown to be valid in relation to small villages (Nicolini & Iammarino, 2013), is also applicable to urban realities, albeit with prudence. Whenever it is necessary to select a sample, it is certainly expedient to stratify it on the basis of month of birth, after which the results may be considered reliable if the percentage of dates of death sourced is around 90%, and especially when numerous "last dates known to be alive" are available.

The results also appear to be reliable in those cases in which the percentage of dates of death is lower, but it is good practice to ensure this by backing them up with those obtained by replacing the estimates based on the sample with other estimates based on data which may be sourced from the scientific literature.

With more particular regard to the evolution of mortality in Modena district, it may be affirmed that this started to decline with the generations

[17] The Province of Modena consists of 47 municipalities and has a population of 702,364 people (on 1/1/2015).

born at the end of the Nineteenth century, and therefore mainly in relation to improvements in public and private hygiene. During the Twentieth century, the industrialisation of the area appears to have had different consequences for males and females: the increase in life expectancy proved to be rather slower for the former.

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Appendix

Cohort Life Tables from Life Courses for the Municipality of Modena

1870 (new results based on archive documents)

males

x	l_x	d_x	q_x	L_x	T_x	e_x
0	100	25	0.25	80.0	3278.3	32.8
1-9	75	19	0.25	530.0	3198.3	42.6
10-49	56	15	0.27	1884.0	2668.3	47.6
50-69	41	24	0.59	653.5	784.3	19.1
70-…	17	17	1.00	130.8	130.8	7.7

females

x	l_x	d_x	q_x	L_x	T_x	e_x
0	100	22	0.22	82.4	3634.0	36.3
1-9	78	12	0.15	608.0	3551.6	45.5
10-49	66	27	0.41	2068.8	2943.6	44.6
50-69	39	18	0.46	679.7	874.8	22.4
70-…	21	21	1.00	195.1	195.1	9.3

1890 (new results based on archive documents)

males

x	l_x	d_x	q_x	L_x	T_x	e_x
0	100	27	0.27	78.4	4100.9	41.0
1-9	73	8	0.11	605.0	4022.5	55.1
10-49	65	15	0.23	2284.1	3417.5	52.6
50-69	50	14	0.28	906.6	1133.4	22.7
70-…	36	36	1.00	226.8	226.8	6.3

females

x	l_x	d_x	q_x	L_x	T_x	e_x
0	100	20	0.20	84.0	3783.2	37.8
1-9	80	18	0.23	605.0	3699.2	46.2
10-49	62	19	0.31	2090.9	3094.2	49.9
50-69	43	18	0.42	819.1	1003.3	23.3
70-…	25	25	1.00	184.2	184.2	7.4

1905 (new results based on archive documents)

males

x	l_x	d_x	q_x	L_x	T_x	e_x
0	100	23	0.23	81.6	4082.4	40.8
1-9	77	14	0.18	589.0	4000.8	52.0
10-49	63	11	0.17	2378.2	3411.8	54.2
50-69	52	25	0.48	847.6	1033.6	19.9
70-…	27	27	1.00	186.0	186.0	6.9

females

x	l_x	d_x	q_x	L_x	T_x	e_x
0	100	21	0.21	83.2	5350.8	53.5
1-9	79	7	0.09	653.0	5267.6	66.7
10-49	72	4	0.06	2839.0	4614.6	64.1
50-69	68	22	0.32	1139.6	1775.6	26.1
70-…	46	46	1.00	636.0	636.0	13.8