

特集：第22回厚生政策セミナー

「長寿化に関する国際シンポジウム—二大長寿国 日本とフランスの比較—」

Highest Life Expectancies: How Long Will Japan Keep the Lead?

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Japan has been the leader in the world female life expectancy since 1984. However, progress has recently slowed, meaning the Japanese advantage could progressively reduce. This study examines which countries may become the new leader in the near future. Among all possible candidates (i.e., former leaders, second-best performers, and new comers), South Korea appears to be most probable challenger. The recent rhythm of progress for life expectancy at birth has been very rapid in South Korea, while the decrease in old-age mortality rates has been spectacular. If Japan and South Korea continue progressing at the same pace, South Korea could overtake Japan by the year 2022.

Over the last 15 years, the decline in mortality has been more rapid in South Korea than in Japan for all ages and all causes of death. This decline is most spectacular for heart and cerebrovascular diseases. Mortality by heart disease has been decreasing since the early 1980s. The control of other circulatory diseases is a more recent development, but also very impressive. Furthermore, the trends for some causes of death that were particularly unfavorable during the 1980s and 1990s reversed at the turn of the century. This includes smoking-related cancer, diabetes, and external causes.

However, if South Korea catches up with Japan and takes the lead among the most advanced countries, this does not mean that the pace of progress for highest life expectancy will remain unchanged. In South Korea, female life expectancy trend has recently slowed in South Korea. The country's arrival as a new leader may coincide with a change in the segmented line of maximum life expectancy. After the first segment was driven by victories against famine and infection during the 19th century, the second began with the Pasteur Revolution and was reinforced by the discovery of efficient tools designed to fight infectious diseases (e.g., immunization and antibiotics). The third segment corresponded to the cardiovascular revolution during the last decades of the 20th century. The future rhythm of progress will most likely rely on success in controlling the typical causes of death among the elderly, including mental disorders, old-age respiratory and circulatory diseases, and general frailty.

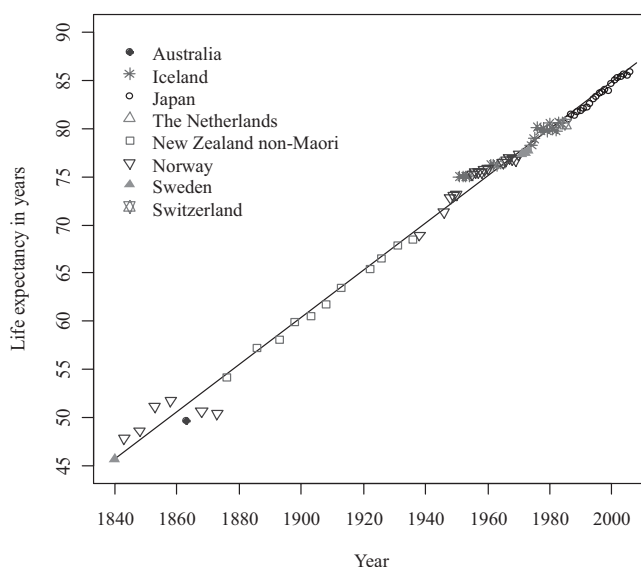
I. Introduction

In a paper published in *Science*, Oeppen and Vaupel (2002) showed that global maximum life expectancy at national levels had followed straight-line trends since the mid-19th century (Figure 1). This was an astonishing discovery that shocked the international scientific community, which was

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mostly convinced that life expectancy had nearly reached maximum levels and would soon plateau. To the contrary, the authors recalled that scholarly predictions about the biological limits of human life expectancy had all been denied by facts.¹⁾ They further claimed that the straight line clearly indicated that the best use of medical progress could still guarantee future life expectancy increases at the same pace for a long time, if not for ever. The rhythm of increase in maximum life expectancy is one quarter of a year each year (as indicated by the straight line in Figure 1), and is expected to continue without slowing. This Oeppen-Vaupel theory includes a corollary issue. That is, each time the life expectancy trend of the current leader country slow, a new country will take the lead, just as has happened in the past.

Figure 1. Maximum female life expectancy since 1840 according to Oeppen and Vaupel (2002)



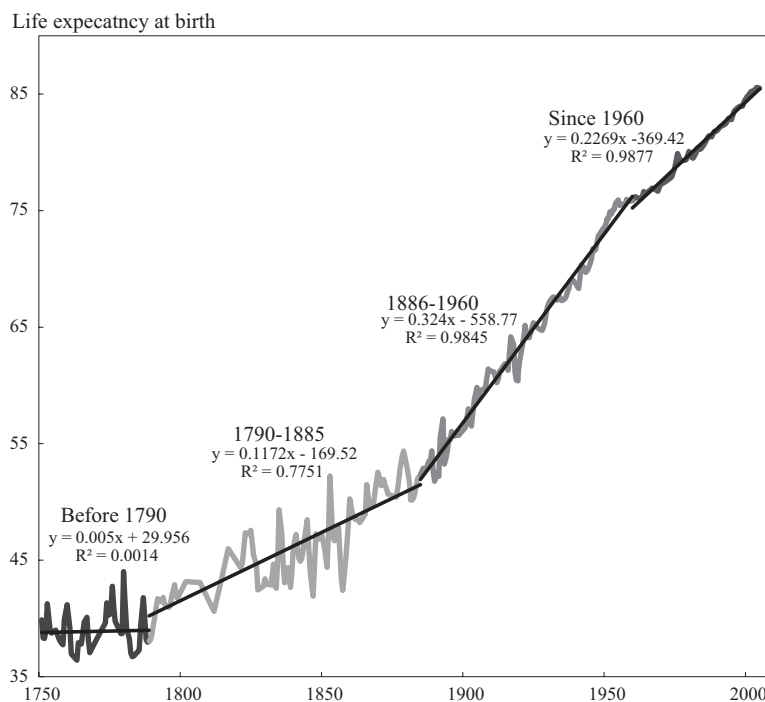
Source: Drawn by authors from data published in Oeppen and Vaupel (2002)

After studying a longer period and excluding dubious data, a few years later, we found that the slope of adjustment changed according to the type of improvements that increased life expectancy (Vallin and Meslé 2009). World-record life expectancy was stagnating at low levels just before the

1) Many authors estimated this limit. As early as 1928, Dublin (1928) wrote that human life expectancy could not exceed 64.7 years (a score that Australia had already reached by 1925). Dublin and Lotka (1936) later revised this estimate to 69.9 years, a level exceeded by Iceland in 1941. Two decades later, Bourgeois-Pichat (1952) proposed a life expectancy of 76.3 years for males and 78.2 years for females, but Iceland broke this new limit in 1975. Benjamin (1982) then proposed a limit of 87.1 years for females, but this was broken by Japan in 2016. Olshanky et al.'s (1990) limit of 85 years for both sexes will undoubtedly be broken soon, while the more audacious limit of 91.4 years proposed by Duchée and Wunsch (1990) will very likely be broken before the end of the century.

end of the 18th century. It then progressed, with the first victories against famine and infection, until the 1880s steadily but slowly. However, progress accelerated sharply when the Pasteur Revolution provided access to groundbreaking new tools, such as immunization and then antibiotics. Conversely, progress slowed during the 1960s, when new improvements in life expectancy had to rely on the decline of cardio-vascular diseases, which were more difficult to fight and less productive in terms of life expectancy gains (Figure 2). A more recent study confirmed the statistical significance of all these changes in the slope of the adjustment lines (Camarda et al. 2012).

Figure 2. Maximum female life expectancy at birth since 1750 (excluding Norway until 1866 and New Zealand)



Source: Vallin and Meslé (2009)

Even if the Oeppen-Vaupel theory of a constant annual progress over one quarter of each year is incorrect, its corollary is still interesting to explore. At first (1750-1780), maximum life expectancies were observed in Sweden, Finland, and England and Wales, alternatively. Denmark took the lead between 1780-1830, Norway did so between 1830-1920, Australia and/or Canada reigned between 1920-1950, Norway again and/or Iceland held the highest rates until 1983, and Japan finally took the lead in 1984. It has remained the absolute leader since. How long can this Japanese advantage last?

This question is quite topical since the rhythm of progress of Japanese female life expectancy appears to be declining. After Japan took the lead, in 1982, female life expectancy grew by an average of .29 years each year for two decades. But, this has declined in more recent years, moving to .14 years each year between 2009 and 2016. It is important to mention that this period includes the year 2011, in which Japan was hit by a tsunami that caused a sudden fall of nearly half a year in life expectancy. However, life expectancy had already exceeded its 2010 levels by 2012. Although devastating, the tsunami seems to have slightly hindered continuous progress, but did not radically alter the overall rhythm. Mean annual progress even a little bit better after than before (.19 year per year in 2012-16 instead of .15 in 2002-10), but far from the .29 of the first 20 years of leadership. Japan's slowed progress makes the earlier question double. Can any country catch up with Japan over the next few years? Will a new leader maintain a higher growth rate in life expectancy?

II. Three possible types of challengers

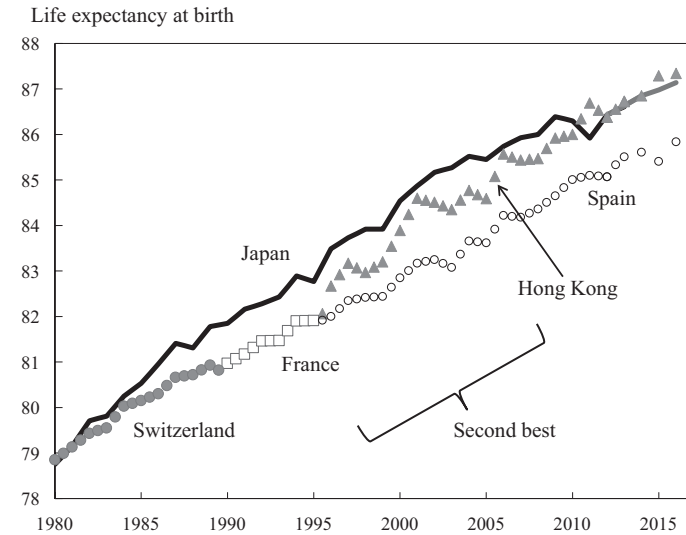
One way to determine potential candidates that may exceed Japan's performance is to look at historical second-best performers. We also thought of looking at countries that were top leaders before Japan (e.g., Nordic European countries or the Netherlands) and those that have shown impressively accelerated progress in recent decades (e.g., Hong-Kong, South Korea, and Singapore). For these different countries, we studied statistical adjustments in the national series to identify possible changes in the slopes of life expectancy progress which could reveal accelerated trends that were likely to be more rapid than Japan's in the near future.

1. Recent second-best countries

While Japan became the leader during the early 1980s, several countries have taken the second position since then. Switzerland became the second-best performer immediately after Japan took the lead in 1984 (Figure 3). However, this did not last long. France exceeded Switzerland in 1989 for second place before losing this position in 1996, less than seven years later. Here, a question becomes exceedingly relevant. Should Hong Kong have been considered on its own? If so, it was second-best until catching up to Japan and actually taking the lead in 2010. Consequently, our initial question would no longer remain unanswered since this event would have already given us a definitive fact. Yes, Japan was challenged and overtaken by new leader Hong Kong. This is true even if the 2011 gap between Japan and Hong Kong was somewhat artificial due to a peak in the mortality rate caused by the Fukushima catastrophe (Figure 3). However, Hong Kong does not quite provide fair competition in this area. First, it is not an independent country. The philosophy in this work is rooted in international comparisons. Furthermore, Hong Kong is rather peculiar, as it is almost totally comprised of a single urban area. This biases the comparison since other areas

contain much more heterogeneous combinations of urban/rural populations. Even if Hong Kong is removed from consideration, another country has already exceeded France. Spain became second-best in 1996 and has since kept that position.

Figure 3. Second-best performers since Japan took the lead in maximum female life expectancy

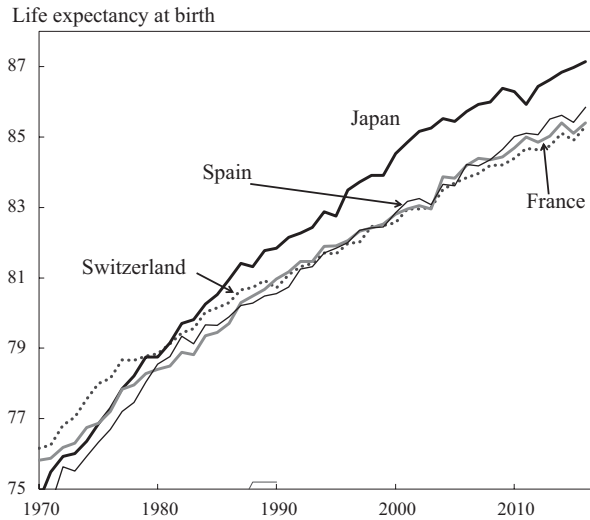


Source: HMD

2. The three recent "second-best" (Hong Kong excluded)

Three countries (Switzerland, France, and Spain) have ranked second since Japan took the lead. Is there a chance that any will really challenge Japan in the near future? It is quite possible since recent progress of each is a bit faster than that of Japan (Figure 4). However, the differences are small. Since 2002, while female life expectancy grew by .14 years each year in Japan, it grew by .19 in Spain, .17 in France, and .16 in Switzerland. Furthermore, if only the most recent years (2012-2016) are considered to avoid integrating the 2011 Japanese tsunami year, Japan is doing as well or better than the three European countries at a progress rate of .19 years. Yet, this is probably not the best comparison since Spain, Switzerland, and especially France were severely affected by exceptional flu epidemics between 2015-2017. At any rate, while the three recent second-position countries are possible challengers, they are ultimately not very likely to exceed Japanese leadership.

Figure 4. Comparison of recent female life expectancy trends in Japan and the recent "second-best" of Switzerland, France, and Spain (excluding Hong Kong)

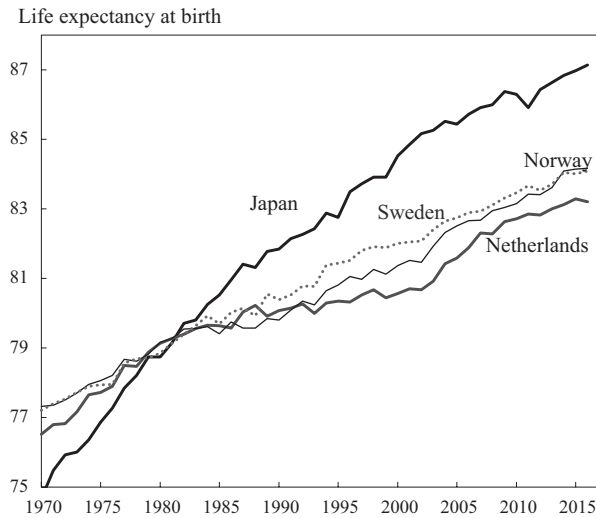


Source: HMD

3. Former leaders

Another possibility is to look at former leaders such as Sweden, Norway, and the Netherlands. It would have seemed sheer folly to expect these nations as possible challengers while they were dramatically diverging from the Japanese trend prior to 2000 (Figure 5). However, these three countries have been doing much better for a dozen years. Their annual gains in female life expectancy are no longer negligible; they are not far behind Spain, France, and Switzerland (i.e., .19 years each year in Norway, .18 in the Netherlands, and .14 in Sweden between 2002-2016).

Figure 5. Comparison of recent female life expectancy trends in Japan against three main former leader countries (Sweden, Norway, and the Netherlands)



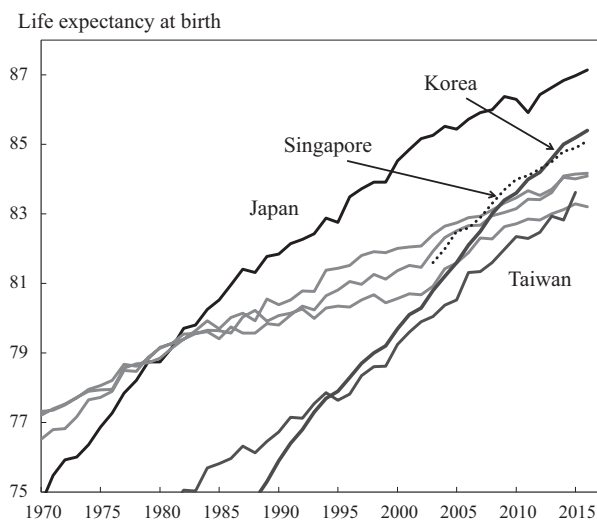
Source: HMD

Nevertheless, their ability to catch up with Japan in the near future is much more improbable than for the three countries that have most recently reached second best. Not only do they have tiny advantages on Japan in terms of recent progress speed, they share the great disadvantage of being far behind current Japanese achievements. In 2016, female life expectancy was three years shorter in Norway and Sweden than in Japan and even greater in the Netherlands at four years, while it is less than two years in Spain, France, and Switzerland (1.3, 1.7, and 1.8, respectively). Even if current trends are nearing Japanese levels, it could take much longer for Sweden, Norway, or the Netherlands to exceed Japan before the three most recent second-best countries are able.

4. Possible newcomers

Neither the recent second-best nor the former leaders are very strong challengers. It is thus appropriate to look at countries that have recently progressed at very fast paces and have already achieved quite high life expectancy levels. These countries most likely fall outside the traditionally developed world, in regions where there is great socioeconomic potential. What about emerging countries that are still well behind Japan in performance, but where life expectancy is growing at an exceptionally faster rhythm? Particular attention must be drawn to the recent trends in Singapore, South Korea, and Taiwan (Figure 6). These three developing countries have not only already caught up or even exceeded the three former leaders mentioned above, but their pace of progress has been much faster than Japan's over the last decades.

Figure 6. Comparison of recent female life expectancy trends in Japan against those in three newcomer countries (Singapore, South Korea, and Taiwan)



Sources: HMD, Statistics Korea, National Statistics Republic of China (Taiwan), Statistics Singapore

Compared to the .14 years each year seen in Japan between 2002-2016, female life expectancy grew by .27 years in Singapore, .29 in Taiwan, and as high as .39 in South Korea. South Korea is by far the most impressive, especially since it combines this recent rapid progress with a small gap between itself and Japan of less than two years. This is much smaller than that seen in the three former leader countries, and is very close to that seen in recent second-position holders.

Nevertheless, let us summarize the complete panorama resulting from a rough prolongation of the recent past trends before further examination of this very promising case.

5. What could be prolonging recent past trends?

It is possible to estimate the year in which each country will reach the 2016 Japanese life expectancy level and then, the year when it could catch up with Japan by applying the mean pace of each observed increase between 2002-2016.

South Korea would accordingly be the first to reach the 2016 Japanese level (as soon as 2020). Next would be Singapore (2022), Spain (2023), France (2024), Switzerland (2025), and Taiwan (2029). The Netherlands and Sweden would finally achieve this number in 2035 and 2037, respectively.

It would take much more time for most to catch up with Japan. This is because Japan is also expected to continue progressing at its most recent pace. However, South Korea could manage to

catch up very soon, as early as 2022! The next, Singapore, will likely have to wait another eight years, until 2030, while the third, Taiwan, would not do so until 2042. It is interesting to note that this second step would first be taken by the three newcomers, while the three second-bests are expected to reach the first goal (2016 Japanese level) very rapidly after Singapore and earlier than Taiwan. The three second-bests have the immediate advantage of already nearing Japan levels. However, the three newcomers could catch up with Japan much easier thanks to their faster rhythms of progression. Spain will likely not achieve this before 2042; it would take even more time for France (2082) and Switzerland (2128), while Sweden may have to wait for hundreds of years.

South Korea is a particularly fascinating case since it could not only reach the 2016 Japanese level by 2020 but may also catch up with Japan two years later. This prediction is in accordance with a recent, more sophisticated mortality forecast made at the Imperial College of London (Kontis et al. 2017). No other country seems to have any chance of doing better! South Korea thus deserves a more precise examination and confirmation.

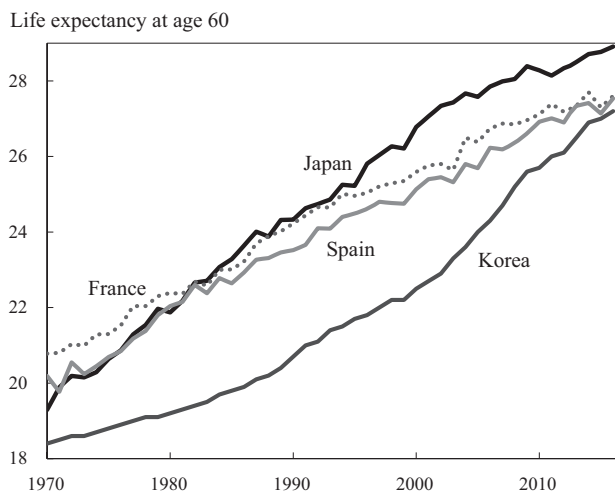
III. South Korea: The most probable challenger

Life expectancy at birth trends are not sufficient to ensure that recent paces of progress are sustainable. At least two more precise aspects should also be examined. First, it is very important to determine what is really happening in old-age mortality: at these very high levels of life expectancy, increasing the elderly survival rate is crucial for increasing overall life expectancy. It is also useful to analyze the trends in causes of death in order to speculate on reducing pathologies that would be most important in the future.

1. Accelerated progress at old ages

As shown in Figure 7, female life expectancy at age 60 is now progressing much faster in South Korea than in Japan; this is the result of two successive accelerations. The first started in 1984, while the second and most decisive was in 1998. Rather strikingly, the latter coincides with the 1998 Asiatic financial crisis, but this is not necessarily a surprise since economic crises do not always result in health crises. It may sometimes actually be the opposite.

Figure 7. Comparison of trends in female life expectancy at age 60 in Japan and South Korea since 1970



Sources: HMD, Statistics Korea

On the other hand, this acceleration strongly contradicts pessimistic hypotheses on the quality of the Korean civil registration system. It is quite possible that old-age deaths were under-registered in the past and that such under-registration has regressed. Even if deaths are still not totally registered, improvements in registration coverage and/or increasingly accurate age reports would result in an underestimated pace of progress.

Regardless, the most important aspect here is that gains in life expectancy at age 60 have been much greater in South Korea than in Japan for almost 20 years. In contrast, progress in France and Spain has been slower than in Korea, which is already very close to those two countries. Indeed, it is notable that the pace of progress has slightly slowed in Korea over the last five years, but this phenomenon is actually greater in Japan.

2. Favorable changes in cause-of-death profiles

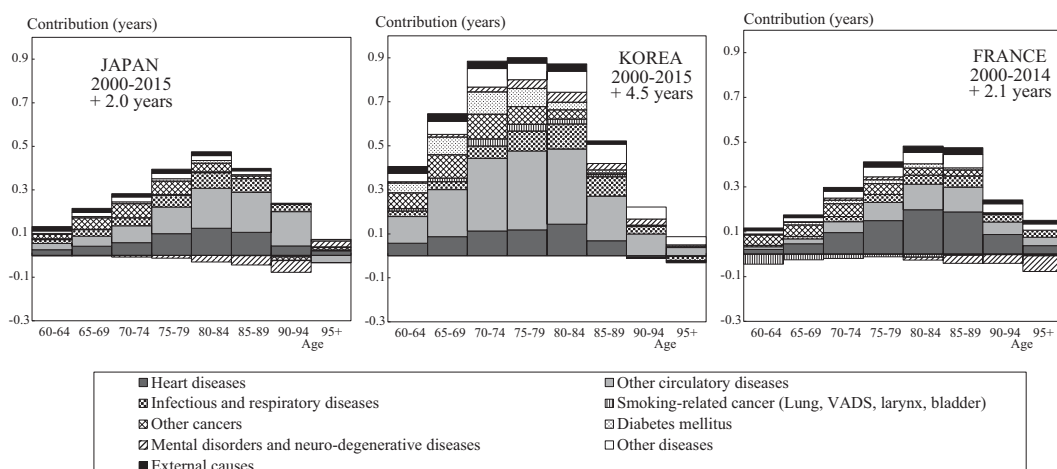
Figure 8 shows the contribution of mortality changes by age group and ten major groups of causes to the increase in life expectancy at age 60 since the year 2000 in South Korea as compared to Japan and France²⁾. Gains are all much larger in South Korea than in Japan for almost all causes (Figure 7). Deaths from ill-defined causes (including senility) have been proportionally redistributed among all specific causes. Gains structures differ significantly between the three countries.

Not only are Korean gains much higher than those in Japan, but this is true at all ages, including

2) Analysis was done between 2000-2015. However, 2015 cause-of-death data were not available for France (available data for 2000-2014 were thus used).

the oldest and for all causes of death. However, this Korean advantage substantially varies according to the cause of death. While gains due to the decrease in heart disease mortality are rather similar in both countries, South Korea benefited from a much more important decline in mortality from other cerebrovascular diseases. For the rest, Japanese gains are still only significant for infectious diseases and cancers. Not only are these gains larger in Korea, there are also important benefits due to the decline of other causes, especially diabetes, mental diseases, and "all other causes." Finally, containment of the greatest killers (i.e., cardiovascular diseases and cancer) has resulted in much greater life expectancy gains at age 60 in South Korea when compared to those in Japan. In addition, the decline of all other causes of death has resulted in significant gains in Korea, while in Japan they are tiny or even negative.

Figure 8. Age and cause components of changes in life expectancy at age 60 in South Korea when compared to Japan and France

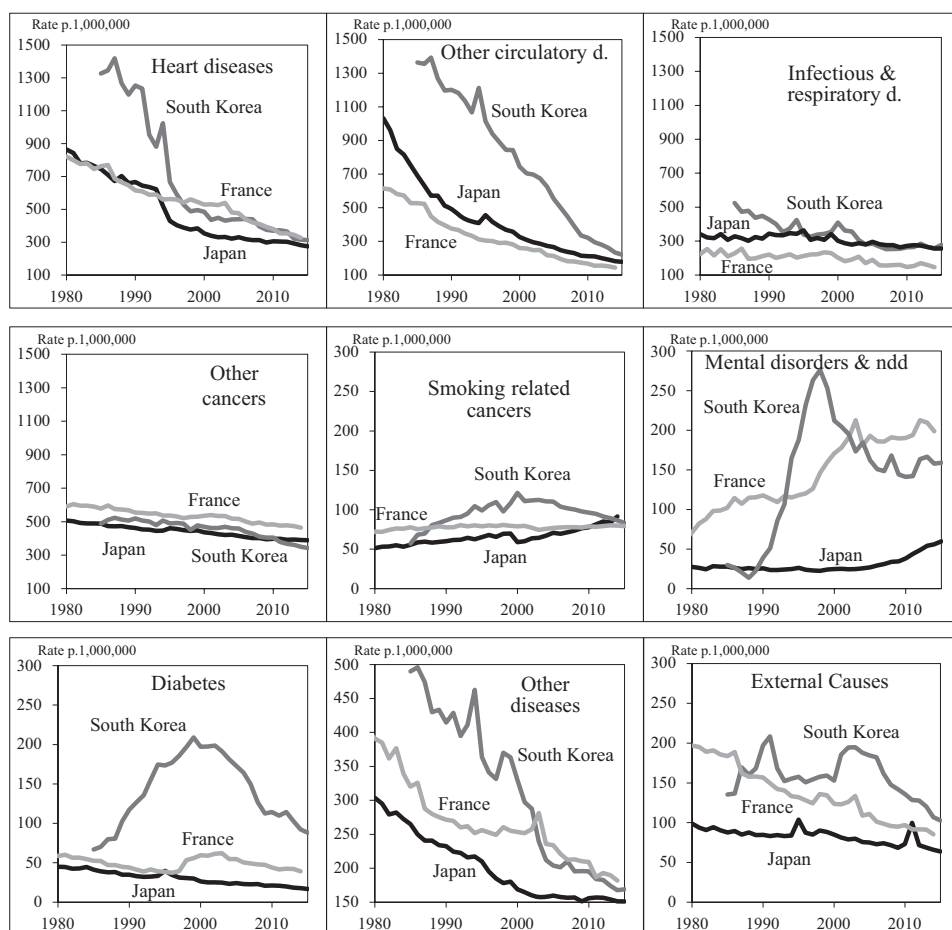


Source: Authors' computations from WHO data

Figure 9 shows the Korean annual changes in standardized death rates according to cause at age 60+ since the 1980s as compared to those in Japan and France. Infectious diseases are no longer a significant problem in Korea; the levels of mortality resulting from these causes have been nearly the same in Korea and in Japan since the beginning of the 1990s and are not very higher than those in France. Once very high in the early 1980s, cardiovascular mortality rates have also fallen dramatically. The decline of heart disease was particularly spectacular during the 1980s. These rates became lower than those in France and very close to Japanese rates as early as the mid-1990s. The control of other circulatory diseases is more recent, but also very impressive. By 2016, Korea was almost at the same level as Japan and not far from France (which has been at the world minimum for a long time). These two former main killers are no longer the most crucial

contributors to the gaps between Korea and Japan or France. For cancer (except from smoking), Korea has never had much higher levels than Japan and has consistently remained below France. Korea has even fallen even below Japan in recent years. Although the risks are smaller, it is of particular interest to underline the rather recent changes that have occurred in the four main causes of disease that were once major threats to the future of Korean health (i.e., smoking-related cancer, mental disorders, diabetes, and external causes). Mortality resulting from all four causes steadily increased during the 1980s and 1990s, but reversed at the turn of the century. Smoking-related cancer rates are now as low as those in Japan, while diabetes and external causes seem to be nearing the rates seen in both France and Japan. The only causes that could moderate an optimistic view are mental disorders, which do not appear to have continued the same rate of fall during the most recent years.

Figure 9. Annual changes in age-standardized mortality rates at age 60+ according to causes of death in Korea, Japan, and France



Source: Authors' computations from WHO data

3. The importance of changes in epidemiological profiles

If we had studied national trends in the 1950s or 1960s, would it have been possible to predict that Japan would take the lead a few decades later? This is quite improbable. The radical change in leadership was a result of the cardiovascular revolution, which was hardly predictable before the mid-1970s. Japan emerged as the best performer because of its ability to reap immediate benefits from medical innovations that decreased the major causes of death during the early 1970s. This was in turn a result of its own epidemiological, economic, social, and behavioral contexts. Furthermore, it seems that Japan remained the leader because it also pioneered a new step of the health transition through its fight against causes of death at very old ages (Meslé and Vallin 2006). Quite identically, South Korea has made spectacular gains against both cardiovascular mortality and various other old-age diseases since 2000, while all such benefits have slowed in Japan. This reveals a path for South Korea to catch up with Japan in terms of life expectancy within a couple of years.

IV. Conclusion: A change in the pace of progress?

A new country taking the lead is not sufficient to maintain the pace of increase in the world maximum life expectancy. It may be very probable that South Korea will catch up to Japan very soon. However, this does not mean that it will be able to continue such progress at the same pace. To the contrary, we have already seen its pace slow over the past five years. Hong Kong already exceeded Japan in 2010, the year before the aforementioned tsunami. This example is interesting. Although ineligible as a real challenger, Hong Kong proved that exceeding Japan was not a guarantee for sustaining the pace of Japanese progress seen at the end of the last century. As shown in Figure 6, life expectancy at age 60 has also slightly slowed down in Korea over the last decade. It would not be a great surprise if the arrival of a new leader coincides with a new change in the segmented line of the maximum life expectancy trends. This new segment could be jointly driven by several countries, including Japan, Korea, and others among or outside those that deserve examination today soon after. The slope of this new segment would characterize countries that continue to improve life expectancy rates by controlling causes of death typical of the oldest ages, including mental disorders, old age respiratory and circulatory diseases, and general frailty.

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最長寿命：日本はいかに長くトップであり続けるか

フランス・メレ， ジャック・ヴァラン

日本は1984年以降，女性の平均寿命に関する世界のトップであった。しかしながら，最近では伸長は緩やかとなり，日本の優位性はだんだんと小さいものへとなりつつある。本研究は，近い将来，どの国が新しいトップとなりうるかを検討する。全ての候補国（すなわち，以前トップだった国，二番手の国，新たな国）の中で，韓国が最もトップに近い国であると考えられる。韓国における最近の平均寿命の伸長速度は非常に速く，とりわけ高齢死亡率の低下は目覚ましいものであった。仮に日本と韓国がこれまでと同じペースで伸長を続けたとしたら，韓国は2022年までに日本を追い越すだろうと考えられる。

過去15年以上にわたり，全ての年齢と全ての死因について，韓国の死亡率低下は日本よりも速かった。この低下は，特に心疾患と脳血管疾患において最も顕著である。心疾患死亡率は1980年代初頭から減少してきた。他の循環器疾患のコントロールが進んだのはより最近であるが，この効果も大きいものであった。さらに，特に1980～1990年代に改善が芳しくなかったいくつかの死因のトレンドについても，21世紀初頭から一転して改善に向かった。これらの死因の中には，喫煙に関連したガン，糖尿病，外因による死亡が含まれている。

しかしながら，もし韓国が日本に追いつき，平均寿命が高い国々の中でのトップとなっても，最長平均寿命の伸長ペースがこれまでと変わらないということの意味するものではない。韓国では女性の平均寿命の伸長は最近緩やかとなっている。この国の新しいトップとしての登場は，最長平均寿命を表す線分の変化点に対応することになるかもしれない。第1の線分は19世紀の間の飢饉と感染症への勝利による伸長を示し，第2の線分はその後のパスツール革命によって始まり感染症に対抗する効率的なツール（例えば予防接種や抗生剤など）の発明により加速された伸長を示す。そして第3の線分は20世紀の最後の数十年間における心血管革命による伸長に対応している。一方，将来の伸長速度は，精神障害，高齢期の呼吸器・循環器系疾患，一般的な虚弱など，高齢者における典型的な死因のコントロールの成功により多く依存するだろう。

（訳：石井 太）