Authors' Response to Commentaries

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According to Wilson (1), "... any plausible unifying theory that seeks to marry longevity, functional disability, and health perception must involve political, social, cultural, psychological, and economic factors." On the contrary, Fries (2) states: "A general theory of biological aging ... needs to precede a general theory of population aging, which then could be derived from it, and inconsistencies and contradictions explained." Even, if the latter seems to be tailor-made to answer the former, and vice versa, it is significant that they were both comments on our article, which proposes broad outlines for a general theory on population aging. Their independent suggestions that we did not fully consider the social and political factors as well as the biological factors may indeed indicate that we have achieved a balanced approach.

Wilson and Fries are 2 of the 13 scholars, biologists, demographers, epidemiologists, and clinicians, including several geriatricians, who reacted to our proposal, providing together a reasonable sample of gerontological thinking (1–13). First, we thank all of them for their participation. Their pleasure was obvious and their contributions were, for the most part, positive. We have really enjoyed beginning this debate, although the number of points raised cannot all be answered here. We have therefore selected a few to begin with, and apologize to the remainder. We acknowledge that, at present, our article lacks depth and detail, as underlined by Carnes and Bernard (4), but, again, our aim was to propose the main outline for a general theory of population aging and to open the debate rather than complete it.

Proposing a General Theory of Population Aging

We disagree with the opinion that a general theory of (individual) biological aging needs to precede a general theory of population aging. The survival and longevity of any individual within human populations depends on a long and complex interplay between biological factors and the social organization of the group (i.e., the population), its level of economic development, including biological and medical technologies, and its ability to transform its environment. Taking the individual from the group or the population from the environment is meaningless when studying aging (14). Since the work of Strehler and Mildvan (15), we now have a greater understanding of the plasticity of aging (16,17). Most of us today understand that health or longevity, at the individual or population levels, is the result of several factors including genes, environment, and some chance or chaos (18). There is no longer a belief that the potential maximum life span is approximately 100 or 110 years, or that there are no more centenarians today than in ancient times (19–21).

Guralnik (9) provides the best summary of our proposed outline, noting that, through time, "there may be a circling back, where, first sicker people survive into old age and disability rises, then the number of years lived with disability decreases as new cohorts of healthier people enter old age, but finally, the number of years lived with disability rises again when the average age of death goes so high that many people spend their last years at advanced old age burdened by multiple chronic diseases and frailty." Obviously, this itself could form the basis of a theory. Indeed, several commentators propose refinements to our proposal. Deeg (5), for instance, wishes to complement the global theory with something more local and gives three arguments in support: local forces, period factors, and initial levels of disability. However, when proposing a general theory of population

aging, we need to identify the strongest trends behind local or period factors. For example, when identifying long-term mortality improvement, we cannot average past years, mixing poor and good years. Looking only at the good years identifies a more fundamental trend, largely hidden by the fluctuations of the past, and this is the approach followed by Oeppen and Vaupel when studying the record life expectancies to reveal the most fundamental trend in life expectancy increase (22). The mortality crisis in Russia and other Eastern European countries is an historical event and, as such, belongs to the fluctuations of the past. A general theory should help to identify the major trends behind local or historical events, not the opposite. Nevertheless, the contributions of Deeg and others provide us with thought.

In the same vein, Wilson (1) stresses the role of caring in enhancing longevity as opposed to the more usual view of blaming premature death on disease and extrinsic factors. Carnes and Bernard (4) stress the role of the initial level of aging, noting that, "In the early stages of population aging, the expected good health of the relatively younger old people in the emerging postreproductive population would favor the compression of morbidity hypothesis," and that later "there will be a tension between the aging and heterogeneity-driven expansion of morbidity and the biomedical and societal efforts to mitigate the morbidity consequences of aging." Deeg (5) also emphasizes the role of the initial level of disability, noting that compression is more likely when there is room, that is, when disability levels are high. Using the converse idea, Deeg (5) suggests that the disability increase observed in Australia might be because the disability level was initially low. In their analysis of the Australian data, Davis and colleagues derived their estimates from the 1993 and 1998 surveys using definitions consistent with the 1981 and 1988 survey screening questions (23). Therefore, changes in definitions cannot explain the increase in disability observed in this country as had been suggested by Caplan and Harper (3). A change in societal attitudes, earlier diagnosis of chronic conditions, and better treatment are common to all Western countries and are not specific to Australia. All these comments reinforce our outline. With socioeconomic development comes improvements in care that increase survival. In the early stages of population aging, the relatively young age of the older population and the initial high level of disability would favor the compression of morbidity hypothesis, and this could partly explain how a phase of expansion can be followed by a phase of compression and vice versa.

Measuring Disability and Interpreting Change Over Time

Almost all of the commentators mention the difficulty in measuring disability and interpreting change over time. They stress that chronic diseases, impaired functions, disability, or frailty are different concepts and that there are many questions aimed at measuring disability (3,7,9,12). Ignoring differences and other features in survey design may lead to apparent inconsistencies in disability trends, as illustrated by the recent debate devoted to the "true" trend in cognitive decline (24–26). Guralnik (9) stresses that different subgroups and cultures may differentially interpret questions on their disability. We agree that REVES (Réseau sur l'Esperance de Vie en Santé), the International Network on Health Expectancy and the Disability Process, was one of the first significant enterprises that aimed to systematically disentangle all of these issues at an international level (27–29). As noted by Guralnik (9), objective physical performance assessment through physical tests is promising to define an underlying level of functional status against which we can calibrate self-report of functional limitations and disability—an approach that might offer new avenues to further enhance health data harmonization, especially in different cultures. On the other hand, we must remember that the evidence showing that perception of health status is a more reliable predictor of health outcomes than many objective parameters (1). In other words, functional assessment, itself important to clinicians for achieving patient goals, should complement, but not replace, self-report (6).

Compression of Morbidity and Compression of Disability

Not surprisingly, many commentators focus on the compression of disability that is generally expected over the coming years, with changes in the built environment and advances in technology and assistant devices being the main contributors by easing the performance of daily activities (7,12). Goodwin (8) observes "if we want to picture the 4 million [American] centenarians in 2050, we should think of our current patients in their late 80s." But this is exactly what we don't know! We don't know if disability is largely avoidable until very close to death, whatever the ages reached. These optimistic scenarios will only occur if the postponement of disability outpaces that of death (9). Guralnik (9) also notes that if future populations look more like the current [United States] high education population, they would live longer and have higher active life expectancy, although their total number of person-years of disability could be higher. This is a recurring theme found by the REVES network when comparing male and female life and active life expectancies (30). So how do we measure our success if an increase in active life expectancy can accompany an absolute increase in the number of old people with disability? We agree with Guralnik (9) that, to answer this question, we need to develop a new epidemiology of extreme longevity, particularly addressing quality of life.

Compression of disability can be carefully distinguished from compression of morbidity (12). The prevalence of reported morbidity can increase due to earlier diagnosis and longer survival while the prevalence of disability can decrease due to environmental modifications. In between these, the prevalence of functional limitations takes an increasingly important role in helping to assess whether the excess in current reported morbidity, for example, due to earlier diagnosis, is less severe than that reported in the past. Although Fries (2) remains the champion of the theory of "compression of morbidity" in its original version, others are now making refinements, for example, proposing that compression occurs when active life expectancy increases faster than the total life expectancy. Therefore, a limit to life

expectancy increases is no longer a necessary condition for the occurrence of "compression" (31). Distinguishing morbidity, functional abilities, and disability enriches the concept of compression because an expansion of morbidity will probably occur in parallel with a compression of disability as discussed by Mor and Perls (12). So, the true question is about functional abilities and the way to measure them. Can we postpone physical, sensory, and cognitive functional limitations to the same extent that we postpone deaths? How much can we prevent diseases and reduce medical expanses?

What can be the impact of unfavorable trends in children's health, such as the obesity epidemic? Deeg (5), for instance, wonders whether the current advances in neonatal care of preterm births or increased use of in vitro fertilization can play against life expectancy increase. As noted by Carnes and Bernard (4), it is almost impossible to project how current changes in the health of younger populations may impact overall longevity. If the prevalence of childhood obesity on the one hand is increasing, several fatal diseases are becoming curable. On the other hand, if we give 70 years to the current teenagers for entering the oldest-old age group, we can see that the potential impact of childhood obesity will not be sensitive before long.

Future Prospects on Human Longevity

Wilson (1) considers that the increase in life span is not as well established as the increase in life expectancy, and wonders whether the increase in longevity is mere conjecture. In fact, two means have been proposed for measuring the life span and its increase: 1) the maximum life span and indicators such as the maximum reported age at death, and 2) the late mode of the ages at death measuring the most typical life span under a given mortality regime (32). Both maximum and mean life spans are clearly increasing in countries with good-quality data (29,32–36). Therefore, the best available evidence is in favor of an increase in longevity. We agree that care is needed until there are more confirmatory studies. However, we cannot maintain that this apparent increase will last forever nor can we accept, like Fries (2), to a "point of paradox," which would prevent life expectancy exceeding 87 years. We must keep an open mind and rigorously examine the empirical data and available evidence on the plasticity of aging.

We certainly do not know the frequency of centenarians in our distant past, as mentioned by Olshansky (13), in Rome or Athens for instance, or whether the maximum age at death has ever increased during the second millennium, but we do have enough historical data from the 16th century to maintain that octogenarians were rare in the 17th century (16) and centenarians probably exceptional before the 19th century (37). The previous models of population aging totally overlooked the emergence of new age groups through the epidemiological transition, and therefore we cannot explain its dynamics. Again, a theory must reconcile past trends and anticipate the future, aiding us to build scenarios, even those feared, such as the accumulation of extremely old frail persons, and thereby allowing the development of strategies to ameliorate the effects (38).

There is increasing evidence that family is an important dimension of longevity as underlined by Mor and Perls (12). Siblings not only share genes, but also share a number of environments: family, social group, and region, all playing a role in observed longevity. In epidemiology, socio-economic status is a key predictor of mortality. We need more studies to understand the degree to which extreme longevity is explained by shared family factors: sharing genes, belonging to the better off, or living in a favored region. The probability of becoming a centenarian is presently increasing rapidly, and this makes it more difficult to compare the meaning of being a centenarian today with, say, in 1990. More and more centenarians should display fewer and fewer exceptional characteristics.

Introducing Frailty

Whatever the life course morbidity profile of centenarians, "survivors," "delayers," or "escapers" (39), whatever their health status was when they were 90 years old (40), almost all centenarians are dependent at least in instrumental activities of daily living (41).

Again, the clear critiques of Fries (2) and Wilson (1) about the way we present frailty encourage us to consider whether we have a comprehensive understanding of this phenomenon. We do not equate frailty with disability. A person with a disability can be robust and live within the community, independently or not, but without specific health and mortality risks. Yes, we equate frailty with increased risk of disability (42) and death (43,44). The concept of frailty is not new. What is new is the emergence of frail persons. Previously frail persons were dying too fast to accumulate. While no operational definition of frailty still exists, frailty appears in gerontology as a fourth dimension of the individual health status. It is conceptually different from age, comorbidity, and disability even if it is statistically associated to these three other dimensions. Frailty is the loss of the ability to cope with daily stress, whatever the stress (social events, passage of seasons, minor diseases) and whatever the cause (loss of reserves or loss of the ability to mobilize and use them).

Only the provision of specific shelters and protecting the oldest-old from most of their daily stress allows them to survive. The built environment, confinement within the family, the development of modern nursing homes, and the provision of essential nursing services such as providing meals, all help to explain the current accumulation of frail persons. The 2003 summer heat wave in Europe and the oldest-old hecatomb following the lack of air-conditioning in most nursing homes, illustrate perfectly well our point. Wilson claims that "the concept of frailty as an embodiment of reduced functional reserves is an inevitable precedent of nonaccidental death at any age." This is correct, but at younger ages, nonaccidental deaths are due to lethal diseases such as cancers or heart diseases, which do not allow frail persons to accumulate. The combination of the absence of clear life-threatening diseases and a protective environment explain the accumulation of frail persons among the oldest-old. The causes of death for the oldest-old are poorly understood, and their death certificates contain mainly imprecise causes of death (45).

From Theory to Action

Kane (11) warns, "The hurricane is coming." Of course, the baby boomers will eventually reach an age, say 85 years, where the prevalence of disability and frailty becomes significant, but this will not occur before 2030 and 15 more years will pass before the nonagenarian group will be made solely of baby boomers. The current emergence of extremely old persons is related more to those born in the first part of the 20th century. It is therefore even more urgent that we understand the relationships between increased longevity and the health of the oldest-old in its three main components: morbidity, functional limitations, and disability, taking into account all possible mediator factors. Indeed, Jagger (10) states that the "purpose of a general theory on population aging is not only to describe where we are in the process but also to learn how we might 'interfere' with the process." She lists all the possible factors, extraindividual and intraindividual, that interfere with the disablement process and that might delay it. Most researchers emphasize the necessity of creating common measures of health such as the interRAI for long-term care services (46) or the EuroREVES package at the population level (29). Several agree on the need for a regular International Aging Survey "using truly comparable measures on a carefully selected set of countries, chosen for their similarity and variability across a range of the important factors" (10).

Provocatively, Wilson (1) claims that "[s]tudying global aging from the scientific perspective" is not an interesting venture for the gerontological community, and chooses to conclude with a quotation by Isaac Asimov that "... life is pleasant, death is peaceful, it's the transition that troubles." She adds that geriatrics is concerned with this transition. However, we feel that geriatrics, specifically gerontology, should be as much about successful or healthy aging and postponement of frailty or disability as about palliative care. The quality of years lived is probably the most important criteria by which to measure our success: quality of the active years but also quality of the years lived with disability and of the years lived as a frail person, and, of course, quality of the last years and days of life (47). However, we should keep in mind that giving priority to quality of life and providing the best available care each time it is necessary will probably further increase longevity and the number of more extremely old persons.

At the end of this discussion, we can refine our initial proposal, adding more details about the plasticity of aging and mortality to environment, including local conditions, general housing conditions, and the importance of caring. It seems, however, that nobody has really disputed the logic of our proposal and the challenge that constitutes the emergence and rapid accumulation of extremely old persons. Action starts with information and data collection. Obviously, one of the first steps taken should be the development of reliable health measures allowing us to monitor functional health status, the level of frailty, and the quality of life of the oldest-old. The implementation of an International Aging Survey would contribute greatly.

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