Investigating the nutrition transition in rural regions of low- and middle-income countries: the case of three Senegalese villages

Topic: population dynamics and changes associated with modernity in rural Senegal

The demographic, epidemiological, and sanitary transition models, have been theorised to summarise the change observed or expected at both local and global levels, when it is thought to be structural, long-lasting, and generalised (Kuate Defo 2014). Although it is acknowledged that populations in Low- and Middle-Income Countries (LMICs) are facing rapid social, environmental and economic transformations, it is debated whether their imbricated causes and consequences can be modelised under transition theories originally coined for industrialised countries. Nevertheless, such models are useful to make hypotheses about current and future change in populations where data is scarce. In rural parts of the Global South, the impact of global change is often overlooked, not only because rural areas are thought to be isolated from phenomena such as modernisation or globalisation, but also because of the scarcity of data. Yet, rural inhabitants themselves say they experience such change (Lucey and Grimm 2021; Vanhoutte 2023). We intend to investigate the reality and the scope of current transformations in rural areas of Senegal, with the support of the nutrition transition model.

Theoretical focus: the nutrition transition

The nutrition transition focuses on the nutrition-related dynamics of populations. This dimension, although selective, encompasses various social, economic and epidemiological changes (Popkin 1993). When populations are subjected to structural transformations such as population growth, urbanisation, expansion of the industrial or service sectors to the detriment of agriculture, their dietary habits shift from locally produced meals, based on a few prevailing staples, to a diet dominated by industrial food items, more likely to be ultra processed and contain high amounts of trans- and saturated fats as well as free and added sugar (Popkin 1999). While under-nutrition withdraws, diet-induced metabolic diseases rise, fostered by a concomitant reduction of physical activity. This epidemiological side of the nutrition transition produces a shift in the population bearing the highest burden of malnutrition: while under-nutrition is especially fatal for children under 5, non-communicable diseases (NCDs) favoured by non-optimal diets are more prevalent among adults.

Senegal is considered one of western Africa's countries most engaged in the nutrition transition (Abrahams, McHiza, and Steyn 2011). Nevertheless, some questions remain understudied.

- Is the nutrition transition a reality in rural areas? Most studies in LMICs have focused on urban settings, where data is more available and with the idea of an ongoing "urban penalty" for adults in low-resources settings. We intend to take into account the burden borne by rural populations.
- When investigating the nutrition transition, obesity is often used as a proxy for nutrition-related health outcomes, possibly drawing attention away from other nutrition-related chronic diseases. Delisle, Agueh, and Fayomi (2011) suggested that the urban-rural differential is only significant for obesity. The study of causes of

death encompasses all fatal outcomes possibly related with nutrition rather than focusing on a symptom.
- Studies based on children link the nutrition transition to the disappearance of under-nutrition, whereas due to a situation known as the double burden, under-nutrition may keep existing while NCDs rise. Indeed, poor quality diets and foods can lead to both types of malnutrition in the same population (Delisle, Agueh, and Fayomi 2011). It is thus necessary to investigate adult deaths to describe the stages of the nutrition transition.

Data: total and cause-specific mortality from Health and Demographic Surveillance Systems

Signs of ongoing nutrition transition may be visible in mortality trends, and typically include diminishing mortality under 5, and stagnating premature adult mortality.

However, since such structural change in mortality may be associated with a wide variety of factors, it is also necessary to analyse causes of death to make assumptions about a nutritional component of these changes.

Unfortunately, in many rural regions of the Global South, statistics for cause-specific mortality are insufficient. The need for this type of data has thus been answered in some places with a system known as Health and Demographic Surveillance Systems (HDSS).

The HDSS are panel surveys where demographic events are exhaustively recorded within a delimited area. One of the first ones to be implemented was in Senegal, and the country now hosts three HDSS: Bandafassi, Mlomp and Niakhar (Delaunay et al. 2013; Pison et al. 2014, 2018). In these areas where causes of death are rarely certified by a health professional, the HDSS relies on a process known as verbal autopsies (Soleman, Chandramohan, and Shibuya 2006). Relatives of each deceased person are asked a series of questions aiming at describing the circumstances of the death, the medical history and the symptoms displayed by the victim. The answers are then analysed by physicians who determine the most probable cause of death.

Although this data has been used to study mortality transitions and other demographic phenomena, it has been understudied in regards to the epidemiological transition and especially the nutrition transition.

Methods: survival analysis considering causes of death

We will analyse all-causes mortality to evaluate the mortality transition in rural Senegal, especially comparing the trends for children with those of adult populations. The existence of three HDSS sites in Senegal with different social and environmental characteristics will help formulating hypotheses about the factors influencing those trends.

We will also try to unravel patterns in the recorded causes of death, which we hypothesise will be evocative of an epidemiological transition fostered by a nutrition transition. This will be done thanks to a decomposition of the contribution of causes of death to the changes in life expectancy, and an analysis of competing risks over time. First we will compare three groups of causes: communicable, maternal and neonatal causes of death ("group 1"), deaths attributable to noncommunicable diseases ("NCDs") and violent deaths ("injuries"). We

will also analyse how the varying proportion of ill-defined causes of death may influence interpretation of trends in diagnosed deaths.

Then we will focus on causes of death associated with nutrition, comparing the group of causes whose prevalence is linked to a context of sub-optimal nutrition with causes associated with transitional diets and increased sedentarity.

Expected results

Table 1: Life expectancy at birth

	1985-1996	1997-2008	2009-2020
Bandafassi	45.56	51.95	63.99
Mlomp	60.16	62.00	70.08
Niakhar	50.88	57.03	69.15

Regarding mortality and the hypothesis of an epidemiological transition, our first quantitative analyses show a net improvement of life expectancy at all ages over the last decades (see Table 1). However, the drastic reduction in infant mortality contributes more to this progress than other age groups. Indeed, the relative decrease of mortality in adults is smaller, and even more in older adults (see Figure 1). This is in line with the epidemiological transition.

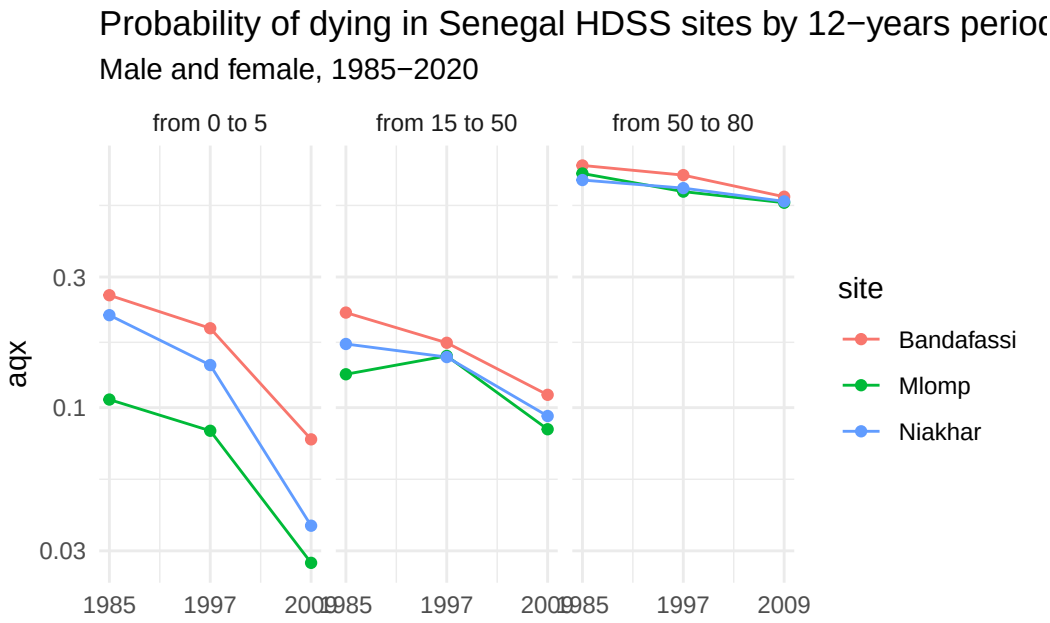

Figure 1: Probability of dying

Further investigating the mortality patterns of adults, we observe different trends between sites and sexes, that can only partially be explained by causes already studied in the

zone (Guyavarch et al. (2010); Kodio et al. (2002)). Furthermore, a 2008 study in one of Senegal HDSS sites has shown that noncommunicable causes of death already played a more important role than what is usually assumed (Duthé and Pison 2008). It is thus necessary to investigate causes of death to understand better the diachronic and synchronic differences observed, and take into account cause-specific trends that may be undetectable in all-causes mortality.

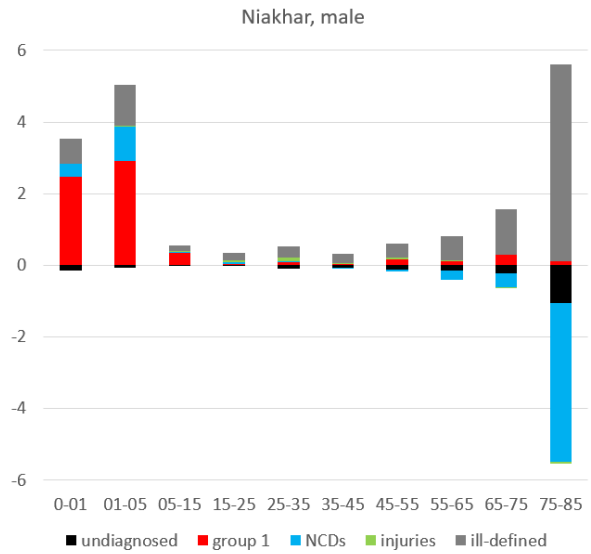

Figure 2: Decomposition of life expectancy at birth by age and group of cause

Figure 2 shows that despite a significant improvement in life expectancy at birth between 1985-1996 and 2009-2020, NCDs at older ages have contributed negatively to this difference. Therefore, the role of NCDs in mortality is an epidemiological reality that is already impacting the population. Nevertheless, this difference is not *per se* attributable to exposure to new risks. Indeed, given the rise in life expectancy over this timespan, inhabitants of the HDSS sites are nowadays more likely to survive to older ages, when NCDs are most likely to happen. To go further, we will compare sites and periods using standardised rates.

In order to further evaluate the hypothesis of the nutrition transition, we will also analyse more specifically other categories of causes of death. We expect to find decreasing mortality rates for communicable causes of death, which would be likely due to several factors including immunisation, but favoured by an improved nutritional status. We also expect to see an increase in deaths caused by certain NCDs associated with low physical activity and dietary risks, especially cardiometabolic diseases. Eventually we will analyse the trends in ill-defined causes of death, for we assume multi-morbidity or lack of medical care (conditions that make it more difficult to make an accurate diagnosis) are more likely to happen with NCDs and metabolic conditions such as type 2 diabetes or hypertension.

References

Abrahams, Zulfa, Zandile McHiza, and Nelia P. Steyn. 2011. "Diet and mortality rates in Sub-Saharan Africa: Stages in the nutrition transition." *BMC Public Health* 11. https://doi.org/10.1186/1471-2458-11-801.

Delaunay, Valerie, Laetitia Douillot, Aldiouma Diallo, Djibril Dione, Jean-François Trape, Oleg Medianikov, Didier Raoult, and Cheikh Sokhna. 2013. "Profile: The Niakhar

Health and Demographic Surveillance System." *International Journal of Epidemiology* 42 (4): 1002–11. https://doi.org/10.1093/ije/dyt100.

Delisle, Hélène F., Victoire Agueh, and Benjamin Fayomi. 2011. "Partnership research on nutrition transition and chronic diseases in West Africa - Trends, outcomes and impacts." *BMC International Health and Human Rights* 11 (SUPPL. 2): S10. https://doi.org/10.1186/1472-698X-11-S2-S10.

Duthé, Géraldine, and Gilles Pison. 2008. "Adult mortality in a rural area of Senegal: Non-communicable diseases have a large impact in Mlomp." *Demographic Research* 19 (37): 1419–34. https://doi.org/10.4054/DemRes.2008.19.37.

Guyavarch, Emmanuelle, Gilles Pison, Géraldine Duthé, Adama Marra, and Jean-Philippe Chippaux. 2010. "Mortality due to External Causes in Three Rural Areas of Senegal." *European Journal of Population* 26 (4): 483–505. https://doi.org/10.1007/s10680-010-9213-y.

Kodio, Belco, Luc De Bernis, Mariame Ba, Carine Ronsmans, Gilles Pison, and Jean-François Etard. 2002. "Levels and causes of maternal mortality in Senegal." *Tropical Medicine & International Health* 7 (6): 499–505. https://doi.org/10.1046/j.1365-3156.2002.00892.x.

Kuate Defo, Barthelemy. 2014. "Demographic, epidemiological, and health transitions: Are they relevant to population health patterns in Africa?" *Global Health Action* 7 (SUPP.1). https://doi.org/10.3402/gha.v7.22443.

Lucey, Taylor K., and Kerry E. Grimm. 2021. "Connecting political ecology of health and disease with 'structural stigmatization': declining use of forest foods and medicines in Kedougou, Senegal." *Journal of Political Ecology* 28 (1): 1–22. https://doi.org/10.2458/JPE.2996.

Pison, Gilles, Baptiste Beck, Ousmane Ndiaye, Papa N Diouf, Paul Senghor, Géraldine Duthé, Laurence Fleury, Cheikh Sokhna, and Valérie Delaunay. 2018. "HDSS Profile: Mlomp Health and Demographic Surveillance System (Mlomp HDSS), Senegal." *International Journal of Epidemiology* 47 (4): 1025–33. https://doi.org/10.1093/ije/dyy075.

Pison, Gilles, Laetitia Douillot, Almamy M Kante, Ousmane Ndiaye, Papa N Diouf, Paul Senghor, Cheikh Sokhna, and Valérie Delaunay. 2014. "Health & demographic surveillance system profile: Bandafassi Health and Demographic Surveillance System (Bandafassi HDSS), Senegal." *International Journal of Epidemiology* 43 (3): 739–48. https://doi.org/10.1093/ije/dyu086.

Popkin, Barry M. 1993. "Nutritional Patterns and Transitions." *Population and Development Review* 19 (1): 138. https://doi.org/10.2307/2938388.

———. 1999. "Urbanization, lifestyle changes and the nutrition transition." *World Development* 27 (11): 1905–16. https://doi.org/10.1016/S0305-750X(99)00094-7.

Soleman, Nadia, Daniel Chandramohan, and Kenji Shibuya. 2006. "Verbal autopsy: Current practices and challenges." *Bulletin of the World Health Organization* 84 (3): 239–45. https://doi.org/10.2471/BLT.05.027003.

Vanhoutte, Lucie. 2023. "Du modèle établi au terrain en humanités en santé." *Médecine/Sciences* 39 (5): 463–67. https://doi.org/10.1051/medsci/2023063.