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CONTRIBUTED PAPER

Inequality – actuarial perspectives

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Abstract

Inequality is an inherent quality of society. This paper provides actuarial insights into the recognition, measurement, and consequences of inequality. Key underlying concepts are discussed, with an emphasis on the distinction between inequality of opportunity and inequality of outcome. To better design and maintain approaches and programmes that mitigate its adverse effects, it is important to understand its contributing causes. The paper outlines strategies for reflecting on and addressing inequality in actuarial practice. Actuaries are encouraged to work with policymakers, employers, providers, regulators, and individuals in the design and management of sustainable programmes to address some of the critical issues associated with inequality. These programmes can encourage more equal opportunities and protect against the adverse financial effects of outcomes.

Keywords: Inequality; Mortality differentials; Morbidity differentials; Social security programmes

1. Introduction

Individuals[1] and population segments have different characteristics, experiences, histories, and expectations. These can lead to social inequality (hereafter referred to as "inequality"), where differing socioeconomic and demographic population segments have different financial and social conditions, including income, wealth, opportunities, and rewards. These, in turn, can result in a range of morbidity and mortality outcomes and affect how people see themselves and act toward others.

This paper, motivated by the wide gaps in inequality outcomes by socioeconomic status in many countries, provides actuarial perspectives on the recognition, measurement, and consequences of inequality, as well as approaches used to reduce its impacts. The objective is to discuss and provide actuarial insights into social, financial, and economic aspects of inequality and its outcomes.

The fundamental concepts underlying the understanding, measurements, analysis, and effects of inequality are presented. Section 1 describes the characteristics and drivers of inequality, the metrics used to measure it, and the consequences of inequality, including related topics such as fairness, discrimination, inequality of opportunity, inequality of outcomes, and the distinction between relative and absolute inequality.

Section 2 focuses on inequality's effects, implications, metrics, and drivers, addressing its adverse impacts on society and individuals, particularly in relation to poverty. The considered aspects include income and wealth, locale, life expectancy, mortality, morbidity, and educational attainment. Section 3 relates inequality trends to actuarial assumptions and approaches and Section 4 examines approaches that can mitigate the adverse effects of inequality, including

[1]"Individuals" and "population segments" in this paper may also apply to households, businesses or other entities, regions, and countries.

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education, social security, and healthcare programmes. While most actuaries work in the private sector, public programmes often provide the most effective solutions to inequality-related issues, as affordability concerns can hinder private sector solutions; hence, our emphasis on public inequality solutions. The paper focuses on the causes and effects in areas where actuaries practice can provide helpful insights and practical solutions, summarising the role of actuaries vis-à-vis inequality.

The intended audiences for this paper include actuaries, with an emphasis on public sector actuaries, as well as decision-makers and stakeholders of systems serviced by actuaries, such as insurers, reinsurers, regulators, government agencies, policymakers, and interested members of the public.

2. Inequality Effects, Metrics, and Drivers

Inequality, as measured by income and wealth, or as evident in pervasive inequities in access to education, healthcare, and opportunities, can adversely affect individuals, society, and the economy (Piketty, 2013). Historically, many wars, civil disturbances, revolutions, and genocides were caused, in part, by forces generated by actual or perceived inequality. Some social policies, such as social security, minimum wages, and laws addressing discrimination against population segments, have also been partly or wholly triggered by inequality-related issues.

A moderate level of inequality can benefit an individual, society, or economy if it creates an incentive to strive for excellence and take risks. However, inequality has been considerable and even increasing in many countries where such incentives are seemingly out of reach. According to the International Monetary Fund (2017), seven out of ten people live in countries where income inequality has risen over the last thirty or more years. The COVID-19 pandemic demonstrated anew the adverse effects of inequality through the lack of access to protective resources and vaccines for some populations, resulting in a greater number of deaths.

The good news is that, despite increases in inequality in many countries, numerous individuals are better off today, measured by income, wealth, or educational achievements, than they would have been several decades ago. According to the World Bank (2024), there was an impressive reduction globally between 1990 and 2024 in extreme poverty,[2] from about 36% of the population to about 8.5%. Over the past four decades in China and India, about 1.1 billion people have been lifted above the extreme poverty line. However, overall, the rate of decline has slowed in the last decade.

The 2030 Agenda for Sustainable Development – the United Nations' blueprint for a better and more sustainable future – calls for a reduction in inequality both between and within countries[3]. The International Labor Organization (ILO, 2019) concluded that, although technological innovations are providing "countless opportunities" for workers, unless these are deployed by a human-centred agenda that invests in people, work institutions, and decent, sustainable employment, the risk exists of "sleepwalking into a world that widens existing inequalities and uncertainties."

Various disciplines, including economics, law, sociology, philosophy, and politics have addressed inequality and its implications. Actuaries, who are extensively involved in managing financial institutions and public programmes and are concerned with quantifying financial and demographic risks, have a special interest in inequality and its impacts. Particular focus is thus

[2]Extreme poverty is the most severe type of poverty, defined by the United Nations as "a condition characterised by severe deprivation of basic human needs, including food, safe drinking water, sanitation facilities, health, shelter, education and information". The World Bank defined it as *people living in 2024 on less than US$2.15 a day.*

[3]United Nations' Sustainable Development Goal (SDG) 10, *Reduce inequality within and among countries,* and SDG 5, *Achieve gender equality and empower all women and girls.*

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given here to the role that actuaries can play in the design and management of programmes and products aimed at offsetting some of the effects and consequences of inequality.

2.1. Inequality Concepts and Assessment

2.1.1. Inequality of Opportunity and Inequality of Outcomes

A key concept underlying discussions of inequality is the distinction between inequality of opportunity (ex-ante – potential) and inequality of outcomes (ex-post – actual results). The former represents the condition of having an equal starting point, expectation, or access, that is, a level playing field, without undue disadvantages for an individual or group because of their status, experience, institutional constraints, or regulations. Inequality of outcomes focuses on the range of consequences for a specific group of individuals or a population segment, whether the outcomes are measured in terms of economic performance, progress, education, or mortality. These outcomes can be of considerable concern or benefit to those directly affected or to others. Society and actuarial practice are affected by both types of inequality.

Fleurbaey and Peragine (2013) show how both ex-ante and ex-post concepts relate to the fairness of sources of individual achievements, where unfavourable outcomes due to circumstances (e.g., social background or inheritance) are considered unfair and less desirable than compensated outcomes resulting from differences in unequal efforts and personal responsibility. This is partly due to the exclusion or inability of a population group to participate in educational, social, or economic life, constraining growth and development. They also present evidence that people living in a land of equal opportunities do not favour redistribution, a typical ex-ante inequality solution. This, together with the relative ease of managing ex-post solutions, may explain why public programmes tend to offer inequality-related solutions.

Rawls (2001) indicated that inequality of opportunity, which may be subject to factors such as sex, location, ethnicity, or family, can be at least as important from both an individual and societal viewpoint as inequality of outcomes that can arise from a combination of natural endowments, opportunities, and individual efforts, or random events.

"The rich get richer while the poor get poorer" – an old expression, but often true, as those in the lowest income or wealth quantile(s) can find it hard to overcome disadvantages. This can result from a lack of access to high-quality healthcare and education, malnutrition, weak infrastructure, and inadequate public transportation. Other implicit factors, such as limited contact with others or lack of personal networks, can be difficult to measure. Now that the Internet, mobile phones, social media, and artificial intelligence make accessing information regarding those in better circumstances easier, greater frustrations regarding inequality will become even more widely apparent.

Some factors, such as educational attainment, involve elements of both inequality of opportunity and inequality of outcomes. Therefore, it can be essential to focus on both equal opportunity and equal outcomes wherever possible. According to Atkinson (2015), although opportunity may be most important from a societal viewpoint, today's inequality of outcomes can shape and affect tomorrow's inequality of opportunities. For example, in a defined benefit pension programme with benefits equal to a given percentage of wages, the person with lower wages will earn a lower pension income. Similarly, low-income families can become locked in the cycle of poverty, as they lack the resources and education necessary to escape poverty.

2.1.2. Fairness, Discrimination, and Inequity

Fairness can be assessed in the context of a system of values influenced by society's attitudes and cultural mores, as well as those of the individuals or groups involved. As such, it is largely subjective, and it is rare for anything to be entirely fair to everyone. Nevertheless, some value fairness over equality, especially where success is a function of talent and effort.

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Fairness concerns have often been raised about wage gaps and other differential treatments concerning sex, minorities, or other population segments. For example, women have often been underpaid compared to men for similar work. Today, some laws require disclosure of, or even limit, the ratio of the highest remuneration level in certain public companies to the average or lowest salary in these organisations.

In contrast to these social constructs, "actuarial fairness" focuses on the prices and expected costs of covered risks associated with financial products (such as insurance), thereby achieving individual equity (American Academy of Actuaries, 2011). Such prices are more likely to be understood than subsidy-based and socially adequate prices that strive to make affordable coverage available to all or most of a particular group.

A related concept is inequity, defined by Global Health Europe (2009) as "unfair, avoidable differences arising from cultural biases developed over time, poor public governance, corruption or cultural exclusion, or an indefensible result of human failure, invoking a moral outrage." Inequality can be viewed as being natural, while inequity is viewed as being human-made, often associated with ex-post inequality resulting from cultural, social, economic, or regulatory actions. Determining the relative contributions of nature and nurture can be complex, involving not only statistical calculations but also ethical, moral, and legal considerations.

2.1.3. Assessing Inequality and Its Consequences

In assessing inequality and its consequences, the emphasis is on differences in characteristics between and within alternative categorizations of population segments, as well as on trends in these differences and alternatives. Actuarial analysis is usually conducted on an ex-ante or expected basis, accompanied by documentation of the choices made. To this end, a series of questions should be addressed in the context and objectives of the analysis, as summarised in Figure 1.

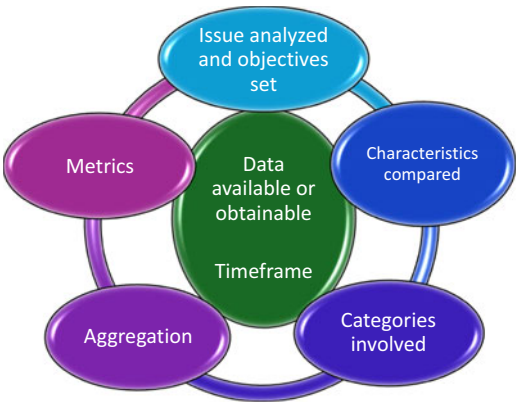


Figure 1. Framework for inequality analysis.

These questions include, among others:

What are the *objective(s)* of the analysis?

- Who are the stakeholders and intended (and unintended) users?
- What is the inequality being studied, for example, of income, wealth, health, longevity, or happiness?
- Is it an assessment of a particular inequality, related inequities, or their causes, outcomes, or consequences?

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- What will be the planned use of the analysis, e.g., as an input to the cost-benefit analysis of a public policy decision, the establishment of the price of a product, an assessment of the compensation structure of a financial institution, or the quality of a public health or educational system?
- What form will it take – analytical comparison, qualitative analysis, or both?

What *characteristic(s)* are being compared?

- What characteristics of individuals or groups are being compared? Multiple characteristics, such as social or economic characteristics, may be used, as well as those related to mortality and morbidity risks.
- Economic characteristics can include income (e.g., wages, self-employment profits, investment income, private or public social transfer benefits, public goods, and services), wealth, or consumption. They can be measured on a per-capita or per-household basis.
- Gross Domestic Product (GDP) per capita is often used as a proxy for income, as it can be readily available on a national level.
- In longitudinal analyses, adjustment may be appropriate, for example, for changes in inflation, relative currency values, consumption patterns, purchasing power, population dynamics, and demographic factors.
- Alternative definitions of characteristics may be better associated with inequality measures and trends (Rose, 2018). For example, deducting taxes and transfer payments can considerably reduce reported income inequality; in some cases, the Gini coefficient (index) can decrease by up to a third when comparing income on a before and after-tax basis.

What are the *categories* or groupings of interest?

- Population segments can be based, for example, on age, sex, marital status, language, religion, range of income or wealth, race/ethnicity, type of location, extent of debt, disability, or employment status.
- Both income and wealth measure economic status, with income measured over a time period and wealth being a point-in-time measure.
- Some categories can be clearly defined (e.g., birth cohort), while others are fuzzy or continuous (e.g., economic status) or even ill-defined (e.g., ethnic group).

What are the *aggregations* or ranges of values of the categories over which the characteristic(s) are compared?

- Examples of units include income, age, and geographical ranges (e.g., global, national, or local).
- Level of aggregation can change the findings of an analysis, both within and across countries, because of differences in, for example, definitions and scope of measures, fixed costs, standards of living, tax systems, social benefits (e.g., access to or quality of healthcare or education), and labour market regulations.

What *metrics* are used?

- Several metrics or methodologies may be used to measure the extent of inequality. For example, the average value, the median value, or the Gini coefficient.
- Inequality of opportunity can be especially difficult to measure, partly because it represents potential rather than actual outcomes – thus, it may not be directly observable. Proxies are often used.

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What *data*/*information* are available or obtainable?

- The availability, quality, reliability, relevance, and objective nature of the data or information used in the analysis are of central importance.
- Relevant and reliable data being accurate, clear, timely, consistent over time and space, credible, and with minimal response bias may be difficult to obtain. This may especially occur when dealing with individuals of extremely high or low income or wealth, and in lengthy or multinational studies.
- The most appropriate source(s) of data may depend upon the application. They can include, for example, tax records, surveys, or insurance records.
- In many cases, income or wealth may be underreported because of the use of offshore accounts, gig or informal work, subsidies, or the absence of accurate tax filings. Objectively derived data, such as that obtained through professional measurement or from birth certificates, are preferable to self-reported data, although the latter may be more readily available. If appropriate, estimates or adjustments may be necessary.
- Significant changes in conditions or the economic or social environment over the covered period(s), especially if volatility, asymmetry, or non-linearities are involved, can affect data or suggest needed adjustments.

What *timeframe* is involved?

- Populations, societies, and markets change. Although the past can often provide useful information, it may represent a biased indicator(s) of the future unless adjusted.
- The selected period studied depends on the objective(s) of the analysis, what is being studied, available and comparable reliable information, and the underlying drivers and trends.
- It is important, where practical, to use data from the same or similar periods. If cycles have occurred, experience for complete cycles should be included. Comparisons over more extended periods are often more appropriate than short-term comparisons, except when significant changes in drivers or conditions occur over a longer period.
- Careful consideration or adjustment may be needed if a discontinuity or change event has occurred, because conditions before and after it may not be comparable. For example, technological discontinuities (e.g., the introduction of the mobile phone, internet, armed conflict, or a pharmaceutical advance) can bring with them so much change that simple extrapolations from pre-discontinuity conditions may be inappropriate or misleading.

The perspectives of prospective stakeholders should be considered in determining prioritisation and tradeoffs among actions and their implementation. For example, should inequality be considered from the perspective of those in the bottom quantile or from society as a whole? Are differential subsidies or incentives justifiable between individuals or groups? For example, do they result in a greater reward for taking on greater risks that may benefit society as a whole?

To remain objective, multiple approaches, analytical methods, viewpoints, or scenarios should be considered to develop a clear, comprehensive, and objective assessment.

2.2. Metrics of Inequality, Modelling, Aggregation, and Grouping

It is essential to use relevant metrics and assess the quality and consistency of the underlying data used to analyse the extent of inequality and its consequences. This is especially true because much of the publicly available information regarding inequality can be misleading, mean different things to different people, or be derived from inconsistent sources. Further, applying multiple metrics or multiple data sets may help ensure an unbiased analysis.

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Many of the metrics used are standard statistical and economic measures, while others are more inequality-specific. Several texts, including those by the Haughton and Khandkep (2009), Cowell (2011) and Cowell et al. (2017), provide detailed discussions of these metrics. Visual data comparisons can lead to enhanced insights, even when less statistically rigorous. Consistent with actuarial standards of practice[4], actuaries may find it useful to discuss and be transparent with non-actuaries about how these metrics, considerations, and practices are applied.

The following are commonly used metrics and techniques employed in the study of inequality:

- Statistical measures include range, average (statistical mean), median (the 50th percentile value), mode (the most common value), percentile (a specified percentage of the probability distribution), standard deviation, coefficient of variation (a volatility measure), and regression coefficients.
- Both the range and shape of the distribution of the item measured can be important. For example, the distribution of incomes in a highly unequal society is quite different from that of a population with a solid middle class.
- Quantile (e.g., quartiles, quintiles, deciles) segments, the sorted values of the observed data into equal parts, can be usefully compared. A q-quantile divides the data into q parts. An inter-quantile range eliminates the top and bottom quantiles, focusing on the core of the distribution. The top quartile is the highest quantile of a distribution; for example, inequality can be expressed in terms of the percentage share of total income or wealth of the highest-income group.
- Ratios of values of one quantile relative to corresponding values of a different quantile. For example, the Palma ratio (Tutor2u, 2023) is the ratio of the top decile to the bottom four deciles.

According to Cowell (2011), there are four desirable properties for an inequality measure:

- Transfers: A reduction in inequality occurs when income transfers from the rich to the poor (the rich become not-so-rich, and the poor become not-so-poor).
- Independence: Inequality does not change when everyone's income is changed while leaving the individual's share unchanged.
- Scale: Inequality should not depend on the size of the population; for example, when doubling the population, the inequality remains unchanged.
- Decomposability: Inequality remains the same within subgroups of the population.

Three ways to look at inequality are:

- The social welfare function (Haughton and Khandkep, 2009) considers how society treats and prioritises welfare, similar to social utility:

$$W(y_1, y_2, \cdots, y_n) = \sum_{i=1}^{n} U(y_i) \tag{1}$$

  where $U(y)$ is the utility of the welfare form (or the individual) or its aversion to inequality. A related approach uses, for example, a measure of relative wage inequality within a firm, computed as the ratio of the wage of the top-earning employee to the firm's median wage. This has been used to assess the reasonableness of the wages of the highest-earning employees of a firm.

[4]See International Actuarial Association, International Actuarial Standard of Practice 1, *General Actuarial Practice*.

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- Information theory builds measures of inequality by analogy between the probabilities of events (in the range of 0 to 1) and shares of income, used as weights in a valuation.
- The structural approach builds on axioms and principles essential in developing an index of inequality.

The Gini coefficient (Gini, 1912) is a primary measure of the statistical dispersion of a characteristic such as income or wealth. It measures the concentration of a metric in a population commonly used to assess the extent of a population's inequality.

- Its value ranges from 0.0 (perfect equality, e.g., where all population members have the same income) to 1.0 (perfect inequality, e.g., where one person earns all the income). A Lorenz curve can represent it, a graphical representation of the distribution of income (or wealth) within a population, where percentiles of the population are plotted against the cumulative income of those at or below that percentile. The more income (wealth) is equally distributed, the closer this curve is to the 45° line. Conversely, the more unequal the income (wealth) distribution, the more concave it will be.
- However, a low Gini coefficient does not always indicate a low level of inequality. For example, the income Gini for Sweden is low (about 0.30 in 2021), while its wealth Gini is high (about 0.88 in 2021). In Sweden, considerable social welfare benefits are available, home ownership is relatively low, and earned income is heavily taxed. As a result, non-earned income (wealth in various forms) tends to be underestimated in income Gini, although it affects wealth Gini (Cowell, 2011; Cowell et al., 2017).

Social inequality, as well as disease prevalence or life expectancy, is sometimes expressed in terms of its "relative" and "absolute" aspects. Absolute inequality is calculated by subtracting the value of one group from another. Relative inequality shows the proportional difference between the values of subgroups (Harper & Lynch, 2006).

From information theory, entropy measures the degree of randomness in a set of information. Entropy means disorder and chaos. Several measures of entropy can be applied to inequality, for example:

- Theil's index (Theil, 1967) is a special case of the entropy function, designed for (economic) inequality purposes by measuring how far the observed entropy "distance" the population is from the lowest possible entropy (reached if all individuals have the same income).
- Mean logarithmic deviation index, the average of the log of each group's average income divided by the group income, is another measure of income inequality that equals zero when all incomes are equal and increases as incomes become more unequal. It is used to decompose population inequality into inequality within and between groups, and is sensitive to changes in the lower tail of the distribution.

Actuaries often compare the mortality of population segments, for example, relative patterns of female-to-male mortality or the ratio of the age-adjusted mortality of subpopulations with different characteristics (e.g., medical conditions, income, or level of education). These comparisons can use a standard set of weights corresponding to a given population at a specified time with the same mix of characteristics, such as sex or smoking status. Similar measures can be applied to disability, morbidity, and longevity. Note that the inequality within a subgroup or population segment can also be significant—this may be gleaned through multivariate analysis or predictive analytical methods.

A model of inequality can be quite complex, involving several variables or a combination of variables. However, a concern with overly complex models is that they can over-fit the data; that is, they may not capture the most important relationships or patterns and may not be helpful for

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forecasting. A modeller needs to keep in mind the 80/20 Pareto rule (also known as the Pareto Principle (SixSigma.us, 2021)), which suggests that for many studies, roughly 80% of the effects can be identified or resolved by analysing 20% of the causes, or 80% of the modelling effort can be expended to explain 20% of the relevant findings.

Some mortality analyses have examined the extent of population heterogeneity by analysing the distribution and standard deviation of, for example, age at death. In some cases, actuaries can reduce the overall standard deviation in their models by recognising inequalities, additional variables, causes of death, or subgroups.

Using multiple/proxy measures, ranges, distribution shapes, clusters, groupings, time periods, or alternative scenarios can enhance many analyses. For example, while age-standardised mortality of the U.S. Hispanic population has generally been reported to be lower than the corresponding mortality of the U.S. non-Hispanic White population (referred to as the Hispanic mortality paradox), differences in smoking prevalence and mix of native-born and immigrant populations may explain a portion of this difference (Fenelon, 2013). This example may enhance the understanding of the inequality within or between these groups by simultaneously comparing mortality outcomes while considering ethnic, smoking, and immigration characteristics.

Groups of individuals with one or more similar characteristics (e.g., income, age, sex, location, and country) might be combined with respect to these characteristics to increase the credibility of the data being assessed. In other words, aggregation and grouping may be appropriate or desirable. Predictive analytics can also be useful. Alternative groupings can be based on different characteristics. In any case, care is needed since the use of alternative groupings may affect the findings.

Illustrating possible misleading impacts of aggregation, in the first half of the twentieth century, different levels of inequality would have been found in certain European countries if the population from their colonies (with free movement of people) were combined with that of the colonising countries. Further, the range of average income between countries can be quite large, which can complicate comparisons both between and within multinational blocks, such as the Organization for Economic Co-operation and Development (OECD), the European Union (EU), and the Association of Southeast Asian Nations (ASEAN).

2.3. Drivers of Inequality

There are multiple drivers of inequality, the mix and importance of which can differ by country, region, population segment, and time. Their interactions can result in high and unstable correlations, as well as partial and reverse causations, which may change over time. This complexity and interactions can contribute to difficulty in determining the primary driver(s) and relations. For example, the causal relationships between income inequality, mortality, and self-rated health (Shimonovich et al., 2022) suggest the use of more complex indicators and the aggregation of several individual factors, which can be identified through multivariate analysis or predictive analytics.

The structure of the economy and the labour market can significantly impact inequality. Technological advancements enable shifts in economic status and job roles, propelling society through stages of agriculture, industry, service, and information. Each development stage alters the nature of employment, leading to shifts in the required skill mix and increased unemployment when mismatches occur. For example, the transition from agricultural to industrial jobs usually decreases the number of rural jobs and increases the number of generally higher-paid middle-class jobs, may result in a decrease in inequality.

The shift to service and information-based jobs in many countries has had several consequences, including an initial increase in lower-skilled jobs, sometimes followed by a decrease as these jobs are taken on by robotics and other technologies, and simultaneously fewer, but higher-skilled and compensated jobs. Similar developments are expected from the recent

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introduction of artificial intelligence, though it is too early to estimate its impact. These changes have, overall, increased inequality within the labour force.

Christine Lagarde, then head of the International Monetary Fund, indicated in 2015 that IMF research showed that less inequality is associated with greater macroeconomic stability and sustainable growth; if the income share of the poor and middle class is increased by 1 percentage point, GDP growth *increases* by as much as 0.38 percentage points over five years (Lagarde, 2015).

Considering inequality within countries, Milanovic (2016) pointed out that there have been two basic views regarding why inequality decreased in the twentieth century:

- Structural, promoted by Kuznets (1955), including
  - economic forces, including urbanisation and industrialisation
  - expanded educational attainment
  - other public or community services and support
  - population aging increases demand for social retirement security and public healthcare, which can result in greater taxation or lower quality services
  - widespread subsidies and social assistance/welfare/care to help overcome the unaffordability of essential services
  - social cohesion that helps a society in times of war or depression.
- Political, espoused by Piketty (2013), includes wars (especially in Europe) requiring greater taxation, asset depletion in economic depressions (sharply reducing asset values and wealth), and pro-labour legislation.

The Kuznets (1955) hypothesis suggests that, on a macro level, as countries industrialise and incomes increase, their inequality will initially rise (due to the increasing productivity associated with more heterogeneous occupations) and then decrease (once traditional workers become a minority of the working population).

Milanovic (2016a and 2016b) suggested that there have been two Kuznets waves, with the first occurring between about 1850 and 1912 and a second upswing since the 1980s, reflecting rapid technological changes in many higher-income countries. This transition has led to a shift from manufacturing jobs to those in service, information, and communications. Economic resources and consequential wealth have been increasingly concentrated in the hands of the owners of capital, while labour has tended, on average, to become relatively poorer, thereby increasing inequality.

Milanovic (2023) categorised global inequality into three eras:

(1) An increase between the industrial revolution in the early 19th century to the middle of the 20th century, driven by widening gaps between and within countries, especially between the industrialised world and the rest
(2) A further increase to the end of the century, characterised by a reduction in inequality within countries, which peaked around 1988 with the rise of a middle class and a welfare state in many countries
(3) Since around 2000, there has been a reduction in inequalities between countries due mainly to the economic rise of China, from a Gini coefficient of 0.694 in 1988 to 0.601 in 2018. Milanovic observed that historically, people of lower income in the rich world were better off than many in the rest of the world. In any case, vast income and wealth differences can hinder both economic progress and democracy.

At a macro-level, Milanovic (2016) suggested five factors that work toward further increases in inequality in the United States, which are likely to also apply to many other countries:

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1. Continued substitution of labour with capital, recently through the use of technologies such as artificial intelligence and robotics
2. Increasing concentration of capital income
3. Labour income and capital income increasingly captured by the same individuals
4. Marriage/partnerships of highly skilled or knowledgeable individuals
5. Concentration of income/wealth of individuals, reinforcing the political and economic power.

According to Bourguignon (2017), globalisation (especially in supply chains) and skill-biased technological progress are responsible for an increase in the share of total income going to capital and for slow growth in the employment and wages of unskilled labour in developed countries (job migration, e.g., janitors, security support, and caregivers). However, in some countries, labour shortages in these areas have driven up immigration and wages and have reduced inequality.

There has been considerable debate regarding whether globalisation or technological advancements are more significant in driving inequality. Although the effect of these factors differs by industry sector and country, Bourguignon believes technological change has been more significant.

In some cases, conditions underlying one set of inequalities lead to a different set in subsequent generations. For example, the rich are often favoured because they receive both higher labour and capital income. As a result, inequality of wealth tends to increase and is usually greater than inequality of income. In contrast, if some drivers of inequality are eliminated, it may lead to a reduction in other drivers of inequality. For example, an emphasis on required or universal education in one generation can lead to greater financial success in the next one through intergenerational income elasticity, but limited education can lead to the opposite situation.

Drivers of inequality include several factors over which an individual has no or limited control, such as date of birth (age), sex at birth, household background, inherited genetic traits, racial/ethnic identity, and chance. In contrast, an individual can have limited or complete control over other relevant factors, including their attained level of education, willingness and ambition to work harder, longer hours, or over a longer period, preparedness to take risks or be innovative, lifestyle choices, and desire to save rather than consume.

Epidemics and pandemics usually increase inequality and can have a considerable effect on the number of people in poverty, disproportionately affecting households with lower incomes and small businesses. As Sanches-Paramo et al. (2021) note, the COVID-19 pandemic "has translated into a sharp increase in global poverty. About 97 million more people are living on less than $1.90 a day because of the pandemic, increasing the global poverty rate from 7.8 to 9.1%; 163 million more are living on less than $5.50 a day."

Other drivers of inequality include socioeconomic status, including racial and ethnic characteristics; immigrant status and source of immigration; marital status, income/wealth/inheritance, disability/health, educational attainment, employment status, and occupation; family status, structure, and stability; relationship between workers and firms; quality, accessibility, and cost of social, healthcare, and educational services, public policy decisions; and location.

2.3.1. Drivers of Retirement Income Inequality

Discussing the drivers of retirement income inequality can help demonstrate and clarify the concepts mentioned above. Retirement is generally associated with a reduction, often significant, of the retiree's income compared with income while working. Further, retirement and aging are often accompanied by lifestyle changes, such as adapting to a lower income and increasing healthcare costs. In contrast, retirement income remains relatively unchanged, resulting in 78% of Americans struggling to fund their retirement plans (Robinson & Smith, 2024), which contributes to inequality. In an American Academy of Actuaries et al. (2017) survey, more than half of

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respondents in Australia, the United States, and the U.K. indicated they expect a less-than-comfortable retirement, with as many as a third planning never to fully retire and continue working throughout their lifetimes. This process is accelerating in many countries as populations age and people live longer, with employment patterns and stability changing rapidly.

Although retirement income inequality challenges differ around the globe, there are several common drivers, including:

- Saving for retirement while working: Those with smaller incomes have less discretionary income to contribute to retirement savings than others. Increases in home prices keep a larger portion of the population out of the housing market, thus reducing the availability of home equity that can be used to finance retirement. Although those who have accumulated a nest egg for retirement may have available savings and investment options, many may discount the advantage of lifetime income guarantees (such as through annuities) in comparison with current consumption, partly due to a lack of financial knowledge, time, and means to pay for appropriate expertise to advise them regarding what is best for their situation.
- Work/income patterns: Women who balance working, child-rearing, and caring for parents are more likely to experience volatile work patterns and earnings. Less educated individuals tend to have lower-paying jobs and more intermittent paid work, which leads to increased challenges in accumulating savings or pension benefits.
- Family structure: The family has traditionally been a primary source of retirement security, forcing seniors without supportive families to be more self-sufficient. Evolving family structures around the world, including increases in dual-income households, single parenthood or not having children, divorces, changes in family and personal relationships, and further urbanisation, will affect inequality and its consequences.

2.4. Inequality and Poverty: Relative and Absolute Concepts

Arguably, poverty can represent a more severe economic and moral problem than inequality. Both, however, can raise questions concerning the fairness of the system people live in, such as whether economic unfairness resulting in low social mobility is more important than income and wealth inequality (i.e., are fair ex-ante opportunities more valuable than ex-post equality outcomes?). According to Andrews and Leigh (2009), "inequality may be more acceptable in a society with a high level of social mobility ... [and] moving from rags to riches is harder in more unequal countries".

Inequality, by definition, is a relative concept. If everyone in a population progresses or regresses consistently according to a specific metric, there is no change in inequality within that population. In contrast, other characteristics such as sex, geographical location, and health status are absolute characteristics, although their meaning or value can vary. There are also hybrid concepts such as poverty, which, although its definition can depend upon an absolute criterion (e.g., inability to attain a minimum standard of living for survival, such as a specified income or wealth for a household of four), also contains a relative aspect (e.g., when compared with the average standard of living in a community). In addition, it can change over time and location; for example, smartphone ownership may be viewed as a luxury in one community and a necessity in another.

Most people compare themselves to their peer group or neighbours. The poor in one country might be considered rich in another, although they may still feel poor. Poverty should thus be viewed in the context of the benchmark used for comparison.

Economic inequality and poverty are, of course, highly interconnected, representing different aspects of the same issue, as those in poverty are typically located in the lowest part of the income

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or wealth distribution. However, economic inequality can exist without poverty if everyone in a community lives above the defined poverty line. In contrast, if no one is living above this poverty line, everyone is in poverty. For example, the Gini coefficients for Bangladesh and Japan are fairly similar (0.33); however, the average annual income in Bangladesh is about US$2,900, compared to about US$39,000 in Japan.[5]

Poverty is usually associated with a lack of social cohesion, poor health, lack of quality housing, inadequate public education, apprenticeship training and opportunity for the individual, expensive childcare, and high crime and rates of incarceration. Governments can take responsibility for helping to overcome these challenges by addressing essential functions such as healthcare, housing, education, public transportation, and ensuring personal safety. People with low incomes are also subject to greater financial instability, food insecurity, and mental stress, partly because of their limited contingency resources.

The doctrine of sufficiency (Frankfurt, 1987) suggests that what is important to the individual is not relative economic equality, but rather the extent to which an individual has "enough," a non-comparative standard of acceptance of a person's circumstances in the context of personal goals. In other words, everyone should have enough to satisfy their fundamental human needs, rather than comparing themselves to or competing with others. Still, the alternative comparative approach is used quite often, for example, by the OECD.

The comparative approach often quantifies and compares characteristics and the extent of poverty by using a deprivation index that aggregates several factors that, in combination, capture key characteristics of poverty in a population. There are several such measures, such as the United Nations' Multidimensional Poverty Index (MPI) used by the United Nations Development Programme and the Oxford Poverty and Human Development Initiative 2019. The MPI is composed of ten indicators, weighted by health (1/3 for malnutrition and death of a child under 18 in the last five years), education (1/3 for years of schooling and school underattendance), and standard of living (1/3 for cooking fuel, sanitation, drinking water, electricity, housing, and home assets). Based on surveys conducted between 2011 and 2022 (UNDP, 2024) across 110 countries, about 1.1 billion people (18% of the global population of 6.2 billion) are multidimensionally poor.

There is a large variation in multidimensional poverty. Half of those who are multidimensionally poor are children under age 18, while a third are children under age 10. In addition, there is little or no association between economic inequality (measured by the Gini coefficient) and the corresponding MPI value. In the ten selected countries for which changes over time were analysed, deprivation declined faster among the poorest 40% of the population than among the total population.

Another composite index is the Human Development Index (HDI), which is the geometric mean of three factors:

(1) Health as assessed by life expectancy at birth
(2) Education as measured by the mean years of schooling for adults aged 25 years and older and expected years of education for children of school-entering age
(3) Standard of living as measured by gross national income (GNI) per capita. HDI uses the logarithm of income to reflect the diminishing importance of income with increasing GNI. It can be used to assess the overall socioeconomic status of a population and better understand trends in mortality and markets for products of financial institutions.

Currently, the most commonly used international threshold for extreme poverty is defined by the World Bank (2024) as income of less than US$2.15/day per person in 2025. The vast majority reside in Sub-Saharan Africa and South Asia. The World Bank reports that the global number of people in extreme poverty decreased substantially, from about 36% in 1990 to about 9.3% in 2018,

[5]https://www.worlddata.info/country-comparison.php?country1 = BGD&country2 = JPN.

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and more than one billion people escaped extreme poverty due mainly to economic growth. Still, as shown in Baler et al. (2021), while extreme poverty has declined in most of the world since 2000, it is projected to remain stable in the most fragile countries.

3. Inequality Trends and Actuarial Assumptions

Section 2 presented the characteristics and anticipated outcomes of inequality and poverty, as well as the crucial underlying concepts, metrics, and drivers of inequality. This section emphasises the consequences of inequalities between and within countries, regions, and time periods. The emphasis is on the dispersion of income, wealth, mortality, and morbidity, based on factors including socioeconomic and sociodemographic characteristics such as income and wealth, age, sex, location, and educational attainment.

Several examples from various countries illustrate the assertions made in this section. However, examples and outcomes of the COVID-19 era are mostly excluded, as the pandemic has significantly changed lifestyles, economic realities, mortality, and actuarial experience, which are still being investigated. Events such as COVID-19, which disproportionately affect those with lower incomes or wealth, can directly or indirectly result in, for example, further increases in health disparities and reductions in longevity.

Insights into inequality outcomes can enable actuaries involved in quantifying financial and demographic risks and managing private sector financial institutions and public programmes to develop more accurate actuarial assumptions, prepare more detailed and valid models, and better illustrate the volatility and resulting uncertainty of future projections.

3.1. Income and Wealth Distributions

Income and wealth inequalities are represented by their distributions. They can be important for several areas of actuarial practice, including marketing planning, underwriting, standard setting, determining the financial stability of insurance programmes, developing mortality and morbidity expectations for life and health insurance, as well as pension and social security programmes.

Inequality in the distribution of income can be influenced by the factors that generate it, such as production, labour, capital, and entrepreneurship, as well as by government policies in areas like taxation, subsidies, and income redistribution programmes. The distribution of wealth is similarly affected by the distribution of income, consumption, inheritance, and prior wealth. Both distributions can be affected by economic markets and developments.

In many developed countries, there has been a relative reduction in income for those in the middle range of the skill ladder (Bourguignon, 2015), resulting in a U-shaped income distribution, mainly due to the loss of wages in the middle part of the wage scale to competition from both unskilled labour in less developed countries and use of new technologies. This is illustrated in Figure 2, which shows the increase in actual hourly wage dispersion in the United States during the 21st century, with the escalation of wages for top earners compared to the median of the entire working population.

Income and wealth inequalities differ by country. For example, according to the World Inequality Database (2024), the share of U.S. wealth over the last fifty years held by adults in the bottom 50% of income (ignoring the effect of income tax), decreased from 19.0% in 1962 to 17.4% in 1987, and to 10.4% in 2022, while the share of income of those with the highest 10% of income increased from 36.1% in 1962 to 37.5% in 1987, and then to 48.3% in 2022. The corresponding percentage share of wealth for the highest 10% of wealth went from 71.2% in 1962 to 63.3% in 1987 and 70.7% in 2022, while for the bottom 50%, it went from 1.3% in 1962 to 1.9% in 1987, and 1.5% in 2022. The labour income share (before income taxes) of females went from 34.1% in 1991 to 39.4% in 2019, with the current ratio of average female wages to average male wages estimated

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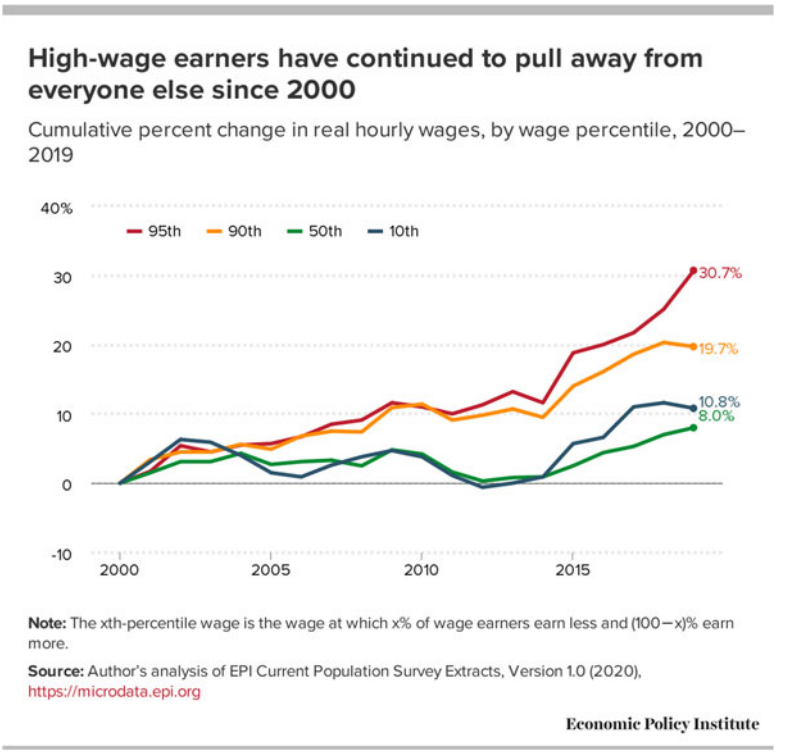


Figure 2. Cumulative real hourly wage percentage changes, U.S., 2000–2019.
Source: Gould (2020).

to be between 82% and 84%. Although examining changes reveals noticeable differences by country, the patterns exhibit broadly similar trends.

Figure 3 compares recent trends in inequality as measured by the Gini coefficient in the U.S. and Britain. Note the significant difference between the Gini coefficient when measured before and after taxes and transfers.

The shape of wage and income distributions has differed by location and time. Rachel and Summers (2019), using the OECD Database on Household Income Distribution and Poverty with disposable income adjusted for household size, demonstrate in Figure 4 the changes and differences in the Gini coefficient of income across the OECD developed countries.

Trends in, and patterns of, wage inequality can have a significant impact on actuarial practice, where assumptions concerning wage-level dispersions and trends are used. Such trends are important in social security and pension practices, as well as in the analysis of safety net programmes, where they impact the design, financing, and estimated adequacy of benefits and revenues.

By studying tax records, Piketty (2013) found significant increases in inequality in many countries since the 1960s. A spirited debate, including one by Auten and Splinter (2023), has emerged regarding whether inequality has been increasing or decreasing in many countries. Austen and Splinter contend that Piketty's methodology is flawed because he did not adequately allocate underreported income from retirement income, corporate and other income taxes, and how income is reported on tax returns, as well as a lack of full recognition of government transfer payments They claim that inequality has barely budged since 1960 in the United States, with the top 1% receiving 9% of after-tax income in 2019, up only slightly from 8% in 1960. Pinkovskiy et al. (2024) found that many wealthy individuals underreport their income to avoid taxes, and

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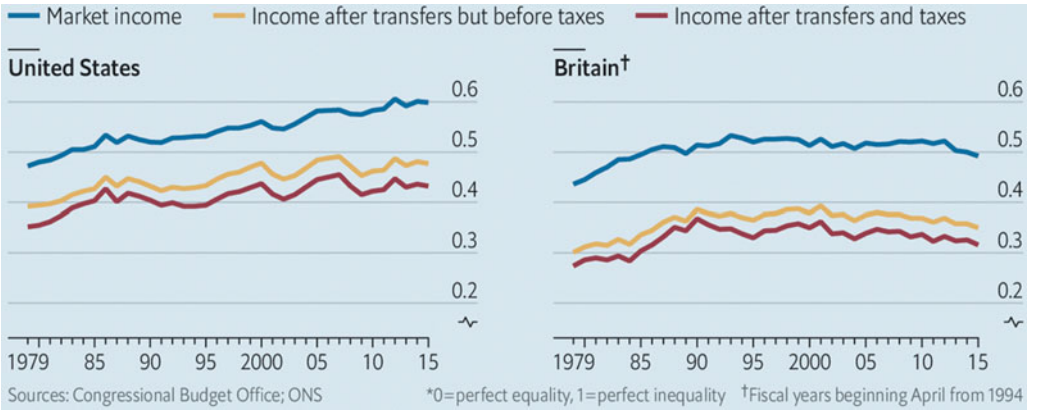


Figure 3. Inequality measured by Gini coefficient – U.S. and Britain, 1979–2015.
Sources: Congressional Budget Office; ONS, The *Economist* (2019).

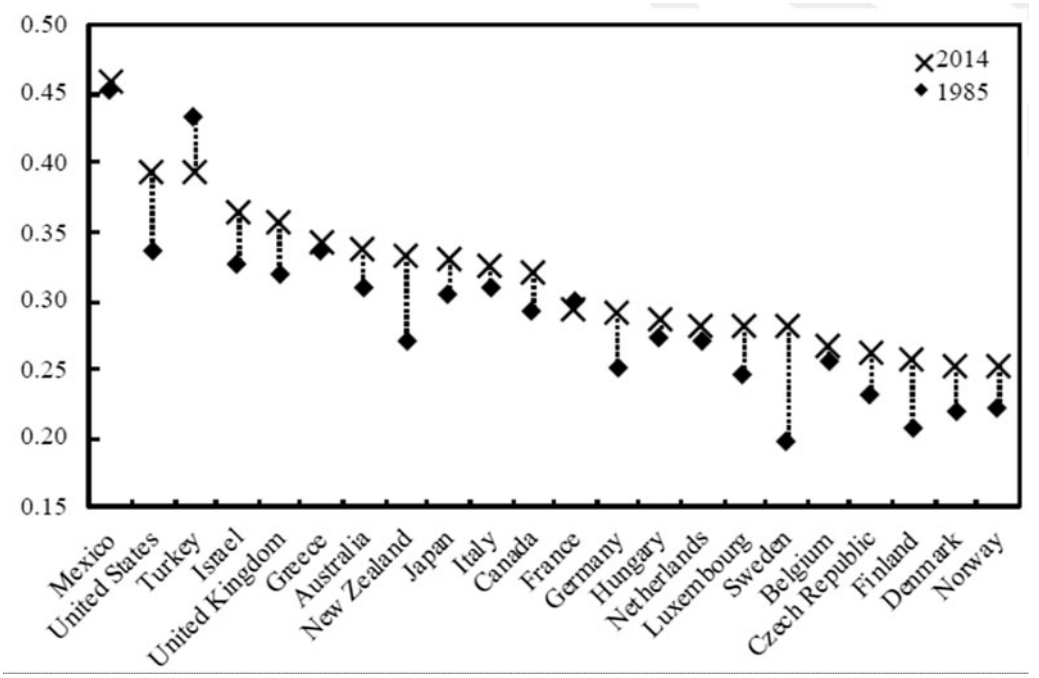


Figure 4. Gini coefficients of disposable household income across the OECD.
Source: Rachel and Summers (2019).

many low-income individuals underreport their income to avoid jeopardising their safety net benefits.

Supporters of Piketty (e.g., Gale et al., 2023) have, in turn, claimed the opposite, indicating that the top 1% of taxpayers' share of after-tax and transfer income rose from 9% in 1960 to 15% in 2019. In any case, inequality in countries such as the United States is significant and unlikely to subside, although no consensus has been reached on the extent to which it has worsened recently; inequality and its consequences persist and may be intensifying.

Studies of relative inequality of income and wealth have found far more inequality in wealth than in income (Piketty, 2013). Over the long term, inheritance and the ability to invest assets in

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the stock market and other investment vehicles, such as real estate, enable the wealth of those who participate in these programmes to increase relative to non-participants. Inherited wealth inequality is significantly greater than overall wealth inequality, although these two measures are positively correlated; inherited wealth rises less in proportion to other wealth as the wealth scale increases (Davies et al., 2024).

3.2. Mortality

Mortality risk, measured by mortality rates or life expectancy, is significantly affected by inequality and its drivers. Differences in socioeconomic status and lifestyle behaviours can significantly impact various causes of ill health, multimorbidity, healthy life expectancy, and longevity. The relative importance of these mortality-related factors varies by location, demographic factor, and time period. Additionally, there is a feedback loop between the direct and indirect causes of death and the drivers and outcomes of inequality.

Mortality inequalities are often studied using single causes, dimensions, or determinants (e.g., relative to poverty levels, educational attainment, income, types of occupation, and geographical locations[6]), which are often found to be correlated. An alternative approach is to construct a composite index, such as the Index of Multiple Deprivation developed in the U.K.[7] shown in Figure 5, which assigns weights to seven deprivation domains (income, employment, education, health, crime, housing, and living environment), each with several sub-indicators, for a total of about 40 indicators. Such an index can be considered a proxy for socioeconomic status.

In a mortality study, an actuary needs to recognise differences between the composition of the population studied and the population to which its results are applied, including their risk characteristic composition, which includes the extent of its inherent inequality. Although the most extensive and credible mortality experience is usually that of a country's overall population, both the composition and trends in mortality of its major segments can change over time. For example,



Figure 5. 2015 U.K. index of multiple deprivation.
Source: Office for National Statistics (2015) https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/464431/English_Index_of_Multiple_Deprivation_2015_-_Infographic.pdf.

[6]For examples of difference in life expectancies in several countries by geographical location see UN Population Division Data Portal (2025).

[7]Khang and Kim (2005) was based on the 1998 National Health and Nutrition Examination Survey of South Korea, Barbieri (2022)'s Socioeconomic Index Score consisted of eleven variables, and the United Nations' Multidimensional Poverty Index is discussed in Section 1.5.

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if an actuary is developing a mortality assumption for a specific segment with a different mortality trend than the population as a whole, the mortality improvement factor applied to the specific segment should not be the same as that for the entire population. Instead, an estimate of the segment-specific mortality factor should be applied. Similar considerations apply to studies of disability.

3.2.1. Socioeconomic Status and Mortality

There is a vast body of literature that discusses how mortality differs by socioeconomic status (e.g., income, wealth, location, and composite indicators) and behavioural lifestyle factors (e.g., smoking, heavy episodic drinking, and extreme obesity).

For example, based on experience reported in ten studies (covering Europe and the United States) published after 2012, Probst et al. (2020) found that socioeconomic and lifestyle factors adversely affect mortality, especially of those with lower income, with considerable correlation between many of these factors; alcohol use, for example, explained up to 27% of socioeconomic mortality inequalities.

In contrast, Khang and Kim (2005) studied household income as a socioeconomic status indicator, along with biological risk factors (e.g., body mass index and blood pressure), health behaviours (e.g., smoking and exercise), psychological factors (e.g., depression), and early life exposure (e.g., educational attainment) as mortality indicators. One of their main findings was that "biological risk factors, health behaviour, and psychosocial factors made minor contributions to the reduction of excess mortality risks for low-income groups," while educational attainment and physical characteristics such as height better explained mortality than socioeconomic factors.

Adverse elements of lifestyle, including excessive nutrition, addictions that include smoking/drugs/drinking, and lack of physical activity, can contribute to premature deaths, ill health, disabilities, and increased healthcare costs. Although subject to personal choice, the utilisation of these personal actions is influenced by and can in turn affect an individual's job, living conditions, and personal investment in preventing ill health and accessing healthcare. They not only contribute to inequality, but can also disproportionately adversely affect those on the lower rungs of the economic ladder.

Further, Cairns (2018) demonstrated the widening gap in mortality rates between those in the higher and lower deciles of the Index of Multiple Deprivation. Figure 6 compares the English age-standardised mortality rates at various income levels for individuals aged 65 to 89 of both sexes from 2000 to 2015.

Illustrating the relationship between Average Indexed Monthly Earnings (AIME) of U.S. Social Security retiree beneficiaries (representing nearly all the U.S. population) and mortality, Bosley (2024) found a significant difference in mortality across AIME quintiles, which represent average lifetime earnings. Figure 7 shows these relationships for male and female beneficiaries aged 70 through 74 by quintile to all such beneficiaries. In the United States, there has been an especially large spread in mortality between the lowest quintile and those with higher income, with an increasing divergence over the period 2005 and 2022.

Similarly, Chetty et al. (2016) found, based on the relationship between mortality beginning at age 40 and pre-tax household income in the United States, as shown in Figure 8, that both life expectancy at birth by income and the gap between life expectancies of various income quartiles increased for both males and females between 2001 and 2014. Chetty et al. found that higher income was associated with greater longevity. Between 2001 and 2014, life expectancy increased by 2.34 years for males and 2.91 years for females in the top 5% of the income distribution, but only by 0.32 years for males and 0.04 years for females in the bottom 5%. The gaps in life expectancy between the wealthiest 1% and the poorest 1% of individuals were 14.6 years for males and 10.1 years for females. Life expectancy was not significantly correlated with the Gini coefficient of income inequality within income quartiles: for individuals in the bottom quartile of the income

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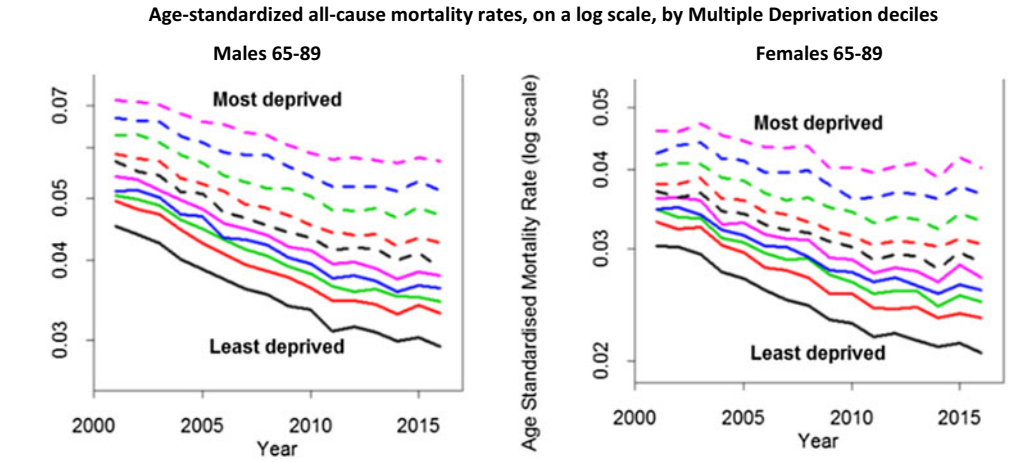


Figure 6. Socioeconomic mortality trends in England.
Source: Cairns (2018).

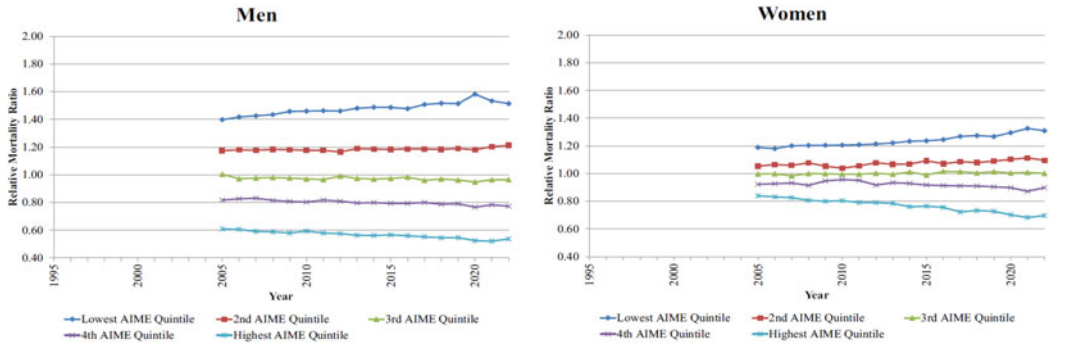


Figure 7. U.S. Mortality rates for ages 65–69 based on quintiles of AIME of Social Security beneficiaries, 2000–2022.
Source: Bosley (2024).

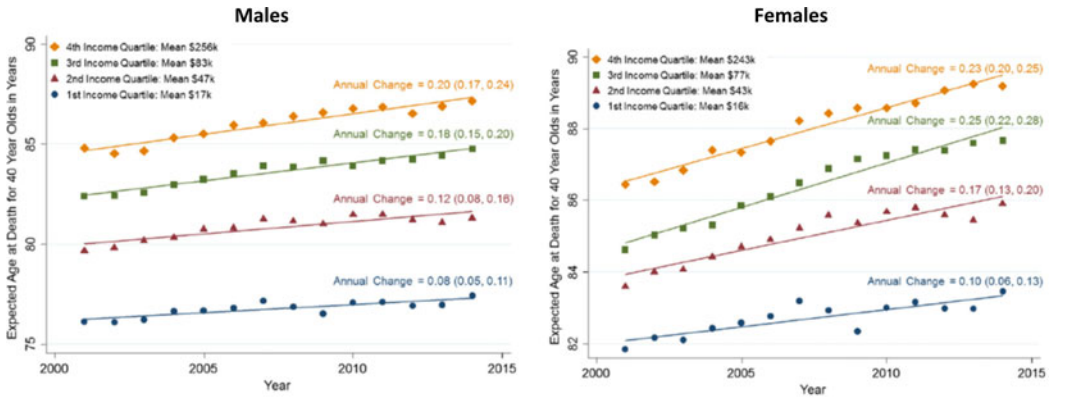


Figure 8. U.S. Life expectancy at birth by quartile, with mean annual change, 2001–2014.
Source: Chetty et al. (2016).

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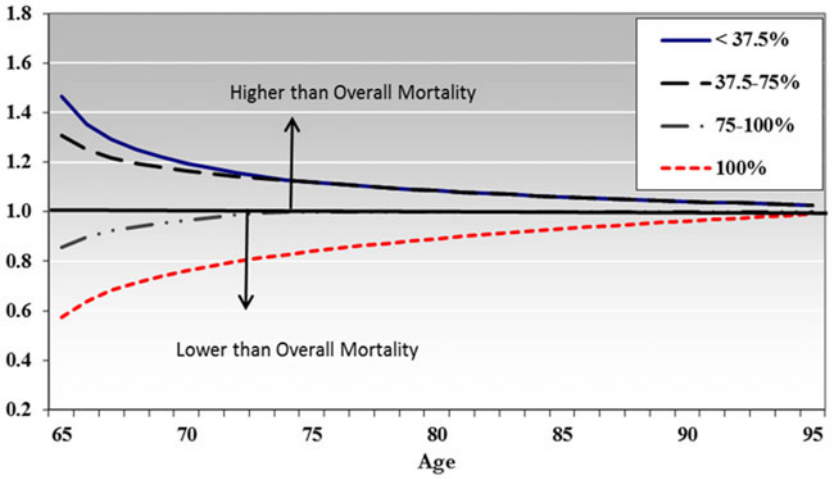


Figure 9. Retirement mortality by level of pension and age for males in Canada, 2013.
Source: Office of the Superintendent of Financial Institutions (2015).

distribution, the correlation was $r = 0.20$, whereas it was equal to -0.37 in the upper-income quartile.

3.2.2. Age and Sex

Actuaries support products and programmes that involve the entire age spectrum for both sexes, and differences in mortality and morbidity caused by age and sex are significant. It is especially worthwhile to examine mortality separately at both young and old ages, as it can differ, sometimes dramatically, for these most vulnerable and sensitive population segments, together with other sociodemographic characteristics and factors.

The impacts of these age-dependent factors tend to narrow at older ages. Figure 9 shows the relative level of mortality for Canada Pension Plan's male beneficiaries by size of pension and age. At age 65, the mortality rates of those with the highest pensions are about 45% lower than the average, and those with the lowest pension amounts are about 45% higher. Similar decreases at older ages have also been found in Social Security (United States) experience (Bosley, 2024).

Mortality rates for children, especially at birth and of infants, can also differ significantly by socioeconomic status. Several papers (e.g., He et al., 2015) discuss this difference in the United States. He et al. found that states with higher rates of poverty tend to have higher infant mortality rates. In 2005–2009, Mississippi was the state with the highest level of poverty, with infant mortality rates of 1040 per 100,000 live births, compared to 666 in the United States overall.

3.2.3. Causes of Death

Analysis by causes of death is an important part of actuarial work. This analysis often reveals noticeable inequalities at both national and global levels.

For example, Kinge et al. (2019) found that for all income quartiles for both males and females above age 40, the primary source of age-standardised Norwegian mortality during 2005–2015 was cardiovascular diseases, followed by cancers. Figure 10 illustrates mortality rates by income quartile and sex, revealing significant mortality differences between quartiles for each major cause of death. Individuals at every percentile in the household income distribution live longer on average than individuals in the next lower income percentile. For those whose income was below the median, the largest difference was due to substance abuse disorders. The difference in life

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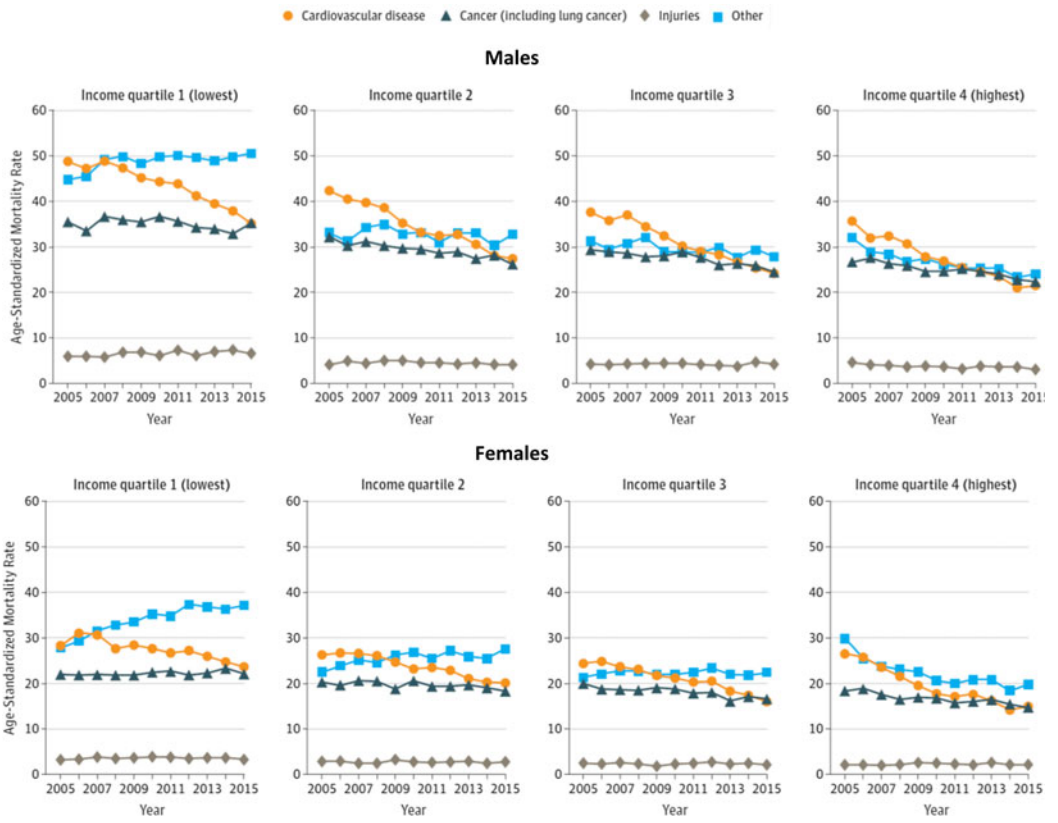


Figure 10. Selected age-standardised mortality cause of death in Norway, 2005–2015.
Source: Kinge et al. (2019).

expectancy at birth between the richest and poorest 1% was 8.4 years for females and 13.8 years for males, while the difference between the top and bottom quartiles was 6.0 years for females and 8.0 years for males.

Many causes and outcomes of death in developing countries have roots in societal, economic, and technological circumstances, including the availability, access, and affordability of quality healthcare, nutrition, potable water, and sanitation. The cost and products of medical research have proven unaffordable in many less-developed countries, as well as some developed ones. Other societal factors affecting lower-income countries, such as inadequate preparedness for natural disasters, poor working conditions, and inadequate weak healthcare infrastructure, transportation infrastructure that contributes to road injuries, emerge as leading causes of mortality for some age groups. Although improving, mortality rates in many low-income countries remain significantly higher than those in most developed countries. International public-private sector cooperation has led to substantial positive developments, reducing mortality inequality between countries.

Future reductions in mortality will require effective recognition of the drivers and earlier identification of conditions associated with the leading causes of death, especially in areas where those in lower socioeconomic groups may be especially vulnerable to those drivers. Figure 11 shows the leading causes of death in low and high-income countries in 2019. Except for heart disease, stroke, and lower respiratory diseases, all other causes of death are currently different between these two types of countries. Cancer, one of the leading killers in high-income countries,

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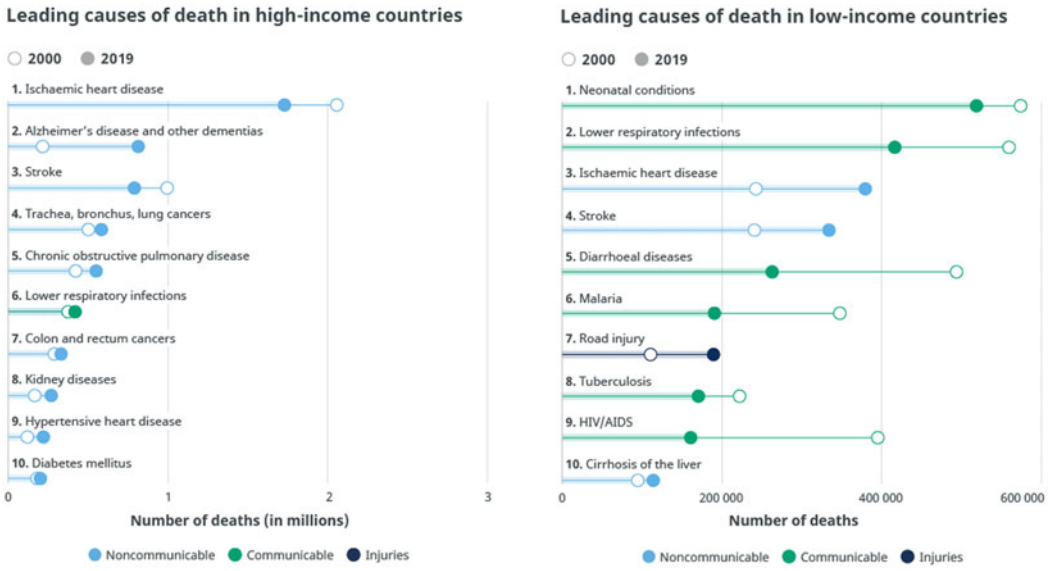


Figure 11. Leading causes of death for high and low-income countries, 2019.
Source: WHO Global Health Estimates. Note: World Bank 2020 income classification.

is not yet a leading cause of death in many low-income countries. For low-income countries, communicable diseases can be of significant importance.

Bosworth and Zhang (2015) found that, based on a study of individuals born between 1910 and 1961, there was a significant decline in mortality from cancer and heart conditions for older Americans in the upper half of the income distribution, while there was no corresponding reduction in mortality for those in the bottom half of the distribution. They also found that income inequality has increased the mortality of those with adverse socioeconomic factors among more recent birth cohorts compared with birth cohorts before 1930. This has led to an overall increase in mortality inequality despite aggregate mortality improvement.

3.2.4. Location

Inequality in mortality by geographic location, sometimes serving as a proxy for income or wealth, can be significant. The Office for National Statistics (ONS, 2014) stated that "several studies have shown that geographical variations in life expectancy can largely be accounted for by individual and area-based deprivation or disadvantage."

As shown in Figure 12, according to Dwyer-Lindgren et al. (2017), gaps in life expectancy at birth among United States rural and urban counties (within a state) in 2014 could be as much as 20 years. However, the conclusions reached can be complex; for example, Currie and Schwandt (2016) found that in the United States "among adults aged 50 and over, mortality has declined more quickly in richer areas than in poorer ones, resulting in increased inequality in mortality", but "among children, mortality has been falling more quickly in poorer areas, with the result that inequality in mortality has fallen substantially"

Bennett et al. (2018) found that between 2001 and 2016, the life expectancy gap between the least and the most deprived areas of England widened from 6.1 to 7.9 years for females and from 9.0 to 9.7 for males, respectively. ONS (2019) indicated (Figure 13) that life expectancy at birth of females living in the most deprived areas of England decreased between 2012–2014 and 2015–2017 by 0.3 years from 78.7 years. In contrast, during that period, female life expectancy at birth in the least deprived areas increased by 0.2 years from 86.2 years, widening the gap between

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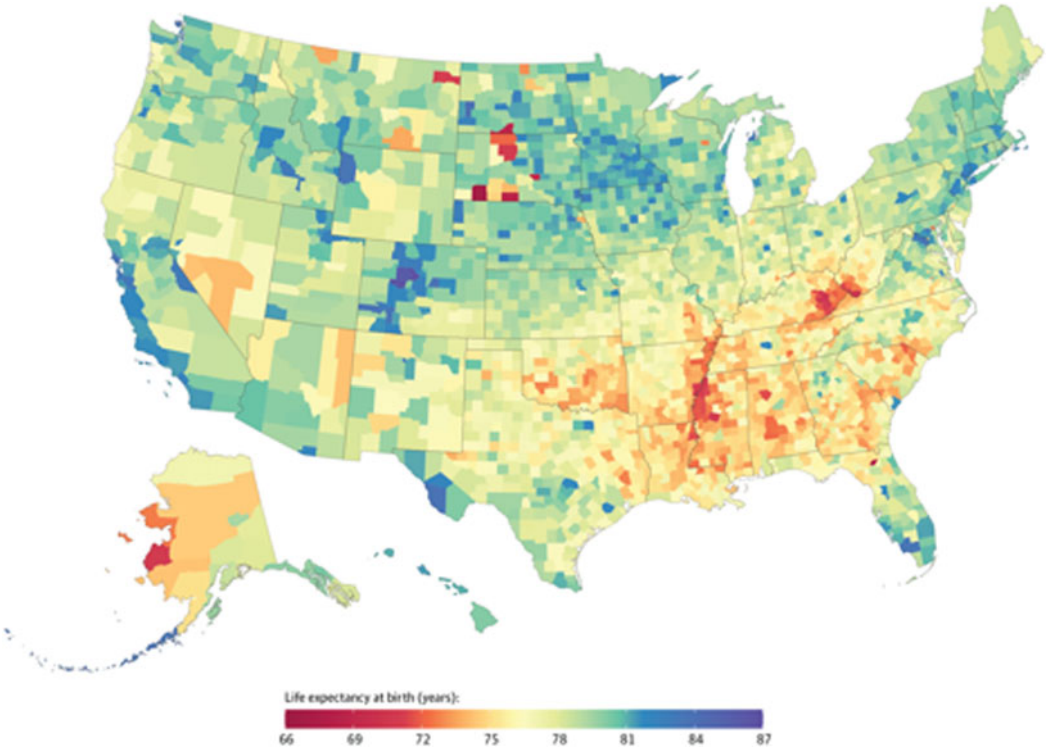


Figure 12. Life expectancy at birth across U.S. counties, 2014.
Source: Dwyer-Lindgren et al. (2017).

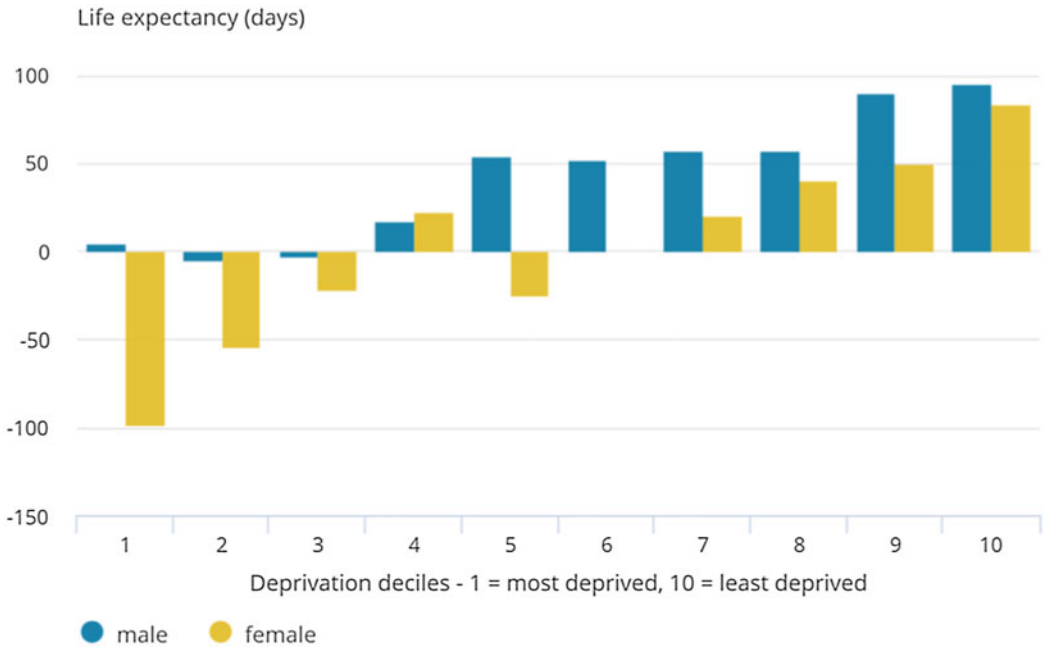


Figure 13. Change in life expectancy at birth (days) between 2012–2014 and 2015–2017, by sex and deciles of those living in deprived areas, England.
Source: Office for National Statistics (2019).

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Figure 14. Life expectancy at birth by country, both sexes, 2019.
Source: World Health Organization (2023).

the rich and poor by half a year. For males, the life expectancy at birth gap was greater – 74.0 years in poorer areas compared to 83.3 years in richer ones. The slight decrease in life expectancy at birth among poor males contrasts with the significant increase in life expectancy among the most affluent males.

Although urban inhabitants usually have greater access to health resources, benefits, and opportunities (such as jobs) than those living in rural areas, in many parts of the world, cities contain both gated/gentrified sub-communities consisting of the better off and ghettos/slums/favelas with people at lower socioeconomic status.

Actuarial analysis by geographical location is becoming more widespread, as many insurance companies conduct their analysis and develop premiums on a more granular level (e.g., postal codes).

3.2.5 Differences in Mortality between Countries

Inequality in mortality between "poor" and "rich" countries has existed for decades, if not centuries. Various mortality risk characteristics, including type of work, age distributions, behavioural factors, leading causes of death, socioeconomic conditions, nutrition, environmental factors, and public health infrastructure, have contributed to this inequality. These can affect the life expectancy of population segments differently at different times.

Figure 14 illustrates life expectancy at birth in 2019 worldwide. While many high-income OECD countries enjoy a life expectancy at birth of over 80 years, those in some lower-income African countries are below 60 years.

The last century has seen a reduction in mortality inequality between countries, especially because of dramatic decreases in infant, child, and maternal mortality. As shown in Table 1, over the last sixty years, life expectancy at birth in developing countries in Africa, Asia, and Latin

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Table 1. Life expectancy at birth by region

Region	1950	2025
Africa	37	64
Asia	42	75
Europe	62	79
Latin America & the Caribbean	49	76
Northern America	68	80
Oceana	62	79
World	46	74

Source: United Nations Data Portal Population Division (2025).

America has increased by 25 to 32 years, compared to 10–15 years in developed countries in Europe and North America.

3.2.6. Educational Attainment

Many studies have shown a strong correlation between mortality and educational attainment.[8] Although actuarial analysis has not often directly reflected educational attainment, it can be a significant factor.

Figure 15 illustrates the impact of education on the life expectancy of males aged 25 in OECD countries. All countries exhibit differences in life expectancy by education level, ranging from 49.3 to 53.6 to 57.5 years for males with low, medium, and high educational attainment levels, respectively, and from 56.1 to 59.3 to 61.3 years for females with the same educational attainment levels. Lübker and Murtin (2022) demonstrated that, compared to an identical study conducted five years earlier, the absolute gaps in life expectancy between individuals with high and low educational attainment at age 25 have increased by 0.4 years and 0.5 years on average for males and females, respectively. Murtin (2017) also showed that the level of education has a somewhat smaller impact on life expectancy at age 65, with differences ranging from 2 to 7 years for males and from 1 to 5 years for females. Such differential effects are also affected by other characteristics, such as age, sex, birth cohort, racial/ethnic mix, and smoking history (Murtin *et al.*, 2017 and United Nations Data Portal Population Division 2025).

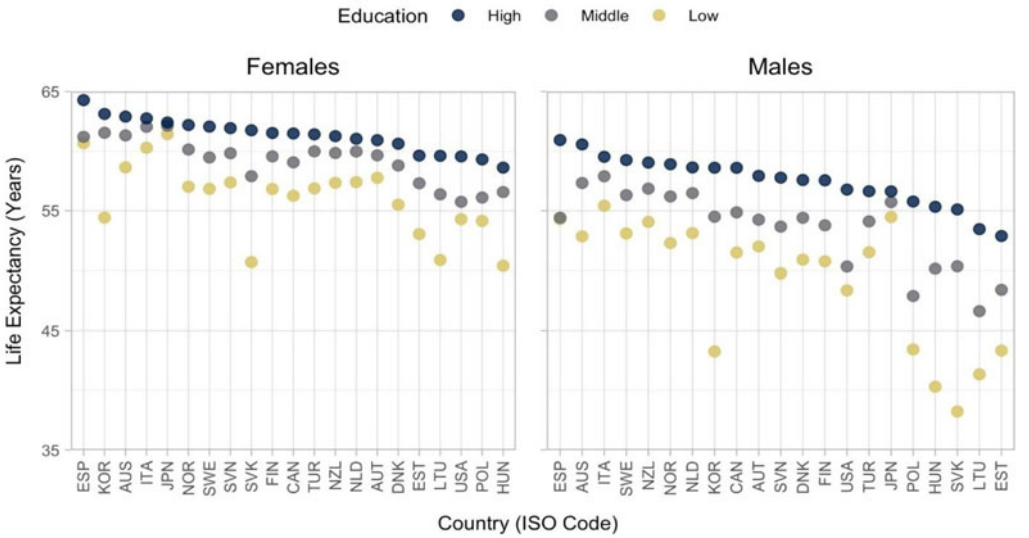
Lleres-Muney et al. (2020) found that for cohorts born between 1906 and 1915 in the United States, conditional on surviving to age 35, one additional year of education is associated with roughly 0.4 more years of life for both males and females. They found that education gradients increased across cohorts and decreased as individuals aged.

Olshansky et al. (2012) assessed United States disparities in life expectancy by race and education from 1990 to 2008. They stratified data by age, race, sex, and level of completed education. They found a wide disparity in life expectancy at birth between the highest-educated non-Hispanic Whites and the lowest-educated (less than 12 years of schooling) non-Hispanic Blacks (14.2 years for males and 10.3 years for females). Both education and socioeconomic status were highly correlated with life expectancy across all sexes, ethnic/racial categories, and age groups.

Research conducted by the OECD (2012) and Rogers et al. (2010) have shown that children from lower socioeconomic backgrounds also have a significantly lower chance of achieving a higher level of education. The OECD found that students' socioeconomic background has a

[8]For example, for the United States. See Olshansky et al. (2012) and Rogers (2010).

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Note: 'Low level of education' = 'No schooling' + 'Primary and lower secondary'
'Medium' = 'Upper secondary' + 'Post secondary non tertiary' 'High' = 'Tertiary education'
Note: Estimated as of 2016, although data on which this figure is based can differ somewhat. Countries are reported in International Organization for Standardization (ISO) three-letter codes.

Figure 15. Life expectancy at age 25 for males by educational attainment in the OECD, approximately 2016.
Source: Lübker and Murtin (2022).

substantial impact on their educational performance. It is also adversely affected by inadequately trained teachers and lower investment in educational tools, which exacerbate these adverse impacts. Public policies to encourage lifelong learning may help prevent further widening of inequality in mortality.

The extent of basic education has a higher correlation with mortality than advanced education. For example, Figure 16 illustrates the impact of middle or higher education compared to a lower level of education (Crimmins et al., 2011) on relative mortality. As shown, the effect of the difference between middle and low education is greater than that between high and middle education.

3.3 Morbidity and Mental Health

Morbidity (having a physical illness or mental health condition) and mortality are closely linked, both being significant indicators of overall societal health. Changes in morbidity can lead or contribute, as the medical condition(s) progress, to corresponding odds of death. However, especially if well managed, morbidity can have a limited impact on an individual's life expectancy or risk of death.

A population's life expectancy and healthy life expectancy provide concise aggregate measures of the impact of mortality and morbidity. In contrast to life expectancy, healthy life expectancy measures the average number of years an individual is expected to live in good health before death.

The worldwide improvement in mortality, at least over the last fifty years, mainly benefited the longevity and healthy longevity of those in higher socioeconomic groups. Table 2 shows that, based on the deciles of the UK Index of Multiple Deprivation, the differences in healthy life expectancy in England in 2018 were greater than those for life expectancy, suggesting a significant disparity in the duration of ill health and disability by socioeconomic status.

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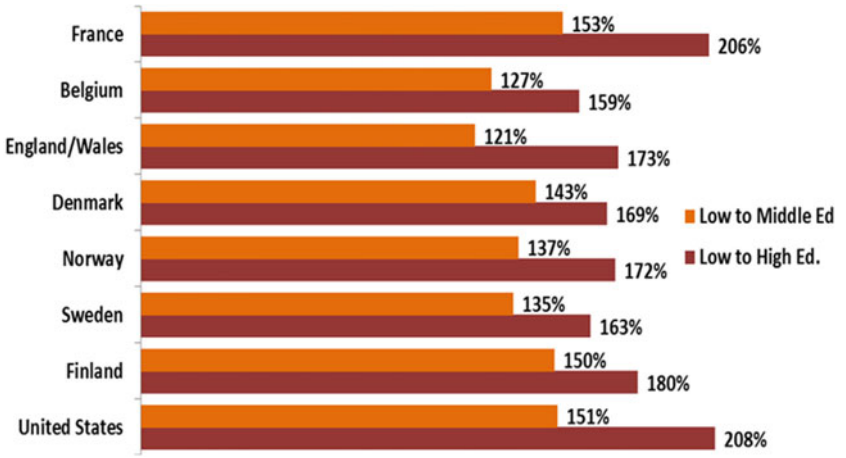


Figure 16. Effect of education on relative mortality for selected developed countries.
Source: Adapted from Crimmins et al. (2011, Table 9.3).

The differences shown in Table 2 can have a significant impact on actuarial assumptions. For example, looking at life expectancy at age 65 (of particular interest to pension actuaries), the differences in these indicators between the most and least affluent deciles of the population ("Range") are about four or five years. In contrast, the range for healthy life expectancy is about seven to eight years. Differences in healthy life expectancy significantly impact the amount of health expenditures and the time spent with limitations on daily activities that can affect the utilisation of long-term care services.

Figure 17 compares the 2016 global burden of mortality and morbidity among adolescents, using rates of Years of Life Lost (YLL) and Years of Life Lost due to Disability (YLD) per 100,000 population as useful measures. The burden shown in Figure 17 decreases substantially with increasing income in each age and sex group. As for age, the burden is higher among adolescents aged 15 to 19 across all income groups, for both males and females.

Mental health is an often-overlooked problem. As described in World Health Organization (2001) indicated that the World Health Organization (WHO) estimated that one in four people will be affected by mental or neurological disorders at some point during their lives, with about 450 million people currently suffering from such conditions. Mental health appears highly correlated with socioeconomic status in the United States. In Figure 18, it is shown that 8.7% of adults with income below the federal poverty level have had severe psychological distress, compared with 1.2% of adults with income at or above 400% of the federal poverty level.

Momen et al. (2020) found that among people born in Denmark between 1900 and 2015, followed from 2000 to 2016 for mental and physical conditions, "most mental disorders were associated with an increased risk of a subsequent medical condition; hazard ratios ranged from 0.82 to 3.62, and varied according to the time since the diagnosis of the mental disorder". Together with a potentially greater incidence of mental health disorders for those of lower income, there may be an increased risk of subsequent medical conditions for such subpopulations.

Cognitive impairments (dementia) are especially important in providing long-term care services. In a study of individuals older than 50, Crimmins et al. (2018) found that those with greater educational attainment have a lower prevalence of dementia, as well as fewer years with the

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Table 2. Life Expectancy and healthy life expectancy by socioeconomic status, England 2018

	Males			Females		
	Most affluent	Least affluent	Range	Most affluent	Least affluent	Range
			At birth			
Life expectancy	83	74	9	86	79	7
Healthy life expectancy	70	52	18	71	52	19
Proportion in "good" health	84%	70%	14%	83%	66%	17%
			At age 65			
Life expectancy	21	16	5	23	19	4
Healthy life expectancy	13	6	7	15	7	8
Proportion in "good" health	64%	39%	25%	65%	37%	28%

Source: Office for National Statistics (2018).

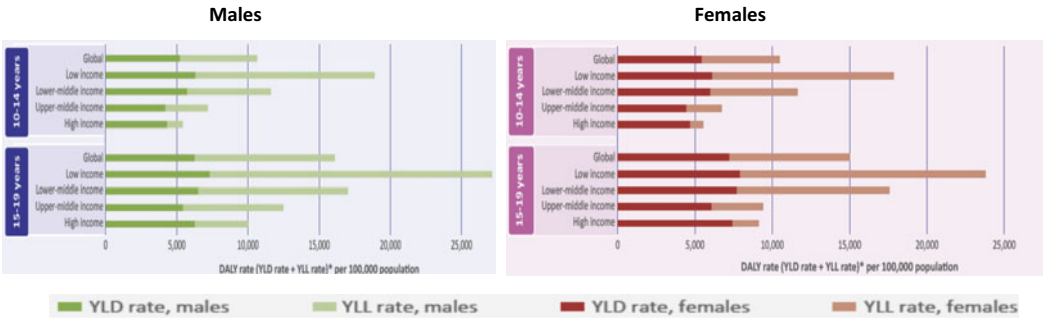


Figure 17. Global 2016 adolescents' all-cause mortality & morbidity burden, by income group, age and sex.
Source: World Health Organization (2016).

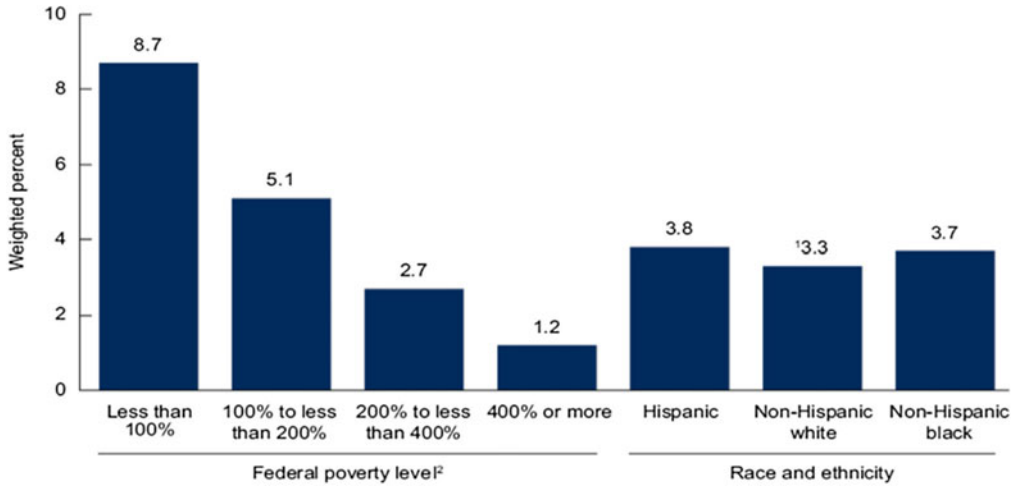


Figure 18. Age-adjusted percentage of adults with severe psychological distress, by income relative to the federal poverty level, and by race and ethnicity, U.S., 2009–2013.
Source: U.S. National Health Interview Survey of 2009–2013.

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condition, and more years of cognitively healthy life, which is an important source of mortality reduction.

4. Actuaries and Remedies to Inequality

This section extends the framework developed in Section 2 and the patterns and outcomes of inequality discussed in Section 3. It describes the design and financing of products/programmes to manage, alleviate, and mitigate some causes and adverse consequences of inequality, particularly those affecting the relatively less well-off. It also addresses the potential contributions of actuaries in these areas.

Governments traditionally protected their people from conflicts, provided law and order, and helped ensure their sovereignty – the right to be free of outside interference. Governmental responsibilities have been extended to managing the economy and providing certain public services and social programmes. Today, essentially all governments provide a range of social programmes, particularly serving those who are most vulnerable. Providing these programmes may be shared, at least to some extent, by commercial organisations and volunteers. This section emphasises governmental activities, such as education, social security, retirement, disability, and healthcare programmes and benefits, addressing deviations in the characteristics of subgroups from the "average" or "desired" levels.

The actuarial profession's expertise in analysing the risks and sustainability of financial programmes often involves risk evaluation at different stages and developments of inequality. In the past, analysis and policy recommendations involving inequality may not have been considered traditional fields of actuarial practice. Actuaries, however, are well-positioned to collaborate with policymakers, employers, providers, regulators, and individuals in the design and implementation of sustainable programmes that promote equal opportunities and mitigate adverse outcomes. The need to rigorously analyse costs, benefits, outcomes, and risks of new or revised approaches has led to greater actuarial involvement in the design, assessment, and management of areas such as insurance, healthcare, and retirement benefits, even though actuaries may not participate in all aspects of these programmes' management of risks and costs.

This section outlines how programmes and approaches addressing the challenges posed by ex-ante or ex-post inequality can benefit from actuarial input, particularly since private and public sector financial institutions and programmes must be managed sustainably to fulfil their long-term financial commitments.

4.1. General Considerations

Policies and programmes aimed at reducing inequality need to recognise its causes and consider their impacts. A good example is the increase in the eligibility age for social security retirement programmes, which can disadvantage individuals in lower socioeconomic groups who need to work longer to maintain a decent standard of living, given their shorter life expectancy.

The desire for equal rights demonstrates some of the issues presented by efforts to reduce inequality. Eliminating gender inequality from actuarial considerations through the imposition of unisex rates for insurance, retirement benefits, and credit can be a two-edged sword. On the one hand, since females generally live longer, using a unisex premium structure – rather than sex-specific – increases the costs of life insurance policies for females relative to those for males, effectively subsidising one sex over the other. In contrast, the opposite situation arises for pension funding.

There is no single or simple solution to all the issues associated with inequality; changes can take a long time, if ever, to be effective. Nevertheless, approaches used have included right-to-work laws, minimum income, gender equality, accessible and quality healthcare, enhanced and effective universal education, and technology training, as well as accommodations for people with

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disabilities. Such programmes often result in higher economic growth, more well-paying jobs, investment in human capital, better infrastructure, transportation, healthcare, education, and reliable energy. At the same time, they may introduce new inequalities by subsidising some population groups at the cost of others.

Introducing inequality-reducing programmes can have unintended and undesirable consequences, such as the overuse of or excessive funds and subsidies, which can lead to an increase in unnecessary government jobs and projects, possibly supporting corruption and fraud. These programmes can contribute to increased unemployment, as employers seeking higher profits may substitute local employees with immigrants, adopt technological approaches, outsource, or employ other techniques. Programme desirability can depend on who is affected, the incentives and alternative jobs available or provided to them, and the effectiveness of the programmes. Their impact can also depend on whether a tight or loose labour market exists.

An inherent tension can exist between treating everyone equally and addressing everyone's needs. Since addressing these inequality issues can involve a society's fabric, culture, beliefs, and history, the proposed solutions are often politically or socially sensitive. Progress often results from public pressure or judicial rulings rather than natural economic forces.

These are complex issues, often involving multidimensional, multifaceted, multicultural, multiclass, and multigenerational considerations that complicate the design, planning, and running of such programmes.

One approach to mitigate undesirable consequences of inequality-reducing programmes is to use a multiple-tier system tailored to address the needs of those in each tier. To illustrate, a total financial support system to reduce risks of employment disruption could include:

- social insurance benefits provided through mandatory participation, possibly including governmental subsidies
- group insurance and retirement programmes supported or sponsored by an employer
- for those without a sponsoring employer, private sector insurance and savings programmes, partly subsidised by the government
- public safety net programmes, possibly involving income- or means-testing, used when the former tiers are deemed inadequate to satisfy the basic needs of some individuals.

Communities, charitable organisations, and voluntary groups often actively support efforts to reduce inequality and its consequences. Examples, sometimes tailored to individual circumstances, include strong support for the poor, disabled, and elderly by religious groups; charity-based and voluntary organisations that support the aged, disabled, and disenfranchised children, women, and families; and microinsurance and microfinance initiatives that involve the community in remunerating losses. In many countries, these efforts replace or supplement efforts otherwise expected of governments, although they may not be able to supply continuous, sustainable help to those in need.

Actuaries provide services to numerous organisations that help manage the adverse aspects of inequality. These organisations include insurance companies, retirement plan sponsors, providers of savings management for retirement and credit, safety net programmes, and government policymakers/regulators. Their products and programmes address the causes and consequences of inequality, as well as the potentially adverse financial impacts due to, and in turn affected by, contingent events or conditions such as death, longevity, ill health, accidents, property damage, and lawsuits. These consequences can have a significant impact on the financial security of individuals and the sustainability of organisations and governments. If not addressed, those involved would suffer, likely further exacerbating inequality.

The primary roles of actuaries regarding these programmes include:

(1) assessing their costs and benefits

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(2) preparing analyses that can help decision-makers to assess whether programmes achieve their objectives and are sustainable in the long term.

This is achieved using actuarial tools such as predictive analytics, stochastic analysis, artificial intelligence, and scenario analysis, which recognise the range and distributions of expected outcomes.

To assess private and public sector products and programmes, actuaries gather information and data concerning relevant demographic, economic, financial, regulatory, and environmental phenomena and their impacts on these products and programmes. Often, they also consider societal and political conditions, events, and trend, as applicable. The data may be either public or proprietary, generated by a wide range of organisations. Scepticism regarding the data may be warranted, as future conditions and trends may not replicate those of the past, and as the data may be represented in different forms and formats and may be incompatible. In addition, data can be of low quality, incomplete, inconsistent, or irrelevant to the issues being assessed. In some cases, the experiences of different population segments can diverge, for example, due to inequality, especially when changes in these population segments are expected. Finally, relationships between data can be associative, rather than causative, with trends that differ between components. As a result, data should be decomposed where practical to distinguish between fluctuations, trends, cycles, and structural changes.

A fundamental characteristic of most population segments is that both their ex-ante and ex-post experiences are of interest. Factors that influence this experience can be either observable or unobservable, the latter possibly being due to inadequate data or information. Indeed, heterogeneity, uncertainty, and time values are key concepts that underpin the application of actuarial science. The disaggregation of data, combined with behavioural science, technologies such as predictive analytics and artificial intelligence, and actuarial science, can help address the causes and outcomes of the inequalities involved, expressed in terms of resulting costs, benefits, and population developments. Actuaries can also develop methods and measures to assess the dynamic effects and uncertainties associated with inequality, using pricing or costing models, risk adjustment, underwriting, reserving, and cost-benefit analysis.

A better understanding of the relevant costs, benefits, and risks of alternative programme designs can inform both private sector and public policy decision-makers who determine the effects and advisability of social security contributions, insurance prices, subsidies, and cross-subsidies.

4.2. Education-Based Solutions

Education, the foundational investment in human capital, is a critical factor in the long-term mitigation and reduction of inequality. The scope and quality of education significantly determine the future course of inequality and can have a profound impact on an individual's life course, including their health, longevity, income, and wealth. An effective educational system can break the intergenerational transmission of poverty and influence and reduce inequality of opportunity. A generation that experiences greater convergence in educational attainment should ultimately help decrease the inequality of outcomes.

Achievement of higher educational attainment depends upon the availability, accessibility, affordability, quality, and relevance of educational resources at all levels, including preschool, primary, secondary, post-secondary college, university, post-university education, and trade training. Although benefit is often gained from higher educational attainment, there may also be a significant opportunity cost of attending secondary and post-secondary education (e.g., lost immediate wages, slower work advancement, cost of study materials, and reduced help with the family business), as well as other expenses (e.g., accommodations), which have a relatively greater financial impact on those whose families have a lower income. Even where education is free or

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largely subsidised, it may exacerbate inequalities, as all taxpayers contribute towards the cost of education, while those who attend are generally from better-off families,[9] especially at higher educational levels, where fees can be significant.

Colleges, universities, and public programmes can enhance the accessibility and affordability of post-secondary and trade training programmes through loans, grants (such as scholarships), part-time work (e.g., assistantships and internships), online and virtual courses and webinars, and other support programmes. Other subsidies can include forgiving student loan interest during or after the education period, providing loans at below-market interest rates, and repayment only when income exceeds a minimum threshold. Many of these programmes, which can differ significantly by country, target those from low-income or middle-class families (Ziderman, 2005).

The size and market for student loans are large in some countries. According to the Education Data Initiative[10], total U.S. student loan debt has ballooned in recent years, reaching around US $1.8 trillion by about 43 million borrowers; many are afraid that their debt could hinder their financial future. Most of this debt was underwritten through federally provided student loans. Forgiveness remains a persistent political and economic issue.

Financial sustainability (i.e., systems that pay for themselves) is not usually the primary objective of education support and student loan systems, as they represent investments in human capital. For example, in the UK, more than 77% of those taking out student loans will have some, or even all, of the loans paid for by the government because many graduates will not earn enough to repay their loans on a timely basis (The Guardian, 2017). Only those with high incomes will eventually repay the full amount of loans. These systems thus redistribute from those with higher incomes to those with lower incomes.

Nevertheless, sustainability is vital to educational support and loan programmes. An actuarial valuation is a helpful tool to project future loans (e.g., the number of students receiving new loans, current loans, loans in repayment, and loans in default), repayment rates, revenues and costs of such programmes, their impact on future budgets, and in risk management.

For example, in Canada, such assistance is provided through the Canada Student Financial Assistance Program (CSFA Program). Currently, almost 50% of Canadian post-secondary students benefit from student loans and grants provided by the CSFA Program. Since 2000, this programme has been directly financed by the government. As a result, the Office of the Chief Actuary (2023) has a statutory responsibility to conduct triennial actuarial reviews (to provide an assessment of the current and previous twenty-five years' cost of the CSFA Program). Projections of these costs are important for government budgeting and determining the cost to taxpayers. During the COVID-19 pandemic, the government introduced several relief measures to help the most vulnerable students. The programme actuaries worked closely with policymakers to quantify the financial impacts of these measures.

Another important educational tool for reducing inequality is financial education, both within and outside traditional schools. Long-term savings and investment management are essential for preparing for life cycle risks and retirement. Many people, however, have limited investment knowledge, aptitude, or patience to focus on their longer-term financial issues. They could benefit from relevant financial education.

Financial education programmes should be practical, entertaining, and focus on practical life skills, including financial decision-making and understanding the interaction of such decisions with relevant public and private programmes. Technology and social media can play a crucial role in ensuring the widespread availability of financial education. Regulators can promote such information, as is done by the Israel Capital, Savings and Insurance Authority, which supports such programmes through its website (https://www.boi.org.il – in Hebrew).

[9]https://brazilian.report/2017/11/06/education-brazil-staggering-inequality/.

[10]Education Data Initiative. https://educationdata.org/student-loan-debt-statistics. Updated March 16, 2025.

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Actuaries can contribute to financial education efforts by participating in the development of educational materials for various interested entities, including insurance companies, pension funds, savings programmes, and social security systems.

4.3. Social Security Solutions

Social security can be provided by a system or programme that provides help and security against life cycle risks, such as unemployment, disability, prolonged sickness, aging, retirement, longevity, and death. It is typically provided through a long-term government programme, which can vary between countries and subpopulations in terms of benefits, types of beneficiaries, eligibility rules, quality, access, and financing. These are often enhanced by additional private programmes such as insurance and pension savings, as well as voluntary community organisations.

Social security programmes encompass both social insurance (e.g., providing healthcare, unemployment, and workers' injury insurance, as well as retirement benefits) and social assistance/welfare/care programmes. Both types can be provided on a universal basis or include limitations and constraints such as means-testing or work/study requirements. Due to the broad scope of these various programmes, we focus on major governmental social security programmes.

Many social security systems provide long-term support, where funds are accumulated or budgeted over the working years of the participants and are paid as benefits when the designated needs arise. The manner in which funds are collected and maintained, benefits paid, and demographics of the affected subpopulations evolve, all affect the sustainability of these systems. Due to these characteristics, the financial soundness of social security systems is affected by the country's economic and demographic development. In turn, the size of these systems and the affected populations make them a significant part of the economy. Further, by their nature, such systems, along with their scope, characteristics, and beneficiaries, are often at the core of liberal-conservative (or left-right) political discussions.

Social security can reduce inequality through two principal means:

- Providing universal benefits in the event of certain lifecycle risks by *implicitly* targeting those in social groups who are more likely to be impacted by these risks. For example, since the health status of those with low income may be worse, they may receive health benefits that are a relatively higher proportion of their income[11].
- Providing benefits and services that *explicitly* target disadvantaged groups. Such benefits may be tailored or targeted to those who would benefit most (e.g., through means-testing[12] or minimum benefits).

Financing can be designed to reduce inequalities. For example, earnings up to a specific limit can be excluded from contribution requirements, or progressive general taxation can be used to finance benefits.

4.3.1. Social Security Benefits

This section discusses, in general terms, various forms of social security programmes and their impacts, which can differ by country, culture, and history, as well as the current and potential

[11]However, some social security benefit programmes may ultimately favour those at a higher socioeconomic status with greater lifetime income, exacerbating inequality (see Brookings Institute referenced in ISSA 2017). For example, in a retirement programme, even with equal monthly benefits, those with better longevity (e.g., those with higher income or wealth) may receive a larger total lifetime benefit.

[12]In some cases, the means-testing process can exacerbate inequality by blocking access to such benefits. e.g., due to the shame involved in claiming such benefits, or the use of difficult-to-complete claim forms (see http://www.un.org/en/ecosoc/meetings/2005/docs/Mkandawire.pdf).

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involvement of actuaries. It is presented by life phase, starting with children and young adults, followed by those of working age and seniors.

4.3.1.1. Children and maternal. Safety net programmes can play a crucial role in ensuring sound childhood development, characterised by a secure and healthy environment, adequate nutrition and physical activity opportunities, and high-quality education that can lead to better lifetime opportunities. However, the income of children in low-income families has declined in many cases, with the most significant drop observed for children in families with the lowest incomes (OECD, 2018). Governments often focus on providing services to this age group, such as pre-kindergarten services, primary education, nutrition, healthcare, and physical activity opportunities for the very young, to reduce present and future inequalities stemming from the lack of access to vital services. At the same time, benefits such as paid parental leave and family benefits can help ensure that families can withstand external shocks (e.g., economic downturns, job loss, family breakdown, extreme climate events, and civil conflicts).

Income transfers, job protection (i.e., the right to return to the same job after maternity leave), paid maternity (and sometimes paternity) leave, grants, child/family benefits, or other maternity benefits (provided in 2015 in at least 94 countries as per the International Labor Organization in 2017), can decrease inequality, as well as result in a reduction in infant mortality. For example, based on data from OECD countries, Tanaka (2005) estimated that a 10-week extension in paid leave decreases post-neonatal mortality rates by 4%. In lower and middle-income countries, each additional month of paid maternity leave has been associated with a 13% reduction in neonatal mortality (Nandi et al., 2016). The design and delivery of parental programmes differ by country.

Numerous studies have noted the favourable impact of child benefit programmes. For Canada, Milligan and Stabile (2008) found that "(these) programmes had significant positive effects on several measures of both child and maternal mental health and well-being, as well as a few measures of child physical health. We also find evidence of direct effects of child benefits on test scores." For the United States, Dahl and Lochner (2008) estimated that "a US$1,000 increase in family income raises math and reading test scores by about 6% of a standard deviation. The estimated effects are larger for children from more disadvantaged backgrounds, for younger children, and for boys."

To date, there has been limited actuarial involvement in programmes related to children, families, and welfare. However, some standalone programmes (e.g., Quebec, 2023) and parental benefits that are part of unemployment insurance schemes (e.g., Office of the Superintendent of Financial Institutions, 2024) have been subject to actuarial analysis. In general, actuarial estimates of participants, families, costs, and benefits could enable better planning and management of children-related programmes. Actuaries can help design and assess the sustainability of these programmes, as well as the appropriateness of their financing. They can also prepare estimates and projections of revenues and expenditures, and assist with integrating these programmes with other safety net and private sector programmes, particularly those involving healthcare systems.

4.3.1.2. Working age population. The working-age population is often defined as those aged 18 to 64, a definition that may vary by country, reflecting the applicable retirement ages, educational processes, and health status in each location. This population often benefits from social insurance and safety net programmes, such as unemployment insurance, legislated minimum wage, guaranteed minimum income, retraining and reskilling, workers compensation and work injury, disability, universal social assistance benefits, family-related programmes such as subsidised daycare and parental leave, healthcare, and savings programmes that facilitate financial preparation for retirement.

Protection against the inevitable adverse financial consequences of certain unexpected life events (e.g., unemployment and ill health) typically has greater value for those with limited resources and lower earnings due to the capping of covered earnings for benefits such as retirement, unemployment, and disability. Countries with relatively high levels of social spending

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on their working-age population and more success in providing for low-income households tend to have less income inequality among the working-age population.

From an actuarial perspective[13], two major social insurance programmes for the working-age population, covering unemployment and work injury risks, are usually characterised by short-term projections for rate-setting and reserve evaluations.

- *Unemployment programmes* often provide several types of benefits, such as a guaranteed level of income during a period of unemployment, through either cash payments or income supplements (e.g., during the COVID-19 pandemic, some countries supplemented income up to a certain percent of pre-pandemic salary) and retraining. Guaranteed income programmes can also provide income averaging for part-time or fixed-term employees, as well as for those in physically demanding jobs. Nevertheless, only 39% of the worldwide labour force is covered by unemployment protection benefits, and only 22% of unemployed workers worldwide receive these benefits. (International Labor Organization, 2017). The effectiveness of young adult unemployment programmes needs to be carefully evaluated, given high housing prices, increasing inequality, and high poverty rates in many countries for those under the age of 24, together with little or no job experience and a mismatch between supply and demand. Spending on the young unemployed may be worthwhile, as it can also significantly impact at-risk poverty rates at older ages. An effective apprenticeship or trade-training system, linked with a proactive unemployment system, can significantly impact young adult unemployment rates.
- *Work injury programmes*[14] provide income replacement, rehabilitation, and medical benefits. The premium structure can incentivize employers to implement a more effective safety programme. These programmes are particularly important for individuals with strenuous or high-physical-risk occupations and lower-income groups. While many developed countries have well-established work injury programmes, their effectiveness in developing countries, especially for their informal sector and small employers, remains an aspirational goal. According to the International Labor Organization (2021), only 35% of the worldwide labour force are covered by law for worker injuries through social insurance. This coverage ranges from 7% in Southern Asia to 83% in Northern America.

Actuarial projections can enhance the effectiveness of programmes by helping ensure their long-term sustainability and financial viability. Actuaries can also be involved in assessing trends, utilisation, and severity. This enables policymakers to analyse whether the benefits are properly targeted and the programmes achieve their goals.

4.3.1.3. Seniors. Retirees with limited financial resources face many risks, including outliving their resources (longevity risk), experiencing fragility and loneliness (mental health risk), as well as incurring unexpected health expenses (health risk), investment losses (market and liquidity risk), decreased home value if they own one (real estate risk), unforeseen needs of family members (dependent risk), and retirement benefit cuts (policy risk). Social security systems are structured to respond to some of these risks, with retirement and healthcare benefits typically being the core of these benefits. However, the amount of retiree benefits for those with lower wages often remains in the same general relation to corresponding benefits for those with higher wages, thus continuing the inequality of working years.

Retirement financing is sometimes budgeted as a tax-based or pay-as-you-go system, where the contributions made in the current period pay the benefits due. The demographic transition of

[13]For example, see a paper on the actuarial involvement in work injury programme at http://www.actuaries.org/CTTEES_SOCSEC/Documents/Role_Actuary_Workers_Compensation.pdf and Canadian actuarial reports on Employment Insurance premium rates Actuarial reports - Office of the Superintendent of Financial Institutions.

[14]For more examples of the structure of work injury programmes, see https://www.issa.int/.

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recent decades, characterised by an aging population and a decrease in the working population's share of the total population, has increased pressure on public finances, particularly on pay-as-you-go systems. Consequently, many retirement systems are currently based on accumulation-based pooling, where contributions are accumulated in a fund whose resources and investment yields are used to help pay future benefits, thereby playing a crucial role in reducing long-term inequality (in partially funded systems).

Contributory retirement programmes are particularly important in countries lacking stand-alone survivor or disability programmes, as they often provide ancillary benefits, such as survivor benefits (for spouses and dependent children) and disability benefits. Nevertheless, it is likely that those with higher incomes contribute more, leading to a redistribution of resources to those with lower incomes.

Universal minimum or income-tested pensions have reduced poverty and income inequality. For example, as per the International Labor Organization (2017), the Older Person's Grant programme provided to citizens, permanent residents, and refugees in South Africa has been estimated to have significantly reduced income inequality, with a reduction in the Gini coefficient from 0.77 (without grants) to 0.60 (with grants). Universal or means-tested tax-financed benefits are particularly critical for older single females, who may not have had a sufficiently long labour market career to accumulate retirement income based on their wages that can keep many out of poverty.

Universal pension programmes are vital in countries with large informal labour markets or unstable formal employment. In these countries, contributory social security programmes provide adequate benefits for those covered, but may not be adequate for others. For example, in the 1990s, several Latin American countries introduced individual contributions accounts. For other countries, see Palacios and Knox-Vydmanov (2013). At the same time, the universal pension programmes of the Latin American countries were curtailed. By the middle of the following decade, these accounts were no longer providing adequate benefits, as many participants (e.g., in Chile) had not contributed enough to build a substantial balance. Berstein et al. (2006) estimated that about 50% of participants would receive a retirement income lower than the minimum pension amount, and many would not contribute for the twenty years required to meet the pension guarantee. At the same time, many of these individuals were not sufficiently poor to qualify for a social assistance pension. Hence, these low- to middle-income individuals would fall into a coverage gap. In response to this problem, ten countries, representing 90% of the Latin American population, introduced or revised their minimum pension programmes between 2011 and 2013.

It has been argued that safety net programmes (with eligibility determined by an income or asset test) were not adequate for those who do not have significant personal financial resources for their retirement years. At the same time, the compulsory nature of contributory employment-related social insurance programmes suggests that those with low earnings may be unable to afford contributions without severely damaging their current standard of living. To overcome this concern, programmes can be redesigned by modifying taxes and other subsidies. The Canada Pension Plan (CPP), for example, excludes certain (relatively low) earnings from the CPP contribution formula, while considering them as paid in the benefits computations. In this way, the contributions from lower-income earners are reduced, while they receive a higher return on their contributions. Brazil took a different approach: employee contribution rates that vary according to salary level, ranging from 8% at lower salaries to 11% for those with higher wages.

The willingness of society to help low-income earners raises the question of why those with a relatively low income should save for retirement (and other life risks) when they can rely on safety net programme benefits, even if those benefits are often relatively modest. In fact, given the aging of the population and competing demands for scarce public resources, policymakers may put the continuation of these safety net programmes at risk. By encouraging everyone to save more during their working life, policymakers can help alleviate future pressure on public retirement

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programmes, targeting available funds to areas with the most significant impact and alleviating the most pressing needs.

The complex tax and financial environment in developed countries makes coordinating universal or means-tested pensions with other sources of income, including contributory social security systems, a difficult yet important task. The overall design of a retirement system represents a balance between multiple objectives, for which several important questions need to be addressed, including: Does a particular pillar (in a system in which a basic fixed state pension is considered as pillar I, a supplementary employer plan as pillar II, personal savings as pillar III, and work income as pillar IV) provide disincentives to save or to stay longer in the workforce? Is the system sustainable? Are the benefits adequate? Does it contribute to or mitigate the effects of inequality? And will individuals be able to maintain their pre-retirement living standards?

Actuaries traditionally prepare valuations of social security retirement (and other) programmes. International Standard of Actuarial Practice No. 2 (ISAP 2*), Financial analysis of social security systems*, is a model standard to assist national actuarial associations in developing guidance for their members. In many countries, such actuarial valuations are mandated by legislation.

Additional guidance is provided by the ISSA-ILO Guidelines on Actuarial Work for Social Security (ISSA-ILO, 2022), which includes a section on policy and strategic issues related to inequality, such as the adequacy of benefits and coverage. For example, concerning assessing adequacy, the guidelines provide that "(t)he actuary should analyse the average amount of benefits and the distribution of benefit amounts in relation to relevant indicators such as average insurable earnings, the national average wage, the minimum wage, the minimum subsistence level and the poverty line to analyse and assess the adequacy of benefit provisions. The average amount of benefits for different profiles of beneficiaries, for example, by gender and career profiles, should also be analysed as far as possible." This type of distribution analysis provides policymakers with relevant information to address inequality issues.

An area of actuarial involvement is the analysis of the relationship between the benefits of the public and private pillars. Such interactions, as well as those with taxes, help ensure that the objectives of each pillar are achieved, including reducing poverty and income inequality and providing adequate income. (Sørensen et al., 2016).

4.4. Healthcare Solutions

Issues associated with inequality relating to the provision of healthcare are similar to those of social security programmes and may depend on whether the country's healthcare is provided through the public sector, private sector, individuals, or a hybrid approach. Additional issues specific to healthcare can arise, whether provided in facilities such as hospitals or a home setting. These issues (sometimes referred to as health inequities) are usually assessed in terms of access/availability, quality, timeliness of treatment, cost, and choice of provider(s). Affordability is a function of both access/availability and cost. It is difficult to optimise all these highly interdependent factors.

Public policy can help reduce health inequality. International health goals have been established by the WHO and the United Nations, first in 1985, and continued through the UN's 2015 Sustainable Development Goals[15] to be reached in 2030. These have met with uneven success but have focused attention on crucial health and inequality-related issues. Several European countries, including the U.K., Finland, and Lithuania, have introduced national targets to address socioeconomic inequalities (Europe Sustainable Development Report, 2022). The impact of policy on inequality, both in theoretical and empirical frameworks, shows that policy can affirmatively

[15]These include, for example, Goal 1 of elimination of poverty, Goal 2 of zero hunger, Goal 3 of good health & wellbeing, Goal 4 of quality education, Goal 5 of gender equality, and Goal 10 of reduced inequalities.

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contribute to population health (Rose, 1992). Providing better health conditions for lower socioeconomic groups is essential for reducing inequality in mortality and morbidity (De Gelder et al., 2017).

Access to and affordability of care are often based upon eligibility for (full or partial) reimbursement and the access/availability of appropriate healthcare infrastructure. Even in fully public programmes, the convenience of obtaining access to healthcare outlets and the accessibility of their services can differ by population segment, location, and income. A weak healthcare infrastructure can create healthcare inequalities. Urban and rural settings present additional challenges. In cities, higher-quality facilities and resources may only be accessible or affordable to those with higher incomes. In contrast, in rural areas, high-quality care may not be accessible to everyone.

Providing healthcare is becoming increasingly expensive almost everywhere, even where it is available, due to the costs of trained staff, diagnostic and treatment equipment, medical advancements, and pharmaceuticals. Cost, in turn, affects affordability, quality, and availability to different population segments. Inevitably, even in fully public programmes, evolution to multiple levels of care can occur, where those with higher incomes will be able to purchase some form of private insurance or other means of obtaining the highest possible level of care.

The primary purpose of providing healthcare is to add healthy years to life, not just more years. Thus, even though healthcare services are usually provided once an adverse condition has manifested itself, it may be more important to act in a preventative manner, including a nutritious diet, adequate physical activity, and avoidance of behaviours such as smoking. These healthy behaviours and habits are particularly difficult to maintain for those who cannot afford them. Better health outcomes will occur if these opportunities are incentivized for all or at least made convenient and affordable.

Healthcare inequality also stands in the way of accessing quality and cost-effective long-term care and services for those who are disabled or older. The ability of many older people and people with disabilities to afford to meet their needs with respect to performing their activities of daily living can be dramatically impaired. People with low incomes are more likely to need such services, while simultaneously lacking adequate resources due to a lower propensity and ability to save, as well as an inability to afford private insurance. Thus, public approaches may be needed, at least on a supplemental basis.

Actuaries can provide objective advice regarding these key healthcare factors, including interlinkages, cost estimates, unintended consequences, and input into many of the design decisions needed. Thousands of actuaries worldwide are involved in costing and analysing the demographics and distribution of healthcare costs. It is important that they consider the needs of individuals with low income or limited access to care in their evaluation and design of these systems and associated products.

4.5. Other Solutions

Many private, commercial, and voluntary insurance and savings programmes can mitigate the vulnerabilities and consequences of inequality. Since they are the subject of many papers and books, they will not be dealt with here other than to indicate that, in many cases, they can be provided through financial institutions, governments, communities, and joint private/public programmes. In some cases, solutions to address inequality can be sought through public and private partnerships or the operation of private sector products, developed and maintained under the oversight of applicable regulators.

Although adverse outcomes or consequences of certain conditions or events (e.g., death, longevity, disability, ill health, property damage, poor credit, or lawsuits) can be addressed by private or social insurance or accumulated individual wealth, many who most need such protection cannot afford it. In these cases, public-sector approaches may be desirable.

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Contributions by actuaries to these solutions can include such functions as:

- Providing input to and analysis of the development of default options tailored for low- and middle-income employees, participants, and their dependents and survivors. Actuarial experience with defined benefit pension plans can provide guidance regarding setting targets aimed at reducing inequality, as well as developing algorithms to determine contribution rates and benefits.
- Assessing the effectiveness of intermediaries and providers in terms of cost and quality of services provided.
- Helping design effective and efficient microinsurance programmes.
- Helping devise programmes to convert home equity into lifetime income solutions, including through the use of lifetime annuities.
- Assisting decision-makers to understand the uncertainties involved under a range of alternative scenarios.
- Designing risk pools that are actuarially sound, practical, and affordable for lower and middle-income individuals.

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