## Regional population structures at a glance

Population ageing is a major demographic challenge for humanity. Since population structures evolve slowly and predictably, the demographic, economic, environmental, and social problems of ageing have been anticipated and discussed for many decades.1 Yet the focus of these discussions has always been the elderly population, with elderly people often defined as those older than a threshold-eq, 65 years or age at retirement—or with a certain number of estimated remaining years of life.<sup>2</sup> Such a focus is quite reasonable and understandable but not entirely correct. Ageing is not exclusively about the size of the elderly population or its proportion of a population; ageing is a function of the entire age distribution of a population. Therefore, to better understand ageing, we need to focus on the evolution of the age structure of the entire population, not just the elderly part.

We offer a new approach to investigate the diversity of population ageing in Europe. To map the whole population age structures rather than any single summary measure of ageing, we used ternary colour coding—a technique that maximises the amount of information conveved by colours. With this approach, each element of a three-dimensional array of compositional data is represented with a unique colour. The use of colour mixtures to encode multiple data dimensions in a single attribute has been proposed by various authors. To our knowledge, ternary colour coding was first used in the context of map design by Judy Olson.3 The approach has since been used to map election results in a three-party system,4 labour force composition by sector,<sup>5</sup> soil textures,<sup>6</sup> composition of arctic sea-ice coverage,7 and causeof-death compositions.8 We used colour coding to explore the differences in population structures across Europe and provide the tools that we developed<sup>9</sup> to streamline its use with R version 3.4.3.

The diverse picture of the colourcoded age structure of European regions (figure) indicates the varying stages of population ageing across Europe. The process of population ageing is not occurring uniformly in all areas of Europe<sup>11</sup> and regions differ substantially: eastern Europe is still undergoing demographic dividend, southern European regions are forming a cluster of lowest-low fertility, the baby boomers are ageing in western Europe, urban regions are attracting young professionals and forcing out young parents, and peripheral rural regions are losing their youths forever. Colour coding allows mapping of all regional population structures in Europe simultaneously. This map is not meant to easily inform the reader of the exact population structure in a specific region, rather, it provides a highly detailed snapshot of all the regional population structures, facilitating comparisons between them. One limitation of the approach is that the maps are not easily interpreted and usable by those who are colour blind; however, our generalised function that mixes colours9 makes it easy to change colours by rotating the colourspace, thus enabling those who are colour blind to use this setting more readily.

In the figure, we can clearly see large-scale and small-scale regional differences in population structures. At the macro level, the distinctions between eastern, western, and southern Europe are evident. Eastern Turkey is the only example of a society that is still at the early stages of demographic transition. At the country level, the centre-periphery contrasts are prominent. We can easily spot all capital regions and major urban areas that have a large working-age population, and their surrounding areas where families with kids tend to settle (ie, the suburbs of Paris). The

population of the remote periphery ages at an accelerated pace because of out-migration of young individuals. Country borders are highly important because they often demarcate territories with different demographic histories (ie, Germany-Poland border). The map also reveals the signs of recent changes in population structures. For example, Spain received a large influx of international migrants in the 2000s,12 eastern Germany experienced a draining effect of out-migration coupled with a decrease in fertility in the past few decades,13 and Poland has had a massive labour out-migration because of European Union integration and more labour migrants moved from major Polish cities.14 This map is a snapshot of the European population at the regional level, and it tells numerous demographic stories.

Ternary colour coding is a useful and intuitive way of simultaneously displaying three-component compositions. We strongly propose a wide use of the presented approach.

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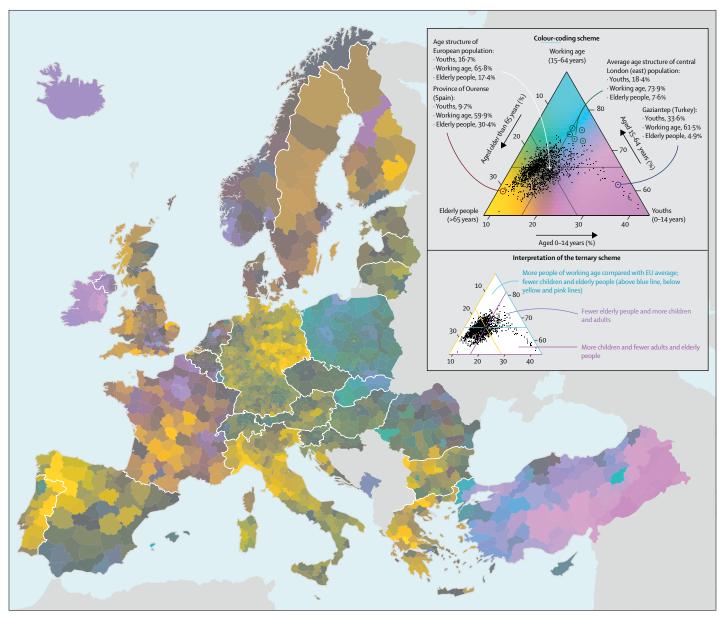


Figure: Colour-coded map of population structures in European Nomenclature of Territorial Units for Statistics 3 regions in 2015

Each population composition in the European Nomenclature of Territorial Units for Statistics 3 regions is uniquely colour coded. Colours show direction and magnitude of deviations from the centrepoint, which represents the average age of the European population, and is dark grey. The hue component of a colour encodes the direction of deviation: yellow indicates an elderly population (>65 years), cyan indicates people of working age (15–64 years), and magenta indicates children (0–14 years). Chroma and lightness components signify the distance from the centre ranging from desaturated and dark colours near the centre to vivid and bright colours at the corners. We provide R code to fully reproduce this map.<sup>10</sup>

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