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Review article

The ethics case for longevity science

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ABSTRACT

Recent advances in biogerontology show that ageing is malleable, opening the possibility of delaying chronic disease and extending healthspan. Ethical debate has been dominated by consequentialist framings, balancing potential benefits against fears of overpopulation, inequality, or loss of meaning. We seek to further this discussion by grounding the case for longevity research not only in outcomes but also in respect for autonomy, self-ownership, and the intrinsic value of life itself. On this basis, we address three kinds of critiques: philosophical appeals to "naturalness", societal concerns about resources, justice and stagnation, and individual worries about meaning and boredom, showing that none provide decisive objections. Beyond rebuttal, we highlight neglected benefits: longevity research drives technological integration like the Apollo program, affirms the priority of existing persons over abstractions, and liberates individuals from rigid age-based expectations. The moral baseline must flip: the burden now falls on defenders of forced ageing to explain why preventable suffering should continue.

1. Introduction

Humanity has long sought to mitigate the challenges of ageing and extend the span of healthy life. Over the past 150 years, global life expectancy has more than doubled (Dattani et al., 2023), yet the biological processes of ageing themselves remain largely unchanged (Tosato et al., 2007). Across cultures, myths speak of elixirs of life, philosopher's stones, and fountains of youth. In Nick Bostrom's well-known allegory *The Dragon-Tyrant* (Bostrom, 2005), ageing appears as an unstoppable beast that devours us all, generation after generation. For centuries, this story of resignation shaped the moral imagination: ageing and death were inevitable, so ethics concerned how best to accept them.

This narrative is crumbling. Over the past few decades, biogerontology has revealed that ageing is not immutable. Lifespan has been extended by tenfold in nematodes (Ayyadevara et al., 2008) and by 50 % in mice (Flurkey et al., 2002). Cellular reprogramming, senolytic drugs, and genetic insights suggest that at least parts of the ageing process can be modified. If these lines of research succeed, they could delay the onset of chronic disease, extend the period of health, and redefine what it means to grow old.

Due to the profound implications of such progress, ethical debate has followed closely behind (Sethe and de Magalhães, 2013; Peng et al., 2023; Woo et al., 2019). However, most discussions have been dominated by consequentialist framings: balancing hoped-for benefits (e.g., reduced healthcare costs, productivity gains) against feared harms (e.g., overpopulation, inequality, loss of meaning). Both critics and advocates tend to treat longevity as a matter of projected outcomes, reducing the ethical question to a contest of demographic forecasts. What remains underexplored is a deeper foundation: whether anti-ageing research is justified independent of its consequences, rooted instead in duties, autonomy, and the intrinsic value of life itself. This paper aims to address that gap. Rather than advancing isolated arguments, we articulate a benchmark ethical case for longevity science by making explicit the foundational assumptions that already guide medical ethics and by showing how they jointly bear on the most persistent objections to life extension. Within this framework, we also develop several original normative claims, most notably concerning the moral priority of existing persons over abstract future populations, the ethical costs of subordinating individual health to collective goals, and the shifting burden of justification as age-related decline becomes increasingly preventable. In doing so, we seek not merely to survey the debate, but to clarify its underlying architecture and reorient how ethical responsibility is

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To this end, we combine the consequentialist analyses with a deontological perspective that foregrounds autonomy, self-ownership, and the intrinsic value of life. On this basis, we examine three types of objections to anti-ageing research: pure philosophical critiques, practical critiques at the societal level, and practical critiques at the individual level.

After addressing these critiques, we turn to the positive case: neglected benefits that go far beyond healthcare savings. Ageing research, we argue, has the potential to function as the "Apollo program of biology", catalysing technological integration and inspiring cultural imagination. It also reinforces an ethic of focusing on actual persons rather than abstractions. Finally, we argue that anti-ageing interventions represent a new wave of human liberation. Just as past technologies freed us from many constraints that were once considered "normal", longevity research can free us from the inevitability of decline at a fixed age. The moral baseline must flip: no longer should scientists justify the pursuit of longer, healthier lives; it is defenders of forced ageing who must justify why preventable suffering should continue.

2. Essential groundings in anti-ageing science and ethics

To narrow the scope of this paper and focus our arguments, we establish a few key assumptions that provide a framework for discussing life-extending interventions. The first and most fundamental assumption is that life has intrinsic value. In ethical discussions of ageing and medicine, it is useful to distinguish between three ways in which life is commonly valued: intrinsic, instrumental and relational. To say that life has intrinsic value is to claim that it is valuable in itself, independently of external measures such as productivity, economic contribution, or social usefulness (Kamm, 1998). By contrast, instrumental value treats life as valuable insofar as it enables other goods, such as work or societal participation, whilst relational value locates worth in the roles and relationships that give individual lives meaning within a social context. These perspectives are not mutually exclusive, and most human lives instantiate all three. However, grounding medical ethics in intrinsic value is crucial, because it ensures that the moral standing of individuals does not fluctuate with shifting political priorities, prevailing social attitudes or interpersonal connections.

Equally foundational is the principle of autonomy, which is often understood solely in negative terms as freedom from external interference, but which also has a positive dimension: the sustained capacity to form, revise, and pursue one's own life plans. Ageing progressively undermines this positive autonomy by eroding physical health, cognitive function, and temporal agency, thereby narrowing the range of meaningful choices available to individuals over time. From this perspective, to die or to undergo preventable decline is not merely to lose additional years, but to foreclose an individual's ongoing ability to shape their own life. Only in situations where suffering is so great that further life would bring no redeeming goods can the loss of life be judged ethically neutral or even beneficial.

A third assumption is the need to avoid what has been called the Tithonus error. In the Greek myth, Tithonus was granted immortality but not eternal youth, condemned to an eternity of frailty and decline. Public debates often evoke this image, imagining life extension as an endless prolongation of debility. Yet modern geroscience explicitly targets healthspan rather than simple lifespan. Its aim is to compress morbidity, reducing the years of disease and disability at the end of life whilst expanding the period of health and vitality (Kennedy et al., 2014).

A fourth assumption concerns the interconnectedness of ageing research with other sciences. Longevity research is not an isolated pursuit but one that draws upon and contributes to regenerative medicine, immunology, genomics, bioinformatics, and artificial intelligence. Breakthroughs in these fields spill over into geroscience, and insights from geroscience in turn strengthen adjacent areas of medicine. This means that attempts to evaluate the social or ethical consequences of ageing research in isolation risk oversimplification: the trajectory of longevity science is inseparable from advances in its neighbouring technologies. Any reliable prediction of its impact must therefore consider these co-evolving fields.

Finally, we must adopt a stance of realism about progress. The complexity of human biology and the need for long-term clinical trials makes a "singularity moment", where a single breakthrough eradicates ageing, highly unlikely (de Magalhães, 2014). Instead, progress in this field will likely be incremental, with each discovery building upon a growing understanding of the biological mechanisms involved. Because these advances will come gradually, societies will have time to adapt their institutions and cultural expectations. This also means it is not sufficient to make one grand prediction about the impact of life extension and hope it holds true centuries from now. What is required is a commitment to ongoing reflection and reassessment.

Taken together, these considerations alter how the continuation of ageing itself should be understood. As long as ageing was genuinely immutable, its harm could reasonably be regarded as unavoidable features of the human condition. However, as age-related decline becomes increasingly tractable through incremental biomedical intervention, its persistence is no longer a fixed background fact but a contingent outcome of collective choices about research priorities and medical action. It is in this descriptive sense that we use the term "forced ageing": not to imply intentional coercion or moral blame, but to denote the continued exposure of individuals to a harmful biological process in contexts where mitigating interventions could, in principle, be developed or pursued. Under these conditions, the default continuation of age-related suffering ceases to be ethically neutral, setting the stage for the objections and debates examined below.

3. Three types of critiques

Objections to anti-ageing research come in many forms, but they can be usefully organised into three broad categories. Pure philosophical critiques question whether death or ageing should be resisted at all, often appealing to claims about nature or the human condition. Practical critiques at the societal level raise concerns about collective consequences, such as overpopulation, inequality, or stagnation of progress. Practical critiques at the individual level focus on the lived experience of extended life, worrying that it might lead to boredom or a loss of meaning. This tripartite classification allows us to offer systematic responses below.

3.1. *Pure philosophical critiques – The "naturalness" argument*

The objection that anti-ageing research is "unnatural" recurs across the literature (Callahan, 1994; Caplan, 2005). On this view, to resist ageing is to resist the human condition itself, an overreach into what should be accepted rather than altered. Standard responses invoke analogy: if anti-ageing interventions are unnatural, so too are antibiotics, vaccination, and organ replacement (Ringel et al., 2025), and yet these are widely embraced. We share this view and believe that anti-ageing interventions should be recognised as the natural continuation of preventative medicine. Much of modern healthcare is not about curing illness once it arises, but about forestalling decline before it manifests. Ageing, as the single greatest risk factor for nearly every chronic disease of late life, belongs in precisely this category. Framing longevity science as a "vaccine of youth" (Davidovic et al., 2010) captures this logic: it aims to forestall predictable pathologies, thereby extending healthspan. To exclude ageing from prevention is not principled restraint but inconsistency, disregarding medicine's central commitment to intervene early, preserve function, and prolong flourishing.

This analogy defence is persuasive but incomplete. Its real strength is that it points to a deeper truth: medicine's very power comes from its

refusal to accept what nature dictates. To vaccinate, to transplant, to engineer, or to extend life is to exercise our rational capacity to make rules for ourselves rather than submit passively to biology. From this perspective, the "unnaturalness" is not a pejorative but the very marker of autonomy. Anti-ageing interventions epitomise this: they express our refusal to treat ageing and physical decline as destiny, and instead enact our duty to alleviate suffering and enable human flourishing on our own terms. Therefore, whilst categorising ageing as a disease remains controversial (Rattan, 2014), this classification is not a prerequisite for justifying action. The true question is not whether ageing fits within a narrow definition of disease but whether addressing it aligns with our natural desire to improve health and life quality.

When it comes to "naturalness", germline modification offers a particularly vivid case study, since genetic engineering represents one of the most strikingly "unnatural" interventions we can presently conceive. As advances in the genetics of ageing continue and longevity-associated genes are identified in humans and model organisms, the possibility of reshaping our biological inheritance becomes increasingly tangible. This represents the ultimate form of self-determination: not only choosing how to live one's allotted years, but reshaping the boundaries of that allotment. Consider *APOE*, the gene most strongly associated with human longevity. Its E4 variant confers a major risk for Alzheimer's disease, and carriers of this allele might one day benefit from germline therapy to alter the locus (Raulin et al., 2022). Although current technical limitations make germline therapy both impractical and costly, it is not difficult to imagine a future in which such modifications form part of a "longevity vaccine". Several *APOE* alleles are already well-characterised, some linked to longer lifespan and reduced Alzheimer's risk. If proven safe and free from major side effects, modifying the germline to reduce suffering and extend healthspan could be not only scientifically defensible but ethically compelling. Other strategies, from introducing protective variants found in centenarians (Lin et al., 2021) to borrowing longevity traits from exceptionally long-lived species such as the bowhead whale (Lagunas-Rangel, 2021), remain more speculative but underscore the same point: what appears most "unnatural" may ultimately prove to be the most powerful expression of autonomy.

An often-unexamined assumption in debates about ageing and genetic engineering is that inaction is morally neutral whereas intervention requires special justification. As a well-documented bias (Feldman et al., 2020), this omission-commission asymmetry becomes increasingly untenable when harms caused by the course of nature become both predictable and preventable. This line of reasoning aligns with arguments advanced by Savulescu et al (Savulescu, 2001; Savulescu and Kahane, 2009)., who have challenged the view that genetic interventions are merely permissible options rather than potential moral requirements. On such accounts, when genetic modification can reliably reduce suffering, prevent disease, or extend healthy life without imposing disproportionate risks, declining to intervene is not ethically neutral. Instead, it represents a choice to allow avoidable harm to persist. Whilst these arguments are often discussed in the context of reproduction or embryo selection, their force extends more broadly to interventions aimed at mitigating predictable biological decline. As experimental evidence accumulates identifying specific genes, pathways, and molecular mechanisms that reliably drive late-life disease and functional decline, declining to intervene can no longer be understood as mere deference to nature. Instead, it becomes a morally significant choice to refuse to use and develop such tools, allowing avoidable harm to persist.

3.2. Practical critiques at the societal level

3.2.1. Overpopulation concerns

One of the most frequently cited objections to anti-ageing research is the fear of overpopulation. The reasoning is straightforward: if people live significantly longer, the global population will rise, placing unsustainable pressure on resources. Combined with rising standards of living and consumption, this is thought to risk ecological collapse. A stronger version of this concern, developed within environmental ethics and ecological economics, holds that even under conditions of declining fertility, extended human lifespans may increase cumulative ecological footprints by prolonging consumption over time within finite planetary systems (Daly and Farley, 2011). On this view, even if life extension would be good for individuals, its collective impact makes it socially undesirable.

At first glance, the concern is intuitive. The twentieth century already saw a dramatic increase in life expectancy, and the global population has indeed grown in parallel (Lutz and K C, 2010). But closer examination reveals that the connection between longevity and population pressure is not so simple. Demography is driven as much, if not more, by fertility rates as by lifespan, although ecological concerns are not exhausted by population size alone. In most developed societies, fertility rates are falling below replacement levels, raising concerns not of overpopulation but of demographic decline (Nargund, 2009). Extending healthspan may mitigate some of the economic strains associated with ageing societies by enabling older individuals to remain healthier, more independent, and more productive for longer. The critiques of longevity science implicitly treat death following reproduction as a morally neutral background mechanism for managing resource use, whilst casting the continued lives of existing individuals as a novel ecological burden, even though in cumulative terms both patterns can impose comparable demands on the environment.

Even if overpopulation were to become a genuine concern, restricting medical progress would still not be the right response. Humanity has faced resource pressures before, from the agricultural limits of the pre-industrial era to the energy demands of industrialisation, and in each case the solution has come not from curtailing life but from technological and social innovation. Advances in agriculture, renewable energy, and resource efficiency continue to expand the carrying capacity of the planet. To single out longevity science as the place where innovation must stop, whilst assuming that no further innovation will address resource concerns, is inconsistent. If resource strain is the problem, the appropriate target is resource management and sustainability policy, not the suppression of life-preserving medicine.

There is also a deeper ethical issue at stake. To argue against anti-ageing research on the basis of overpopulation is to treat the lives of existing individuals as instruments for achieving demographic stability. It subordinates the intrinsic value of life and the autonomy of persons to an abstract goal of population equilibrium. Healthcare systems do allocate scarce resources, but they do so within the remit of healthcare, deciding between treatments, cost-benefit analyses, and quality-adjusted life years. We do not ban cancer therapies because saving patients might increase the population; we do not prohibit reproductive technologies because more children mean more resource use. Health care is about alleviating suffering and preserving life, not about engineering demographic outcomes. To repurpose it for population control would be to alienate life itself, reducing individuals to tools of policy.

Moreover, overpopulation arguments typically reject the person-affecting view (Arrhenius, 2003), the principle that an action is morally good or bad only insofar as it is good or bad for some particular person. They treat potential future persons – hypothetical individuals who might exist if population growth continues – as if their claims outweigh those of living individuals who are already suffering from ageing and disease. This move echoes long-standing debates in population ethics and intergenerational justice concerning what is owed to future generations (Parfit, 1987), particularly whether the interests of merely possible persons can override the basic interests of those who exist now. Whilst future people may warrant moral consideration, their claims are necessarily indeterminate and contingent on present choices, whereas the harms of ageing are immediate, concrete, and borne by identifiable individuals. Ethical reasoning should therefore prioritise those who exist now. The well-being of actual people cannot be

sacrificed on the basis of speculative calculations about future numbers. Even if population control were deemed necessary, it would be more ethical to prevent the creation of future individuals who are currently non-existent, through contraceptive measures and reproductive policies, than to withhold life-preserving technology from those already alive. Anti-ageing interventions preserve and enhance the lives of real, existing persons, whereas overpopulation concerns hinge on abstractions.

Finally, it is necessary to clarify that rejecting overpopulation fears does not downplay ecological risk; instead, it sharpens it. Short lifespans encourage short-term thinking, weakening incentives to invest in sustainability, whereas longer healthspans align self-interest with long-term planetary outcomes. Longevity extends our direct stake in the future, incentivising individuals to live with the consequences of today's environmental choices rather than outsourcing them to later generations. Far from undermining climate responsibility, longevity science strengthens the moral and practical case for sustaining the Earth we will still inhabit.

3.2.2. *Social justice and equality*

Another prominent concern is that anti-ageing interventions will deepen social inequality. Critics worry that treatments will be prohibitively expensive at first, available only to the wealthy, thereby widening health disparities (Mauron, 2005), both within and between high- and low-income regions. On this view, even if life extension is desirable in principle, in practice it risks becoming a privilege of elites rather than a benefit for all. This objection cannot be dismissed lightly. History shows that new medical technologies, ranging from advanced imaging to targeted cancer therapies, often arrive with high costs and limited availability. Health systems must then make difficult allocation decisions, balancing cost against benefit. It is therefore plausible that early anti-ageing interventions will follow a similar trajectory, with unequal access in the short term. Yet, three considerations suggest that inequality is not a decisive objection.

First, history shows that the cost of transformative technologies tends to decline over time. Antibiotics, vaccines, and imaging techniques were once expensive and scarce; today they are widespread and affordable. Even outside medicine, technologies such as mobile phones and computers followed a trajectory from elite luxury to global ubiquity. There is no reason to think anti-ageing therapies will be different. Indeed, because ageing affects everyone, the incentive to broaden markets is particularly strong. What begins as expensive treatments for the few is likely to become mainstream medicine for the many.

Second, if anti-ageing interventions can reduce multi-morbidity, their public health impact would be especially significant (Santos and Cylus, 2024; Scott et al., 2021). Multi-morbidity is one of the greatest challenges facing modern healthcare systems, driving both individual suffering and systemic costs (Tran, 2022). By delaying or preventing the simultaneous onset of multiple diseases, anti-ageing interventions could free resources, reduce hospitalisation, and improve quality of life across socioeconomic strata. In this sense, rather than exacerbating inequality, longevity research could reduce one of its most visible manifestations: the disproportionate burden of disease amongst the elderly poor. As Ringel et al. pointed out in their recent contribution on this topic, "Because aging affects all humans, aging biology research is one of the most egalitarian uses of health care resources" (Ringel et al., 2025).

Third, the ethical question cannot be settled by distributive concerns alone. The fact that some people may benefit earlier than others is not sufficient to show that the research itself is unjust. Health and life are not means to achieve distributive equality but ends in themselves. To deny or suppress interventions that alleviate suffering, simply because they may initially widen disparities, would be to instrumentalise health for an abstract goal. Inequalities should be mitigated through regulation, subsidies, and public investment, as they are with most other medical advances, not by halting progress altogether. The principle is clear: inequity in access should be confronted at the level of distribution, not at the level of discovery.

These considerations also intersect with justice-based approaches in contemporary political philosophy. From a Rawlsian perspective (Rawls, 2020), age-related decline undermines fair equality of opportunity across the lifespan, particularly insofar as deteriorating health constrains individuals' ability to pursue life plans that they could reasonably have expected to sustain. The thought experiment of the "veil of ignorance" can be extended to this biological context: when choosing principles to govern research directions without knowing whether one's most productive and meaningful years will come early or late in life, rational agents would have reasons to protect the conditions that allow life plans to be pursued across the full course of life with roughly comparable scope and ease, and also to favour conditions that expand the total span of opportunity by permitting life extension. In this sense, the predictable erosion of capacity in later life is not merely a natural misfortune, but a fairness-relevant risk to the realisation of long-term autonomy. Capability-based frameworks, such as those developed by Sen (2001) and Nussbaum (2000), similarly emphasise that justice requires securing the basic conditions for agency, participation, and practical reason; these capacities are systematically eroded by ageing and late-life diseases. From these perspectives, the moral relevance of longevity science lies not in maximising lifespan per se, but in preserving the capabilities that make lives meaningfully autonomous. Importantly, these frameworks locate questions of justice primarily at the level of distribution and access. They do not imply that the development of life-preserving or health-extending interventions is itself unjust, but rather that their benefits should be governed and disseminated in ways that respect fairness and inclusion.

3.2.3. *Cultural stagnation*

A further objection is that longer lives might entrench existing power structures and stifle cultural renewal. If individuals remained in positions of influence for centuries, the argument goes, society could ossify into a gerontocracy resistant to change. Yet this concern rests on several questionable assumptions: that ageing necessarily entails rigidity; that social progress depends on biological turnover rather than institutional design; and that creativity is a zero-sum resource requiring the death of the old to make room for the new. In reality, cognitive flexibility and innovation depend far more on education, health, and social openness than on lifespan. Anti-ageing interventions aim precisely to preserve vitality and mental acuity, which are prerequisites for creativity. Moreover, cultural and political renewal can be ensured through institutional mechanisms, such as term limits, elections, and cultural mobility, without relying on mortality as a substitute for reform. Empirically, some societies with high median ages have sustained substantial innovation under particular institutional arrangements. In Europe, countries such as Germany and the Nordic states have maintained high levels of technological and organisational innovation alongside population ageing, reflecting strong investment in education, research, and institutional flexibility rather than demographic youth per se. This suggests that rather than causing stagnation, longer healthy lives could deepen cultural memory, sustain mentorship, and allow knowledge to accumulate over time.

As discussed in the other two practical societal-level concerns, health and life are ends in themselves. Societal turnover and technological development are valuable instruments to help achieve these ends. It reverses the moral order to treat death or generational replacement as prerequisites for progress. Societies exist to enhance the flourishing of their members, not to sacrifice them for the sake of abstract dynamics. To oppose life extension on the grounds of stagnation is therefore to instrumentalise death as a policy tool. The solution to rigidity is not mortality or forced ageing, but better institutions and continuous learning.

3.3. *Practical critiques at the individual level*

Whilst societal-level critiques focus on collective risks, individual-

level critiques raise existential concerns about what life would be like if significantly extended. Two objections dominate this category: that longer lives would deprive existence of meaning, and that they would lead inevitably to boredom.

3.3.1. Loss of meaning

The fear that life extension would erode meaning is not new. Philosophers from Bernard Williams (Williams, 1973) to Leon Kass (Kass and Kass, 1983) have argued that finitude gives shape to human existence: without the boundary of death, life's projects lose urgency and purpose. If we expect to live centuries, or indefinitely, what would motivate us to love, work, or create?

This objection rests on a mistaken view of how meaning is generated. It conflates the drivers of action with the sources of meaning. Human actions can be motivated by positive drivers (e.g., love, passion, a sense of responsibility), or by negative drivers (e.g., time pressure and fear of loss). Both kinds of drivers can produce activity, but only the former contribute to genuine meaning. When urgency and fear are treated as the basis of life's significance, individuals are effectively coerced: valued for their productivity under constraint rather than for their projects, relationships, and creativity pursued as ends in themselves. By contrast, an extended healthspan allows people to act more from positive drivers, such as deepening commitments, exploring new pursuits, and repairing mistakes, without being coerced by the shrinking horizon of mortality. Far from eroding meaning, additional time multiplies the opportunities through which meaning can be cultivated. Empirical research in psychology supports this view: studies of purpose and late-life engagement consistently show that meaning and motivation are closely linked to health, autonomy, and social participation rather than to chronological age itself. When individuals retain functional capacity and agency, later life is often associated with sustained or even increased engagement, contribution, and well-being (Musich et al., 2018).

Moreover, the claim that finitude alone gives meaning risks incoherence. If death were what made life meaningful, then shorter lives would be more meaningful than longer ones. Yet few would suggest that tragedy enhances significance or that a life cut short at 30 is better than one lived to 90. Instead, most people lament premature death precisely because it deprives them of future goods. The "death gives meaning" thesis therefore mistakes a coping strategy for a normative truth. We may reconcile ourselves to mortality, but reconciliation is not the same as justification.

3.3.2. Boredom

Similar to the loss of meaning concern is boredom. If life were dramatically extended, would we eventually exhaust the supply of worthwhile experiences? This worry, however, underestimates both human creativity and the expanding horizon of possible experience. Even within a normal lifespan, many individuals pursue new skills, travel, relationships, and intellectual projects late into life without exhausting interest. A longer healthspan would expand, not contract, the range of available pursuits. Scientific discovery, artistic creation, and personal relationships are not finite goods to be consumed but open-ended domains that generate novelty through continued engagement.

Empirical evidence also undermines the inevitability of late-life boredom. Many centenarians report satisfaction and interest in life despite advanced age (Hao et al., 2019; Lucas, 2007). Their struggles stem from basic resources such as health, cognition and social network (Jopp and Rott, 2006), not from a lack of things to do. If anti-ageing interventions succeed in preserving vitality, the main source of late-life monotony, physical and cognitive decline, would be alleviated. In such a world, boredom is no more inevitable at 150 than it is at 50.

Finally, boredom is not a decisive objection because it is a choice-dependent state. Unlike death, boredom can be mitigated through action, change, or deliberate engagement. To argue against longevity on grounds of boredom is to assume that individuals will choose poorly in how they spend extended years. But autonomy requires leaving that choice in their hands. Personal choice is the key concept here: those who wish to can decline longevity interventions, or even end their lives earlier, whilst others may embrace the opportunity to continue living. The possibility that some may fail to use their time well does not justify denying everyone else the opportunity to have more time at all.

4. The benefits of longevity research

Critiques of anti-ageing interventions, whether philosophical, societal, or individual, often dominate ethical debate. Yet even when defenders respond, they usually frame their arguments in negative terms: life extension is not unnatural, it need not produce overpopulation, it will not destroy meaning. What remains underexplored are the positive benefits that longevity research itself brings, especially benefits that extend beyond alleviated suffering, healthcare savings or productivity gains.

4.1. Technological integration and cultural imagination

Current longevity research can be understood as the embryonic form of what could become the Apollo program of biology. The Moon landing was not merely a triumph of rocketry but of integration: physics, materials science, computing, and human physiology were synchronised into a single system that could not tolerate failure. The challenge itself forced innovation, creating the integrated circuit, advancing systems engineering, and reshaping project management and public imagination. This aligns with existing accounts of mission-oriented innovation (Mazzucato, 2018), which emphasises the role of publicly articulated goals in coordinating diverse scientific, technological, and institutional efforts without prescribing specific solutions.

Geroscience poses an analogous challenge at the biological level. To understand and intervene in ageing requires unprecedented coordination between molecular biology, chemistry, bioinformatics, artificial intelligence, and clinical medicine. Each discipline contributes a partial map of the ageing process, but only their convergence can yield a coherent picture of systemic decline and resilience. Ageing research functions less as a narrow specialty and more as a bridge between disciplines, creating an integrative enterprise where insights from different domains combine to produce results unattainable in isolation.

The result is already visible in a growing stream of technological spillovers. Techniques developed to study cellular senescence illuminate cancer biology (Collado et al., 2007); advances in cellular reprogramming transform regenerative medicine (Cherry and Daley, 2012); and machine-learning models trained to predict biological age are beginning to impact diagnostics across multiple conditions (Poplin et al., 2018; Sabanayagam et al., 2020). Because ageing is the primary risk factor for nearly every chronic disease, targeting its mechanisms acts as a multiplier in which progress in one area accelerates progress in many others. At present, however, geroscience lacks the scale of investment that made Apollo transformative. Fragmented and disease-oriented funding schemes constrain its integrative potential. Yet with a more deliberate, mission-oriented funding model where the biology of ageing is treated as a grand engineering challenge, there is little doubt that geroscience could achieve an Apollo-level synthesis of knowledge and technology.

Equally important is the cultural dimension. The Apollo program altered humanity's imagination, showing that seemingly impossible goals could be achieved and normalising "moonshot" thinking. Longevity research carries a similar symbolic weight. To treat ageing not as destiny but as a solvable challenge reframes the human story from resignation to agency. This cultural shift from acceptance of decline to responsibility for extending flourishing may prove one of the greatest benefits of all.

4.1.1. Emphasis on actual persons, not abstractions

Longevity research also clarifies the ethical priority of actual persons over abstractions. Critics often raise concerns about "the population" in

the abstract, which is the sheer number of humans who might exist in the future. But anti-ageing interventions operate at the level of existing individuals, each of whom suffers from the decline that ageing brings. The ethical imperative to alleviate this suffering should not be subordinated to speculative projections about aggregate numbers.

This emphasis on actual persons aligns with the person-affecting view in population ethics: what matters most is the well-being of those who already exist, not hypothetical future individuals. By focusing on extending the lives of present persons, longevity research embodies this ethical clarity. It reminds us that health care is not a tool for managing abstractions but a duty owed to those whose suffering is real and immediate.

4.1.2. Technical optimism: solving problems with solutions

Longevity science affirms a broader cultural attitude: problems should be solved with solutions, not by shrinking our aspirations. Critics of life extension sometimes argue that, because new challenges may arise, we should refrain from pursuing the science at all. This stance treats human desire for health and life as negotiable, something to be curtailed to avoid technical difficulties.

Yet history shows that the proper response to new challenges is not resignation but innovation. The agricultural revolutions overcame food scarcity; medical breakthroughs transformed once-lethal diseases into manageable conditions. Each of these required technical and institutional solutions, not abandonment of human aspirations. Longevity research belongs in the same lineage. If it introduces new challenges, we should design solutions proportionate to them, not use them as excuses to curtail the pursuit of health itself.

4.1.3. Liberation from age-based expectations

A further benefit of anti-ageing interventions is the potential to dismantle rigid social expectations tied to chronological age. For centuries, societies have operated under the assumption that life follows a fixed timetable: study in youth, work in adulthood, retirement in old age, and death before or around a century. This structure has shaped not only institutions but also personal identity, encouraging the view that certain opportunities, such as education, careers, and relationships, must be pursued "before it's too late".

By extending healthspan, longevity research destabilises these assumptions. If age no longer tracks physical or cognitive capacity in predictable ways, then the notion of being "too old" to start something new begins to lose force. Anti-ageing interventions could allow individuals to learn, work, love, and create across an extended spectrum of life, free from the tyranny of socially imposed deadlines. In this sense, longevity science does not only lengthen life; it expands the domain of freedom within life itself.

This liberation is not merely individual but cultural. It challenges ageism, the prejudice that equates older age with diminished worth or capacity. As chronological age becomes a less reliable marker of ability, the stigma attached to "being old" weakens. In its place emerges a more fluid and inclusive conception of the life course, where people are valued for what they can do and who they are, rather than how many years they have lived.

5. Conclusion

Debates about anti-ageing research have often placed its defenders on the back foot. Advocates are expected to show that interventions will not cause overpopulation, will not exacerbate inequality, will not erode meaning. This framing treats longevity science as suspect until proven innocent, as though extending healthy life were an indulgence in need of justification.

Here we defended longevity science with both consequentialist and deontological approaches. We further argue that the moral baseline must be inverted. Anti-ageing research should be recognised not as a dangerous exception but as a continuation of medicine's deepest commitments: to preserve life, to alleviate suffering, and to respect autonomy. Moreover, its pursuit brings generative benefits: it drives scientific collaboration much like the Apollo program, prioritises the well-being of existing persons, and liberates individuals from rigid age-based expectations.

Framed in this way, longevity research represents the next great wave of human liberation. Just as past revolutions freed us from famine, forced reproduction, and the constraints of manual labour, so too longevity research can free us from the certainty of decline at a fixed age. It dismantles age-based prejudice, expands the space of autonomy, and affirms life itself as an end rather than a means. The question is no longer whether scientists can justify pursuing longer, healthier lives. Instead, the burden now falls on defenders of forced ageing to explain why needless suffering should persist.

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Authorship

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Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used ChatGPT4o and 5 in order to improve language and clarity. After using this tool, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Declaration of Competing Interest

J.P.M is CSO of YouthBio Therapeutics, an advisor/consultant for the BOLD Longevity Growth Fund and NOVOS, and the founder of Magellan Science Ltd, a company providing consulting services in longevity science. Z.Z.H has no actual or potential perceived conflicts of interest to declare.

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