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Prepared by L. Baradel, D. Martini

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INAIL LIFE TABLES FOR WORK-RELATED INJURED OR ILL PEOPLE

L. BARADEL, D. MARTINI

1. Introduction

Italian Constitution guarantees to all citizens the right to health and safety at work places.

The State makes compulsory to insure workers who are involved in hazardous activities against the risk of work-related accidents or illnesses, specifying that the employer must bear the cost.

The National Institute for insurance against accidents at work (INAIL), a non-profit public body, together with other public authorities is part of Italian Welfare system, exclusively to which the State transfers the actions of social insurance. For this reason, it is subject to supervision by the Ministry of Labour and Social Security and the Ministry of the Economy and Finance.
INAIL provides compulsory insurance against accidents at work and occupational diseases, therefore pays social security benefits to employees involved in an accident at work and, in case of death, to their survivors.
For actuarial valuations (pricing, reserving ...) INAIL uses specific ratios that, in compliance with law (Consolidated Law n. 1124/1965, art. 39), must be reviewed at least every five years.
In order to comply with law requirements and to take into account the recent changes in risk at work, Inail "Statistical and Actuarial Office" has carried out a study focused at monitoring mortality (i.e. demographic hypothesis for such ratios) among Inail annuitants.
The purpose of this study is to show the Life Tables made, comparing them with those released by the Italian "National Institute for Statistic" (ISTAT) for Italian population.
Life tables have been constructed analyzing INAIL annuities portfolio.

2. Inail annuities

INAIL provides economic, health care and additional benefits to work-related injured or ill people.
An accident at the workplace is an accident which takes place due to a violent cause - i.e. rapid and in a short period of time - during work, and which leads either to death, a permanent disability to work or a temporary total disability requiring the worker to take sick leave for more than three days; an occupational disease is different from an

accident in its relationship with employment since it is contracted at work over time because of the work undertaken.
INAIL pays a direct annuity to work-related injured or ill people with permanent impairments with a disability degree equal or higher than 16%; it also pays annuities to survivors of workers who died due to the accident or the occupational disease, as long as the requirements of the law are met.

INAIL annuities portfolio can be divided in:

1) Permanent disability annuities;
2) Workers' survivors' annuities.

To underline the features of these two statistical groups, each one will be analyze separately.

2.1. Permanent disability annuities

Two different laws regulate permanent disability annuities:

- Consolidated Law n. 1124/1965;
- Legislative Decree n. 38/2000.

The Consolidated Law n. 1124/1965 applies to accidents that occurred - and occupational diseases reported - before 25th of July 2000 and provides economic compensation for the diminished capacity for work.
New regulations for indemnities are applied to events occurred since 25 July 2000, the date when Decree n. 38/2000 was published in the Official Journal.
Legislative Decree n. 38/2000 redefined the overall role of INAIL, involving considerable innovations, focusing the system on injury to the person of the worker, considered as a violation of the basic right to health; compensation for "biological damage" was therefore provided.
With regard to occupational diseases, Decree n. 38/2000 updated the "Tables of impairments", including about 400 items, making it possible to appraise impairments not previously considered (aesthetic damage, damage to the reproductive system, etc...).
Data reported below (Table 1) show permanent disability annuities portfolio at 31 December 2013.

Table 1 – Permanent disability annuities at 31 December 2013

Law	Type of event		Total	Weight (%)
	Accident	Occupational Disease		
Consolidated Law n. 1124/1965	448.554 78,1%	126.051 21,9%	**574.605** **100,0%**	**84,4%**
Legislative Decree n. 38/2000	87.241 81,9%	19.234 18,1%	**106.475** **100,0%**	**15,6%**
Total	**535.795** **78,7%**	**145.285** **21,3%**	**681.080** **100,0%**	**100,0%**

At 31 December 2013, INAIL permanent disability annuities portfolio is mainly made up of annuities related to events occurred before 25th July 2000 (more than 84% of cases); annuities caused by accidents are 78,7%, those due to occupational diseases are 21,3%. Table 2 shows permanent disability annuities average values.

Table 2 – Permanent disability annuities at 31 December 2013 – Average values

Consolidated Law n. 1124/1965

Type of event	Number of annuities in payment	Average degree at the event	Average age at the event	Average age at 2013.12.31	Average claim age
Accident	448.554	29,7	38,5	70,1	31,2
Occupational Disease	126.051	24,8	46,6	75,5	28,6
Total	**574.605**	**28,6**	**40,3**	**71,3**	**30,6**

Legislative Decree n. 38/2000

Type of event	Number of annuities in payment	Average degree at the event	Average age at the event	Average age at 2013.12.31	Average claim age
Accident	87.241	26,3	44,7	51,3	5,9
Occupational Disease	19.234	24,7	57,1	61,8	4,5
Total	**106.475**	**26,0**	**46,9**	**53,2**	**5,7**

The two groups average values are very different (Table 2): the first group annuitants have a higher average impairment degree at the event, a lower average age at the event and a higher average claim age.
As best described below, claim age, i.e. years from the starting date of annuity to valuation date (in the study: 31 December 2013), affects substantially the level of mortality.
Classes of degree distribution (Table 3) shows that most of the permanent disabilities has a degree less or equal to 40% (over 85% of cases for both statistical groups).

Table 3 – Permanent disability annuities at 31 December 2013 – Classes of degree distribution

Consolidated Law n. 1124/1965

Type of event	Classes of degree at the event (%)					Total
	up to 20	21-40	41-60	61-80	81-100	
Accident	151.451	226.346	49.116	15.313	6.328	**448.554**
Occupational Disease	52.475	60.618	10.697	1914	347	**126.051**
Total	**203.926**	**286.964**	**59.813**	**17.227**	**6.675**	**574.605**
Weight (%)	***35,5%***	***49,9%***	***10,4%***	***3,0%***	***1,2%***	***100,0%***

Legislative Decree n. 38/2000

Type of event	Classes of degree at the event (%)					Total
	up to 20	21-40	41-60	61-80	81-100	
Accident	43.083	34.695	5.726	1.986	1.751	**87.241**
Occupational Disease	11.571	5.806	1.029	679	149	**19.234**
Total	**54.654**	**40.501**	**6.755**	**2.665**	**1.900**	**106.475**
Weight (%)	***51,3%***	***38,0%***	***6,3%***	***2,5%***	***1,8%***	***100,0%***

2.2. Workers survivors' annuities

When the death of the worker is due to the accident or by the occupational disease, INAIL pays an annuity to workers' survivors as long as the requirements of the law are met (Consolidated Law, art. 85). Entitled persons are spouse and children and, in their absence, parents (economically dependents) and brothers and sisters (economically dependents and co-habiting).
Survivors annuities portfolio at 31 December 2013 (Table 4) is mainly made up of annuity paid to spouses (85,9% of cases).

Table 4 – Survivors annuities at 31 December 2013

Survivor	Type of event		Total	Weight (%)
	Accident	Occupational Disease		
Spouse	59.549 *58,8%*	41.803 *41,2%*	**101.352** ***100,0%***	**85,9%**
Child or brother	8.152 *95,3%*	404 *4,7%*	**8.556** ***100,0%***	**7,2%**
Child or brother unfit to work	1.901 *52,9%*	1.691 *47,1%*	**3.592** ***100,0%***	**3,0%**
Parent	4.500 *99,6%*	19 *0,4%*	**4.519** ***100,0%***	**3,8%**
TOTAL	**74.102** ***62,8%***	**43.917** ***37,2%***	**118.019** ***100,0%***	**100,0%**

3. INAIL life tables

The observation period runs from 1996.01.01 to 2013.12.31; the choice of such a range allows us to have a sufficiently consistent database for our statistical analysis.
Below are the aggregates considered in the study, cleaned out from the outliers found during data check phase:

- Annuities in payment at the beginning:	1,380,258
- New annuities during the period (entries):	433,058
- Ended annuities during the period (exits):	1,016,963
- Annuities in payment at the end:	796,353

We calculated mortality rates using "*average lifespan method*", being valid the hypothesis of uniform distribution of entries and exits; frequencies of deaths are "*pure rates*", i.e. not depending on any other cause for elimination.
Exposed to risk of elimination have been computed considering, for each annuitants age, annuities in payment at the beginning of the statistical period, entries during the period, exits by any causes (for example a cause for elimination is the fall of the degree under 16%) during the period and annuities in payment at the end of the period,.

We obtained empirical frequencies of deaths as the ratio between annuities ended for death (d_x) and annuities exposed to risk (E_x), cleaned from any other cause for elimination:

$$q_x = \frac{d_x}{E_x}$$

Empirical data have been smoothed using "*piecewise smoothing*" technique, adopting in particular for central ages (where data are richer) a *moving average*.

In order to take into account the "*longevity risk*", mortality rates have been projected using forecasting factors described in the study called "*The demographic future of the country*", issued by ISTAT in 2011. ISTAT study adopted Lee-Carter parametric model, obtaining mortality trend from Italian population life table of the period 1974-2008 and considering a forecasting period from 2011 to 2065.

3.1. Permanent disability annuitants' life tables

Mortality analysis of permanent disability annuitants has been done separately for:

- events regulated by Consolidated Law n. 1124/1965;
- events regulated by Legislative Decree n. 38/2000.

For each group has been also studied specific mortality, i.e. mortality due to the event that caused disability. Specific mortality rates are useful to calculate the so-called "*Family Insurance*" ratio, the second-order ratio that allows INAIL to assess the future expenditure resulting from possible establishment of survivors' annuities.
As we described in chapter 2.1, the two groups have different average values, especially claim age.
Data show that claim age is the variable that mostly affects the mortality level; indeed, in the early years following the event, until the stabilization of impairing after-effects, the level of mortality is higher for all ages.
For the sake of simplicity, in the following analysis, the annuities regulated by Consolidated Law n. 1124/1965 (with a claim age higher than 13 years) will be called "*High claim age annuities*"; the annuities regulated by Legislative Decree n. 38/2000 (with a claim age equal or lower than 13 years) will be called "*Low claim age annuities*".
The elements necessary to release mortality rates for work accidents or occupational diseases victims are:

1. choice of a suitable observation period;
2. change in mortality depending on the type of event (accident, occupational disease);
3. change in mortality depending on the impairment degree.

3.1.1. High claim age annuitants' life tables

Regarding to high claim age annuities, first of all, we calculated mortality frequencies referring to the whole statistic period (1996-2013). The higher level of mortality of the years between 1996 and 2005 affected these frequencies, so we decided to consider the shorter observation period 2006-2013, characterized by a lower mortality.
Defined the period to refer to, we analyzed separately mortality frequencies for work-related injured and ill people. Since mortality raw rates are very similar, we decided to group mortality for type of event.
Regarding impairment degree at the event, we grouped data in 20 percentage points classes of degree.

Table 5 – Empirical frequencies (x 1.000)
HIGH CLAIM AGE ANNUITANTS

Age	Classes of degree at the event (%)				
	up to 20	21-40	41-60	61-80	81-100
35	1,43	1,98	-	6,10	-
45	2,09	2,44	1,65	2,70	5,44
55	4,59	4,99	6,61	5,10	13,71
65	12,87	12,82	12,41	18,18	17,32
75	28,52	31,98	35,34	37,51	42,38
85	93,18	99,35	101,61	106,29	111,8

Since empirical data are not significantly different for the first three classes, we decided to release only two life tables: the first one for degrees up to 60% and the second one for degrees from 61% to 100%.
Class 81%-100% annuitants have a very high mortality, but we could not calculate a specific life curve for this class because of the poor number of events.
Probabilities of death have been obtained smoothing empirical data, using "*piecewise smoothing*" statistical technique.
Table below shows the comparison between mortality rates of INAIL high claim age annuitants with those released by ISTAT for Italian population (2013). As ISTAT tables are distinct by sex, we weighted them to obtain a unique table according with INAIL annuitants' sex distribution (86% males, 14% females).

Table 6 – Probability of death of Inail permanent disability annuitants with high claim age
Comparison with Italian population (ISTAT 2013)

Age	HIGH CLAIM AGE INAIL ANNUITANTS		ISTAT 2013 sex weighted
	up to 60%	61%-100%	
20	0,58	1,56	0,42
30	0,96	2,46	0,52
40	1,43	2,92	0,95
50	3,11	4,44	2,53
60	7,94	11,53	6,71
70	19,45	26,09	18,35
80	56,72	70,01	53,87
90	163,77	180,23	171,07

Figure 1 – Probability of death of Inail permanent disability annuitants with high claim age Comparison with Italian population (ISTAT 2013)

After smoothing process, as we said in chapter 3, mortality rates have been projected using ISTAT forecasting factors.

3.1.2. Low claim age annuitants' life tables

Regarding to low claim age annuities, we calculated mortality frequencies referring to the statistic period that runs from 2000 to 2013.
For this group, we calculated separately mortality frequencies for accidents and occupational diseases; we verified that ill people mortality is higher than injured one, so we decided to distinguish mortality for type of event.

3.1.2.1 Probability of death – Injured

As done with high claim age annuities, regarding to impairment degree at the event, we grouped data in 20 percentage points classes (Table 7).

Table 7 – Empirical frequencies (x 1.000)
LOW CLAIM AGE ANNUITANTS

-ACCIDENTS-

Age	Classes of degree at the event (%)				
	up to 20	21-40	41-60	61-80	81-100
35	0,52	0,46	-	-	21,70
45	1,46	1,30	1,07	3,37	12,56
55	4,02	3,36	16,04	10,99	18,80
65	8,37	11,53	9,73	12,31	85,41
75	21,74	20,25	29,41	-	45,45
85	83,77	53,57	-	200,00	-

We decided to release two life tables: the first one for degrees up to 60% and the second one for degrees from 61% to 100%.
Empirical data have been smoothed.
Table 8 compares mortality rates of INAIL low claim age injured annuitants with those released by ISTAT for Italian population (2013), weighted to take into account INAIL annuitants sex distribution.

Table 8 – Probability of death of Inail permanent disability annuitants with low claim age
Comparison with Italian population (ISTAT 2013)

-ACCIDENTS-

Age	LOW CLAIM AGE INAIL ANNUITANTS ACCIDENTS		ISTAT 2013 sex weighted
	up to 60%	61%-100%	
20	0,44	2,16	0,42
30	0,84	4,28	0,52
40	1,25	8,54	0,95
50	2,51	13,01	2,53
60	6,02	24,30	6,71
70	14,70	40,99	18,35
80	34,82	84,18	53,87
90	125,55	167,48	171,07

Figure 2 – Probability of death of Inail permanent disability annuitants with low claim age Comparison with Italian population (ISTAT 2013)

-ACCIDENTS-

Mortality rates have been projected also for low claim age injured annuitants.

3.1.2.2 Probability of death – Ill people

Also for occupational diseases victims, regarding to impairment degree at the event, we grouped data in 20 percentage points classes (Table 9).

Table 9 – Empirical frequencies (x 1.000)
LOW CLAIM AGE ANNUITANTS
-OCCUPATIONAL DISEASES-

Age	Classes of degree at the event (%)				
	up to 20	21-40	41-60	61-80	81-100
35	-	-	-	-	-
45	1,20	-	102,56	177,78	333,33
55	2,62	8,64	101,69	315,79	602,15
65	9,34	25,45	150,57	324,23	552,08
75	33,24	74,30	248,65	428,27	750,00
85	152,61	148,84	260,87	404,76	1.000,00

Since 60% is a recurring threshold of occupational diseases' worsening, we decided to release two life tables: the first one for degrees up to 60% and the second one for degrees from 61% to 100%.
Empirical data have been smoothed.
Table 10 compares mortality rates of INAIL low claim age occupational diseased annuitants with those released by ISTAT for Italian population (2013), weighted to take into account INAIL annuitants sex distribution.

Table 10 – Probability of death of Inail permanent disability annuitants with low claim age
Comparison with Italian population (ISTAT 2013)
-OCCUPATIONAL DISEASES-

Age	LOW CLAIM AGE INAIL ANNUITANTS OCCUPATIONAL DISEASES		ISTAT 2013 sex weighted
	up to 60%	61%-100%	
20	0,63	82,17	0,42
30	1,13	104,19	0,52
40	2,79	189,12	0,95
50	8,42	295,72	2,53
60	18,17	389,78	6,71
70	53,83	457,65	18,35
80	115,08	562,3	53,87
90	274,11	749,14	171,07

Figure 3 – Probability of death of Inail permanent disability annuitants with low claim age Comparison with Italian population (ISTAT 2013)

-OCCUPATIONAL DISEASES-

Mortality rates have been projected only for 16%-60% class of degree annuitants because we supposed that survival of ill people with high severity of disability will not improve.

3.1.3 Specific mortality rates

As for generic mortality, specific mortality analysis of permanent disability annuitants has been done separately for high claim age and low claim age annuitants.
For high claim age annuitants we considered two specific mortality curves: one for degrees up to 60% and one for degrees from 61% to 100%; for low claim age annuitants, indeed, we released four curves, depending on type of event and class of impairment.
Table below shows specific mortality rates for some ages.

Table 11 – Specific mortality rates (x 1000)

Age	HIGH CLAIM AGE ANNUITANTS		LOW CLAIM AGE ANNUITANTS			
	Accidents and Occupational Diseases		Accidents		Occupational Diseases	
	up to 60%	61%-100%	up to 60%	61%-100%	up to 60%	61%-100%
30	0,00	0,01	0,01	2,01	0,07	72,93
40	0,00	0,02	0,02	4,92	0,79	170,21
50	0,02	0,80	0,08	8,57	4,75	295,72
60	0,19	1,28	0,08	14,21	11,76	365,43
70	0,69	3,16	0,22	21,13	35,49	403,45
80	3,04	8,73	0,37	50,82	65,09	438,84

Data reported above show that:

- high claim age annuitants have specific mortality rates generally low;
- low claim age injured annuitants have significant specific mortality rates only for impairments higher than 60%;
- low claim age ill annuitants have a high specific mortality increasing with age, especially for serious illness.

3.2. Workers survivors' life tables

Consolidated Law establishes that, when the death of the worker is caused by the accident or by the occupational disease, INAIL pays an annuity to workers' survivors.
Entitled persons are:

- spouse: until death or re-marriage;
- children: legitimate, natural or adoptive children until 18 years of age for all children or until 26 years of age, if students; adults unfit for work as long as such incapacity lasts;

In the absence of spouse and children:

- natural or adoptive parents: if economically dependent until death;
- brothers and sisters: if economically dependent and co-habiting in the same terms as those valid for children.

3.2.1 Surviving widow(er)s' life table

INAIL data, extracted for the observation period 1996-2013, allowed the establishment of specific technical bases for the surviving widow(er)s' statistical group.
Since spouses are entitled to the benefit until death or re-marriage, we calculated probability of elimination considering both causes of exit.
Table 12 compares INAIL widow(er)s' probability of death with ISTAT one, weighted to take into account the INAIL spouses sex distribution (98% widow, 2% widower), for some ages.

Table 12 – Probability of death of widow(er)s
Comparison with Italian population (ISTAT 2013)

Age	INAIL Widow(er)s	ISTAT 2013 sex weighted
20	0,19	0,17
30	0,30	0,25
40	0,67	0,59
50	2,07	1,67
60	4,55	3,88
70	11,41	10,36
80	36,46	34,70
90	130,41	134,39

As shown in Table 12 INAIL surviving widow(er)s' mortality is similar to Italian population's one.
Probabilities of death have been projected with method adopted for the other statistical groups.
Regarding re-marriage probability, we observed that it is significant only for ages between 20 and 40.

Figure 4 – Probability of elimination (death and re-marriage) of widow(er)s Comparison with Italian population (Istat 2013)

3.2.2 Orphans' life table

Orphans (or brothers and sisters) probability of death is that of Italian population, sex weighted (50% females, 50% males) and projected using ISTAT forecasting factors. Empirical frequencies of end of studies derived, indeed, from INAIL database.

Figure 5 – Probability of elimination (death and end of studies) of orphans Comparison with Italian population (ISTAT 2013)

Probability of elimination at age 26 is equal to one, because 26 is the maximum age at which one student is entitled to receive such benefit, as prescribed by law.

3.2.3 Orphans unfit for work life table

Life table for orphans (or brothers and sisters) unfit for work has been released adapting disabled table of Italian National Institute of Social Security (INPS) to INAIL statistical group.

3.2.4 Parents' life table

Since INAIL statistical group of parents entitled to benefit is not large enough, mortality rates for these survivors are Italian population ones, sex weighted (81% females, 19% males).

4. Conclusion

INAIL annuitants' mortality analysis shows a strong correlation between mortality rates and the following variables: annuitants' age, claim age, type of event and impairment degree.
Table13 reported average mortality rates for each of the six permanent disabilities annuitants groups.

Table 13 – Average mortality rates (x 1000)

HIGH CLAIM AGE ANNUITIES		LOW CLAIM AGE ANNUITIES			
Injuries and Occupational Diseases		Injuries		Occupational Diseases	
up to 60%	61%-100%	up to 60%	61%-100%	up to 60%	61%-100%
35,58	44,03	4,07	14,70	31,59	449,56

Data show that, in case of high claim age, after the stabilization of impairing after-effects, the impairment degree doesn't affect a lot the level of mortality; mortality rates depend substantially from high age of exposed to risk.
For low claim age, indeed, impairment degree has an important rule, especially for occupational diseases, for which 60% is a recurring threshold of worsening.

High level of mortality for occupational diseases is also due to the high age of those exposed to risk: usually occupational diseases occur after a long latent period.
Table 14 reports exposed to risk average age.

Table 14 – Exposed to risk average age

	HIGH CLAIM AGE ANNUITANTS		LOW CLAIM AGE ANNUITANTS			
	Accidents and Occupational Diseases		Accidents		Occupational Diseases	
	up to 60%	61%-100%	up to 60%	61%-100%	up to 60%	61%-100%
Average age (μ)	68,8	68,8	48,4	46,5	60,7	67,4
Standard deviation (σ)	12,97	13,35	12,58	12,72	10,27	9,08
Pearson ratio (σ/μ)	0,19	0,19	0,26	0,27	0,17	0,13

Figure 5 – Exposed to risk age distribution

Table 15 shows life expectancy of INAIL permanent disability annuitants, compared with that of Italian population.

Tabella 15. Life expectancy of Inail permanent disability annuitants
Comparison with Italian population (ISTAT)

Age	HIGH CLAIM AGE ANNUITIES		LOW CLAIM AGE ANNUITIES				ISTAT 2013 sex weighted
	Accidents and Occupational Diseases		Accidents		Occupational Diseases		
	up to 60%	61%-100%	up to 60%	61%-100%	up to 60%	61%-100%	
20	59,57	55,55	62,68	47,98	51,12	8,97	60,88
40	40,53	37,68	43,50	31,05	32,12	4,00	41,44
60	22,54	20,61	25,34	17,24	15,79	2,03	23,09
80	8,32	7,60	10,20	7,62	5,55	1,25	8,38

Data reported above show that, for higher claim ages together with low and mid impairment degree, mortality of Inail permanent disabilities annuitants is wholly similar to Italian population mortality. For lower claim ages there is a substantial difference between accidents and occupational diseases, with particular emphasis on the most serious diseases, including all forms of cancer (even those related with asbestos), that cause a very low life expectancy.

5. Abstract

INAIL "*Statistical and Actuarial Office*" has carried out a study focused at monitoring mortality among INAIL annuitants, comparing it with that of Italian population.
Life tables have been realized using the statistical period of observation 1996-2013, analyzing separately the statistical group of permanent disability annuitants and the one of injured or ill workers' survivors.
For permanent disabled annuitants, our study shows that the variables that mostly affect mortality level are claim age, impairment degree and, only for low claim age annuities (regulated by Decree 30/2000), type of event (accident or occupational disease).
Analysis results show that, for higher claim ages together with low and mid impairment, as a result of the stabilization of after-effects, mortality of Inail permanent disabilities annuitants is wholly similar to Italian general population mortality, with no significant differences between the two events; whilst for lower claim ages there is a substantial difference between accidents and occupational diseases, with particular emphasis on the most serious illness.
The purpose of our study was also an analysis of the *specific mortality* (due to the event) of permanent disabled annuitants, needed to calculate the so-called "*Family insurance*", the second-order ratio that allows Inail to assess the future expenditure in case of death of the injured or ill worker.
The analysis of the survivors group focused on widow(er)s and orphans.
Life tables built for these sort of survivors have the peculiarity to consider, in addition to death, other causes of annuity termination, such as re-marriage for widow(er)s and end of studies for orphans.

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