statistiche report

Istat Istituto Nazionale di Statistica

POPULATION AND HOUSEHOLDS PROJECTIONS | BASE 1/1/2022

Italy tomorrow: a smaller, more heterogeneous population with more differences:

The new projections of the country's demographic future, updated to 2022, return trends that are difficult to dispute, albeit in a framework with some uncertainty. **The resident population is decreasing**: from 59 million on January 1, 2022 to 58.1 mln in 2030, to 54.4 mln in 2050 to 45.8 mln in 2080.

The **ratio of working-age** (15-64 years) **to non-working-age individuals** (0-14 and 65 years and older) will decrease from about **three to two** in 2022 to about **one to one** in **2050**.

Even within a common background of aging, the structural differences between the North and the South of the country are amplified.

Households are increasing but with a smaller average number of members. **Fewer couples with children, more couples without**: by 2042 only one in four households will consist of a couple with children; more than one in five will have none.

34.5%

Share of individuals aged 65 and over in 2050

23,8% in 2022.

2.13

The average number of members per household in 2042

From 2.32 in 2022.

9.8 million

People expected to live alone in 2042

From 8.4 million in 2022.

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Population decline in coming years almost a certainty

In line with the trends that have emerged in the country over the past 8 years, the "median" projection scenario involves a decline in the resident population in the next 8 years as well: from 59 million on January 1, 2022 (projection starting point) to 58.1 million in 2030, with an average annual rate of change of -2‰. In the medium term, the population decline would be more pronounced: from 58.1 million to 54.4 million between 2030 and 2050 (average annual rate of change of -3.3‰) (Table 1).

In the long term, the consequences of the projected population dynamics on the total population become more important. Between 2050 and 2080 the population would decrease by an additional 8.56 million (-5.7‰ average annual rate of change). Under this assumption the total population would amount to 45.8 million in 2080, achieving an overall loss of 13.2 million residents compared to today.

The evolution of the total population reflects the principle, typical of demographic forecasting, of being more uncertain the further away from the base year. In 2050 its 90% confidence interval (i.e., that its assumed value falls between two extremes with 90% probability) is between 52.2 and 56.5 million. Thirty years later it is between 39 and 52.8 million.

Thus, in the most favorable case the population could experience a loss of "only" 6.2 million between 2022 and 2080, including 2.5 million already by 2050. In the least favorable case, on the other hand, the population decline would touch 20 million individuals between now and 2080, 6.8 million of them already on the 2050 horizon. It would seem inevitable, then, that the population may face decline, even though the numerical evidence is profoundly different, calling into the picture not only demographic but also social and economic scenarios with different impacts.

Gradual depopulation affects the whole territory, albeit with differences between the North, the Center and the South, which show a more significant situation especially in the latter distribution. According to the median scenario, in the short term a slight but significant increase in population is expected in the North (+0.3‰ annually until 2030), on the contrary in the Center (-1.6‰) and especially in the South (-5.5‰) the decline in residents is irreversible.

In the mid-term (2030-2050), and even more in the long-term (2050-2080), this demographic picture tends to expand, with population decline generalized to all geographic distributions but more strongly in the South. Looking at the long term, the North could shrink by 2.7 million by 2080 but by just 276,000 when looking at 2050. Quite different is the evolutionary path of the population in the South, which could reduce by 8 million in 2080, 3.6 million of them already by 2050.

Obviously, the above considerations must also be evaluated in light of the profound uncertainty that underlies them. In the North, a path of progressive population growth (up to 28.5 million residents by 2080) is also potentially possible, as represented by the upper bounds of the confidence interval throughout the projection horizon. Conversely, in both the Center and the South such a possibility is never contemplated, even under the most favorable scenario assumptions.

TABLE 1. RESIDENT POPULATION BY GEOGRAPHICAL AREA. MEDIAN SCENARIO AND 90% CONFIDENCE INTERVALS. Years 2022-2080, January 1st, million (*)

Geographic area	2022	2030	2040	2050	2080
North	27,4	27,4	27,4	27,1	24,7
		[27,3 / 27,6]	[26,9 / 27,9]	[26,0 / 28,2]	[20,9 / 28,5]
Centre	11,7	11,6	11,3	11,0	9,3
		[11,5 / 11,6]	[11,1 / 11,5]	[10,5 / 11,4]	[7,9 / 10,7]
South	19,9	19,1	17,8	16,3	11,9
		[19,0 / 19,1]	[17,5 / 18,1]	[15,7 / 16,9]	[10,2 / 13,6]
ITALIA	**59,0**	**58,1**	**56,5**	**54,4**	**45,8**
		[57,8 / 58,3]	[55,5 / 57,5]	[52,2 / 56,5]	[39,0 / 52,8]

(*) Values under the confidence intervals in square brackets.

Future demographic behaviors will not reverse current trends

The median scenario of the forecasts shows that in the transition that will lead the population from today's 59 million individuals to about 46 in 2080, we glimpse, in aggregate, 21.5 million births, 44.9 million deaths, 18.3 million immigrations from abroad versus 8.2 million emigrations. In the most reliable scenario, therefore, the face of the population changes dramatically, and not only as a matter due to the extension of the prediction horizon. To what extent this transformation may occur depends on the uncertainty associated with the various assumptions about future demographic behavior, but not to the extent of bringing today's birth-death gap back into balance.

Even in the most favorable birth and death scenarios, the projected number of births does not offset the number of deaths. The upper bound of the 90 percent confidence interval for births (a scenario in which the average number of children per woman grows to 1.85 in 2080) identifies a lower amount of births than deaths projected along the lower confidence limit (Figure 1).

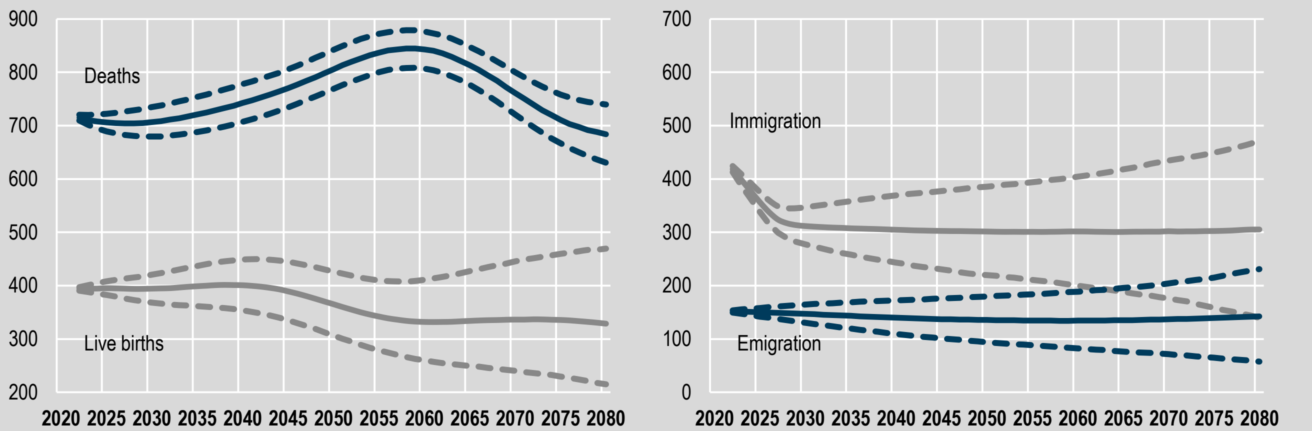
In the median scenario, where fertility growth is assumed from 1.24 children per woman in the base year to 1.46 in 2080, the maximum births would be 401,000 in 2038. Thereafter, the further increase in average reproductive levels does not lead to a parallel increase in births, as the decline in women of childbearing age becomes progressively significant, thus reducing the country's reproductive potential. Keep in mind that in 2022 the number of women aged 15-49 is 11.7 million, and under the median scenario, this contingent will contract almost linearly: from 10.8 million in 2030 to 9.2 million in 2050, to 7.7 million in 2080.

Similar structural changes will affect the evolution of mortality, which will continue to express a sustained number of death events annually, up to a peak of 845 thousand in 2059 according to the median scenario. This is despite good expectations on the evolution of life expectancy (86.1 and 89.7 years expected at birth in 2080, for men and women respectively, with a gain of 5.7 years for the former and 5.2 years for the latter over 2022).

The median scenario contemplates largely positive net foreign migration movements. A particularly pronounced prospect in the first 7 years of the forecast, with an annual average of more than 200 thousand net entries, is followed by a phase of prolonged stabilization that continues throughout the projection period at an annual average of 165 thousand.

In light of the assumptions made, migration flows would not counterbalance the negative sign of natural dynamics. Nevertheless, they are shown to be marked by profound uncertainty, as there are a variety of factors that could give rise to diverse scenarios. We only need to think of the growing migratory pressures exerted in the countries of origin or of the potential offered by the prospects on the PNRR as well as, on the other hand, of the current uncertainties dictated by the continuation of the war crisis and the political-economic crisis, with the possible triggering of a new economic recession at the international level. The analysis of such long-term results must therefore be accompanied by great caution, since the 90% confidence interval of the net foreign migration balance returns extremes in 2080 ranging from -20 thousand to +349 thousand, thereby revealing the two eventualities that the country may both over-accentuate its degree of reception and be in a position to contain it.

FIGURE 1. NATURAL AND MIGRATORY POPULATION MOVEMENT, MEDIAN SCENARIO, AND 90% CONFIDENCE INTERVALS IN ITALY. Years 2022-2080, January 1st, million.



Italy case study for aging population

The structure of the population has for years been the subject of an increasingly profound imbalance, due to the typically Italian combination of increasing longevity and consistently low fertility. Stably on the world podium of aging, today the country has the following age distribution: 12.7 percent of individuals are up to 14 years of age; 63.5 percent between and 15 and 64 years of age; and 23.8 percent from 65 years of age and up. The average age, meanwhile, has risen to 46.2 years, which makes the country, along with a few other examples in the World (Spain, Greece in Europe; South Korea and Japan in Asia) one of the cases in the world's attention for demographers as well as for experts in economics and sustainable development (Table 2).

Future prospects imply an amplification of this process, which is more governed by the current age distribution of the population than by assumed changes about the evolution of fertility, mortality and migration dynamics, based on a ratio of importance, roughly, of two-thirds and one-third respectively.

In 2050, people aged 65 and over could account for 34.5 percent of the total according to the median scenario, while the 90 percent confidence interval ranges from 33.2 percent and 35.8 percent. Whatever happens, the impact on social protection policies will be significant, having to cope with needs for an increasing share of the elderly.

Young people up to 14 years of age, although in the median scenario fertility is expected to partially recover, could account for 11.2 percent of the total by 2050, registering a moderate decline relatively speaking but not in an absolute sense. On the level of intergenerational relations, on that year there will be an unbalanced ratio of over-65s to children, to the extent of more than three to one.

Contributing most to the absolute and relative growth of the elderly population will be the transit of the large generations of the baby boom years (born in the 1960s and first half of the 1970s) between the adult and senile ages, with concomitant reduction of the working-age population. Indeed, over the next 30 years, the 15-64 year-old population would fall to 54.3 percent based on the median scenario, with a potential range of 53.2 percent to 55.4 percent. As with the elderly population, therefore, a certain evolutionary picture is in the future, with potential repercussions on the labor market and on how to ensure the level of welfare needed by the country.

Among future demographic transformations, the marked aging process in the South (Table 2) should be highlighted. Although this geographic distribution still has a younger age profile, the average age of its residents transitions from 45.3 years in 2022 to 49.9 years in 2040 (median scenario), surpassing the North, which in the same year reaches an average age of 49.2 years, starting in the base year from a higher level, namely 46.6 years. Looking at the long-term perspective, the South would slow down but not stop its course, reaching an average population age close to 52. By that time, on the other hand, both the North (50.2 years) and the Center (50.8) would have already begun a process of slowing down the aging process, which in the case of the Center could even lead to the beginning of an initial process of population rejuvenation.

TABLE 2. MEAN AGE OF THE POPULATION BY GEOGRAPHIC AREA, MEDIAN SCENARIO AND 90% CONFIDENCE INTERVALS Years 2022-2080, January 1st, in years and tenth of year (*).

Geographic area	2022	2030	2040	2050	2080
North	46,6	47,9	49,2	50,1	50,2
		[47,8 / 48,0]	[48,7 / 49,7]	[49,1 / 51,1]	[47,7 / 53,1]
Centre	46,8	48,4	50,0	51,0	50,8
		[48,2 / 48,5]	[49,5 / 50,5]	[50,0 / 52,0]	[48,3 / 53,6]
South	45,3	47,4	49,9	51,5	51,9
		[47,3 / 47,5]	[49,4 / 50,4]	[50,5 / 52,5]	[49,4 / 54,8]
ITALy	**46,2**	**47,8**	**49,6**	**50,7**	**50,8**
		[47,7 / 48,0]	[49,1 / 50,1]	[49,7 / 51,7]	[48,3 / 53,6]

(*) Values under the confidence intervals in square brackets.

By 2042, more than 26 million households in Italy

Within twenty years, an increase of more than 850,000 households is expected: from 25.3 million in 2022 to 26.2 million in 2042 (+3.4 percent). These are increasingly smaller households, characterized by greater fragmentation, whose average number of members will fall from 2.32 persons in 2022 to 2.13. Households with at least one family nucleus (that is, marked by the presence of at least one couple or parent-child relationship) will also vary their average size from 2.95 to 2.78 members.

The increase in the number of households will mainly result from a growth in non-family households (without family nuclei) (+17%), which rise from 9 to 10.6 million, coming to account for more than 40% of total households in 2042. In contrast, family households (with at least one nucleus) show a decrease of more than 4 percent: such households, now 16.3 million (64.3 percent of the total), will fall to 15.6 million in 2042, thus constituting only 59.5 percent of households (Table 3).

Such a decline in households with nuclei stems from the long-term consequences of Italy's ongoing socio-demographic dynamics. Indeed, the aging of the population, with an increasing life expectancy, generates more single people, the prolonged decline in the birth rate increases the number of people without children, while the rise in marital instability, as a result of the greater number of couples' dissolution, results in a growing number of single persons and single parents.

In 20 years, 37.5 percent of households will consist of one person

The idea of a family suggests the presence of at least two people, but in reality there has always existed among families a component of people living alone. While in the past it was predominantly young men who left their family of origin for work, for some time now it has been the proportion of elderly people living alone that characterizes this "micro-family." Established phenomena, such as increased life expectancy and marital instability, imply that this household type will grow by 17 percent overall, increasing its contingent from 8.4 to 9.8 million within 20 years. Moreover, much of the increase in the overall number of households is due to the growth, absolute and relative, of single people.

Gender differences are substantial. Men living alone will have a 13% increase, rising to over 4.2 million in 2042. Single women are expected to grow even more (+21%), leading to an increase from 4.6 to 5.6 million.

One-person households, due to their age composition, have an important social impact, considering that it is especially at older ages that single people increase significantly. If in 2022 the share of single people aged 65 and older already accounts for about half of those living alone (48.9 percent), it would reach nearly 60 percent in 2042.

TABLE 3. NUMBER OF HOUSEHOLDS BY TYPE. Years 2022*, 2032, 2042, median scenario, thousand.

TIPOLOGIA	2022	2032	2042
Total households	**25.313**	**25.843**	**26.169**
with at least one family nucleus	***16.286***	***16.059***	***15.582***
without family nuclei	***9.027***	***9.784***	***10.587***
Lone persons	8.374	9.062	9.810
Male lone persons	*3.766*	*4.022*	*4.245*
Female lone persons	*4.607*	*5.040*	*5.564*
Childless couples	5.203	5.546	5.689

TIPOLOGIA	2022	2032	2042
Couples with children	8.065	7.322	6.620
with at least a child under 20	*5.069*	*4.320*	*3.975*
Single mothers	2.235	2.303	2.319
with at least a child under 20	*940*	*947*	*998*
Single fathers	482	575	643
with at least a child under 20	*169*	*187*	*205*
Other type opf household**	955	1.036	1.089

(*) The multipurpose survey on "Daily Life Aspects" are released on a two-year average. Here, however, the data refer to 1st January. For 2022 this can give rise to differences.

(**) Multi-person households (several people living together who do not form a nucleus) and households with more than one family nucleus.

Mostly elderly among people living alone

In absolute terms, among the 9.8 million people expected to live alone in 2042, 5.8 million will be 65 years and older, a growth of 42 percent over 2022. Living alone has different characteristics for men and women. In 2022 among men living alone, more than three in ten are over 64 years old, while among women this ratio rises to more than three in five (63.5 percent).

Over the years, the projections show a scenario in which the incidence of over-65s in the overall single-person households grows in such a significant way that it represents a potential alarm bell for the fragility of these individuals, who in many cases will require care and support. For single men aged 65 and older, an increase of 600,000 is projected by 2042, while single women of the same age are estimated to increase by as much as 1.1 million. The former would come to represent 41.3 percent of the total number of single men in that year, the latter as many as 72.8 percent of single women (Figure 2).

Among households, fewer couples with children, more couples without, and more single parents

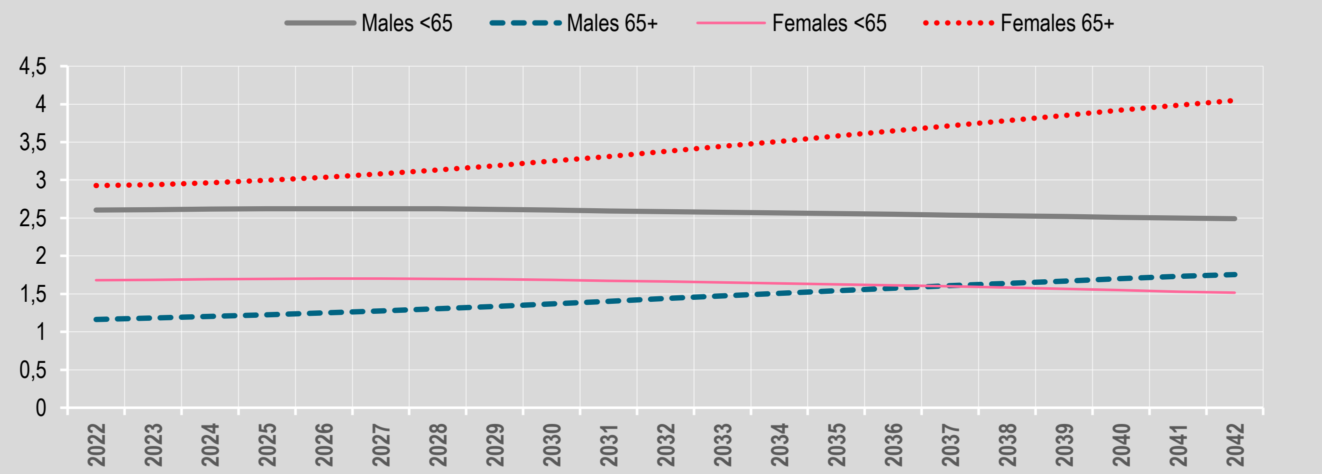
Due to the low levels of fertility experienced in recent years and based on the assumptions produced in the median scenario on this issue, couples with children are expected to decrease substantially. This household type, which today has more than three out of ten families (31.9 percent), could drop to a quarter of total households (25.3 percent) in 2042.

Between 2022 and 2042, their consistency would decrease by 18 percent, from 8.1 million to 6.6 million. Taking into consideration the age of the children, the largest decrease will occur among couples with at least one child aged 0-19 (-22%). Falling from 5.1 million households in 2022 to 3.94 million in 2042, their share will drop from 20 percent to 15.2 percent of total households (Table 3).

In twenty years, childless couples will increase from 5.2 to 5.7 million, an increase of 9 percent and a share of the total rising from 20.6 to 21.7 percent. Such a significant shortening of the numerical gap between couples with children and those without, now 2.8 million but in 2042 amounting to just 900,000, suggests that in the long term the country could see an overtaking of the latter over the former.

The increased prevalence of marital instability in the country will lead to an unexceptional but significant increase in single-parent households, which will rise from 10.7 percent of total households in 2022 to 11.4 percent in 2042. The development of this household type will remain partly restrained by both low fertility levels and the tendency of single-parent individuals to regroup in other households or form reconstituted families. In 2022, there are 2.7 million single parents, more mothers (2.2 million) than fathers (about 500,000), accounting for 8.8 percent and 1.9 percent of total families, respectively. By 2042, lone fathers, while remaining in the minority compared to lone mothers, could amount to more than 600 thousand (2.5 percent of total households). In that year, single mothers will, by a small increase, reach 2.3 million (8.9 percent), so that the number of single parents would rise to about 3 million overall.

FIGURE 2. **LONE PERSONS BY SEX AND AGE-CLASS. Years** 2022-2042, median scenario, thousand.



Family transformations will affect the population structure

The age structure of the population broken down by family role allows us to observe the changes within the households over the next twenty years.

Overall, current demographic dynamics continue the downward trend of new generations, causing an imbalance in favor of older generations. There are currently no signs of a reversal in the number of births in the coming years, even considering the most favorable assumptions about the average propensity of couples to have one child or to have one more. This is due to both the decreasing number of women of childbearing age and the persistent tendency to postpone parenthood.

A comparison of the 2022 population with the projected 2042 population, broken down by family roles, shows the demographic and social changes that are expected in these twenty years (Figure 3). Specifically, there will be a decrease in partners in couples with children (from 27.5 to 22.6 per 100 people living in households), an increase in people in couples without children (from 17.7 percent to 19.4 percent), the latter especially if they are elderly, while individuals in the position of child will decrease from 29.4 percent to 24.1 percent.

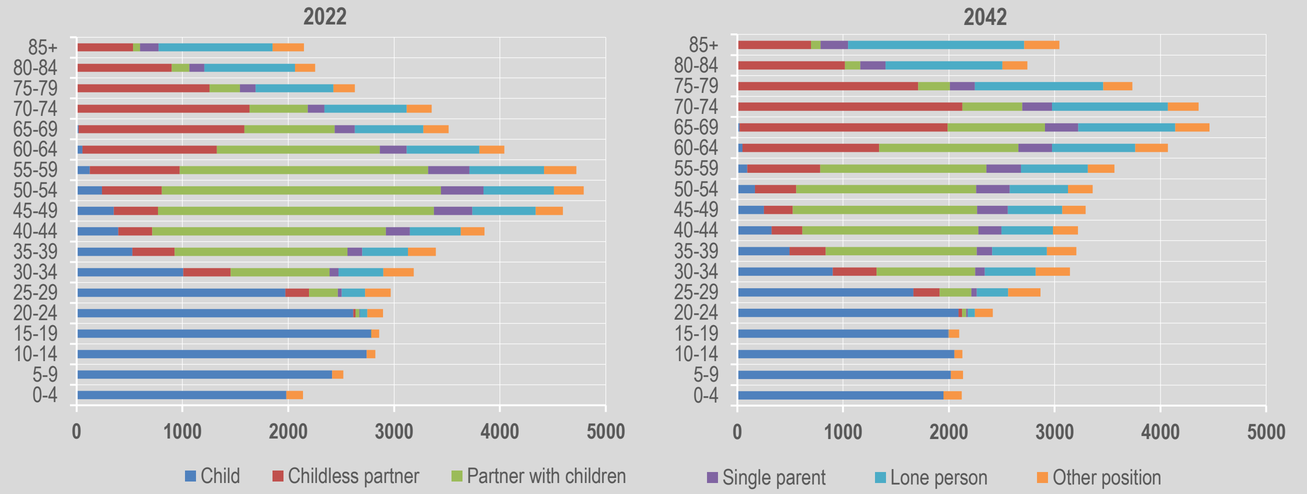
The increase in childless partners will have greater intensity among people aged 65 and older, for whom an increase of 1.7 million people (+28.5%) is expected. The prolonged survival of partners, in particular, means that the number of individuals living in couples without children will grow, either because of their acquired independence, although increasingly later in life, or because they didn't have children in the past. Due to the prolonged low birth rate, the position of child up to age 24 will see a 19 percent decrease (from over 12 million to just under 10). Among single people, in addition to the increase that will occur among those over 65, there is expected to be a growth in young people living alone between the ages of 25 and 39. An overall increase of 10.5 percent is projected for this youth component, especially among men, which would see it increase from just over 1 million in 2022 to about 1.2 million in 2042.

Widespread decline in the territory of households with at least one nucleus

Household types are transformed over time by demographic dynamics and social behavior specific to different parts of the country, resulting in marked differences in the various territorial areas.

Already in 2022 in the North, the share of households with at least one nucleus is lower than in the South (63.2 percent and 67.0 percent, respectively). The expected change for this type of households is substantial, such that in 2042 they could constitute 58.4 percent of total households in the North and 62.4 percent in the South, registering in both cases a reduction of about 5 percentage points. For the Center, family households (accounting for 62.8 percent in 2022), are projected to make up 57.9 percent of total households in 2042, approaching the share projected in the North.

FIGURE 3. POPULATION BY HOUSEHOLD POSITION AND AGE-CLASS. Years 2022 e 2042, median scenario, thousand.



Faster household transformations in the South

Couples with children are the household type that will undergo the greatest change in the next two decades, not only in Italy as a whole but in all geographic breakdowns. As much as the South might remain the area of the country with the highest proportion of couples with children, a decline of more than seven percentage points (from 36.1 percent in 2022 to 28.5 percent in 2042) is expected for this household type in this area. A similar reduction is expected in the Center (from 29.7 percent to 23 percent), while in the North the decrease remains below six percentage points (from 30 percent to 24.2 percent).

Most of this decrease concerns couples with at least one child under 20 years of age, compared to couples with only children over 20. In the North, the former fall from 19.3% in 2022 to 15.4% in 2042 (4 percentage points less out of the 6 points lost by couples with chidren regardless their ages) and in the Center from 19% to 14.3% (5 points lost out of 7 overall). In the South, projections show a broader demographic crisis. Here, couples with at least one child up to age 19 would decline by about seven percentage points, accounting for almost all of the decline in couples with children. For couples with "young" children, therefore, there is a process of territorial convergence. In contrast, for couples with more "mature" children there remains a difference in favor of the South, in part due to longer time to leave the family of origin in this part of the country.

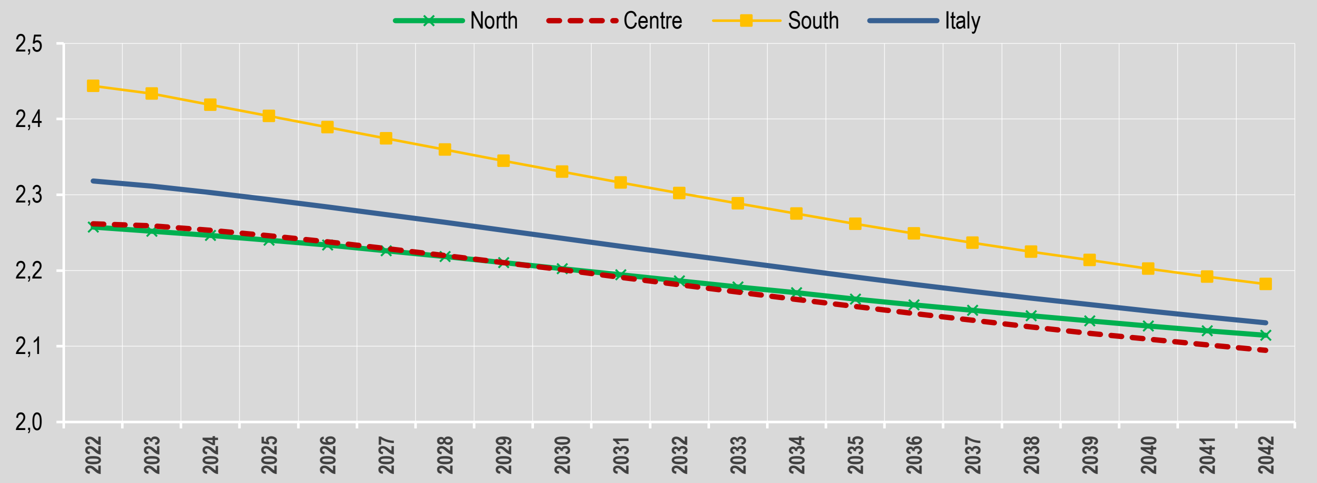
While in Italy as a whole, single persons will grow from 33.1 to 37.5 percent, in the territory this national average value arises from different realities: in the North-Central Italy it starts from a higher initial presence of single persons, at 34 percent, which tends to grow to about 39 percent. In the South, where it starts from lower intial levels of single persons, amounting to 30.3 percent, a more rapid development is expected that will lead this family type to represent 35 percent in 2042.

Childless couples will continue to be more prevalent in the North, remaining stable. A greater change is expected in the South, where, compared with a less widespread initial situation, childless couples will increase from 17.9 percent to 19.5 percent. Lone parents in the North are found to be stable at around 10 percent throughout the period under analysis. In the Center and the South there is a greater presence that will growth to reach 12.1 percent and 13.3 percent in 2042, respectively.

The combination of projected family transformations will cause the average family size to continue to decline nationally (from 2.32 to 2.13 components) and territorially. The North and the Center are characterized by identical 2022 values (2.26 components) and similar dynamics, although the Center may have a slightly lower final average size in 2042 (2.09 versus 2.11).

The South, due to higher fertility rates in the recent past, has always been characterized by the presence of larger average households than the rest of the country. Today, with lower reproductive levels even in this territorial area, this primacy (of 2.44 components in 2022) tends to become less sharp. In the future, although it is predicted to maintain it until 2042, the expectation is for a further decrease to 2.18 components (Figure 4).

FIGURE 4. AVERAGE HOUSEHOLD SIZE BY GEOGRAPHIC AREA. Years 2022-2042, median scenario



Glossary

Age specific fertility (rate): the ratio of the number of live births to women between the ages of x and x + 1 and the average number of women of that age in a given year.

Average number of children per woman: the number of children a woman would have if she was subjected to the fertility calendar (in the form of age-specific fertility rates) of a given calendar year during her reproductive life span.

Birth (rate): ratio between the number of live births in the year and the average amount of the resident population, multiplied by 1,000.

Cohort component (model): the continuous calculation algorithm that in iterative mode simulates the evolution of the fundamental population equation by age group, allowing to determine the demographic flows and to obtain the surviving population at the end of each year.

Couple: two people linked by an emotional and sentimental relationship. Can be formed by opposite or same sex people. The bonds between people in couples can be formal (de jure couple: married, civilly united or de facto cohabiting pursuant to law 76/2016) or informal (de facto couple).

Death: the cessation of any sign of life at any time after the vital birth.

Demographic projection: elaboration that shows the future development of a population when certain assumptions are made regarding the future course of mortality, fertility and migration.

Deterministic demographic projection: elaboration on the future development of a population, summarized in a single series of values obtained from a single set of demographic assumptions, which does not report any measure regarding the uncertainty usually associated with the results.

Dependency ratio: ratio between the population of inactive age (0-14 years and 65 years and over) and the population of active age (15-64 years), multiplied by 100.

Elderly dependency ratio: ratio between the population aged 65 and over and the population aged 15-64, multiplied by 100.

Emigration for abroad (rate): the ratio between the number of emigrations to abroad and the average amount of the resident population, multiplied by 1,000.

Family households (or households with at least one family nucleus): includes couples with children, couples without children, single parents, families with two or more nucleus.

Non family Households (or households without nuclei): people living alone or multi-person families; this latter do not constitute a family unit even if composed of several people.

Family nucleus: group of people linked by ties of marriage, kinship, affinity, adoption, protection, or by emotional ties, cohabitants and having habitual residence in the same Municipality. It can also be constituted by a single person.

Household: set of people who form a couple or a parent-child relationship. It means a married couple, civilly united or cohabiting, with or without children, or even a single parent together with one or more children who have never been married. Within a household there may be one or more family nucleus, but there may also be none, as in the case of households formed by an isolated member (one-person household) or several isolated members (multipersons household).

Household typology: classification based on the presence or absence of at least one nucleus and by type of nucleus.

Immigration from abroad (rate): the ratio between the number of immigrations from abroad and the average amount of the resident population, multiplied by 1,000.

Internal emigration (rate): the ratio between the number of internal emigrations and the average amount of the resident population, multiplied by 1,000.

Internal immigration (rate): the ratio between the number of internal immigrations and the average amount of the resident population, multiplied by 1,000.

Internal migration balance: difference between the number of registrations for change of residence from another Municipality and the number of de-registrations for change of residence to another Municipality.

Internal net migration (rate): the difference between the internal immigration rate and the internal emigration rate.

Life expectancy at age "x": the average number of years that a person of completed age "x" can count to survive in the hypothesis that, in the course of his subsequent life, he was subjected to the risks of mortality by age (from age "x" up) of the year of observation.

Life expectancy at birth: the average number of years that a person can count to live from birth in the hypothesis that, in the course of his existence, he was subjected to mortality risks by age of the year of observation.

Live birth: the product of conception which, once expelled or completely extracted from the maternal body, regardless of the duration of gestation, breathes or manifests other signs of life.

Mean age: mean age of the population at a certain date expressed in years and tenths of a year.

Mean age at birth: the mean age at birth of mothers expressed in years and tenths of a year, calculated considering only live births.

Migratory balance with abroad: difference between the number of registrations for change of residence from abroad and the number of de-registrations for change of residence to abroad.

Mortality (rate of): ratio between the number of deaths in the year and the average amount of the resident population, multiplied by 1,000.

Natural balance: difference between the number of births and the number of deaths.

Natural growth (rate): the difference between the birth rate and the death rate.

Net migration with abroad (rate): the difference between the immigration rate from abroad and the emigration rate with abroad.

Old age (index): ratio between the population aged 65 and over and the population aged 0-14, multiplied by 100.

Predictive (or confidence) interval: an interval associated with a random variable yet to be observed, with a specific probability that the random variable falls within it.

Probabilistic demographic projection: elaboration on the future development of a population, summarized in a set of values or in a probability distribution, in which the variables used are of a random nature that cannot be predicted with certainty and in which not all assumptions are equally probable.

Probability of death: the probability that an individual of precise age x will die before the birthday x + 1.

Projection: development expected in the future.

Projection probability of death: the probability that an individual of age x (in years completed on 1st January) will not survive within the year.

Projection probability of interregional migration: the probability that an individual of age x (in years completed on January 1st) moves residence between two regions before the end of the year.

Range: measure of the variability of a quantitative phenomenon defined by the difference between its maximum and the minimum value.

Registration and de-registration for transfer of residence: registration concerns people who have moved to a Municipality from other Municipalities or from abroad; the de-registration concerns people who have moved to another municipality or abroad.

Resident population: constituted in each Municipality (and similarly for other territorial divisions) of people with habitual residence in the Municipality itself. Persons temporarily residing in another Municipality or abroad, for the exercise of seasonal occupations or for reasons of limited duration, do not cease to belong to the resident population.

Scenario approach: the description of the context, even conceptual, in which the population is projected. In a deterministic approach it usually refers to the main or central assumption. In a stochastic it can refer to the assumption identified as mean or median.

Simulation: the quantitative implementation of a single set of demographic assumptions to be launched in the cohort-component model in order to obtain a single set of demographic projections.

Total balance: sum of the natural balance and the total migratory balance.

Total growth (rate of): the sum of the total net migration rate and the natural growth rate.

Total migratory balance: the sum of the migration balance with abroad and the internal migration balance.

Total net migration (rate): the sum of the net internal migration rate and the net migration rate with abroad.

References

1. ABS - Australian Bureau of Statistics (2019), *Household and Family Projections*, *Australia. Household and family projections (based on different assumptions of living arrangements) for Australia, states and territories and capital cities. Reference period: 2016 – 2041*. https://www.abs.gov.au/.
2. ABS - Australian Bureau of Statistics (2019), *Household and Family Projections, Australia methodology. Reference period: 2016 – 2041*. https://www.abs.gov.au/methodologies/household-and-family-projections-australia-methodology/2016-2041
3. Alho J., Keilman N. (2010), *On future household structure*. Journal of the Royal Statistical Society Series A, 2010, vol. 173, Issue 1, 117-143.
4. Alho J.M. e Nikeer T. (2004), *Uncertain population of Europe - summary results from a stochastic forecast*. http://www.stat.fi/tup/euupe/rp_reports_e_pub.html.
5. Alho J.M., Spencer B.D. (2005), *Statistical demography and forecasting*. New York: Springer.
6. Bernard A., Bell M. (2012), *A Comparison of Internal Migration Age Profile Smoothing Methods*. Working Paper 2012/01. Queensle Centre for Population Research, The University of Queensle.
7. Billari, F.C., Corsetti G., Graziani R., Marsili M. e Melilli E. (2014), *Towards stochastic forecasts of the Italian population: an experiment with conditional expert elicitations*. Proceedings of the 6th Eurostat/UNECE Work Session on Demographic Projections, pagg. 326-338, Istat, 2014.
8. Billari, F.C., Corsetti G., Graziani R., Marsili M. e Melilli E. (2014), *A stochastic multi-regional model for Italian population projections*. Budapest, 25-28 giugno 2014, European Population Conference. http://epc2014.princeton.edu/papers/140361.
9. Billari, F.C., Graziani R. e Melilli E. (2012), *Stochastic population forecasts based on conditional expert opinions*. Journal of the Royal Statistical Society. Series A. 175(2): 491-511.
10. Blangiardo G., Barbiano di Belgiojoso E., Bonomi P. (2012), *Le previsioni demografiche delle famiglie*. In: Donati P. (a cura di), *La famiglia in Italia. Sfide sociali e innovazioni nei Servizi*. Osservatorio Nazionale sulla Famiglia. Rapporto biennale 2011-2012. Volume I Aspetti demografici, sociali e legislativi. Pagg 91-123.
11. Box G. E. P., Jenkins G. M., Reinsel G. C. and Ljung G. M. (2015), *Time Series Analysis: Forecasting and Control*, 5th Edition. Published by John Wiley and Sons Inc., Hoboken, New Jersey, pp. 712. ISBN: 978-1-118-67502-1.
12. Booth H. (2006), *Demographic forecasting: 1980 to 2005 in review*, International Journal of Forecasting, 22: 547–581.
13. Cooper J., Bell M. e Les M. (1995), *Household and Family forecasting Models: a review.* Review of IPC Long-Terrm Projections Model. Paper No. 3. Australian Housing and Urban Research institute in conjunction with Demographics Australia.
14. CBS (2011), *Key figures of the population forecasts 2010-2060*. Statline, Centraal Bureau voor der statistiek, http://statline.cbs.nl/statweb/.
15. Corsetti G., Marsili M. (2012), *A stochastic population projection from the perspective of a national statistical office*. European Population Conference. Stoccolma, 13-16 giugno 2012, EAPS. http://epc2012.princeton.edu/papers/120635.
16. Corsetti G., Marsili M. (2013), *Previsioni stocastiche della popolazione nell'ottica di un Istituto nazionale di statistica*. Rivista di statistica ufficiale, n. 2-3, p. 5-29, Istat.
17. Eurostat (2015), *People in the EU: who are we and how do we live?* - 2015 edition, Luxembourg: Publications Office of the European Union.
18. Eurostat (2020), *Methodology of the Eurostat population projections 2019-based (EUROPOP2019)*, Technical Note, Directorate of Social statistics, Population and migration, Luxembourg, 6 April 2020.
19. Graziani R., Keilman N. (2011), *The sensitivity of the Scaled Model of Error with respect to the choice of the correlation parameters: A simulation study*. Working Paper 37. Carlo F. Dondena Centre for Research on Social Dynamics, Università Bocconi, Milano.
20. Istat (1989), *Previsioni della popolazione residente per sesso, età e regione – Base 1.1.1988*, Note e Relazioni, n.4.
21. Istat (1997), *Previsioni della popolazione residente per sesso, età e regione – Base 1.1.1996*, Informazioni, n. 34.
22. Istat (1989), *Previsioni del numero di famiglie italiane dal 1995 al 2020*. Notiziario. Serie 4. Foglio 41 – Anno X No. 19. Dicembre 1989.
23. Istat (2001), *Previsioni della popolazione residente base 1° gennaio 2000*, Statistiche in breve, www.istat.it.

24. Istat (2003), *Previsioni della popolazione residente per sesso, età e regione, base 1.1.2001*, Informazioni n.13.
25. Istat (2006), *Previsioni demografiche nazionali 1° gennaio 2005-1° gennaio 2050*, www.istat.it, Nota informativa, 22 marzo 2006.
26. Istat (2008), *Previsioni demografiche 1° gennaio 2007-1° gennaio 2051*, www.istat.it, Nota Informativa, 19 giugno 2008.
27. Istat (2011), *Il futuro demografico del paese - Previsioni regionali della popolazione residente al 2065*, Statistiche Report, www.istat.it, 28 dicembre 2011.
28. Istat (2017), *Il futuro demografico del Paese – Previsioni regionali della popolazione residente al 2065*, Statistiche Report, www.istat.it, aprile 2017.
29. Istat (2018), *Il futuro demografico del Paese – Previsioni regionali della popolazione residente al 2065 – base 1.1.2017*", Statistiche Report, www.istat.it, maggio 2018.
30. Istat (2019), *Il futuro demografico del paese - Previsioni regionali della popolazione residente al 2065 – base 1.1.2018*, Nota metodologica, www.istat.it, ottobre 2019.
31. Istat (2021), *Ricostruzione della popolazione residente per sesso, età e comune, Anni 2002-2018*, Nota informativa, www.istat.it, marzo 2021.
32. Istat (2021), *Indicatori demografici – Anno 2020*, Statistiche Report, www.istat.it, 3 maggio 2021.
33. Keilman N. (2018) *Family Projection Methods: A Review*, March 2018, DOI: 10.1007/978-3-319-93227-9_12. In book: Analytical Family Demography. Publisher: Springer
34. Keilman, N. e Brunborg, H. (1995), *Household Projections for Norway, 1990-2020*, Part I: Macrosimulations, Statistics Norway, Oslo-Kongsvinger.
35. Keilman, N. Kuijsten A. and Vossen A. (1988), *Modelling Household Formation and dissolution*. Clarendon Press - Oxford.
36. Keilman N., Pham D.Q. e Hetle A. (2002), *Why population forecasts should be probabilistic - illustrated by the case of Norway*, Demographic Research, 6(15): 409-454.
37. Kono S. (1987), *The headshhip rate method for projecting households*, in Bongaarts J., Burch T., Wachter K., *Family Demography, Methodhs and their Applications*, Clarendon Press-Oxford.
38. Lavit, C. (1988), *Analyse conjointe de tableaux quantitatifs*, Masson, Paris.
39. Lavit, C., Escoufier, Y., Sabatier, R. and Traissac, P. (1994), *The ACT (Statis method)*. Computational Statistics and Data Analysis, Volume 18, Issue 1, 97–119.
40. Lee R.D. (1998), *Probabilistic Approaches to Population Forecasting,* Population e Development Review, 24: 156-190.
41. Lee R.D., Carter L.R. (1992), *Modeling and forecasting U.S. Mortality*, Journal of the American Statistical Association, September, vol. 87, n.419.
42. Lee R.D., Miller T. (2001), *Evaluating the performance of the Lee-Carter method for forecasting mortality*, Demography, November, vol. 39, p. 537-549.
43. Lutz, W., Sanderson W.C. e Scherbov S. (1998) *Expert-Based Probabilistic Population Projections*, Population e Development Review, 24: 139-155.
44. McDonald, P. and R. Kippen. (1998), *Household Trends and Projections: Victoria 1986–2011*. Canberra: Demography Program, The Australian National University.
45. Marsili M. (2007), *Demographic projections: the impact of net international migration on population ageing in Italy*, Atti del Convegno Intermedio della SIS 2007 "Rischio e Previsione", Università Ca' Foscari, Venezia, 6-8 giugno.
46. Marsili M. (2020) *Scenari demografici, previsioni per l'uso*, Atti della 13° Conferenza nazionale di statistica, Dall'incertezza alla decisione consapevole: un percorso da fare insieme, Roma, 4-6 luglio 2018, pagg. 246-252, Istat, 2020.
47. ONS – Office for National Statistics (2020), *Methodology used to produce household projections for England: 2018-based. User guidance about uses, methodology, assumptions and input data for household projections for England.* https://www.ons.gov.uk.
48. Paciorek, A. (2014), *The Long and the Short of Household Formation*. Real Estate Economics, Forthcoming, Available at SSRN: https://ssrn.com/abstract=2469334
49. Rogers A. (1985), *Regional Population Projection Models*. Beverly Hills. CA: Sage.
50. Rogers A., Castro L. (1981) *Model migration schedules*, International Institute for Applied System Analysis, Laxenberg, Austria, RR-8 1-30, November 1981.

51. Rowan S., Wright E. (2010), *Developing stochastic population forecasts for the United Kingdom: Progress report e plans for future work*. Eurostat-UNECE Work session on demographic projections, Lisbon, 28-30 aprile 2010, Methodologies e Working papers, Commissione Europea.
52. Schmertmann C.P. (2003), *A system of model fertility schedules with graphically intuitive parameters*, Demographic Research, 9(5): 81-110.
53. Shaw C. (2008), *The National Population Projections Expert Advisory Group: results from a questionnaire about future trends in fertility, mortality e migration*. Population trends n.134, Winter 2008, Office for national statistics.
54. Stoto, M. A. (1983), *The accuracy of population projections*. Journal of the American Statistical Association. 78: 13–20.
55. Tuljapurkar S., Lee R.D. e Li Q. (2004), *Random scenario forecast versus stochastic forecasts*. International Statistical Review. 72: 185–199.
56. Terra Abrami V. (1998), *Le previsioni demografiche*, Il Mulino, Bologna.
57. UNECE (2018), *Recommendations on Communicating Population Projections*, United nations economic commission for Europe, United Nations, New York and Geneva, agosto 2018.
58. United Nations(1973), *Methods of projecting households and families*, Manual VII, New York.
59. United Nations (2019), *World Population Prospects 2019: Methodology of the United Nations population estimates and projections*, Department of Economic and Social Affairs/Population Division, ST/ESA/SER.A/425.
60. Wilson T. (2013), *The sequential propensity household projection mode*, DEMOGRAPHIC RESEARCH VOLUME 28, Article 24, Pages 681-712, http://www.demographic-research.org/Volumes/Vol28/24/ DOI: 10.4054/DemRes.2013.28.24.

Methodological note

1) Regional population projetions by age and sex. Years 2022-2080

Istat's regional demographic projections are built with the aim of representing the possible future trend of the population, both in terms of total numbers and in terms of age and sex structure. The information produced represents an important tool to support decisions in economic and social policies, such as those relating to pension, health, education and housing systems. The projections are periodically updated by reformulating the evolutionary assumptions underlying fertility, survival, international and internal migratory movements.

The new set of projections replace those based on 2021 published by Istat in September 2022. Istat is the owner and responsible for the production and dissemination of the projections, as documented in the National Statistical Program. With this new release a new three-year production cycle starts after those of the years 2016-2018 and 2019-2021. This methodology was defined, between 2009 and 2015, by a working group with researchers from Istat and the Luigi Bocconi University of Milan.

The methodological approach, around which the forecasting model works, is of a semi-probabilistic nature. The fundamental characteristic of probabilistic forecasts is to consider the uncertainty associated with the predicted values, determining the confidence intervals of the demographic variables and giving the user the possibility to independently choose the degree of confidence to be assigned to the results.

Compared to the "deterministic" approach, more widely used on an international scale and also adopted by Istat in the past (up to the 2011 based projections), this represents a significant methodological advance. In fact, in the deterministic model the user does not have probability measures associated with the results. Thus, a further advantage of the probabilistic method is the fact that the user can stop to trust uncritically on the work of projection makers, who with the typical "low / high" variants define a priori the alternative boundaries to the variant retained "most likely", generally identified as "main" or “medium” or “central” scenario".

The quantification of uncertainty does not represent the only advantage of the probabilistic model. Another one is the more effective representation of the evolution of a population. In the probabilistic model, in fact, the definable scenarios are infinite on the theoretical level (although in reality, as will be seen later, a finite number is always selected), so assumptions of low survival are mixed with assumptions of high fertility or medium level of migration, or the opposite. Instead, the assumptions of the high/low scenarios of the deterministic approach are defined by pursuing an output oriented logic: the high scenario contemplates assumptions of maximum increase in survival, fertility and migrations, while, on the contrary, the low scenario contemplates only assumptions of minimum. The construction of such opposing scenarios actually captures the goal of determining a future range for the population and its structural components, but based on concomitant assumptions with low chance of occurring.

The subsequent sections contain general information and briefly illustrate the steps that made it possible to build the projections. These sections include information on the following aspects:

- base population
- projection technique
- time horizon
- panel of experts
- expert questionnaire and probabilistic model
- relationship between national and regional projections
- data
- corrective component of nowcasting for short term assumptions
- confidence intervals and median scenario
- regional fertility projections
- regional mortality projections
- regional projections on international migration
- regional projections on internal migration
- comparison with previous projections
- comparison with the projections released by Eurostat and the United Nations
- data dissemination and terms of use
- contact information and personalized data requests.

Base population

The base population is the one broken down by sex, single age group and region as of 1 January 2022, as identified by the last Census of Population and Housing. The population includes all people usually residing in Italy, of any citizenship, while it does not include Italian citizens residing abroad, nor citizens illegally or irregularly present on the national territory who are not enrolled in any municipal register.

Projection technique

Projections are carried out with an iterative technique between 1 January and 31 December of each year, using the so-called "cohort-component" method. To the initial population, in correspondence of each age group, immigrations (from abroad or from other regions) are added while deaths and emigrations are subtracted (for abroad or for other regions), thus obtaining the population alive at the end of the year. Live births in the course of the year have also to be computed and, among them, those still alive as of December 31st, net of deaths and migratory movements that concern them.

For the population (stock), age is defined in completed years on 1 January (from 0 to 110 years and over). The same concept applies for flow data (births, deaths and migratory movements). This allows to identify, always and in any case, the demographic events by single year of birth of the subjects involved, ensuring the required consistency within the population equation.

It is assumed that demographic events may occur linearly at any time of the year. Between death and migration (internally or abroad) it is assumed incompatibility, that is, they cannot involve the same individual in the same year.

Deaths are determined by multiplying the resident population by age group on 1 January by the respective (projection-)probabilities of death, i.e. those involving subjects belonging to the same cohort.

Births in a given year are achieved in three steps. In the first, the average number of women for each fertile age (obtained as the average of the populations of that age at the beginning and end of the year) is multiplied by the respective fertility rate. In the second, the sum of the births by age of the mother is calculated, obtaining the total number of births in the year. In the third, births are broken down by sex using the fixed ratio of 106 male births per 100 female births.

Projections have a territorial profile and are built in the logic of the multi-regional model, a model which, with particular regard to internal migratory flows, simultaneously and coherently works the distinct territorial units of reference. The model on internal migration starts from the construction of a multi-regional matrix of migration probabilities by region of origin, region of destination, sex, and age. This matrix, applied to the population at risk of migration, identifies a coherent series of immigrants and emigrants in each forecasting year.

Time horizon

Projections cover the period between 1 January 2022 and 1 January 2080. The main purpose is to provide with information on the future development of the population in the short term (2030), and therefore to provide with information in the medium (2050) and long term (2080). With regard to this latter time reference information, data should be used with caution since the results become the more uncertain the further we go from the base year (2022). This risk is the more concrete the more attention is paid to the smaller territorial units, as in the case of some Italian regions.

Panel of experts

A panel of national experts supported Istat in formulating the demographic assumptions for Italy as a whole. The assumptions for the regions, on the other hand, were handled by Istat on the basis of a specific "bridge" methodology between the national and regional assumptions. The experts who replied to the questionnaire (with CAWI technique), providing with useful and complete information to define the assumptions, were 121. They were voluntarily recruited by Istat among the most illustrious experts in demographic-social studies. In particular, there are 69 women and 52 men, mainly employed in universities (68) or in other public research bodies (42). The mean age of the respondents is 51 years while their work experience is on average 23 years.

In all the phases that involved the building of the methodological framework underlying the projections, Istat made use of the concrete cooperation of Francesco Billari and Rebecca Graziani of the Bocconi University in Milan.

In tutte le fasi che hanno riguardato la costruzione dell'impianto metodologico alla base delle previsioni, l'Istat si è avvalsa della concreta cooperazione di Francesco Billari e Rebecca Graziani dell'Università Bocconi di Milano.

Expert questionnaire and probabilistic model

The probabilistic method adopted is based on the opinions of experts (expert-based model) to define the future evolution of the most important demographic indicators. It falls within the broader class of random scenario models. This model, used for the definition of probabilistic scenarios at a national level, is based on the elicitation of a series of parameters from which the future stochastic evolution of each demographic component is derived. Experts are asked to provide values at a given year "t" with regard to a series of summarized demographic indicators, conditional on the values assumed by the same indicators in instants of time prior to year "t" (Billari, Graziani and Melilli, 2012).

The method has the advantage of being simple and flexible. In fact, in the questionnaire, the necessary demographic components are summarized through the following indicators: the average number of children per woman; life expectancy at birth by sex; immigration and emigration from abroad. The other information necessary for the production of the projections, such as that regarding the age-breakdown of demographic events, is purposely kept out and subsequently processed in order to make the questionnaire and the forecasting model itself parsimonious.

TABLE A1. MEAN VALUES, VARIANCES AND CORRELATIONS UNDER ASSUMPTIONS OF THE EXPERTS BY DEMOGRAPHIC INDICATOR. Years 2021, 2050 and 2080

Indicator	Total fertility rate	Life expectancy at birth – Men	Life expectancy at birth – Women	Immigrations (thousand)	Emigrations (thousand)
Year 2021					
Observed value	1.25	80.3	84.8	318	158
Year 2050					
Mean assumption	1.38	84.3	87.8	302	136
High assumption	1.54	85.7	89.1	368	169
Variance	0.016	1.239	1.106	2,613	667
Year 2080					
Mean assum. conditional to 2050 mean assumption	1.50	86.2	89,6	304	142
Mean assum. conditional to 2050 high assumption	1.66	88.0	91,1	389	187
High assum. conditional to 2050 mean assumption	1.68	88.2	91,5	402	192
Variance	0.058	4.586	3.689	10,302	2,774
Correlation 2050-2080					
Correlation coefficient	0.67	0.67	0.64	0.65	0.67

Two time points are considered for each demographic indicator: an intermediate year "t1" and a year "t2" corresponding to the last forecasting year. In the questionnaire submitted to the experts, "t0 = 2021", "t1 = 2050", "t2 = 2080", thus generating two sub-intervals, 2019-2050 and 2050-2080. Expressing the value of life expectancy at birth in the year 2080, given its expected value in 2050, is a practical example of how the mechanism works.

The demographic indicators are assumed, for the sake of simplicity, independent of each other (for example, the total fertility rate is not influenced by the level of migration and vice versa), although the model allows in its generalized version the possibility of interacting among them. It is also assumed that the pair of elicitations at 2050 and 2080 of a given indicator has a bivariate normal distribution.

Under these conditions, once the mean values provided by the experts have been obtained, it is possible to estimate the variance associated with each of the two future time instants as well as the correlation between the first and the second period (Table A1). On the basis of the corresponding bivariate normal distributions, 3,000 simulations were then carried out with the Markov Chain Monte Carlo method[1].

The last estimation step is aimed at calculating the values of each parameter in the intermediate years of the two sub-intervals 2021-2050 and 2050-2080. This activity is carried out, for each of the 3,000 simulations, by interpolation with quadratic curves, passing through the known points corresponding to the years 2021, 2050 and 2080. Thus, the definition of 3,000 stochastic curves for each demographic indicator has been achieved at national level. As an example, Figure A1 describes the bundle of trajectories relating to the number of children per woman, obtained from the procedure described above.

[1] The choice fell on the years 2050 and 2080 in order to identify two time intervals of similar length.

The choice to consider a number of 3,000 simulations is the result of a compromise between two needs, both strategic: 1) faithfully representing the uncertainty of demographic events; 2) optimizing the machine times for processing the projections. The latter, despite today's availability of increasingly powerful and sophisticated hardware / software tools, represents a technical aspect which is anything but secondary, given the huge amount of data processed.

FIGURE A1. PROBABILISTIC EVOLUTION OF THE TOTAL FERTILITY RATE IN 3,000 SIMULATIONS OBTAINED FROM EXPERT OPIONIONS. YEARS 2021-2080

The survey tool Limesurvey

To create the electronic questionnaire for collecting data from the experts, the Limesurvey tool was used, an open-source software distributed under the GNU General Public License (GPL) and created on the LAMP platform, for the creation and management of online surveys and questionnaires.

It allows, through an intuitive user interface, the rapid development of web questionnaires and the management of all the subsequent phases of data collection, from the creation of the list of respondents and the related contact methods, to the monitoring of the survey, up to the export of the answers. Various types of questions are allowed, it supports multilingual surveys, and is fully graphically customizable via templates with responsive layouts, i.e. whose content adapts to the dimensions of the browser of the device used.

Istat began using the software more than a decade ago, hosting it and periodically updating it on its servers (exposed and internal), for different types of direct data collection processes in a web environment.

The questionnaire in question, composed of a personal data section and 6 thematic sections (of which 5 reserved for demographic forecasts and 1 for household forecasts, see paragraph 2 below), was implemented faithfully respecting the consistency and validation checks between the values of the questions within the same section and between those belonging to different sections. To this purpose, it was necessary to reprogram (in javascript) the interaction with the user to force him to insert in the various questions, from time to time, an appropriate number of decimal figures, customize the final table on family positions, as well as configure some general graphic aspects.

The list of experts was pre-loaded in the system and each of them was randomly assigned a unique participation code (token), through which the link (URL) for completing the questionnaire is composed. Each participant received an invitation email in their inbox with this link together with a brief information; he had the possibility to access the questionnaire from any browser and from any device (including smartphones) and to complete the questionnaire even in different sessions.

Finally, the system allowed the Limesurvey administrative backend to repeatedly solicit respondents who had not accessed or completed the questionnaire.

Relationship between national and regional projections

The probabilistic model releases a set of 3,000 national simulations for each summary demographic indicator. Since the objective of the Istat projections is also to give indications at a territorial level, so continuing the longstanding tradition of the multi-regional model, a "bridge" procedure has been implemented between the definition of national and regional inputs. The approach pursued is therefore top-down on the side of the assumptions building while, as will be seen later, it is bottom-up on the side of the production of final outputs.

The main action is to derive 3,000 regional stochastic scenarios from the 3,000 national ones. The first operation in this sense is to elaborate an intermediate deterministic forecast, applying the multi-regional cohort component model. From this forecast, obtained by extrapolating the regional trends considered most probable for each component (see following paragraphs), the same summary indicators of the previously described stochastic model are obtained, i.e. average number of children per woman, male and female life expectancy at birth, migratory movements with foreign countries. Such a first intermediate forecast, unique and deterministic, essentially resembles that which in a deterministic approach would be labelled with the term "central scenario".

The transition from the regional deterministic model to the regional stochastic model is achieved by multiplying, and repeating the procedure 3,000 times, the regional deterministic forecast for the relationship between the national stochastic and the deterministic forecast. In formula, indicating with "n" the generic simulation (n = 1, ..., 3,000), with "j" the regional territorial code, with DR the deterministic regional forecast, with SR the stochastic one, with DN and SN, respectively, the national deterministic and stochastic forecast, we have:

$$\mathrm{SR}^{\mathrm{j}}_{\mathrm{t,n}} = \mathrm{DR}^{\mathrm{j}}_{\mathrm{t}} \times \frac{\mathrm{SN}_{\mathrm{t,n}}}{\mathrm{DN}_{\mathrm{t}}}$$

thus linking, in each simulation, the vector of regional values to the national stochastic reference value. Note that with regard to the synthetic indicators of immigration and emigration from abroad, we have:

$$\mathrm{DN}_{\mathrm{t}} = \sum_{\mathrm{j}} \mathrm{DR}^{\mathrm{j}}_{\mathrm{t}}$$

$$\mathrm{SN}_{\mathrm{t,n}} = \sum_{\mathrm{j}} \mathrm{SR}^{\mathrm{j}}_{\mathrm{t,n}}$$

Once the synthetic stochastic indicators have been obtained at the regional level, we move on to the construction of the inputs necessary for the application of the cohort-component method, i.e. the (projection-)probabilities of death by age and sex, the age specific fertility rates and the distribution of immigrants / emigrants from abroad by age and sex. The procedure therefore associates each summary indicator with its own sex-age breakdown. The latter, not treated in a stochastic way, is the one that derives from the regional deterministic model and, from simulation to simulation, adapted to the specific synthetic stochastic indicator.

The coupling of the 3,000 death probability vectors (each vector develops a number of elements equal to the "number of regions X age classes X sex X forecast years") with the 3,000 fertility vectors, and the same number on immigration and emigration from abroad and, finally, with the 3,000 O / D probability matrices of internal migration, it is randomly executed.

After introducing a corrective nowcasting component (see next paragraph) relating to the very first years of forecasting, the cohort component model is then run 3,000 times, thus obtaining the required outputs: population by age and sex, demographic flows by age and sex, plus the series of demographic indicators to support the analysis, from generic rates (birth, mortality, etc.) to structural indicators (mean age, dependency rations, etc.).

The results at national level (as well as those at geographical area level) in the context of each regional simulation are obtained by sum (bottom-up approach). Therefore, the amount of the expected population, deaths, and migrations, classified by age and sex, and births by age of the mother that are determined at the national level are the sum of the forecast regional trajectories. The assumed national levels relating to the summary indicators placed into dissemination, for example regarding life expectancy or the average number of children per woman, are recalculated ex-post on the basis of these regional summaries.

It should be noted that the stochasticity introduced at the regional level, borrowed top-down from the national one and limited only to summary indicators, may result not sufficient to reproduce the randomness of the various demographic events. This is particularly true in small areas where uncertainty tends to be relatively higher. For this reason, although the number of simulations still offers ample guarantee of representativeness of the variability on a regional scale, it is more appropriate to speak of a semi-stochastic approach when referring to regional projections.

A second observation concerns the fact that in the Istat model a generalized statistical treatment of the covariance between the Regions is excluded (for example: the forecast of increase / decrease in fertility in a given region how much it conditions or how much is in turn conditioned by the forecast of increase / decrease in another). To this solution, also excluded for reasons of parsimony of the model, another one was preferred, that of territorial convergence. In fact, the initial deterministic regional model, subsequently transformed into a stochastic model through the procedure described above, is built on the assumption of very long-term convergence (2120, well beyond the last year of projections) between the regions for each fundamental demographic component. This implies that the 3,000 regional stochastic scenarios represent 3,000 different hypotheses of convergence of demographic behaviours among regions.

The main hypothesis underlying the convergence is that the socio-economic and cultural differences currently existing between the regions are destined to disappear in the long term. Therefore, their progressive cancellation would also involve a generalized rapprochement of demographic behaviours. The idea of convergence is not new in demography and there are many examples of demographic forecasts that follow it (Eurostat and the UN, in particular), including past Istat ones. In Istat projections, convergence is understood as the progressive shift of a given demographic behaviour towards a very distant point in the future which represents the instant of full regional convergence (in the sense that at that point the values would be identical for the different regions), but that in reality it is far from being reached within the time horizon considered (2020-2070). In fact, it is correct in this circumstance to speak more of a model of semi-convergence than of a model of full convergence.

Data

The assumptions defined at the regional level in the preliminary deterministic model, before the transition to the stochastic model, were obtained by extrapolating future trends from the analysis of the observed time series. In particular, these assumptions were defined using the following data series:

– for fertility, the mother's age-specific rates for the period 1977-2021;
– for mortality, the (projection-)probabilities of death by age and sex for the period 1974-2021;
– for internal and international migrations, the changes of residence by age and sex of 2016-2019 and 2021 (without 2020).
–

Corrective component of nowcasting for short term assumptions

Before being launched at full capacity along the time horizon with the cohort-component method, the probabilistic projections incorporate a corrective nowcasting factor (from the term nowcast = forecast of the present). With this operation we intend to ensure that the forecast relating to the very first years is as much in line with the trend that emerged in the last period or in the last historical year (jump-off effect). This type of operation is particularly suitable in years characterized by sudden, and as such unpredictable, changes in the demographic situation. This is the case, as happened in 2020 and to a lesser extent in 2021, of the effects caused by the Covid-19 pandemic on all components of the demographic change. Not only, albeit primarily, on mortality, but also on birth rates and internal and international changes of residence.

Since the base population of the projections is that recorded as of January 1, 2022, it was necessary put in place some short-term correction of the predicted inputs that affected the first projections years. The correction, in particular, takes advantage of the information from the provisional demographic balance - Year 2022, which Istat released in March 2023. With this, in fact, we want to take into account not only the events that characterized the 2022, but also the subsequent years within which it is assumed that the pandemic effects may end and allow the short term inputs to be in line with medium and long term ones[2].

From the computational point of view, the review of the short-term assumptions is carried out by applying correction factors. For example, let E_b^j be the number of demographic events predicted in the first year based on the median scenario in region j. Instead, let $\widehat{\mathrm{E}}_b^j$ be the observed value of such events or, in the absence of the actually observed value, the best estimate that can be obtained (for example, using nowcasting procedures or similar statistical models). The ratio:

$$\mathrm{r}_\mathrm{b}^\mathrm{j} = \widehat{\mathrm{E}}_\mathrm{b}^\mathrm{j} / \mathrm{E}_\mathrm{b}^\mathrm{j}$$

represents the correction factor to be applied to the statistical measures that give rise to type "E" events in year "b" for region j. For example, if these events were the total number of births then the quantity:

$\hat{\mathrm{f}}_{\mathrm{b,x}}^{\mathrm{n,j}} = \mathrm{r}_\mathrm{b}^\mathrm{j} \cdot \mathrm{f}_{\mathrm{b,x}}^{\mathrm{n,j}}$ with x=14, … , 50 and n=1, … , 3000

[2] Furthermore, bearing in mind the iterative calculation mechanism offered by the cohort component method, i.e. a mechanism of continuous stock-flow interaction over time, the correction imposed in the first years also affects the outcome of all subsequent years, up to 2080.

represents the series of fertility rates by age of the mother (n-th simulation) corrected for year "b". Similar considerations apply to the determination of the correction coefficients relating to mortality and migratory movements. As regards 2022, the correction factors were constructed by comparing the data of the provisional demographic balance of each region, released in March 2023 by Istat, to the projections previously produced for that year[3].

For the years after 2022, the correction factors are applied for a limited period of the time horizon, processing weights that progressively tend to one. In particular, the number of years for which the correction factor is applied to the series of interest is obtained from:

$$Y^j = \mathrm{abs}\left(1 - r_b^j\right) \cdot \epsilon$$

with ϵ arbitrary quantity, appropriately chosen to ensure that, on regional average, the number of years to guarantee the return from short-term to medium-long term projections does not exceed 5 years. At this point, the levels of the correction factors for the years following "b", for a total of "Y" years, are given by:

$$r_t^j = \frac{r_b^j \cdot \left(b + Y^j - t\right) + (t - b)}{Y^j} \quad \text{with } t = b, b+1, \dots, b + Y^j - 1$$

Confidence intervals and median scenario

Once the calculation procedure inherent to the 3,000 regional simulations has been launched, uncertainty is calculated for all possible information levels, from the predicted population to the flow data, also broken down by age and sex. These margins of uncertainty depend in turn on the uncertainty inherent in the future levels of mortality, fertility and migration that are also made available. The dissemination of the results contemplates the release of only the confidence intervals of 90%, 80% and 50% but it is possible to define intervals on any scale of interest. The confidence interval provides information on how likely it is that a given demographic indicator falls within predetermined limits. From this point of view it should be remembered that this probability itself represents a forecast, as it is based on hypotheses whose validity is uncertain. Furthermore, in no case should the extremes of the confidence interval be interpreted as extreme limits, upper or lower, of future demographic behaviour.

The construction of a confidence interval is here based on the determination of the percentiles in the distribution of the 3,000 simulations. For example, the 90% confidence interval for a given indicator is determined by considering the distribution values that fall between the 5th and 95th percentiles. It is also recalled that the uncertainty always refers to the domain of the specific estimated parameter. The limits of the confidence interval for a given hierarchical level are estimated on their own, and not constructed by summation of limits obtained at a hierarchically lower level of disaggregation. The criterion is also applied in non-territorial hierarchical contexts; for example in the composition by age of the population or in that by sex.

The "median scenario" was built with the aim of defining a "punctual" forecast that can be adopted as the most likely reference of future demographic evolution. This scenario corresponds to a 3001-th simulation, obtained by construction, but which in fact was not detected in the observation field of the 3,000 simulations. Its set of assumptions is identified by taking as a reference the median value between all the simulations at the level of the individual demographic components (fertility, mortality, migration) within the possible combinations of the covariates age, region and year of forecast. For example, the median scenario specific fertility rate at the age of 32 in the Tuscany region, in the year 2040, is identified as the median value with these characteristics identified among all the simulations. The same specific rate but at the following age, or in the following year, is identified with the same procedure but it probably arises from a different simulation. For the identification of the median scenario on mortality and migration, the procedure is identical but with the additional covariate of sex. Furthermore, for internal migrations, the selection also includes the region of origin and destination.

The scenario is therefore “median” from the side of the fundamental inputs. From the point of view of the outcome (population and expected flows) that this scenario generates once the procedure for cohort-components has been launched, for the typical properties of the median it returns values very close to the median ones.

Regional fertility projections

For regional fertility the projections concerned the classic parameters of intensity and age-breakdown, i.e. the average number of children per woman and the distribution of specific fertility rates by age of the mother.

The average number of children per woman was represented using ARIMA models (n, p, k), searching, separately for each region, the one most suitable for predicting the future intensity of reproductive behaviour. On the basis of the 1977-2021 historical series the predominantly model was an ARIMA (2,0,0) with intercept.

[3] Cfr.: Istat, la dinamica demografica – anno 2022, https://www.istat.it/it/files/2023/03/Dinamica-demografica2022.pdf.

The fertility age profile was modelled using a quadratic splines function system (Schmertmann, 2003). This model functionally describes the curve of specific fertility rates standardized as a function of three parameters: the age of onset of the fertile age α; the age P in which fertility reaches its maximum level; age H, subsequent to P, in which fertility is halved compared to the maximum level. By specific standardized fertility rate we mean the specific fertility rate normalized to the unit, where the value one corresponds to the maximum value observed within its age distribution.

The quadratic splines model fits five second-degree polynomials to the fertility curves. The final function is continuous with the first derivative also continuous. Moreover, thanks to suitable mathematical restrictions it is uniquely determined by the three parameters [α, P, H] mentioned above.

In practice, the prediction of the specific fertility rate is transformed into the prediction of the three parameters (through ARIMA models) which express it functionally, once the series has been estimated in the period 1977-2021. To do this, a hypothesis of convergence between the Italian regions was adopted, assuming that the territorial differences in terms of reproductive behaviour tend to decrease in the long term. From an operational point of view, full convergence was set in 2122. In particular, the convergence constraint provides that, from 2022 to 2122, the parameters of the regional vector [α, P, H] converge linearly to the values of a hypothetical national vector, specially designed for the operation.

Regional mortality projections

Regional mortality projections were produced using the Lee-Carter model (1992) in the variant proposed by Lee-Miller (2001), a model in which the adjustment procedure leads the fitted probabilities of death to reproduce precisely the observed level of life expectancy at birth, rather than the total deaths observed as in the original version. Furthermore, here the model is applied to death probabilities rather than to mortality rates of the original formulation.

The model approximates the logarithmic form of the probability of death using three synthetic parameters, one of which is related to the trend [k(t)] and two related to the age distribution [(a(x), b(x)].

As for fertility, also for mortality the construction of the model originates from the definition of a provisional reference scenario at national level. The forecast is determined by projecting into the future the only national trend parameter k(t), whose series is identified over the period 1974-2021, while the parameters a(x) and b(x) remain invariant over time in this phase. In particular, due to its substantial linearity, the k(t) parameter was projected to 2080 with a random walk with drift.

The assumptions at the regional level are derived from the provisional national reference scenario, by first estimating the regional values of the three parameters in 1974-2021 with the same methodology and, subsequently, by making each regional parameter converge to the corresponding national parameter at 2122. Therefore, as a consequence of the convergence process and unlike the classical approach of the Lee-Carter model, here the regional parameters a(x) and b(x) are also varied over time.

Regional projections on international migration

In order to capture the most recent trends, the regional projections of migratory flows with abroad focus the analysis only on the last five years, namely 2016-2019 and 2021. The year 2020 was deliberately censored to avoid incorporating into the forecasts the effects of the lockdown.This need, considering the complexity of predicting international migratory flows by resorting to analysis of long historical series, leads to use a very simple model. Without forgetting that at this level of operations it is a question of structuring an intermediate deterministic model, whose values are subsequently calibrated on the intensities produced by the expert-based stochastic model.

In the first year of the projection, the total values of immigration and emigration from abroad are set equal to the mean value observed over the last five years. In accordance with the general convergence framework of the deterministic model, it is therefore assumed that in each region inflows and outflows converge linearly in the long term (2122) at the same level, which is to the initial half sum of the two values.

Once the totals of inflows and outflows up to 2080 have been determined, the associated age and sex breakdown are derived by applying the Castro-Rogers model (Rogers and Castro, 1981) to the 2016-2019 and 2021 series. With this model it is shown that the characteristic age profile of migrants can be described, regardless of the intensity of the phenomenon, by a mathematical function composed of 4 additive components and up to 11 predictive parameters. These parameters, whose estimate in the observed period is produced thanks to a generalized procedure for non-linear models (category in which the Castro-Rogers function fully falls), are kept constant in the forecast period. The conclusive result is therefore that the global intensity of migratory flows with abroad may vary over time but on the basis of a constant composition by age.

Regional projections on internal migration

Interregional migrations are developed according to a multidimensional approach, which allows to simultaneously consider the areas of origin and destination of migratory flows, to define the entrances in a given area as the sum of the exits with that destination from all the other areas of the system. The system is by construction consistent for all the forecast years since the marginal row and column of the O/D matrix, corresponding respectively to the inflows and outflows in/from each region, give the same sum, corresponding to the amount total of movements within the national territory.

The probability of migration specific for age (110), sex (2), region of origin (21) and destination (21) represents the basic component of the O/D matrix composed of 110x2x21x21 = 97020 cells for each calendar year. The probabilities are estimated on the basis of the levels observed in the individual years of the 2015-2016 and 2021 period, censoring the year 2020 as in the case of international migration. The probability vectors thus obtained, at the level of each annuity, are subsequently modelled using the Castro-Rogers function.

Therefore, indicating with

$$m_{x,s,t}^{i,j}$$

a generic (projection-)probability of migration for an individual of age "x" and sex "s" between the region "i" and the region "j" relating to the year "t" (t = 2016, ..., 2019, 2021), is assumed that this represents a normal random variable with an average equal to the mean value of the five-year period and variance equal to the variance detected in the five-year period:

$$\mu_{x,s}^{i,j} = E\left(m_{x,s,t}^{i,j}\right)$$

$$\sigma_{x,s}^{i,j} = E\left(m_{x,s,t}^{i,j} - \mu_{x,s}^{i,j}\right)^2$$

From the above mentioned random variables, 3,000 values are randomly extracted for each of the 97,020 elements of the O/D matrix, thus giving rise to the random creation of 3,000 different matrices. The O/D matrix relating to the median stochastic scenario is identified by taking as a reference the median value between all the simulations within the possible combinations of the covariates sex, age, region of origin and region of destination. This median matrix is also used with the preliminary purpose of producing the deterministic forecast of the population, prior to the transition to the actual stochastic model (see previous paragraph on the relationship between national and regional projections).

Note that in the context of each simulation (including the median scenario) the O/D matrix is assumed to be invariant over time. The hypothesis underlying the model is based, in fact, on maintaining a propensity for mobility that remains constant throughout the time horizon. This implies that internal migratory flows evolve over time only because of the variations affecting level and age structure of the population exposed to the risk of migration.

Comparison with previous projections

An assessment of the change that occurred between the last two rounds can be made by comparing the median scenarios of the projections based on 2021 and 2022.

First of all, a rather limited difference should be noted between the total base population 2022 (59 million 30 thousand) and that which had been estimated in the median scenario on the same date by the projections based on 2021 (58 million 984 thousand).

On the side of the expected flows in the period of common projection (2022-2070), a less positive assessment can be seen in the projections based on 2022 for fertility and mortality, where 18.2 million births and 37.8 million deaths were expected against respectively 19.2 and 37.1 of the previous exercise. The forecasts on international migration, on the contrary, are more favorable for the 2022 base year. The latter, in fact, presents in the common projective segment a global net migratory balance equal to 8.4 million individuals against 6.4 million of the forecasts based on 2021.

The difference between the final populations of the two distinct projections is also small (as of January 1, 2070, just 315 thousand units more for the median scenario 2022 based), confirming the substantial stability of the projections based on 2021, despite the change in the base population and short-term adjustments to the balance components. From this point of view, table A2 highlights how the process of reviewing the assumptions for all demographic components only affected the first years of forecasting.

TABLE A2. 2021 AND 2022 MEDIAN SCENARIO ASSUMPTIONS FOR THE MAIN DEMOGRAPHIC INDICATORS. Years 2022, 2030, 2050 and 2065.

Median scenario	Total fertility rate	Life expectancy at birth – Men	Life expectancy at birth – Women	Immigration (thousand)	Emigration (tohusand)
Year 2022					
Base 2021	1.27	80.3	85.0	287	134
Base 2022	1.24	80.4	84.5	418	151
Year 2030					
Base 2021	1.37	82.2	86.2	281	145
Base 2022	1.30	81.8	85.8	312	147
Year 2050					
Base 2021	1.50	84.7	88.1	258	131
Base 2022	1.38	84.3	87.8	302	136
Year 2070					
Base 2021	1.55	86.5	89.5	244	126
Base 2022	1.44	85.8	89.2	302	137

Comparison with the projections released by Eurostat and the United Nations

In order to compare the projections produced by Istat with those of other bodies, it makes sense to take as a reference the projections released by Eurostat and the United Nations Population Division (UNPD). For years, the statistical institute of the European Union has been carrying out the task of producing demographic forecasts on a regular basis for all member countries. The latest release is based on 2022, whose main reference scenario is the so-called baseline scenario. The UNPD, in turn, also produces demographic projections on a regular basis through the World Population Prospects, which include all the countries of the globe. In this latter case, the latest available exercise is based on 2022 and the main reference scenario is the so-called medium variant.

It should be noted in the introduction that, despite the comparability on the level of projective technique, the exercises produced by the two international organizations present some methodological differences compared to the Italian one. Among these, in the first place, the fact that the two international models examined here are uninational, i.e. they project the resident population in Italy as a whole without taking into account the demographic development of the regions.

Table A3 shows the main scenario assumptions compared. As regards migratory flows, the comparison is limited to net migration as both Eurostat and UNPD build the assumptions directly on this indicator (without distinction between immigrants and emigrants).

The UNPD projections present very limited assumptions in terms of net migration, not only in the initial projection period but over the entire projection horizon. In the medium and long term the assumptions continue to be rather differentiated between the various producer bodies. In particular, with regard to migratory movements, where compared to a UNPD that is rather cautious about Italy, Eurostat is opposed with a much more optimistic vision. This evidence is partly due to the Eurostat methodology, which, in addition to predicting the underlying evolution of net migration, incorporates an additive replacement-migration component into the model[4].

The assumptions on fertility are quite similar, although in the medium-long term Eurostat and UNPD produce more favourable forecasts than Istat. The assumptions on survival are also not particularly distant, however Eurostat and especially UNPD highlight very favourable expectations about the lengthening of life expectancy, which are only partially glimpsed in the Istat model.

The development of the different demographic assumptions therefore gives rise to differences in terms of expected results which, as regards the evolution of the total population, can be appreciated in Figure A2. The UNPD projections give a much more pessimistic evolution of the population which approximates the lower limit of Istat confidence interval.

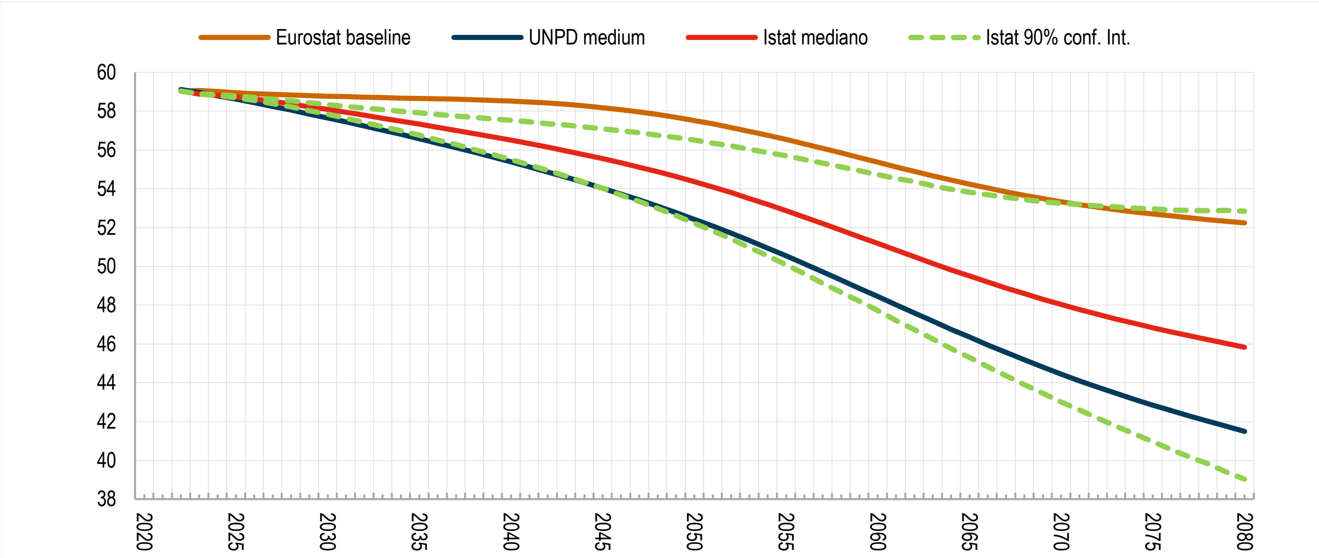
[4] This component assigns in each forecast year an additional quota of net migrants in the measure equal to 10% of the reduction found in the population of working age (15-64 years).

TABLE A3. COMPARISON BETWEEN LATEST MAIN ASSUMPTIONS ON ITALY MADE BY ISTAT (MEDIAN SCENARIO), EUROSTAT (BASELINE) AND UNPD (MEDIUM). Years 2022, 2030, 2050 and 2080.

Scenario	Total fertility rate	Life expectancy at birth – Men	Life expectancy at birth – Women	Net migration (thousand)
		Year 2022		
Istat Median	1.24	80.4	84.5	267
Eurostat Baseline	1.24	81.1	85.5	348
UNPD Medium	1.29	82.0	86.0	58
		Year 2030		
Istat Median	1.30	81.8	85.8	165
Eurostat Baseline	1.28	82.4	86.8	270
UNPD Medium	1.35	83.2	87.1	58
		Year 2050		
Istat Median	1.38	84.3	87.8	166
Eurostat Baseline	1.37	85.0	89.0	240
UNPD Medium	1.44	85.8	89.6	58
		Year 2080		
Istat Median	1.46	86.1	89.7	163
Eurostat Baseline	1.48	88.1	91.9	228
UNPD Medium	1.50	89.4	93.1	58

The Eurostat scenario, given the significant impact of a more sustained net migration, is particularly optimistic. Up to the point of maintaining a population even wider than the upper limit of the 90% confidence interval of Istat projections for most part of the time horizon. Nonetheless, the evolutionary trajectory of the population is consistent between the three scenarios. In fact, all of them foresee a progressive decline of the population which tends to worsen in the medium-long term.

FIGURE A2. TOTAL POPULATION ACCORDING TO ISTAT, EUROSTAT AND UNPD SCENARIOS. Years 2022-2080, million.



2) Households projections, by region. Years 2022-2042

Household projections show the future trend of the number and type of households that will characterize the population in Italy from 2022 to 2042. These projections derive from the application of a static method, based on propensity rates, applied to the projected population. The purpose is to provide with an integrated system of information that can be useful to several users, both public and private, who deal with goods and services intended for families rather than for individuals. Given the importance of the role of the family, both at the protective level and for individual choices and paths, the demand for information on households arises from planning needs in various areas. First of all, we can consider the decisions to be taken in economic and social policies, such as those relating to housing, social and welfare systems for the young and the elderly. Last, improve the planning of productive strategies of durables goods for households and energy consumption is another potential task.

Territorial level and time horizon

Household projections are disseminated at regional and national level. The base population is the one observed on 1.1.2022 while the elaborations cover the period from 2022 to 2042.

Data

Several set of data have been implemented. Among them, the official probabilistic projections - base 1.1.2022 of the median scenario to be used as reference for the future evolution of the resident population by sex, age and region; the Base Population Register at 1.1.2021 and 1.1.2022 to estimate the share of population living in institutional cohabitation by sex and single year of age; the Multipurpose Survey "Aspects of daily life", which provide with a long time series (from 2002 to 2022), to derive the family structures by typology and position. The concept of household here in use is the "de facto family". Adopted in all Istat Multipurpose surveys, it identifies a household as "the set of people linked by ties of marriage, kinship, affinity, adoption, protection, or from emotional ties, cohabitants and having habitual residence in the same Municipality".

Model

The model is based on an adaptation to the Italian context of the method known as "Propensity model". Such a model has been used for recent years by the Australian Bureau of Statistics (ABS) to project households in Australia and New Zealand (ABS, 2019). It is a static method that goes beyond the classic "Headship rate model", overcoming the concept of 'head of household' and providing a much more detailed set of information. Predictions of the number of future households, their average size and composition, and the population by family role can be easily obtained. The method relies on Propensity rates, defined as the proportion of people of age x in household position i at time t

$$\text{Propensity Rate}_{x,i,t} = \frac{P_{x,i,t}}{P_{x,t}}$$

For example, the propensity for a 30-year-old person to live in a couple with a partner will be given by the ratio between the number of 30-year-old people living in a couple and the total population of 30-year-olds.

The advantages of the method are many: it ties easily to population projections; there is no need to analyse transitions between potential family positions, typical of a dynamic model; it is simple to apply and provides with high detailed results. However, some drawback is also present, which arise mainly from the static nature of the method, do not allowing to reproduce the process of household formation and dissolution. Thus the application of propensity rates to the resident population may in some cases determine inconsistencies in term of global results, for example between sexes or for household positions within age-classes, a problem that it is therefore necessary to solve with ex-post adjustments.

The method consists of 5 steps:

- Step 1. Estimate the base-year and projected population living in households
- Step 2. Calculate household propensity rates
- Step 3. Modelling future trends of household propensity rates
- Step 4. Derive the projected population in the different household positions
- Step 5. Calculate the number, type and size of projected households.

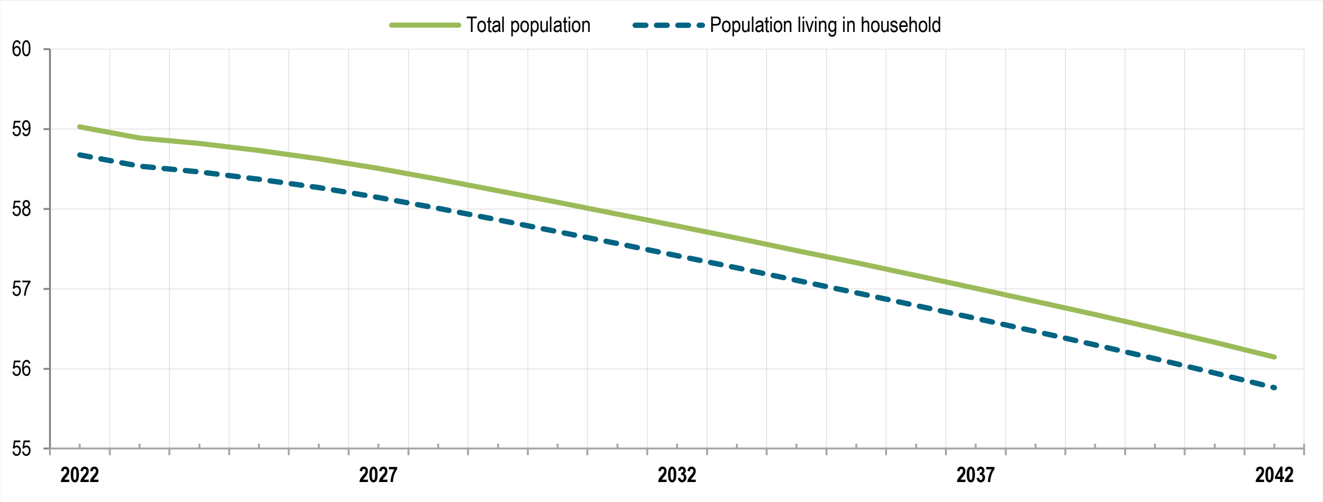
The various steps are explained in detail below.

Step 1. Estimate the base-year and projected population living in households

The base-year population is represented by the resident population by gender, age and region at January 1st, 2022, as collected from the last register-based Census. Then, making a preliminary estimate of the population living in households, excluding individuals residing in institutional households (hospitals, barracks, prisons, nursing homes, religious buildings, etc.) is necessary. This operation should then be repeated for every projected year, deducting from the regional projections (whose reference is also in this case the overall resident population) the share of the institutionalized population.

From the Base Population Register as of 1.1.2021 and 1.1.2022, the (average) percentage incidences of the population living in institutions by sex, five-year age group, and region were calculated. Given the substantial stability of this population over time, these percentage values are assumed to be constant throughout the time horizon of the projection. Applying the 100 complement of these incidences to the total population from 2022 to 2042, we obtained the population living in households by region, sex, and age group (Figure A1).

FIGURE A3. TOTAL POPULATION AND POPULATION LIVING IN HOUSEHOLD. Years 2022-2042, median scenario, million.



Step 2. Calculate household propensity rates

The second step consists on calculating the propensity rates to live in a given household position by gender and 5-year age groups for the following 10 household positions:

1. lone person;
2. person in a childless couple;
3. person in a couple with at least one child under 20 years of age;
4. person in a couple in couple with all children aged 20 and older;
5. single parent with at least one child under 20 years of age;
6. single parent with all children aged 20 and older;
7. child (living with one parent in a couple or with a single parent);
8. other person living in a family household[5];
9. person in multi-person household (e.g., 2 siblings living together or a divorced individual who has returned home to a parent);
10. person in a household with 2 or more families.

Positions from 2 to 8 refer to individuals in one-family households. People living in households with 2 or more family nucleus have been considered in a separate category, since this typology constitutes a small share of the total number of households (approximately 1.5%).

As mentioned above, propensity rates are constructed as the proportion of persons of age x in category i. In this context, the age variable was considered in five-year classes and the rates were also disaggregated by sex, as the latest variable is very discriminating in household behaviour. Hereinafter, these rates are referred to as *Living Arrangement Propensities* (LAP):

$$\text{Propensity Rate}_{x,i,s,t} = \frac{P_{x,i,s,t}}{P_{x,s,t}} = \text{LAP}_{x,i,s,t}$$

where x= five-year age group 0-4, 5-9, ..., 80-84, 85+, i= family position, s=sex, t=time.

[5] Family refers to people who form a couple or a parent-child relationship. It means a married couple, civilly united or cohabiting, without children or with single children, or even a single parent together with one or more children who have never been married. Within a household there may be one or more families (family households), but there may also be none, as in the case of households formed by a single member (one person household) or several isolated members (multi-person household).

LAPs are calculated using data from the *Aspects of Daily Life* (AVQ) survey, along the entire 2002-2019 time series. Since regional estimates by sex and age groups leads to a paucity of data in small regions, it was decided to group regions into "macro-regions".

A multivariate statistical analysis, including various sociodemographic context factors[6], has generated the following 5 groups of regions:

- Group 1 - North-west (Piemonte, Valle d'Aosta, Lombardia, Liguria);
- Group 2 - Eastern Adriatic (Veneto, Emilia-Romagna, Trentino-Alto Adige, Friuli-Venezia Giulia, Marche);
- Group 3 - Tyrrhenian (Toscana, Lazio);
- Group 4 - South (Campania, Puglia, Calabria, Sicilia);
- Group 5 - Central (Umbria, Sardegna, Abruzzo, Molise, Basilicata).

Step 3. Assumptions on future trends of household propensity rates

It is now necessary to make assumptions about the evolution of household propensities from 2022 to 2042. To this end, some modifications to the Propensity rates method have been introduced. The new approach is based on the introduction of a new synthetic indicator, constructed as the sum by age of the LAP, weighted by the years lived at the various ages (L_x). This new indicator is named *Total Propensity Rate per household position* (TPT):

$$\mathrm{TPR}_{i,s,t} = \sum_{x=0-4}^{85+} \mathrm{LAP}_{x,i,s,t} * L_{x,s,t} = \sum_{x=0-4}^{85+} \frac{P_{x,i,s,t}}{P_{x,s,t}} * 100 * L_{x,s,t}$$

where i=household position, s=sex, x=five-year age class, t=time.

$L_{x,s,t}$, representing the number of years lived in the age class x by sex s in year t, are derived from the projected life tables of the median scenario.

The TPR for a given household position represents how many years on average a generation of individuals expects to live in that position, assuming over the life course the family behaviours and mortality conditions as observed in a given calendar year. It is, therefore, a life expectancy in that family status, shifted from the cross-sectional to the longitudinal observational dimension. In other words, it takes on the same meaning that better-known cross-sectional indicators have, such as the average number of children per woman, the life expectancy at birth or the total marriage rate.

As can be seen in Table A4, if in 2002 a man counted on living as a single person an average of 5.8 years (out of a total life expectancy of 77.2), in 2022 the expected time in this state rises to 9.6 years (out of a total of 80.4). In contrast, as a result of declining birth rates, in 2002 women expected to live 14.3 years (out of a total of 83) as a person in a couple with at least a child under 20, but in 2022 this expected time has fallen to 12.8 years (out of a total life expectancy that has since risen to 84.5 years). As a final example, the time in "child" status has increased from 30.4 to 31.7 years for males and from 27.6 to 29.3 for females, due to the prolonged stay of young people within the family of origin.

In order to hypothesize future trends in propensities, we proceeded to project the Total Propensity Rates by single family position, and then to estimate its distribution broken down by age group ($\mathrm{LAP}_{x,i,s,t}$) in each projected year. Predicting total intensity in a first step made it possible, on the one hand, to more easily translate the assumptions about family behaviour and, on the other, to keep together the trends in the various household positions. These latter, if projected separately by single age group, would be more difficult to control with the risk of obtaining unreliable results (e.g., a higher rate for the "child family position" at intermediate ages than at younger ones).

The final goal of Step 3, which is to define the projected LAPs from 2022 to 2042 by region, was achieved by first performing the projection in the 5 established territorial groups (Step 3.1), and then moving from these to a regional detail (Step 3.2).

[6] In order to identify homogeneous groups of regions, united by common family structures and similar evolution over time, a dynamic principal component analysis was carried out using the STATIS methodology. The analysis examined the main socio-demographic variables at the regional level in the years 2002-2019, including: fertility rates, mean age at birth, average size of families, separation and divorce rates, female employment rates, internal and foreign migration rates, quotes of some family types (single people, couples with and without children, single parents, etc.). The procedure was optimized by eliminating the variables with low latent variability explained by the axis.

TABLE A4. TOTAL PROPENSITY RATES BY HOUSEHOLD POSITION AND SEX. Years 2002-2022

Household position	MALES					FEMALES				
	2002	2007	2012	2017	2022	2002	2007	2012	2017	2022
Lone person	5.8	6.4	8.1	8.9	9.6	10.4	11.1	12.1	12.4	11.9
Partner in a childless couple	13.1	14.2	14.1	14.2	13.7	12.1	13.0	13.0	13.2	13.0
Partner with at least a child <20	14.5	13.8	12.8	12.7	12.0	14.3	13.9	13.1	13.1	12.8
Partner with all children >=20 anni	8.8	8.5	7.9	7.3	7.1	8.5	8.1	7.2	6.7	6.7
Lone parent with at least a child <20	0.2	0.2	0.3	0.3	0.4	1.2	1.4	1.9	2.0	2.3
Lone parent with all children >=20 anni	0.5	0.6	0.8	0.8	0.8	2.9	3.0	3.2	3.1	3.1
Child	30.4	30.8	31.0	31.2	31.7	27.6	28.0	27.9	27.9	29.3
Person in a multi-person household	0.9	1.2	1.3	1.4	1.7	1.7	1.6	1.5	1.7	1.7
Person in a household with 2 or more families	2.1	2.0	2.5	2.7	2.3	2.3	2.2	2.7	3.2	2.7
Other position	1.0	0.9	1.0	1.0	0.9	2.0	1.7	1.7	1.4	1.3
Totale	**77.2**	**78.6**	**79.7**	**80.5**	**80.4**	**83**	**83.9**	**84.5**	**84.8**	**84.5**

Step 3.1 Projecting LAPs in the 5 territorial groups

The total propensity rate for each household position and sex ($\mathrm{TPR}_{i,s,t}$) was predicted through the combination of two pieces of information:

- trend extrapolation over the period 2002-2022, using time series analysis models. ARIMA, Random walk with drift or Linear Trend type models were applied for each household position and sex (Table A5);

- experts' views on future levels to 2050 at the national level regarding the TPRs of the main household positions by sex.

Regarding the first activity, an example of the application of the above models is shown in Figure A4, where the behavior of the Northwest spatial group for the main family positions is depicted. More generally, with regard to each area of the country, variations in time spent in various household position are assumed, resulting in:

– an increase of “single people”;
– a decrease of “partners with children”;
– a slight increase of “partners without children”;
– an increase of people in “child” position;
– a slight increase of “lone parents”, especially fathers;
– a substantial stability of "other people" living with a family household;
– a slight increase of “persons in households with 2+ families”.

TABLE A5. PREDICTIVE MODELS OF TOTAL PROPENSITY RATES BY HOUSEHOLD POSITION AND SEX
(Prevailing model among the 5 territorial groups) *

Household position	Males	Females
Lone person	RWD || ARIMA(1,0,0)	RWD
Person in a multi-person household	RWD	RWD
Partner in a childless couple	ARIMA(2,0,0)	RWD
Partner with at least a child <20	RWD	RWD
Partner with all children >=20 anni	RWD || ARIMA(2,1,0)	RWD || ARIMA(2,1,0)
Lone parent with at least a child <20	RWD	RWD
Lone parent with all children >=20 anni	RWD	RWD || ARIMA(2,1,0)
Child	RWD || ARIMA(2,0,0)	RWD || ARIMA(2,1,0)
Other person	RWD	ARIMA(1,0,0)
Person in a household with 2 or more families	ARIMA(1,1,0)	ARIMA(1,1,0)

*RWD=*Random Walk with Drift model*; ARIMA=*AutoRegressive Integrated Moving Average model*.

On the other hand, Table A6 shows the average values to 2050 expressed by experts in the online questionnaire of the Survey "Expert's assessment on the future evolution of the main demographic indicators in Italy" carried out by Istat in 2023. This module was implemented this year for the first time with the purpose of including the experts' opinions in the decision-making process that produces the final output regarding the values of regional TPRs projected from 2022 to 2042. Each expert was asked for an opinion so that the sum of their TPRs (by sex) projected to 2050 was equal to the value of their projected life expectancy in 2050 (central value). There were 87 experts who provided complete information. Using linear interpolation, the values of TPRs were then calculated expert-based (national level and by sex) for the entire projection period 2022-2042.

TABLE A6. MEAN VALUES OF EXPERTS' OPINIONS ON TOTAL PROPENSITY RATES BY HOUSEHOLD POSITION (TPT) AND SEX. Year 2050

Household position	MALES	FEMALES
Lone person	11.8	14.3
Partner in childless couple	14.1	13.4
Partner in couple with children	18.8	19.2
Single parent	2.3	5.8
Child	32.1	29.5
Other position	5.1	5.4
Total	**84.2**	**87.6**

The final values of total propensity rates for each group of regions were derived using the following formula:

$$\mathrm{TPR}_{\mathrm{s,i,t,g}} = \frac{\mathrm{STPT}_{\mathrm{s,i,t,g}}}{M\mathrm{STPT}_{\mathrm{s,i,t}}} * \mathrm{ETPTs,i,t} \quad \mathrm{t} = 2022, \dots, 2042$$

where STPTs,i,t,g is the value predicted for group g through the time-series model for sex s, household position i, and year t; MSTPTs,i,t is the groups' weighted average of the values predicted with the time-series models for sex s, family position i, and year t, and where the population size of the groups of regions is used as the weight in the average; ESTPTs,i,t is the value predicted with the expert questionnaire for sex s, household position i, and year t. In this way, the initial values (predicted with the time-series models) of the predicted ESTPTs in the individual group are re-proportioned by a coefficient that is equal to the ratio of the value provided by the expert to the value from the time-series models at the national level. The result of this operation brings the final values closer to the experts' opinions.

Estimation of the predicted distribution by age, i.e. $\mathrm{LAP}_{\mathrm{x,i,s,t}}$ from 2022 to 2042, was obtained using predicted TPR, predicted years lived L_{x}, and observed distributions from AVQ survey data over the three-year period 2017-19. For this latter purpose, the mean 2020-22 distributions by single position in the household were weighed by two coefficients: one to account for the predicted TPT in year t relative to that in the 2020-22:

$$\mathrm{WP}_{\mathrm{s,i,t}} = \frac{\mathrm{TPR}_{\mathrm{s,i,t}}}{\mathrm{TPR}_{\mathrm{s,i,2020-22}}} \qquad \mathrm{t} = 2022, \dots, 2042$$

and a coefficient expressing changes in mortality over time:

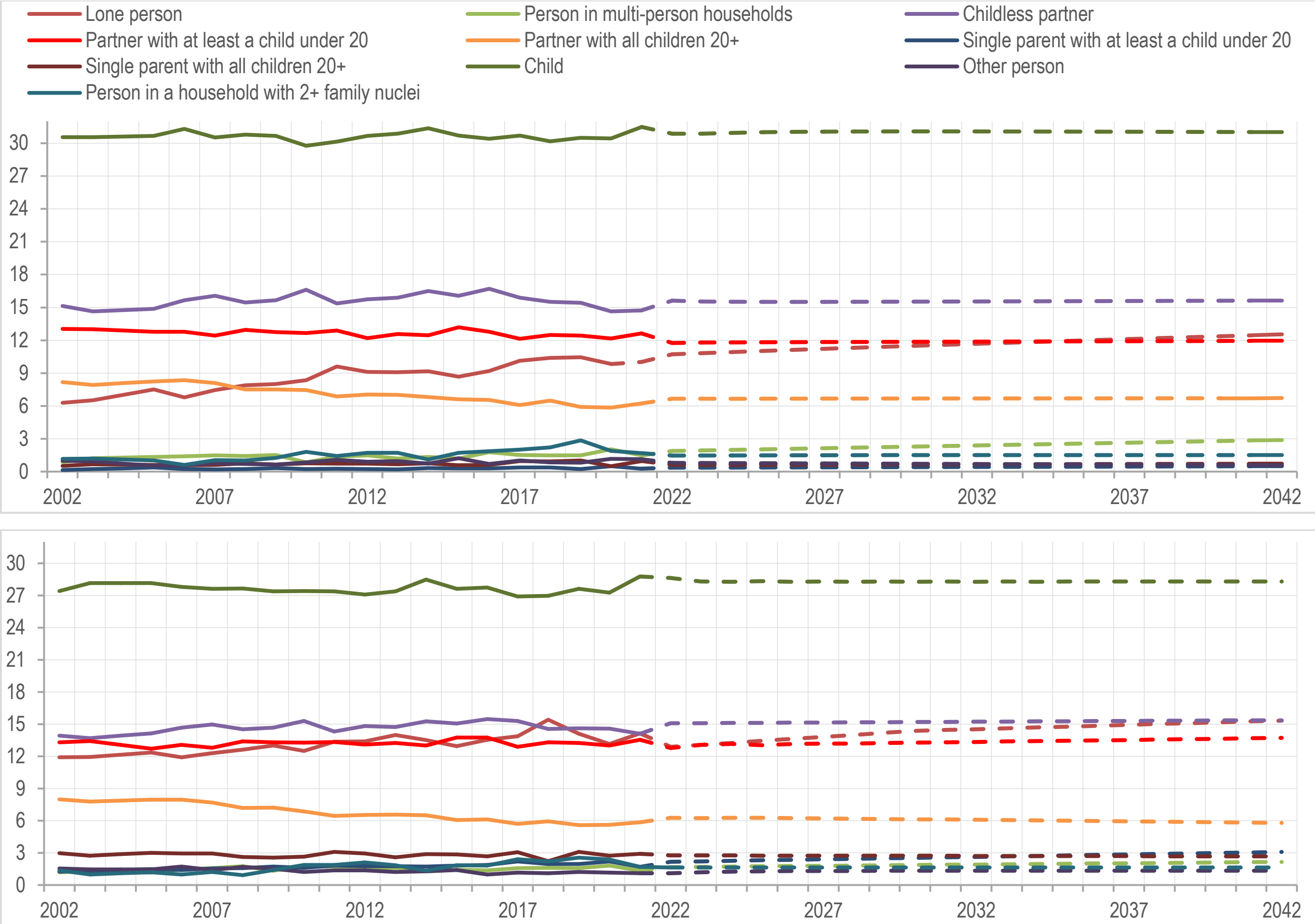
$$\mathrm{WL}_{\mathrm{x,s,t}} = \frac{\mathrm{L}_{\mathrm{x,s,2020-22}}}{\mathrm{L}_{\mathrm{x,s,t}}} \qquad \mathrm{t} = 2022, \dots, 2042$$

Therefore, household propensities throughout the projection horizon were calculated using the formula:

$$\mathrm{LAP}_{\mathrm{x,s,i,t}} = \mathrm{LAP}_{\mathrm{x,s,i,2017-19}} * \mathrm{WP}_{\mathrm{s,i,t}} * \mathrm{WL}_{\mathrm{x,s,t}} \qquad \mathrm{t} = 2022, \dots, 2042$$

where: x=age groups 0-4, ... ,85+, s=sex, i=household position.

FIGURE A4. TOTAL PROPENSITY RATES BY HOUSEHOLD POSITION AND SEX. North-west. Years 2002-2042.



Since the method of estimation did not assume annual variation about the age distribution of LAPs, it was implicitly assumed that behaviours in terms of family choices would maintain in the future an age-group distribution proportional to that found in the AVQ survey in the three-year period 2020-2022. Last, the sum of LAPs by household position in each age group approximates but does not always equal the value of 100, so ex-post adjustments were necessary.

Step 3.2. Projecting LAPs in the regions

In order to project households at the regional level, it is necessary to ensure that each region has its own socio-demographic specificity within the projecting group to which it belongs. Considering that, a regional correction factor has been defined to be applied to the LAP projections of the various territorial groups in order to obtain those specific to each region:

$$\mathrm{FC}_{\mathrm{r,i}} = \frac{\mathrm{TPR}_{2020-22,\mathrm{i,r}}}{\mathrm{TPR}_{2020-22,\mathrm{i,G}}}$$

where i=household position, r=region, G=group to which region r belongs.

The projected LAPs for the spatial groups are then multiplied by the regional correction factor calculated in this way, determining the series of regional LAPs from 2022 to 2042. For example, for the single male person, the detected TPR in Piemonte is 11.06 while in group 1 it is 10.08. The correction factor is therefore equivalent to 1.10 in this case. This means that since Piemonte has a higher TPR than the group to which it belongs, an adjustment must be made by multiplying all LAPs at different ages and projected years by 1.10, increasing the level slightly.

Step 4. Obtain the projected population by single household position.

In this step, the regional propensities are applied to the projected population living in households, as it was obtained in Step 1. The projected population in the different household states by sex, age group, and region from 2022 to 2042 is then derived.

Step 5. Calculate the number, type, and size of projected households

The projected number of households is obtained directly from the population separated by family position, gender, and age, as:

- each "single person" represents 1 household (coefficient=1);
- persons in a couple constitute 0.5 of a family (coefficient=0.5);
- each "single parent" represents 1 family (coefficient=1);
- “multi-person households" are obtained by dividing the number of persons living in multi-person households by the average size of this type of household, substantially stable over time and equal to about 2.1 members (coefficient=2.1);
- households "with 2 or more families” are obtained by dividing the number of persons living in households with 2 or more families by the average size of this type of household, which assumes time series coefficient values between 5.1 and 5.4 depending on the territorial group of reference.

Applying these coefficients to the population of sex s and age x yields as a final product the number of households by the family types of interest.

The average number of members is then calculated by dividing the population living in the household to the number of households. It can be disaggregated for total households and those with at least one family (excluding single persons and multi-person households).

For dissemination purposes, multi-person households and those with 2 or more families are considered together in the "other type of household" item.

3) Data dissemination and terms of use

The detailed picture of the assumptions underlying the projections and the main results can be consulted on dati.istat.it (topic: Population and families> Population projections) and demo.istat.it.

The dissemination of the **population projections** is implemented into the three following sections: population structure by sex and single age group; components of the population change; main demographic indicators. Each table shows the values of the median scenario and the lower and upper limits of the 90%, 80% and 50% confidence intervals.

The components of the population balance include:

- population at start and end of the year, total variation
- births, deaths, natural change
- in-migration and out-migration, net migratory balance
- interregional changes of residence, net internal migration balance.

The data described above and those relating to the age distribution of the population are rounded to the nearest unit.

Regarding the demographic indicators, the tables include:

- birth, mortality and natural growth rates
- immigration rate from abroad, emigration for abroad and net migration rate with abroad
- internal immigration rate, internal emigration rate and net internal migration
- total net migration rate and total growth rate
- mean age of the population
- % of population 0-14 years, 15-64 years, 65 years and over, 85 years and over
- structural dependency ratio, elderly dependency ratio and aging index
- total fertility rate
- life expectancy at birth and at 65 years of age by sex.

The dissemination of data relating to **household projections** is articulated into three sections including tables that can be processed on the structure by sex, five-year age group and household position of the population, on the distribution of household by type and on the average number of household members. All results refer to the median scenario.

References

61. ABS - Australian Bureau of Statistics (2019), *Household and Family Projections*, *Australia. Household and family projections (based on different assumptions of living arrangements) for Australia, states and territories and capital cities. Reference period: 2016 – 2041*. https://www.abs.gov.au/.
62. ABS - Australian Bureau of Statistics (2019), *Household and Family Projections, Australia methodology. Reference period: 2016 – 2041*. https://www.abs.gov.au/methodologies/household-and-family-projections-australia-methodology/2016-2041
63. Alho J., Keilman N. (2010), *On future household structure*. Journal of the Royal Statistical Society Series A, 2010, vol. 173, Issue 1, 117-143.
64. Alho J.M. e Nikeer T. (2004), *Uncertain population of Europe - summary results from a stochastic forecast*. http://www.stat.fi/tup/euupe/rp_reports_e_pub.html.
65. Alho J.M., Spencer B.D. (2005), *Statistical demography and forecasting*. New York: Springer.
66. Bernard A., Bell M. (2012), *A Comparison of Internal Migration Age Profile Smoothing Methods*. Working Paper 2012/01. Queensle Centre for Population Research, The University of Queensle.
67. Billari, F.C., Corsetti G., Graziani R., Marsili M. e Melilli E. (2014), *Towards stochastic forecasts of the Italian population: an experiment with conditional expert elicitations*. Proceedings of the 6th Eurostat/UNECE Work Session on Demographic Projections, pagg. 326-338, Istat, 2014.
68. Billari, F.C., Corsetti G., Graziani R., Marsili M. e Melilli E. (2014), *A stochastic multi-regional model for Italian population projections*. Budapest, 25-28 giugno 2014, European Population Conference. http://epc2014.princeton.edu/papers/140361.
69. Billari, F.C., Graziani R. e Melilli E. (2012), *Stochastic population forecasts based on conditional expert opinions*. Journal of the Royal Statistical Society. Series A. 175(2): 491-511.
70. Blangiardo G., Barbiano di Belgiojoso E., Bonomi P. (2012), *Le previsioni demografiche delle famiglie*. In: Donati P. (a cura di), *La famiglia in Italia. Sfide sociali e innovazioni nei Servizi*. Osservatorio Nazionale sulla Famiglia. Rapporto biennale 2011-2012. Volume I Aspetti demografici, sociali e legislativi. Pagg 91-123.
71. Box G. E. P., Jenkins G. M., Reinsel G. C. and Ljung G. M. (2015), *Time Series Analysis: Forecasting and Control*, 5th Edition. Published by John Wiley and Sons Inc., Hoboken, New Jersey, pp. 712. ISBN: 978-1-118-67502-1.
72. Booth H. (2006), *Demographic forecasting: 1980 to 2005 in review*, International Journal of Forecasting, 22: 547–581.
73. Cooper J., Bell M. e Les M. (1995), *Household and Family forecasting Models: a review.* Review of IPC Long-Terrm Projections Model. Paper No. 3. Australian Housing and Urban Research institute in conjunction with Demographics Australia.
74. CBS (2011), *Key figures of the population forecasts 2010-2060*. Statline, Centraal Bureau voor der statistiek, http://statline.cbs.nl/statweb/.
75. Corsetti G., Marsili M. (2012), *A stochastic population projection from the perspective of a national statistical office*. European Population Conference. Stoccolma, 13-16 giugno 2012, EAPS. http://epc2012.princeton.edu/papers/120635.
76. Corsetti G., Marsili M. (2013), *Previsioni stocastiche della popolazione nell'ottica di un Istituto nazionale di statistica*. Rivista di statistica ufficiale, n. 2-3, p. 5-29, Istat.
77. Eurostat (2015), *People in the EU: who are we and how do we live?* - 2015 edition, Luxembourg: Publications Office of the European Union.
78. Eurostat (2020), *Methodology of the Eurostat population projections 2019-based (EUROPOP2019)*, Technical Note, Directorate of Social statistics, Population and migration, Luxembourg, 6 April 2020.
79. Graziani R., Keilman N. (2011), *The sensitivity of the Scaled Model of Error with respect to the choice of the correlation parameters: A simulation study*. Working Paper 37. Carlo F. Dondena Centre for Research on Social Dynamics, Università Bocconi, Milano.
80. Istat (1989), *Previsioni della popolazione residente per sesso, età e regione – Base 1.1.1988*, Note e Relazioni, n.4.

81. Istat (1997), *Previsioni della popolazione residente per sesso, età e regione – Base 1.1.1996*, Informazioni, n. 34.
82. Istat (1989), *Previsioni del numero di famiglie italiane dal 1995 al 2020*. Notiziario. Serie 4. Foglio 41 – Anno X No. 19. Dicembre 1989.
83. Istat (2001), *Previsioni della popolazione residente base 1° gennaio 2000*, Statistiche in breve, www.istat.it.
84. Istat (2003), *Previsioni della popolazione residente per sesso, età e regione, base 1.1.2001*, Informazioni n.13.
85. Istat (2006), *Previsioni demografiche nazionali 1° gennaio 2005-1° gennaio 2050*, www.istat.it, Nota informativa, 22 marzo 2006.
86. Istat (2008), *Previsioni demografiche 1° gennaio 2007-1° gennaio 2051*, www.istat.it, Nota Informativa, 19 giugno 2008.
87. Istat (2011), *Il futuro demografico del paese - Previsioni regionali della popolazione residente al 2065*, Statistiche Report, www.istat.it, 28 dicembre 2011.
88. Istat (2017), *Il futuro demografico del Paese – Previsioni regionali della popolazione residente al 2065*, Statistiche Report, www.istat.it, aprile 2017.
89. Istat (2018), *Il futuro demografico del Paese – Previsioni regionali della popolazione residente al 2065 – base 1.1.2017*", Statistiche Report, www.istat.it, maggio 2018.
90. Istat (2019), *Il futuro demografico del paese - Previsioni regionali della popolazione residente al 2065 – base 1.1.2018*, Nota metodologica, www.istat.it, ottobre 2019.
91. Istat (2021), *Ricostruzione della popolazione residente per sesso, età e comune, Anni 2002-2018*, Nota informativa, www.istat.it, marzo 2021.
92. Istat (2021), *Indicatori demografici – Anno 2020*, Statistiche Report, www.istat.it, 3 maggio 2021.
93. Keilman N. (2018) *Family Projection Methods: A Review*, March 2018, DOI: 10.1007/978-3-319-93227-9_12. In book: Analytical Family Demography. Publisher: Springer
94. Keilman, N. e Brunborg, H. (1995), *Household Projections for Norway, 1990-2020*, Part I: Macrosimulations, Statistics Norway, Oslo-Kongsvinger.
95. Keilman, N. Kuijsten A. and Vossen A. (1988), *Modelling Household Formation and dissolution*. Clarendon Press - Oxford.
96. Keilman N., Pham D.Q. e Hetle A. (2002), *Why population forecasts should be probabilistic - illustrated by the case of Norway*, Demographic Research, 6(15): 409-454.
97. Kono S. (1987), *The headshhip rate method for projecting households*, in Bongaarts J., Burch T., Wachter K., *Family Demography, Methodhs and their Applications*, Clarendon Press-Oxford.
98. Lavit, C. (1988), *Analyse conjointe de tableaux quantitatifs*, Masson, Paris.
99. Lavit, C., Escoufier, Y., Sabatier, R. and Traissac, P. (1994), *The ACT (Statis method)*. Computational Statistics and Data Analysis, Volume 18, Issue 1, 97–119.
100. Lee R.D. (1998), *Probabilistic Approaches to Population Forecasting,* Population e Development Review, 24: 156-190.
101. Lee R.D., Carter L.R. (1992), *Modeling and forecasting U.S. Mortality*, Journal of the American Statistical Association, September, vol. 87, n.419.
102. Lee R.D., Miller T. (2001), *Evaluating the performance of the Lee-Carter method for forecasting mortality*, Demography, November, vol. 39, p. 537-549.
103. Lutz, W., Sanderson W.C. e Scherbov S. (1998) *Expert-Based Probabilistic Population Projections*, Population e Development Review, 24: 139-155.
104. McDonald, P. and R. Kippen. (1998), *Household Trends and Projections: Victoria 1986–2011*. Canberra: Demography Program, The Australian National University.
105. Marsili M. (2007), *Demographic projections: the impact of net international migration on population ageing in Italy*, Atti del Convegno Intermedio della SIS 2007 "Rischio e Previsione", Università Ca' Foscari, Venezia, 6-8 giugno.
106. Marsili M. (2020) *Scenari demografici, previsioni per l'uso*, Atti della 13° Conferenza nazionale di statistica, Dall'incertezza alla decisione consapevole: un percorso da fare insieme, Roma, 4-6 luglio 2018, pagg. 246-252, Istat, 2020.

107. ONS – Office for National Statistics (2020), *Methodology used to produce household projections for England: 2018-based. User guidance about uses, methodology, assumptions and input data for household projections for England.* https://www.ons.gov.uk.

108. Paciorek, A. (2014), *The Long and the Short of Household Formation*. Real Estate Economics, Forthcoming, Available at SSRN: https://ssrn.com/abstract=2469334

109. Rogers A. (1985), *Regional Population Projection Models*. Beverly Hills. CA: Sage.

110. Rogers A., Castro L. (1981) *Model migration schedules*, International Institute for Applied System Analysis, Laxenberg, Austria, RR-8 1-30, November 1981.

111. Rowan S., Wright E. (2010), *Developing stochastic population forecasts for the United Kingdom: Progress report e plans for future work*. Eurostat-UNECE Work session on demographic projections, Lisbon, 28-30 aprile 2010, Methodologies e Working papers, Commissione Europea.

112. Schmertmann C.P. (2003), *A system of model fertility schedules with graphically intuitive parameters*, Demographic Research, 9(5): 81-110.

113. Shaw C. (2008), *The National Population Projections Expert Advisory Group: results from a questionnaire about future trends in fertility, mortality e migration*. Population trends n.134, Winter 2008, Office for national statistics.

114. Stoto, M. A. (1983), *The accuracy of population projections*. Journal of the American Statistical Association. 78: 13–20.

115. Tuljapurkar S., Lee R.D. e Li Q. (2004), *Random scenario forecast versus stochastic forecasts*. International Statistical Review. 72: 185–199.

116. Terra Abrami V. (1998), *Le previsioni demografiche*, Il Mulino, Bologna.

117. UNECE (2018), *Recommendations on Communicating Population Projections*, United nations economic commission for Europe, United Nations, New York and Geneva, agosto 2018.

118. United Nations(1973), *Methods of projecting households and families*, Manual VII, New York.

119. United Nations (2019), *World Population Prospects 2019: Methodology of the United Nations population estimates and projections*, Department of Economic and Social Affairs/Population Division, ST/ESA/SER.A/425.

120. Wilson T. (2013), *The sequential propensity household projection mode*, DEMOGRAPHIC RESEARCH VOLUME 28, Article 24, Pages 681-712, http://www.demographic-research.org/Volumes/Vol28/24/ DOI: 10.4054/DemRes.2013.28.24.

Note

[i] The contents of the paragraph refer to an *Experimental Statistic* in circulation from 29 November 2021. Considering the minimum territorial detail taken as a reference, the data commented on in it must be treated with extreme care, remembering that population projections become more uncertain the more one moves away from the starting point, especially in small geographical entities. It should also be stressed that population projections represent a what-if exercise. In other words, they are elaborations in which the calculations carried out show a particular evolution of the population which is the result of the specific assumptions adopted regarding the demographic behaviour. For information about the methodological process and for access to the database www.istat.it/it/statistiche-sperimentali.