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Convergences and divergences: an analytical framework of national and sub-national trends in life expectancy *

1. INTRODUCTION

Abdel Omran's 1971 theory of "*epidemiologic transition*" was the first attempt to account for the extraordinary advances in health care made in industrialized countries since the 18th century. According to Omran, all societies experience three "*ages*" in the process of modernization: the "*age of pestilence and famine*", during which mortality is high and fluctuating, with an average life expectancy under 30 years; the "*age of receding pandemics*", during which life expectancy rises considerably, from under 30 to over 50; and the "*age of degenerative and man-made diseases*", during which the pace of the mortality decrease slackens, while the disappearance of infectious diseases increases the visibility of degenerative diseases, and man-made diseases become more and more frequent. At the time Abdel Omran was developing his theory of epidemiologic transition, the most knowledgeable specialists, including United Nations experts, saw life expectancies as generally converging[1] towards a maximum age, with the most advanced countries appearing very close to it. According to the United Nations World Population Prospects, the point of convergence was 75 years (United Nations, 1975). In point of fact, in the most advanced countries, the increase in life expectancy slowed down during the 1960s and in some countries has even halted, in particular as concerns men.

The cardiovascular revolution of the 1970s ushered in a new period of progress. However, Jay Olshansky and Brian Ault (1986), followed by Richard Rogers and Robert Hackenberg (1987), while not taking issue on the basic premises of epidemiologic transition theory, introduced the idea of a "*fourth stage*"[2] during which the maximum point of convergence of life

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*The first three parts of this paper are a repetition of an article published in *Demographic Research* (Vallin and Meslé, 2004). The fourth part is completely new.

[1] That idea of convergence is a general basis of the demographic transition theory, not only for life expectancy but also for fertility, and it is very commonly referred to in works related to the application of the theory. It has been discussed by various authors (see, for example, Coleman 2002).

[2] Olshansky and Ault: "*A fourth stage of the epidemiologic transition*". The other authors refer to a "*new*" or "*hybristic*" stage.

expectancies would increase due to advances in the treatment of cardiovascular diseases. Jay Olshansky *et al.* (1990) set this new maximum at 85 years, the same as that chosen by the United Nations at the end of the 1980s for all countries (United Nations, 1989). Today, however, the 85-year threshold is heavily criticised by many authors who believe that no such limit can be set (Vaupel, 2001; Carey and Judge, 2001; Barbi *et al.*, 2003).

Furthermore, the epidemiologic transition, even revised by Olshansky and other authors, seems to be challenged by dramatic exceptions observed since the 1960s in the general trend of increasing life expectancy. Not only have many countries (in particular eastern European countries) lacked the means to experience the cardiovascular revolution, but a number of others, especially in Africa, have not yet completed the second phase of epidemiologic transition, and are now hard hit by the emergence of new epidemics like AIDS, or the resurgence of older diseases (Caselli *et al.*, 2002).

That notwithstanding, these failures however significant do not call into question the epidemiologic transition theory as such. Yet they do indicate that some countries, for reasons inherent to their own history, economic development or culture, have encountered serious obstacles that prevent them from completing certain stages of the transition. In eastern Europe, on one hand, the communist regimes relied almost too exclusively on the centralized administration of modern health care, whereas the shift towards the fourth stage of epidemiologic transition requires significant changes in individual behaviour and being actively responsible for one's own health. In addition, the economies of these countries were involved in a ruinous arms and space race with western countries, leaving them without the means necessary to create an efficient health system to deal with chronic diseases. On their side, the countries of sub-Saharan Africa, which are much more vulnerable to the generalized transmission of HIV due to widespread multiple partnership practices and the wide variability of partner age differentials, were very hard pressed by the epidemic at a time when their very fragile economies were facing a global economic crisis which had already, as it was, wrought its inevitable consequences on quite poor local health services. Prevention methods, and more recently medical treatments, do exist and have proven effective in northern countries, but for the time being Africa cannot afford them. In both cases, health care policies must be improved and adequately funded in order for these countries to achieve their epidemiologic transition.

Abdel Omran's theory of epidemiologic transition may run up against a more profound contradiction in the renewed sharp rise in life expectancy observed in Western countries since the 1970s. Would adding a fourth phase to Omran's initial theory (Olshansky and Ault, 1986; Rogers and Hackenberg, 1987; Omran, 1998) and again a fifth to take on board AIDS (Olshansky *et al.*, 1998) suffice to account for such a phenomenon? In our view, the theory itself must be revised. First, as we have said, the reasons behind the emergence or resurgence of infectious diseases are not different from those governing the second phase of Omran's transition: the danger of infection can never be completely eradicated, only brought under control, and if the battle is fought in unfavourable conditions, all that has been gained can suddenly be lost, as shown by the dramatic situation in Africa. In fact, the situation of eastern Europe and Africa does not so much challenge Omran's theory as question the idea that life expectancies are rapidly converging towards a maximum level. In addition, Western advances in the treatment of cardiovascular diseases since the 1970s can be explained by the development of a new strategy based on advanced medical technology and changes in individual behaviour, diet in particular. But not all countries are equally prepared to adopt these new strategies, as can be seen in eastern Europe. However, in many developing countries which have exceeded a life expectancy of 70 years, the question must be put: will they manage to catch up with western countries in this field, as they did with infectious diseases? Following the proposal made ten years ago by Julio Frenk *et al.* (1991), the concept of epidemiologic transition might usefully be replaced by the wider concept of "health transition", which would include not only the development of epidemiologic characteristics within the overall health situation, but also the ways in which societies respond to the health situation and *vice versa* (Caselli, 1995; Meslé and Vallin, 2000). On that broader canvas, our more modest aim here is to explore the possibility of summarising the historical process within a blueprint that might square with most of the observed trends in mortality.

Arguably, each major improvement in matter of health is likely to first lead to a divergence in mortality since the most favoured segments of the population benefit most from the improvement. When the rest of the population accesses the benefit of the improvement (through improved social conditions, behavioural changes, health policies, *etc.*), a phase of convergence begins and can lead to homogenisation until a new major advance occurs. The entire health transition process thus breaks down into successive stages, each including a specific divergence-convergence sub-process. Arguably, from the 18th century to the present, at least two and even perhaps three of these successive stages have occurred or are developing.

2. OMRAN'S EPIDEMIOLOGIC TRANSITION AS THE FIRST STAGE OF HEALTH TRANSITION

For thousands of years, and notwithstanding dramatic one-off changes at different times and places, human life expectancy probably never exceeded 30 to 35 years for very long until the mid-18th century. This is not to say that the epidemiological profile was constant. To the contrary, recent studies by health historians highlight the succession of *pathocenoses* which from the dawn of prehistory have been characterised by a specific epidemiological dynamic founded on specific pathological patterns (Grmek, 1969, 1994; Biraben, 1996). However, in mid-18th century Europe, a new era began in which the switch from one *pathocenose* to the next one is also reflected by a critical and sustainable improvement in life expectancy. Within approximately two centuries, the epidemiological profile of European populations changed completely, and explaining this change is the main purpose of Omran's theory of the *epidemiologic transition*. At the end of this historical process, which can be put at around the mid-60s, chronic diseases replaced infectious diseases as the main causes of death, while man-made diseases emerged as an additional factor in the global stagnation of life expectancy.

However, just as the industrial revolution was born in Europe, so the pattern of epidemiologic transition was first seen in Europe before spreading to the rest of the world, and even there, in some countries before others. Even now, not all countries have completed that process.

2.1 The pioneers

Between the turn of the 18th century and the 1960s, the history of industrialized countries and especially European populations fits in quite well with Omran's theory. During this period, life expectancy improved dramatically from its ancestral level of 30-35 years to reach about 70 years in the mid-1960s. This, it is well-established, was almost exclusively due to the near eradication of infectious mortality. The big historical epidemics were initially contained mainly by administrative rules preventing the population from contamination (Biraben, 1975). Then, major advances in agriculture and food distribution not only led to the disappearance of famine and starvation, still a concern up to the mid-18th, and even still in the 19th century in some parts of Europe (Reinhard *et al.*, 1968), but also reduced a large share of current mortality due to the synergic complex malnutrition/infection (McKeown, 1976). These improvements were reinforced mainly in the 19th century by major investments in drinking water and sewerage systems. Finally, medical innovation, especially with the

Pasteur era, from immunization to antibiotics, combined with the establishment of social security systems, provided modern industrialized society with near-total protection against major infectious causes of death.

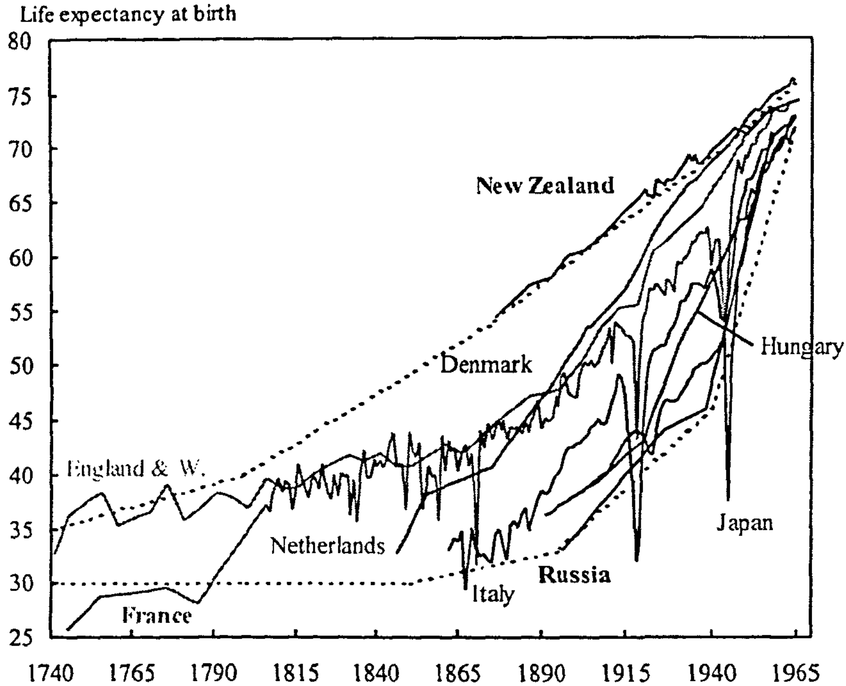
However, not all populations and countries benefited from this progress simultaneously, even in Europe or among other industrialized countries. Figure 1 shows the available data on female life expectancy[3] for selected countries. While very few observed trajectories cover the whole of the two centuries involved, it is quite clear that less than a handful of countries pioneered early sustainable improvements in life expectancy. This improvement started in the latter half of the 18th century in France and England and Wales, but also in Sweden which is not included in Figure 1 to make it easier to read. It is very likely that countries like Denmark and Norway were also among the pioneers, despite the later start of their historical series of life expectancy. Conversely, many European countries, especially in southern and eastern parts of Europe, enter the trend much later. For example, continuous life expectancy improvements did not begin in Italy before the end of the 19th century, and Figure 1 suggests that the same applies to Hungary. This is also the case of several other Mediterranean or eastern European countries not included in Figure 1 for ease of interpretation. The onset came even later in Russia.

Among non-European industrialized countries, Figure 1 picks up two typical cases: New Zealand at the top and Japan at the bottom. Unfortunately, life expectancy series start only around the 1890s for both countries, but it is very likely that New Zealand was among the pioneers, since the commencement of its series shows the country to be far ahead of the others, and it will for long enjoy the highest life expectancy in the world (Oeppen and Vaupel, 2002). Conversely, it was not until the Meiji era that Japan would enter its phase of continuous increase in life expectancy. Thus, depending on their economic, social and political contexts, industrialized countries entered the trend at different times from the late 18th to the early 20th century, but from this point the most recent arrivals advanced more rapidly than the pioneers and the aggregate progress made over these two centuries produced a first stage reflected in major divergences, followed by a second in which all these countries dramatically converged towards the highest level of life expectancy permitted by the reduction in the burden of infectious mortality.

Intuitively, we added two dotted lines to Figure 1 to try and represent the upper and lower limits in between which the life expectancy improvements occurred in industrialized countries. Because very few points

[3] Male trajectories being more affected by short-term variations due to exceptional events like wars, it was thought preferable to use female trajectories to look at long-term trends.

Figure 1 – *Long-term trends in female life expectancy for selected industrialized countries until the mid-60s*



Source: Denmark: Andreev, 2002; England & Wales: Wrigley and Schofield (1981); France: Vallin and Meslé (2001); other countries: various statistical or demographic yearbooks and historical series.

are available from the beginning, but also due to conflicting estimates produced for England and Wales and France, where it cannot be determined to what extent these represent real differences or results from methodological issues, it is difficult to accurately estimate the interval of variation which characterized the pre-transitional stage, but we would contend that most female life expectancies might have ranged between 30 and 35 years. It is much clearer to see that in the mid-1960s, all countries were within very narrow ranges of under 5 years between 72 and 76. Contrast this with the turn of the 19th century, when these countries ranged between 33 and 60 years of life expectancy, meaning a gap of approximately 27 years.

2.2 *The spread to developing countries*

This completion of a first wave of health progress according to Omran's theory also appears to be in progress around the rest of the world, at least since the mid-20th century. Using the United Nations database on demographic indicators, the left graph of Figure 2 shows the life expectancy trajectories of all developing countries since 1950, except sub-Saharan African countries, which follow a different path, and some specific countries which experienced devastating wars or other political strife.

Even though the time frame of the database used does not portray the full picture for most of these countries, it appears very likely that around the 1950s this huge geopolitical aggregate was almost at its peak divergence in terms of life expectancy. With female life expectancies above 65 years, countries like Hong Kong and Puerto Rico were already at levels very close to those of industrialized countries, while others like Yemen, Nepal, Bhutan and Bangladesh were still at levels close to those of 18th century Europe – between 30 and 35 years. Then, in the last five decades, most life expectancy trajectories began converging. Arguably, Hong Kong's trajectory must be taken in isolation as having been closer to that of industrialized countries over the period, and having actually entered the second stage which will be discussed in the following section. By contrast, Puerto Rico is probably still at the end of the first stage, and, the pace differential between Puerto Rico and Yemen's trajectories gives a fairly clear picture of that convergence between most of the developing countries which will then complete Omran's epidemiologic transition. On the right-hand side of Figure 2, these two trajectories are shown together with those of two intermediate but much more populous countries, Mexico and Indonesia, compared against three dotted lines.

The two lower dotted lines are a repetition of those in Figure 1 advanced by 60 years to fit with the starting level of the latest countries. Two things stand out. First, the range of life expectancies at the stage of maximum divergence was greater for to-day's developing countries than for industrialized countries in the past: in the late 1950s, with a female life expectancy of 35 years, Yemen was 36 years lower than Puerto Rico (71), whereas the maximum gap for industrialized countries stood at 27 years. Second, the latest developing countries improved their life expectancy much more rapidly in recent decades than European countries did previously. Within 45 years, Yemen gained 28 years of life expectancy while the lower dotted line indicates a gain of 13 years. Third, even a country like Mexico, where female life expectancy was already over 50 years in the early 1950s, still for a further two or three decades achieved very rapid additional gains.

It is a matter of record that as early as the 1920s and 1930s for the most advanced ones, and especially after World War 2, most developing countries made very rapid progress when they were able to take up European methods of infectious disease control and disseminate their benefit among their population. During this time, developing countries completed most of Omran's epidemiologic transition. Did they achieve more?

The upper dotted line on the right-hand graph of Figure 2 shows the actual non-advanced Norwegian trajectory. No developing countries cross it (except Hong Kong). But Puerto Rico was already nearing it as early as the late 1960s, and thereafter continued to increase at the same pace as Norway. This may indicate that this type of developing country had already reached stage two, which will be discussed below.

2.3 Is sub-Saharan Africa really an exception?

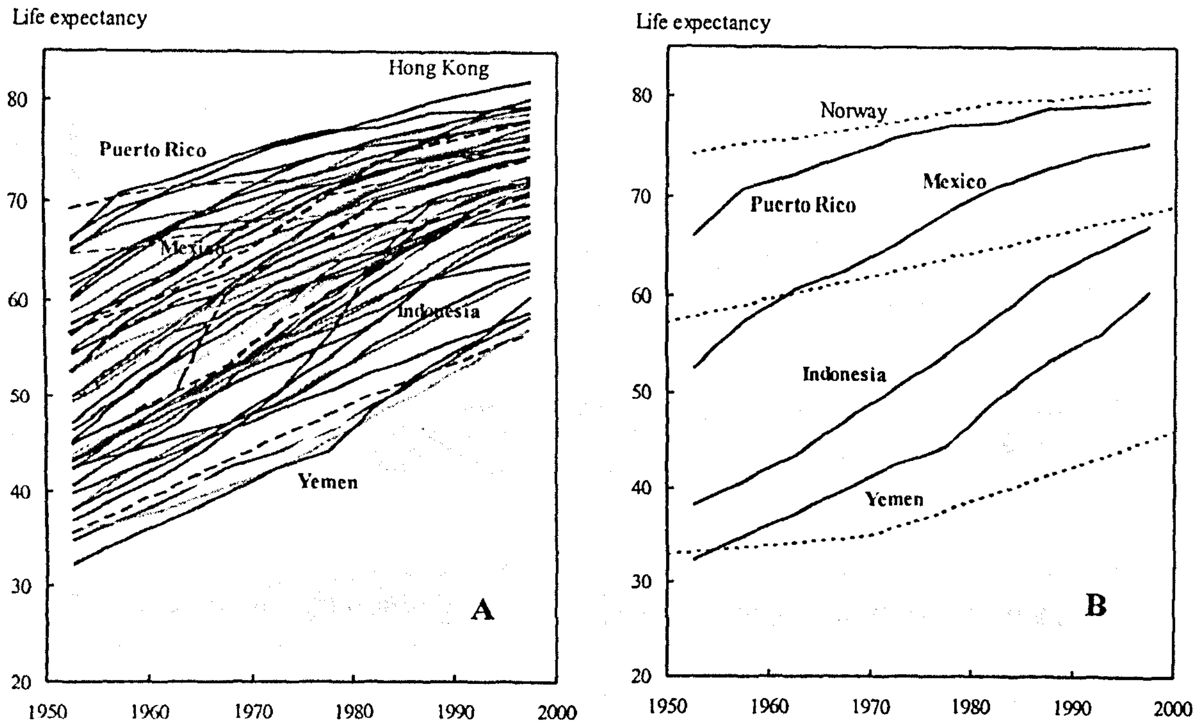
By contrast, a series of countries, mainly in sub-Saharan Africa, seem to be exceptions to this globalization of the first stage of health transition. Not only did a number of conflicts and other forms of political unrest in recent decades put individual countries outside the scheme of Omran's epidemiologic transition but sub-Saharan countries seem to remain more systematically outside the process for a variety of reasons.

Obviously, significant though they are, wars and conflicts have only a passing impact on life expectancy. Usually, they create an exceptional blip before life expectancy very quickly resumes its long term trend. Such was the case in many European countries, especially with the two World Wars. It is also the case for developing countries like Iran and East Timor. In other cases, the recovery is less clear because conflicts are protracted or followed by economic and social problems, as in Iraq, Rwanda, Liberia and Somalia. Nevertheless, these cases do not constitute real exceptions to the epidemiologic transition, since the scheme posits a normal economic and social change ending in Omran's "*third age*".

Sub-Saharan Africa probably calls for more comment. A comparison of the pace of life expectancy increase observed in these countries to that of Yemen or Indonesia (Figure 3) reveals two different situations. The left-hand graph shows countries that enjoyed fairly steady but much slower progress than Indonesia and Yemen, while the right-hand graph portrays countries hit by a severe AIDS epidemic.

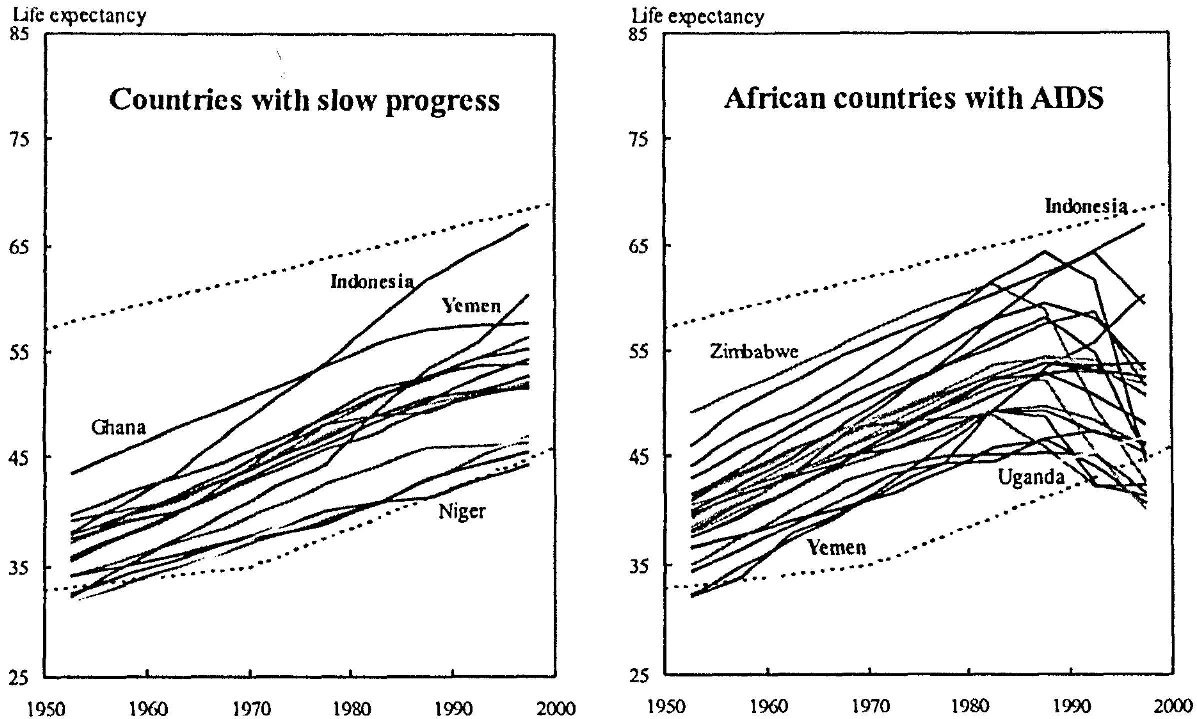
In countries where life expectancy is low and which are still very close to the "age of pestilence and famine", progress is initially slow, since there is no infrastructure and early gains benefit only a small proportion of the population, usually the urban population. Later, the health care system

Figure 2 – *Long-term trends in female life expectancy for developing countries except sub-Saharan Africa and countries affected by war as compared with Indonesia and Yemen*



Source: United Nations (2001).

Figure 3 – *Long-term trends in female life expectancy for sub-Saharan Africa as compared with Indonesia and Yemen*



Source: United Nations (2001).

swings into play, simple and effective means for controlling the major epidemics spread to the population as a whole, and gains in life expectancy acquire momentum. This change in the pace of progress was in evidence even before Omran posited his theory (Bourgeois-Pichat, 1966; Vallin, 1968), and was more recently shown to work very well everywhere in the world except sub-Saharan Africa (Meslé and Vallin, 1996b). The fact is that many sub-Saharan countries have experienced a fairly slow improvement in life expectancy since the 50s, whatever their then level (Figure 3, left). For example, Ghanaian life expectancy was already close to 45 in 1950, much higher than that of Indonesia, but advanced much more slowly. In many of these countries, furthermore, life expectancy improvements slowed down after 1980, which is even more striking. Arguably, however, these unusual trends in the developing world do not necessary contradict the theory. Firstly, because no trajectory on the left-hand graph of Figure 3 falls below the lower dotted line which represents the slowest rate of the European transition. It is readily understandable that sub-Saharan Africa, where the economic take-off was much more difficult than anywhere else in the Third World, should experience paces of progress closer to those of European countries than those of most developing countries. Secondly, because the slowdown observed since 1980 is clearly linked to the economic recession which hit Africa harder than any other developing country after the crisis in the world economic system of the late 1970s. Structural adjustment plans cut heavily into social and health budgets, producing a break in the life expectancy trends. Again, this is more an exception that confirms the rule than a fundamental contradiction to the general scheme.

Furthermore, not all sub-Saharan countries were so slow from the 1950s. As the right-hand graph of Figure 3 shows, several countries that were recently hit by AIDS made life expectancy gains at the same pace as Yemen and Indonesia up to the 1980s. This was especially so for southern and eastern African countries like South Africa, Zimbabwe, Botswana, Kenya, Uganda, *etc.*, where economic progress far outpaced that of the rest of sub-Saharan Africa. Unfortunately, all the countries in the right-hand graph of Figure 3 were severely hit by AIDS regardless of their previous pace of life expectancy increase. In some cases, life expectancy dropped even below the lower dotted line. However, again it can be argued that this trend reversal is not necessarily inconsistent with the theory. AIDS was a new disease and as such took time to be addressed by modern medicine. In fact, since it occurred when much of the world had already completed the first stage of health transition, medical responses were very quickly brought to bear in comparison with new diseases of the past (retrovirus was isolated within a couple of years and triple therapy set within a decade).

Nevertheless, even in the most developed countries, AIDS epidemics spread very rapidly among at-risk groups, who were hard-hit by very high mortality rates. It took a particularly heavy toll in many sub-Saharan African countries for two reasons. First, due to specific sexual behaviour, the main means of transmission was heterosexual and the epidemics caused devastation among the general population. Second, because of the economic and health situation in Africa, the affected groups were unable to draw substantial benefit from the very costly treatments developed in western countries. Once again, it is more probably the pre-requisites for the application of the theory that are lacking than the theory itself which is flawed.

To conclude on sub-Saharan Africa, it is clear that for several major reasons, the first stage of health transition is progressing much more slowly than in most developing countries, and has even been held back in the past two decades.

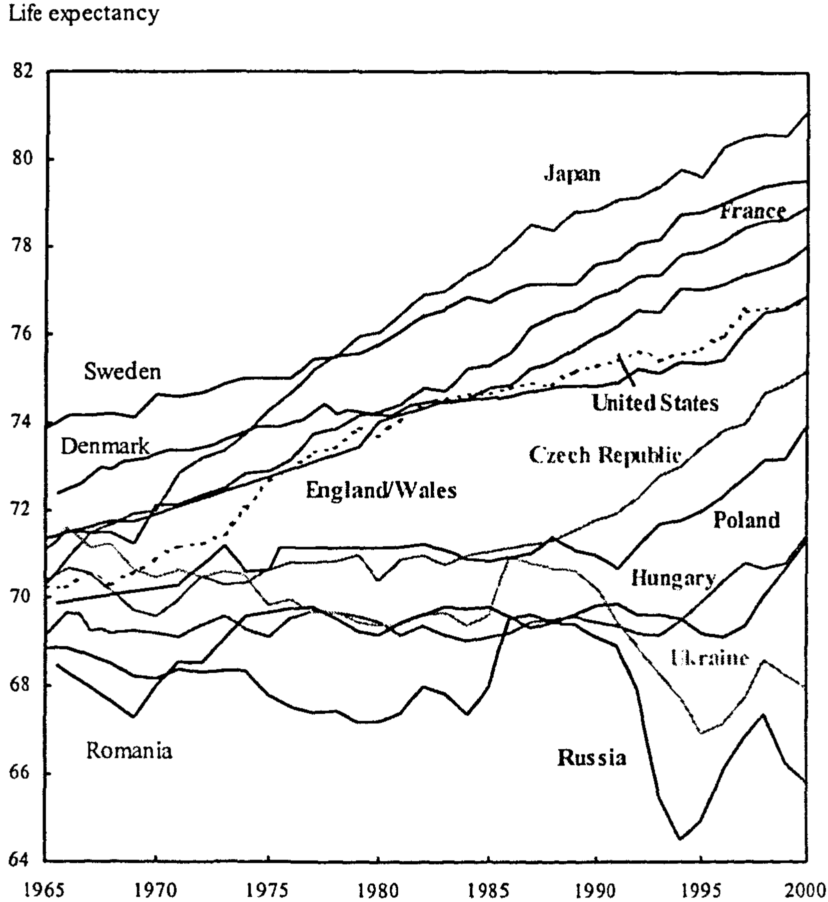
3. A SECOND STAGE: THE CARDIOVASCULAR REVOLUTION

It is now a matter of record that Omran's third age, "the age of degenerative and man made diseases" was not the final one. Not only, have most of the man-made diseases of the time been under control and finally decreased since the end of 1960s, but a new major step in life expectancy improvement was taken with the successful fight against cardiovascular diseases. Arguably, however, it is not an adequate interpretation to see that historical event simply as a fourth "age" of Omran's epidemiologic transition. Rather, it is an entirely new process of divergence-convergence based on a completely new approach to health, the success of which depends very much on society's current capacity to fit in with it. That new step, in fact, began with a dramatic divergence between the two main parts of the industrialized world divided by their social and political systems: East and West.

3.1 A new phase of divergence

Figure 4 shows very clearly that, after the high degree of convergence experienced with the generalized decline in infectious mortality across the industrialized world (Figure 1), the mid-60s mark the start of a new divergence in life expectancy changes. On one hand, all western countries re-established rapid progress in the late 60s after the more or less significant slowdown that many had experienced during that decade, while, by contrast, the ground rapidly made up by eastern countries was followed by a long period of stagnation or even deterioration.

Figure 4 – *Trends in life expectancy (both sexes) since 1965 in industrialized countries*



Source: France: Vallin and Meslé, 2001; Russia: Meslé *et al.* 1998; Ukraine: Meslé and Vallin, 2003; other countries: various statistical and demographic yearbooks.

The widest divergence is observed between Japan, which never experienced any slowdown and where the pace of progress was especially rapid, and Russia, which has been facing the worst situation since the end of Omran's epidemiologic transition. From 1965 to 2000, life expectancy (both sexes) increased from 71 to 81 years in Japan, but fell from 69 to 66 years in Russia. While the contrast was less stark between other countries, the trend was systematic enough to make a clear divide between West and East at least until the late 80s. At that time, even between the least distant countries of the two groups, the Czech Republic and the United States, there was an almost four-year difference, when the two countries were level-pegging in 1965.

That divergence continues to-day for countries of the former USSR, represented here by Russia and Ukraine, despite the wide fluctuation of the late 80s and early 90s, mainly due to Gorbachev's anti-alcoholism campaign and the socio-economic shock of the abrupt switch to a market economy (Meslé *et al.*, 1998; Meslé and Vallin, 2003). All other eastern European countries, however, embarked on a new phase of convergence in the last decade. The Czech Republic was the first of these countries to re-establish progress at the very end of the 80s, followed by Poland and Hungary at the start of the 90s, plus Slovakia, which is not shown in Fig. 4. Even Romania (and Bulgaria, not represented here) now seem to have been entering this new stage of progress for a couple of years (Meslé, 2004b). Since 1991, life expectancy gains in the Czech Republic and Poland have outpaced those in Japan, with an increase of 3.3 years compared to Japan's 2.0 years. At that pace differential, it would take time for them to catch up Japan (42 years for the Czech Republic and even 48 years for Poland). But the trends are moving in the right direction. Furthermore, the comparison with Japan is not really the most felicitous, since, as will be discussed later, Japan may already have embarked on a third stage of the health transition. It is more readily obvious that the Czech Republic and Poland are actually catching up a country like the Netherlands, which will be examined in Section 3 as an example of a country that is completing stage two of health transition but not yet entering stage three. From 1991 to 2000, its increase in life expectancy was only 1.0 year compared to 3.3 in the Czech Republic and Poland.

3.2 The role of cardiovascular mortality

Over and above the fight against man-made diseases described by Omran as a feature of the "third age" of his epidemiologic transition, the second stage of health transition mainly relies on the reduction of cardiovascular disease. This applies equally to the divergence and convergence phases.

A clearer picture of the dominant role of cardiovascular diseases can be gained by examining age- and cause-specific mortality change contributions to life expectancy differentials between two dates (Andreev[4], 1982) for selected countries. Bearing in mind that during that stage of health transition, East-West contrasts were more marked for males than females, only the results for males are presented here. Firstly, Figure 5 compares the

[4] Andreev's method is quite equivalent to those proposed by others, simultaneously (Pollard, 1982) or a bit later (Arriaga, 1984; Pressat, 1985).

breakdown of life expectancy changes in the United Kingdom and Russia over the whole period 1965-2000.

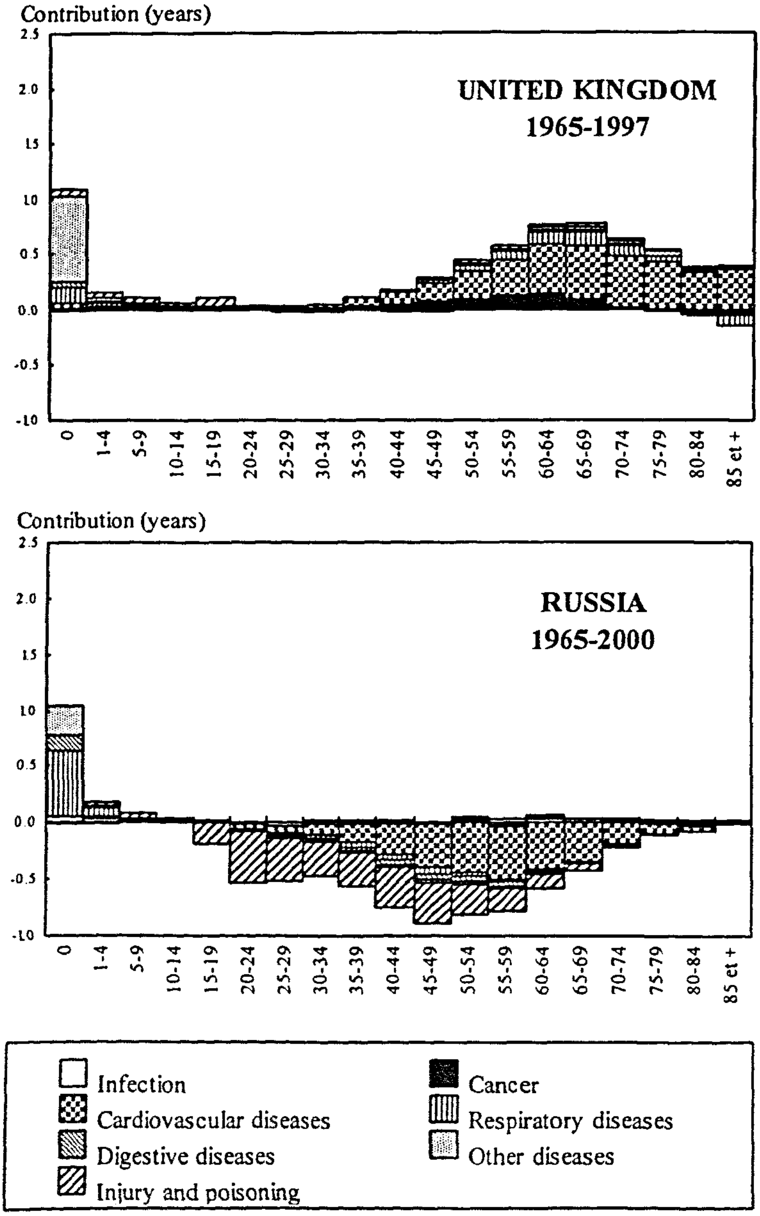
The only common feature between the two countries is the positive impact of the continuing decline in infant mortality, to which 1 year's life expectancy gain in both countries can be credited, notwithstanding somewhat different cause-of-death attributions (mainly "respiratory diseases" in Russia and "other diseases"[5] in the UK). That aside, most of the remaining increase in life expectancy in the UK (5.3 years) stems from the decrease in cardiovascular mortality at adult ages, accounting for as much as 3.5 years, or more than 50% of the total gain of 6.4 years. Among the other sources of gains at adult ages, the decline of "other diseases" and "all cancers" which include "man made diseases" like smoking-related lung cancer plays an important role. During this period, therefore, the United Kingdom clearly benefited from the decline in those diseases which, according to Omran's theory, were the main feature of the "third age" of the epidemiologic transition, and has arguably completed the second stage of health transition. Advances are made at all adult ages over 35, but culminate between ages 60 and 70.

In Russia, by contrast, all these ages are affected by increasing cardiovascular mortality which alone is estimated to have cut 3 years off life expectancy. Another 3-year loss was caused at the same time by a sharp rise in "injury and poisoning" deaths, a category which, in Russia, includes alcoholism as well as road traffic accident, suicide, homicide, *etc.* Russia therefore stands as textbook example of a country which still now conforms to the Omran's "third age": so acute indeed is the pandemic of degenerative and man-made diseases that the remaining decline in infectious diseases at young ages no longer compensates for its spread. The same trends are observed in other republics of the former USSR like Ukraine (Meslé and Vallin, 2003), Belarus (Andreev, 2001), and even the Baltic countries until very recently[6] (Hertrich and Meslé, 1999).

[5] In fact at that age, most of the "other diseases" group correspond to perinatal and congenital diseases.

[6] It seems increasingly likely that after the 1993-94 socio-economic crisis, the progress observed in the three Baltic countries is more than simply being re-established (Meslé, 2004b).

Figure 5 – *Contribution of trends in age-specific mortality for seven main groups of causes to changes in male life expectancy since 1965 in the UK and Russia*



Source: UK: computed from WHO mortality database; Russia: Meslé *et al.*, 1998.

3.3 The beginning of convergence in cardiovascular mortality

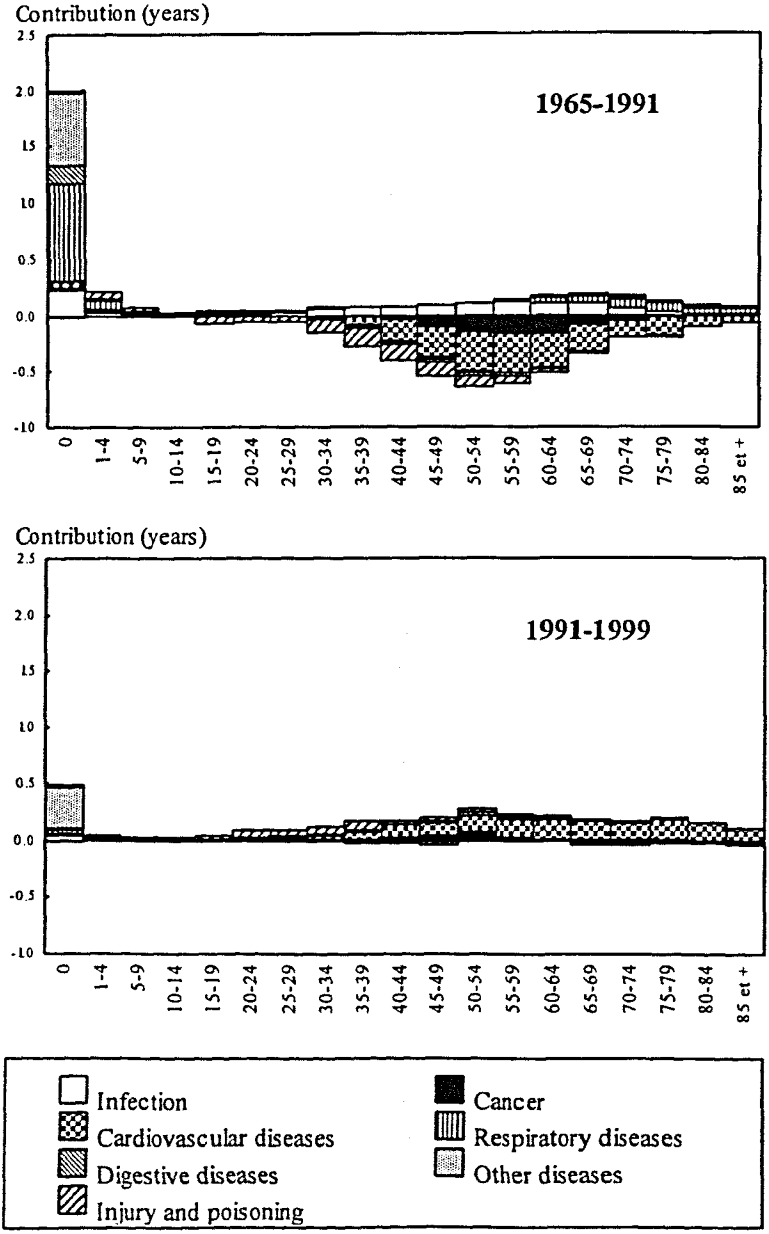
The same can no longer be said of central European countries. In Poland, taken here as an example, the negative trends reversed as early as 1991. During the period of deterioration, from 1965 to 1991, the Polish pattern of age and cause-of-death contribution to the decline of life expectancy is fairly similar to that of Russia (Figure 6), with two noteworthy differences. One is that a still bigger life expectancy gain resulted from a dramatic fall in infant mortality (which, alone, would have produced a two-year gain) and, even at adult ages, significant gains were due to the decline of infectious and respiratory mortality. During that time, Poland was actually thus moving towards completion of the first stage of its health transition. The other is that the impact of injury and poisoning deaths was much less pronounced than in Russia and, conversely, that of cancer was more significant. Other than that, however, years of life expectancy lost due to increasing cardiovascular mortality were fairly comparable. In fact, had the first stage of health transition been completed pre-1965, Poland would have lost almost the same number of years of life expectancy as Russia in that period of general divergence between East and West.

By contrast, since 1991, gains in Polish life expectancy are observed at all ages from almost all causes (second graph of Figure 6). In fact, beyond the 0.5 year gained from the decline of infant mortality, most of the gains at adult ages (2.2 years) are due to the decline of cardiovascular mortality (1.6 years).

To complete this picture of the major role played by cardiovascular diseases during the second stage of health transition, Figure 7 displays the annual trends of cardiovascular age-standardized mortality rates in France and the UK on one hand, and in Russia, Poland, Hungary and the Czech Republic on the other. The graph was plotted with a semi-logarithmic scale for comparability of the pace of trends. Aside from France, which has for long been a case apart in the matter (Richard, 1987; Law and Wald, 1999), all these countries were very close to each other in 1965.

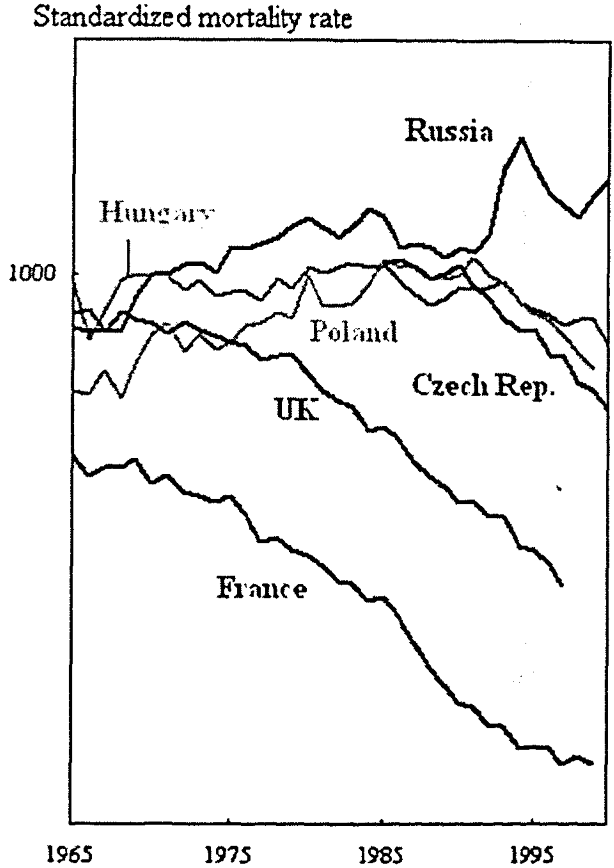
Cardiovascular mortality has declined steadily and sharply in both France and the UK from the outset, but has risen dramatically in Russia. In between these, Poland showed an increase very similar to that of Russia until 1991, followed by a decrease mirroring those of France and the UK. Hungary is a less clear-cut case, posting both slower increases and decreases. No increase can be shown for the Czech Republic because available data from the WHO database only start in 1985, but the decrease exactly mirrors that of Poland.

Figure 6 – *Contribution of trends in age-specific mortality for seven main groups of causes in two stages of changes in male life expectancy in Poland*



Source: computed from WHO mortality database.

Figure 7 – *Trends in male standardized mortality rate from cardiovascular diseases since 1965 in 6 industrialised countries*



Source: France: Meslé and Vallin, 1996; Russia: Meslé *et al.* 1998; other countries: computed from WHO mortality database.

It might be thought that the very similar paces of decline observed in Poland, the Czech Republic, the UK and France in the last decade were not enough to produce any convergence in life expectancy. But they did do so, partly because of the very wide difference achieved in terms of level in 1991, and partly because the age structure of cardiovascular mortality is much older in the UK and France than in Poland and the Czech Republic. At higher levels of mortality, or with a younger age structure, the same pace of mortality decrease produces a higher increase in life expectancy.

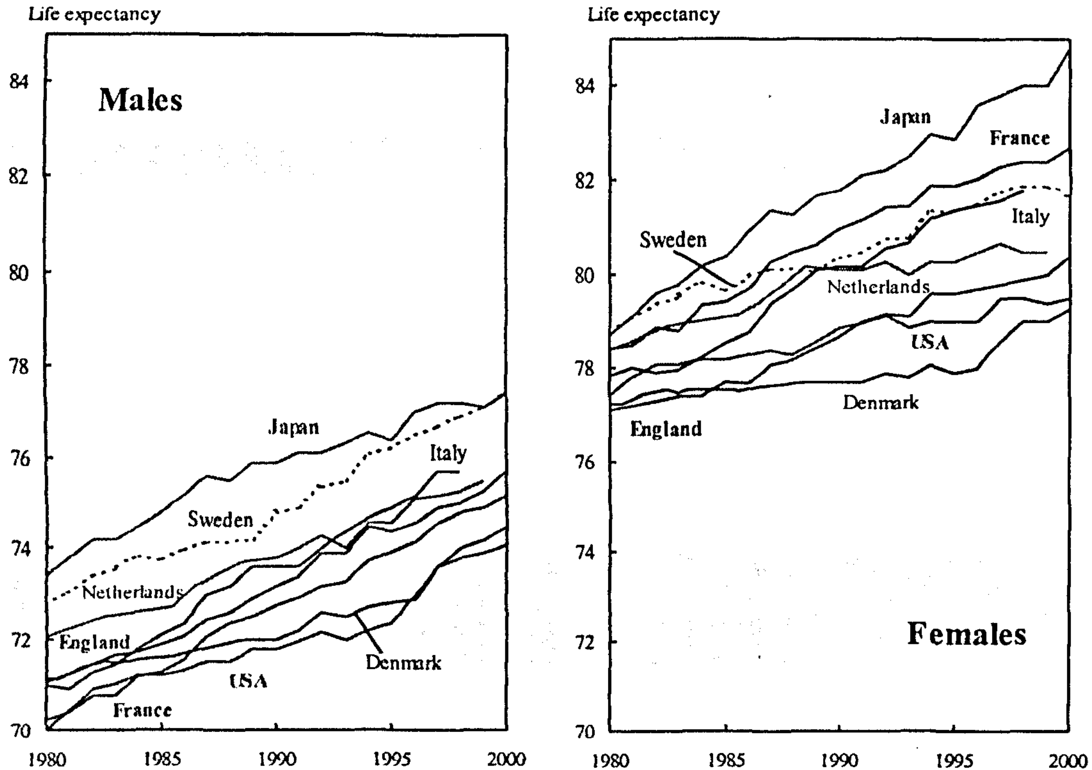
This dual phenomenon of divergence-convergence between western and eastern industrialized countries is arguably the best example of the occurrence of a second stage of health transition based mainly on the trends in man-made and cardiovascular diseases. Initially, the divergence appears with the emergence of a new pathway, re-establishing progress in life expectancy after having gained almost all that could be expected from the fight against infectious diseases in the previous stage. Some countries, like Japan first followed by almost all western countries, were quick to maximize the benefits of new technologies, and perhaps even more so, new means of prevention against cardiovascular diseases, while other countries, mainly in eastern Europe, failed to do so. It is very likely that the failure of the former communist countries was largely due to a double disadvantage. First, their economic difficulties held back the dissemination of costly new technologies, and, second, the highly centralised social system, perfectly suited to fighting infectious diseases, worked to their disadvantage in getting individuals to take responsibility for their own health through behavioural and lifestyle changes.

4. TOWARD A THIRD STAGE: SLOWING THE AGEING PROCESS?

Looking more closely at the most recent trends in life expectancy for western industrialized countries, the question arises: are they already engaged in a third stage of health transition (Figure 8)? For females in particular (right-hand chart, Figure 8), a new divergence can be seen to have started after 1980. The process is less clear for men, but it is noteworthy that male life expectancy is still consistently lower in 2000 than female life expectancy was in 1980. In Japan, for example, male life expectancy was 77.4 years in 2000 when female life expectancy was already 78.8 in 1980. It is even more marked in the USA, with 74.1 for males in 2000 against 77.4 for females in 1980, respectively.

Clearly, females are much further along the road of health transition than males, and so much more likely to enter a new stage first, if there is one. At first glance, the female graph of Figure 8 might seem to suggest a new stage starting with the very marked divergence between Denmark and countries like France and Japan. While progress slackens or even halts in the former from the 80s, it continues at a sustained pace in France and Japan. From 1980 to 1995, female life expectancy gained only 0.7 year in Denmark (from 77.2 to 77.9) but as much as 3.5 years in France (78.4 to 81.9) and even 4 years in Japan (78.8 to 82.8). More recently, Denmark finally re-established progress, gaining 1.4 years (to 79.3) in five years while France

Figure 8 – *Trends in life expectancy since 1980 in some Western industrialised countries*



Source: France: Vallin and Meslé, 2001; other countries: various statistical or demographic yearbooks.

gained 0.8 and Japan 2 years, which could be interpreted as the starting point of a new phase of convergence.

Meanwhile, the Netherlands also entered a long period of stagnation in 1988, where female life expectancy increased by only 0.3 year in more than a decade. Even Sweden experienced a brief halt from 1984 to 1989 before re-establishing progress. Figure 9 displays the contribution of age and cause mortality changes to female life expectancy trends observed in Japan, France, the Netherlands and Denmark from 1980 to 1998 or 1999, according to the country[7].

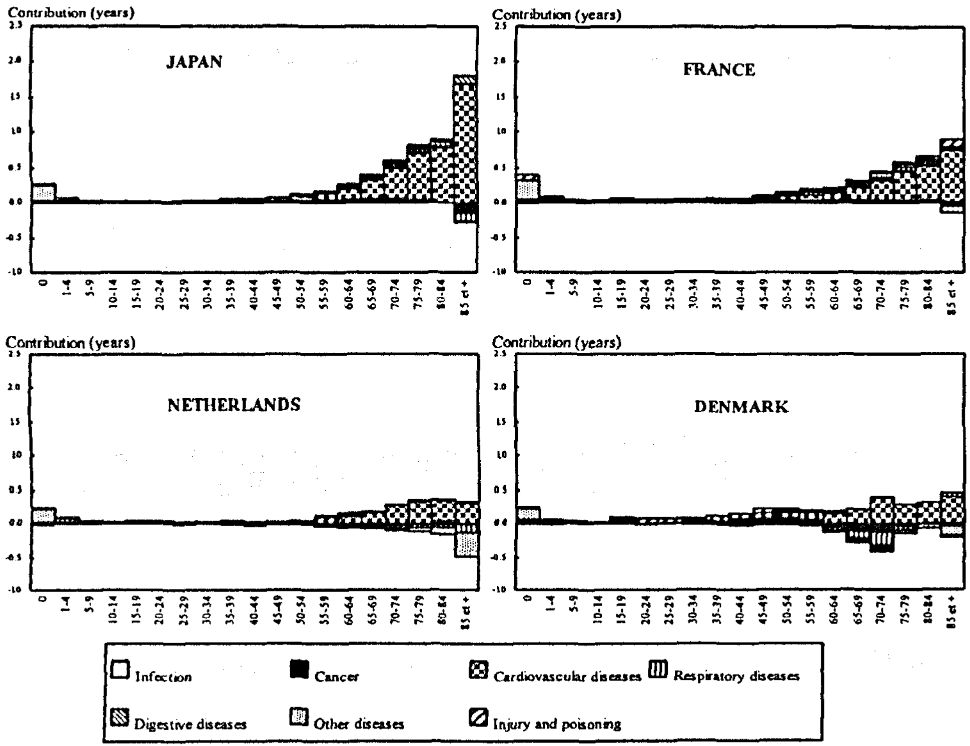
As was seen in Figure 5 for the United Kingdom during the period 1965-1997, the decline of cardiovascular mortality account for the greatest share of life expectancy gains in the four countries, but the biggest contributions do not all come from the same ages. Whereas adult ages were formerly the main contributors, the biggest influence in the last two decades has been that of the oldest age groups. This is especially so in France, and even more so in Japan where of a total 5.6 years of life expectancy gained between 1980 and 1999, almost 1.7 years were exclusively due to cardiovascular decline at age 85+, twice more than for the impact of the same cause at age 80-84! In France, too, the impact of the decline in cardiovascular mortality mainly comes from the oldest age groups. In both countries, that impact increases very sharply with age.

In light of this increasing role of the oldest ages in the decline of cardiovascular mortality, the idea can be entertained of a change in the nature of the cardiovascular diseases involved. Increasing advances in the fight against these diseases are tied up with more general progress against ageing. In Japan, cerebrovascular diseases have for several decades accounted for the greatest share of the total reduction in cardiovascular diseases; likewise, more recently, in France. The current cause-of-death classification is certainly not sufficiently ageing-related to allow a pinpointing of the impact of current strategies in the field of biological ageing, but it seems that the new approaches toward the elderly developed in the past two decades may be creating a new stage of health transition, and that a handful of countries have already gone some way down that new road, while others are lagging. In Denmark and the Netherlands, the impact of cardiovascular decline is also greater and more marked at older ages, but still much less so than in France and Japan. But both countries also show quite significant negative effects of increased cause-by-age-specific mortality.

For that reason, it is important to distinguish precisely those periods in which life expectancy has increased from those where it has stagnated. In the

[7] Data were available until 1999 in Japan, France and the Netherlands, and until 1998 in Denmark.

Figure 9 – *Contribution of trends in age-specific mortality for seven main groups of causes in changes in female life expectancy from 1980 to 1998 or 1999 in Japan, France, the Netherlands, and Denmark*



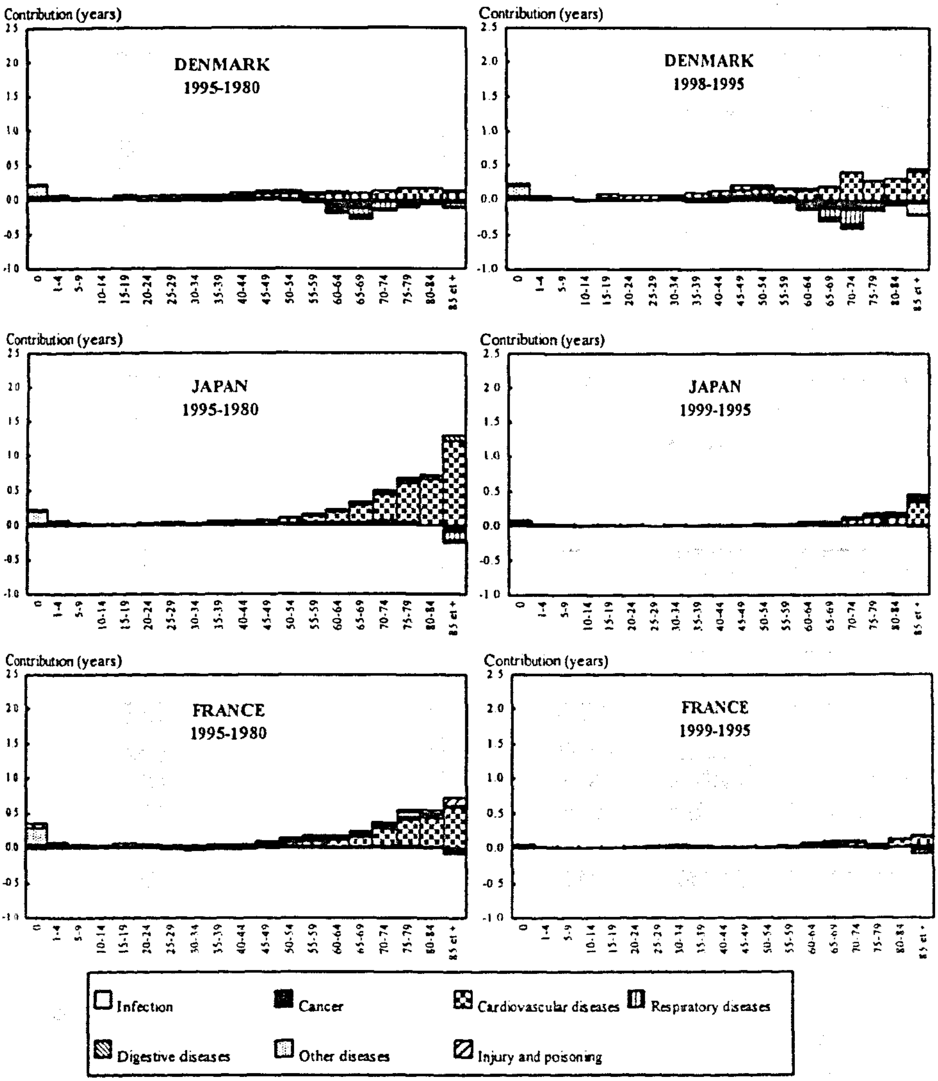
Source: France: Meslé and Vallin, 1996; other countries: computed from WHO mortality database.

case of Denmark, as discussed earlier, female life expectancy stagnated from 1980 to 1995 before progress suddenly resumed in that year. Figure 10 displays the contributions of age and cause mortality trends to changes in life expectancy for the two periods 1980-1995 and 1995-1998. In the first period, Danish female life expectancy might have made small gains, had only cardiovascular diseases been involved, but that progress was completely obliterated by reverse trends in other causes of death like cancer, respiratory diseases and digestive diseases, which in fact are mainly smoking- and drink-related here. In other words, notwithstanding progress in cardiovascular diseases, increases in life expectancy were halted by a deterioration in man-made diseases. Despite that, just as in France and Japan, there is a discernible general move of the contribution of cardiovascular decline to life expectancy increases towards older ages. That is very clearly demonstrated by a comparison of the two parts of Figure 10: in the 3 most recent years, the impact of cardiovascular decline is not only more significant than in the previous 15, it is also much more concentrated around the oldest ages. And it is particularly noteworthy that during these 3 years, that impact is even far more pronounced in Denmark than in Japan and France. This signifies that in this respect, Denmark actually started to catch up on France and Japan. However, once again, that increasing source of progress is partly countered by a continuing worsening of man-made diseases at adult ages. To put it simply, not only have Danish women been late in entering the third stage of health transition, they also failed to complete the second one in terms of man-made diseases.

The Netherlands is very much a case apart. First, female life expectancy continued to increase during the early 80s, but halted in 1988 never to resume until now. Second, the positive influence of a decline in cardiovascular diseases, once again increasingly at the oldest ages, is still even recently much less great than in Denmark. Third, since 1988 the small improvement made possible as regards cardiovascular diseases is completely cancelled out by different causes involving very different ages from those in Denmark.

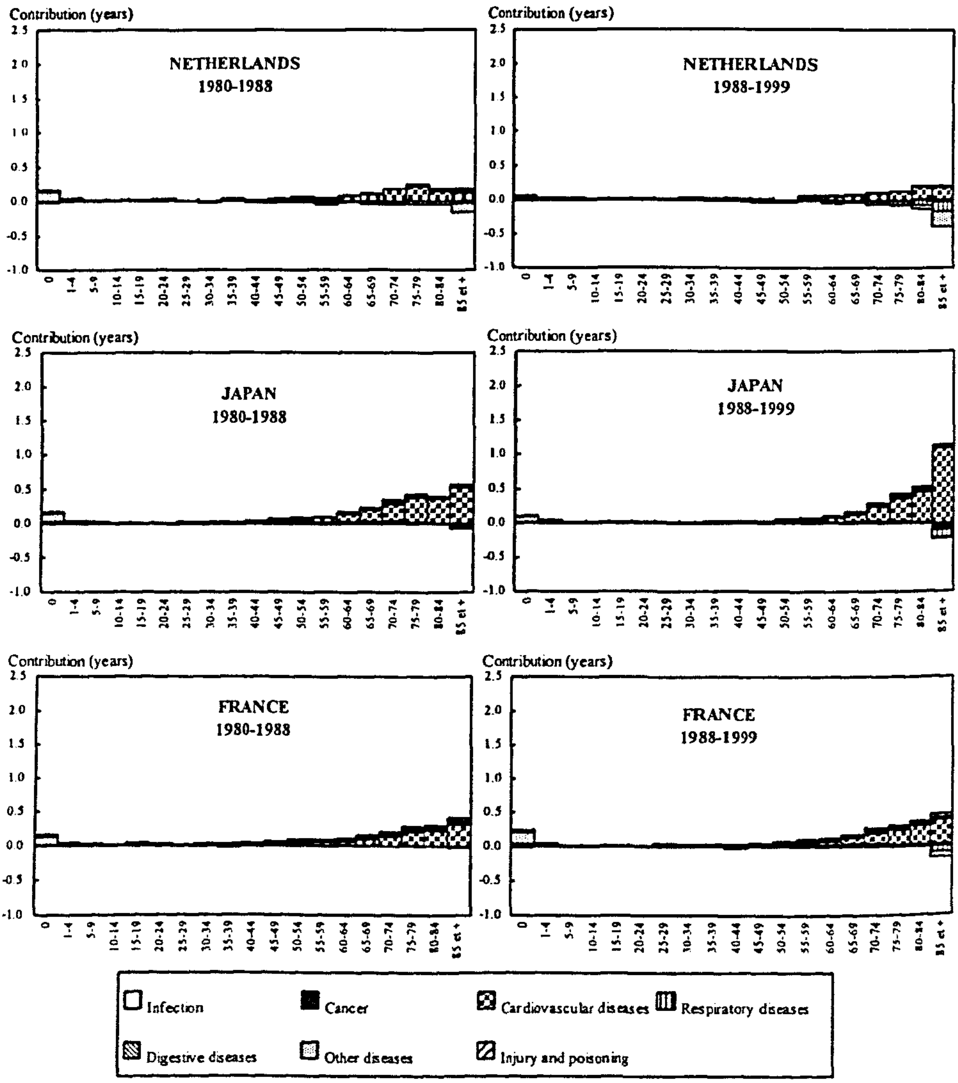
As in Figure 10 for Denmark, Figure 11 compares the Netherlands to Japan and France for two periods: 1980-1988 when female life expectancy is still rising in the Netherlands, and 1988-2000 when it is stagnating. During the first period, most of the progress is due to a reduction in cardiovascular diseases – as in France and Japan – but the ages involved are still not the oldest ones. It is very likely that at this stage the Netherlands is only completing the second stage of health transition. Obviously, it is doing so on better terms than Denmark, since man-made diseases are no longer a cause of reduction of the years of life expectancy gained. However, at the oldest

Figure 10 – *Contribution of trends in age-specific mortality for seven main groups of causes in two stages of changes in female life expectancy between 1980 and 1995 and since 1995 in Denmark as compared to Japan and France*



Source: France: Meslé and Vallin, 1996; other countries: computed from WHO mortality database.

Figure 11 – *Contribution of trends in age-specific mortality for seven main groups of causes in two stages of changes in female life expectancy between 1980 and 1988 and since 1988 in the Netherlands as compared to Japan and France*



Source: France: Meslé and Vallin, 1996; other countries: computed from WHO mortality database.

ages (85+), a new problem emerges with the negative effects of the "other causes" group, which will assume even greater significance in the second period.

It is true to say that in the Netherlands also, the impact of cardiovascular disease decline involves the oldest ages more in the period 1988 to 1999 than in the previous period, and this may be assumed to be related to the third stage of the health transition. But, it is so low overall that it is very clear that the Netherlands are very late, and slow, in entering that third stage, which differentiates it significantly from Denmark where that impact has been even more marked than in France and Japan for the last three years.

Also in the equation, the specific problem mentioned earlier of "other causes" at age 85+ assumes a significant scale: at these ages, losses in years of life expectancy by that group of causes are actually outweighing the gains due to cardiovascular disease decline. And this is compounded by an additional negative effect of respiratory diseases. All told, trends in mortality at the oldest ages have a negative effect on female life expectancy. This is very far from a new stage in the health transition devoted to the fight against ageing!

In fact, within the vague group of "other causes" only one specific cause-of-death group is involved in that process: mental disorders. This is to be discussed because the phenomenon of growing mortality by mental disorder may be a statistical artefact as well as a substantive change. Obviously, the Netherlands might possibly be more affected than other countries by the threat of a "*pandemic of mental disorders and disabilities*" conjectured by some authors like Gruenberg (1978) or Kramer (1980). But it is equally highly possible that recent changes in registration and coding practices have assigned increasing importance to mental disorders as causes of death. The most noted example is Alzheimer's disease, which suddenly spoke to the medical moment in the 80s among physicians in charge of cause of death certification (Meslé and Vallin, 1996a). But, more generally, mental disorders, are increasingly recognised as real diseases and specific causes of death rather than the expected and unavoidable result of an ageing process which is not itself considered as an underlying cause of death.

If the artefact hypothesis is correct, it means that deaths accounted as from mental disorders in the Netherlands would have been classified differently, and very probably among cardiovascular diseases, in other countries like France or Japan. This would then mean that gains in life expectancy due to cardiovascular mortality decline are underestimated in France and Japan, and the contrast between the Netherlands and these two countries for that group of causes would be even more marked than shown on Figure 11. Thus, whatever the reality regarding mental disorders, the comparison between Japan or France and the Netherlands clearly points up the idea of a third stage of health transition centred on the ageing process which first induces a new divergence before ending with a convergence (of which Denmark may be drawing the benefits to-day).

5. WHAT ABOUT SUB-NATIONAL TRENDS?

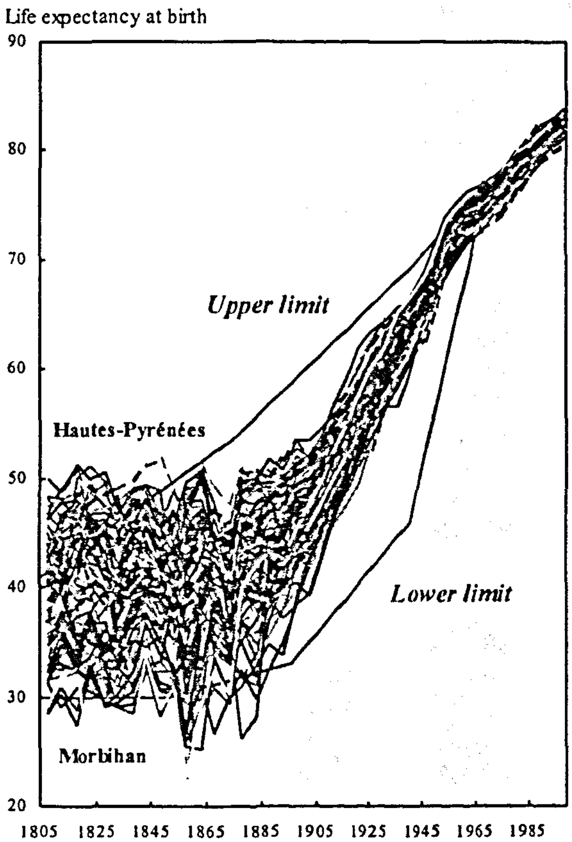
The three first parts of this paper focussed on only one universe to which the pattern of divergence and convergence following each new major advance in health can apply: countries. A useful purpose would be served by taking it further to see how far it might apply to observed within-country mortality trends and differentials. An in-depth exploration of this is beyond the scope of this paper, but an initial overview can be gained by considering selected examples of internal geographical variations, gender differentials and social inequalities.

5.1 Geographical variations

It is a matter of record that in the case of French *départements*, substantial convergence is observed across the 19th century (Caselli and Vallin, 2002). However, that long-term convergence can only be shown for females, as Noël Bonneuil's (1997) reconstruction of life expectancy by département for the 19th century dealt only with females. In Figure 12, female life expectancy trends by French *département* are compared to the upper and lower limits of national trends in industrialised countries, already plotted for Figure 1.

At the beginning of the 19th century, differences between French *départements* were much wider than the gap between these upper and lower limits. Notwithstanding the low national level of life expectancy (less than 40 years), the difference between *départements'* maximum and minimum values was more than 20 years throughout the first half of the 19th century, with a quite stable standard deviation of approximately 5 years (Figure 13). Even later, at the end of the 19th century, when the between-country gap was at its greatest, internal French variations were still very wide: in 1891-1895, with a national life expectancy of 45 years, the difference between maximum and minimum values was 18 and standard deviation 3.9. By contrast, from then to the mid-20th century, differences in French *départements* narrowed very rapidly while national life expectancy rose dramatically: in 1952-1956, with a national life expectancy of 71 years, the difference between maximum and minimum values was only 5.5 and standard deviation 1.1 (Figure 13). At

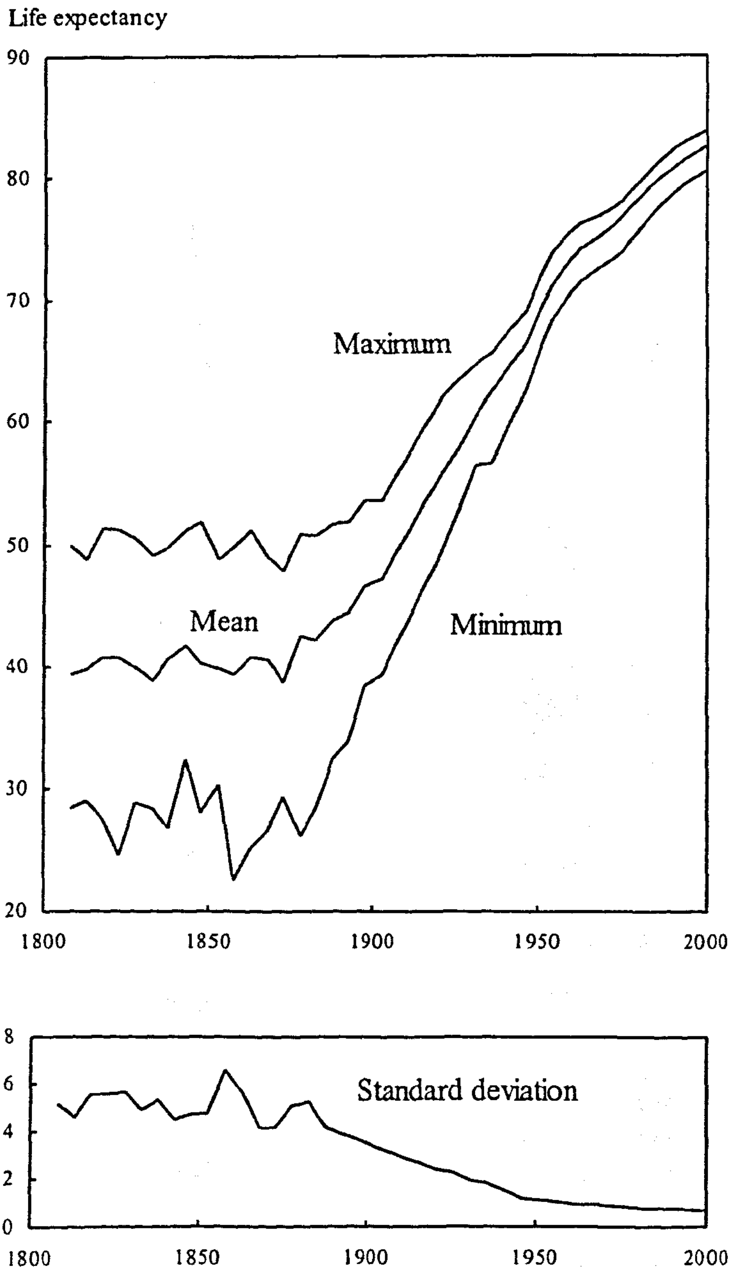
Figure 12 – *Trends in female life expectancy by French* département *compared to the upper and lower limits of national trends in industrialized countries*



Source: Bonneuil, 1997, INSEE, 1964, Labat, 1970, Labat et Viseur, 1973, de Saboulin, 1981, Sautory, 1986, Isnard et Lavertu, 1995.

this level, unlike what was being seen between countries, no divergence appears in the early 19th century among French *départements*. But it may well be that a divergence stage occurred before 1800. The likelihood that some French *départements* always enjoyed life expectancy above 50 years is remote. However, it is also highly likely that in the past mortality differentials between small geographical units were much wider than international variations. Specific local hazards, not only in terms of climatic variation but also economic and social environment, may have played a very important role. For example, the quality of drinking water and practices in

Figure 13 – *Historical trends in maximum, minimum, mean and standard deviation of female life expectancy by French* département



disposal of liquid waste varied widely from place to place, and had a material impact on life expectancy. To begin with, therefore, there was probably greater heterogeneity within each country than between countries.

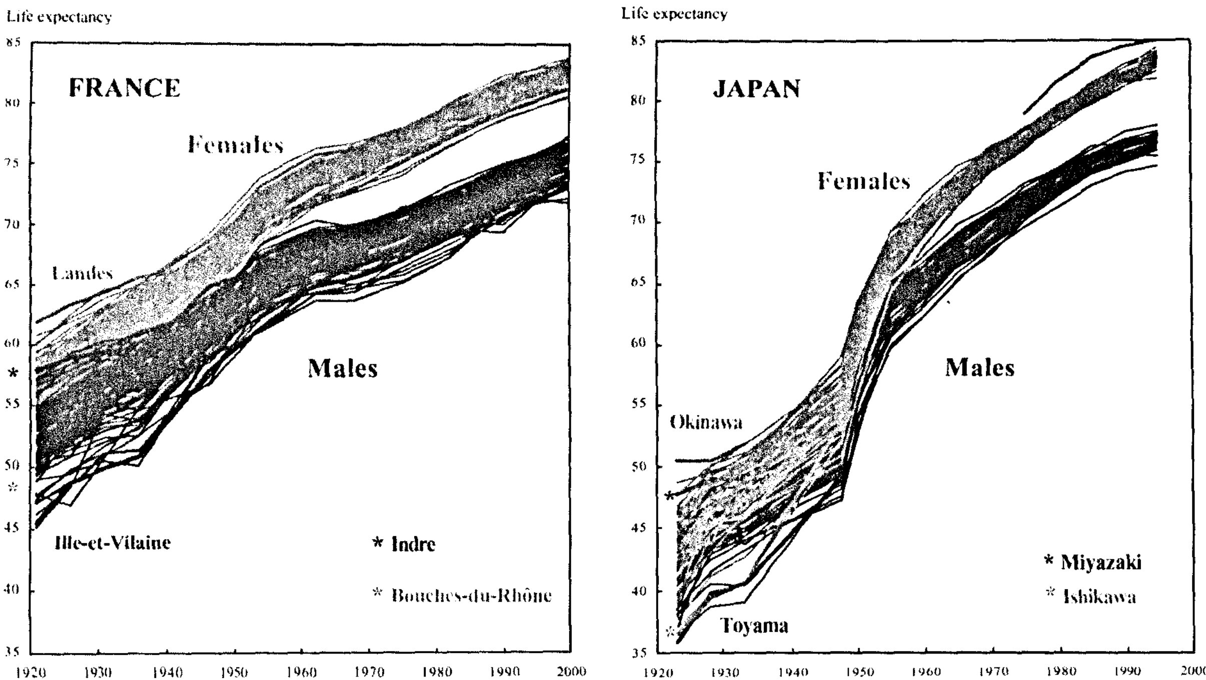
In the second half of the 19th century, by contrast, convergence between French *départements* is even more dramatic and rapid than it was between countries. This is probably the consequence of a centralized economic, social and health policy that was very successful in spreading most benefits of health advances. It was an era of generalization of free-trade on the domestic market, a rapid expansion in means of transport (roads, railways) and the development of food preservation techniques, raising food safety to near-equal levels nationwide. In the same way, public policies developed drinking water supplies, sewerage systems and public hygiene up and down the country. The urban-rural life expectancy gap, which had reached its widest in the early stages of the French industrial revolution in the mid-19th century began to narrow, being all-but eliminated by the turn of the 20th century. The health advances brought by the Pasteur revolution, including the development of personal hygiene, were rapidly delivered nationwide through the new education policy initiated by Jules Ferry, bringing in compulsory, free schooling.

In the second half of the 20th century, and especially after the end of the 1960s, it might have been expected that the cardiovascular revolution would first result in a new divergence, as it had at the international level. That did not happen. As Figure 13 shows, the standard deviation for female life expectancy, far from increasing, continues to decrease slightly from 1.1 in the 1950s to 0.7 in the 1990s. And the position for males is little different (Figure 14), with a standard deviation of 1.6 in 1952-1956 and 1.1 in 1999-2000. Internal geographical variations appear to have been relatively impervious to the dramatic change in French cardiovascular mortality. At that time, the major determinants of that mortality decrease were sufficiently equally distributed country-wide to preclude any divergence. New health behaviours (diet, physical exercise, reducing drink consumption, *etc.*) spread across the country. Modern preventive medicine and treatments were well distributed among *départements*.

The situation is little different in Japan, for which data are available from 1921-25[8] (Figure 14). In the early 1920s, female life expectancy at birth was lower in Japan (41.8 years) than in France (56.7), but the gap between maximum and minimum Japanese prefectural life expectancies (13.9) and standard deviation (3.0) was wider than among French departments (respectively 12.4 and 2.4), notwithstanding that there are only

[8] We are grateful to Ryuishi Kaneko for providing us with life tables by Japanese prefectures from that period to 1995.

Figure 14 – *Geographical variations in life expectancy in France and Japan since the 1920s*



Source: France, see Figure 12; Japan: Mizushima, 1956, Mizushima and Shigematsu, 1964; and official statistics for the most recent years.

half as many Japanese prefectures as French *départements*. Also in the equation is that geographical variations appear to have diminished much more rapidly in Japan than in France: from the early 1920s to the mid-1990s, standard deviation fell from 3.0 to 0.5 (compared to 2.4 to 0.7 in France). This greater convergence observed in Japan is clearly related to the equally much more rapid increase in life expectancy. Unfortunately, no data are available for periods before this.

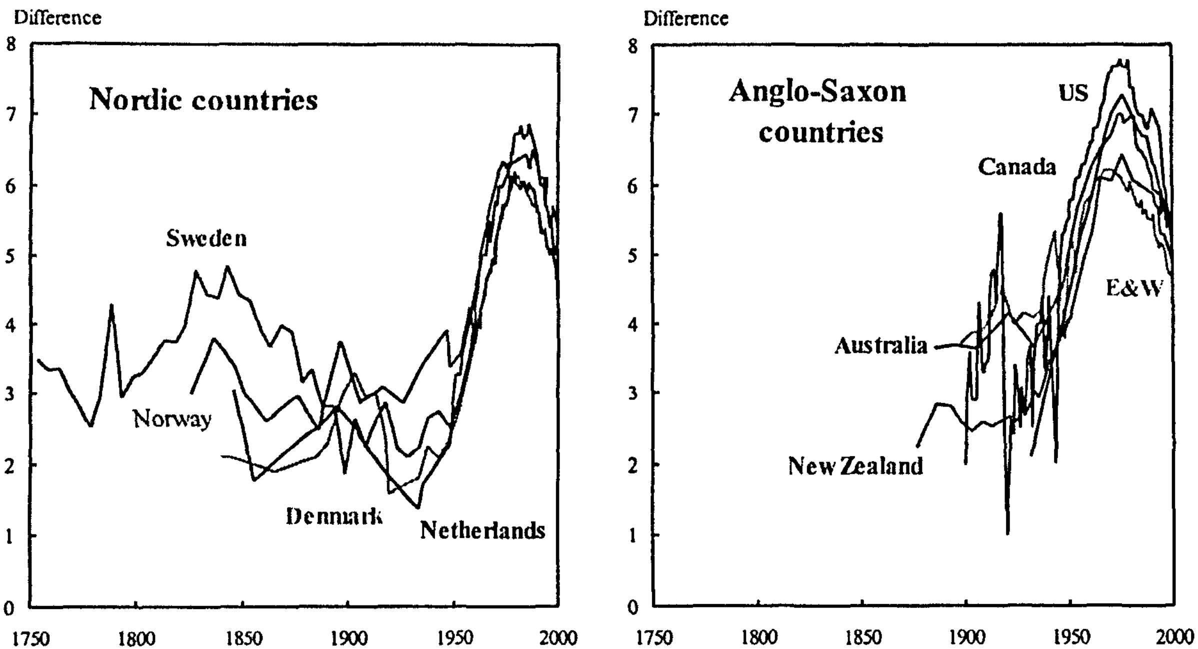
However, for the entire period covered by Figure 14, data are available for both sexes in both countries. It clearly appears that in both cases, recent decades are characterised by a significant divergence between males and females. While in the 1920s male and female geographical variations overlapped to a large extent, that overlap ceased around the mid-1950s in both countries, after which the lowest female life expectancy rises above the highest male life expectancy.

5.2 Gender differentials

However, France and Japan are not the best examples on which to base discussion of the trends in male/female differentials. France has only very recently experienced a new phase of gender convergence, while in Japan, divergence has actually accelerated in recent years (Meslé, 2004a). Better exemplars might be the Nordic and Anglo-Saxon countries where male and female life expectancies have been converging since around the early 1980s (or even the early 1970s in England).

The left-hand side of Figure 15 shows trends in absolute differences between male and female life expectancy in three Nordic countries and the Netherlands. The Swedish series is the longest, but the other three display very similar trends since the mid-19th century. In Sweden, gender differentials first increased in the very early 19th century, decreasing thereafter to stabilise from the end of the 19th century up to World War 2. Then came a fresh steady rise from the 1950s to the 1970s, followed by a renewed drop in the 1980s and 1990s. These wide fluctuations can be interpreted in the same way as for countries, above. Males and females benefited differently from various improvements. In the early 19th century, women benefited more from health advances. Improvements in their social status enabled them to draw more benefit from advances in the reduction of infectious diseases (Vallin, 1993). Half a century later, however, males in turn benefited from the same type of progress, reducing their disadvantage. Later still, a new stage in the health story marked by a huge increase in man-made diseases in the 1950s, followed by success in the fight against cardiovascular diseases in the late 1960s, brought a further rapid increase in

Figure 15 – *Gender-differential trends in life expectancy in selected countries*



the female advantage. Women were much less affected by man-made diseases than men and were also much more able to adapt to the behavioural changes that helped reduce cardiovascular mortality. Trends in differentials dropped again in the early 1980s when man-made diseases came under control and men progressively adopted the new behaviours favourable to the reduction of cardiovascular diseases.

The same is true of Norway, Denmark, and the Netherlands, at least for the period covered by available data. On the right-hand part of Figure 15, very similar trends appear for Anglo-Saxon countries (England & Wales, Australia, New Zealand, Canada and the US) for the more recent wave of changes.

5.3 Socio-economic differentials

Much more complicated as it would be to attempt the same type of interpretation for socio-economic differentials, a good case can be made that differences between social classes, levels of education and so on, could also have varied over time according to ability to draw advantage from the different stages of the health transition.

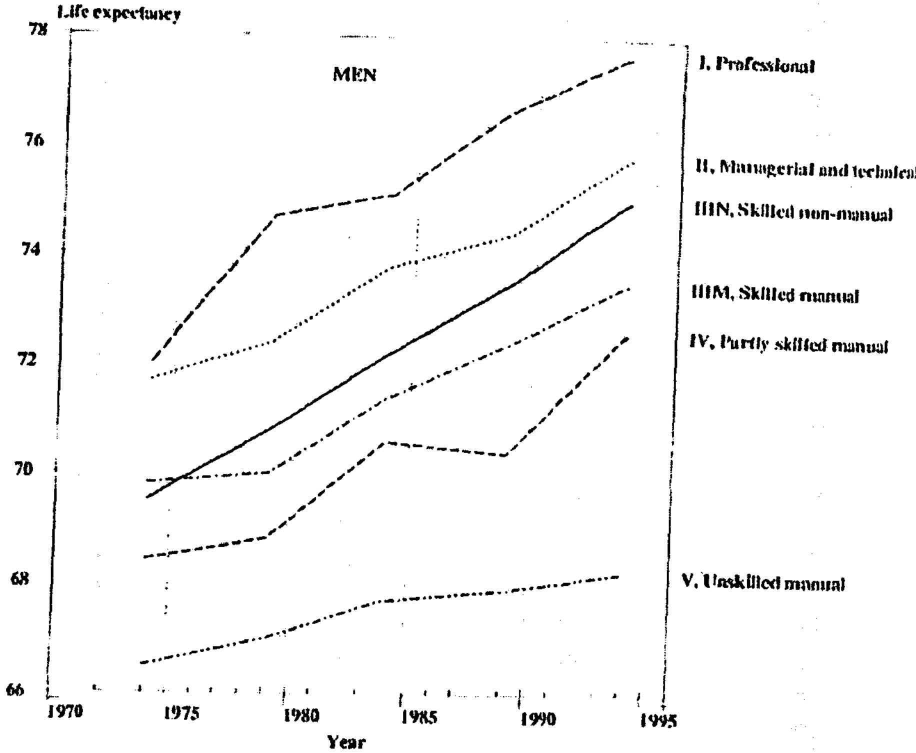
Much of the difficulty here stems from the absence of long historical sets of data and also to the poor comparability of existent data at different times.

However, for recent decades, especially the post-WW2 period where data do exist for different countries, most studies show an increase in the social gradient of mortality, as assessed, for example, in Europe by a recent overview by Tapani Valkonen (2001). For England and Wales, for instance, regular series of social mortality surveys show clearly that life expectancy at birth increased for all social classes, but much more so for the upper than for the lower classes, resulting in a widening gap (Figure 16). As Tapani Valkonen pointed out, "*mortality from ischaemic heart disease (IHD) was a major factor in the increase in mortality differentials among men aged 20 to 64 (Drever and Bunting, 1997, p.106). Mortality from IHD decreased by more than 50% in Classes I and II from 1970/72 to 1991/93, but only 33% in Class IV and 3% in Class V*[9]*. Changes in lung cancer, stroke, accidents, and suicide also contributed to the relative widening of the socio-economic mortality gap*" (Valkonen, 2001, p.245). Once again, it is highly likely that the upper classes were more able to take advantage of the cardiovascular

[9] English studies distinguish 6 social classes: professional (I), managerial and technical (II), skilled non-manual (IIIN), skilled manual (IIIM), partly skilled manual (IV), and unskilled manual (V)

revolution, either by adapting their behaviours or accessing the most sophisticated new medical technologies of screening and treatment.

Figure 16 – *Life expectancy at birth in England and Wales by social class during the period 1972-96, men*



Source: Valkonen, 2001.

6. CONCLUSION

We have tried to show in this paper that it is quite possible to integrate Abdel Omran's original epidemiologic transition (a valid explanatory framework for pre-mid-20[th] century health gains) unchanged into a broader scheme that encompasses both new advances in health and the extraordinary diversity of situations that prevail across the world. Instead of artificially adding a fourth age to the three "ages" of Omran's theory to account for the cardiovascular revolution (Olshansky and Ault, 1986; Rogers and Hackenberg, 1987; Omran, 1998), and even a fifth to allow for AIDS

(Olshansky *et al.*, 1998), it is arguably much more realistic to consider Omran's epidemiologic transition as the first stage of a global process of health transition which develops into several stages depending on different major changes in health strategies. Because not all societies are equally prepared to innovate or drew the benefits of innovation from outside, such major changes naturally result first in a more or less acute process of divergence followed by a process of convergence when late-entering countries become able to catch up the pioneers.

We have identified here three of these major stages, corresponding respectively to the vanquishing of infectious diseases (in fact, Omran's epidemiologic transition), the cardiovascular revolution, and finally the fight against ageing. That identification is still incomplete because historical data are lacking for many countries, but also because the course of events differs between countries each time. In fact, these stages occur at different times for different countries or groups of countries. And it is also possible to enter a new stage without having completed the previous one. For example, some developing countries may very well have entered the second stage by reducing cardiovascular mortality before fully reducing infectious disease mortality. Likewise, it was seen that in all likelihood Denmark very recently entered the third stage before completely addressing the issue of man-made diseases which typify the second stage.

Furthermore, it might be not impossible to find cases in which the order of the stages is varied. In particular, it might have been expected that new, highly effective treatments against cancer would have to be developed before any success against ageing was possible. The recent history of industrialized countries seems to suggest the contrary, but other countries may follow that scenario. More generally, there is nothing to say that countries still involved in the first stage, like many African countries, might not follow a different path in future.

Is what is shown about international contrasts still valid in terms of trends in internal mortality differentials? Even if it was not possible to fully develop this extended discussion, it has been possible to show that neither observed geographical variations, nor gender or social class differentials contradict our new approach. Notwithstanding the lack of sufficient long-term trends, it clearly appears that elements of divergence and/or convergence movements can also be associated with inter-group timing differences in their entrance into a new process of health improvement. It also appears that the various stages of health transition can be experienced either successively in some groups or almost simultaneously in other groups. Thus, as among countries at the international level, among sub-groups within a given population, timing, pace, and order by which the different stages of health transition occur can be largely interpreted on the basis of their different abilities to draw benefits from major health advances, even if expanding our approach to infra-national differences still requires further investigation.

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