The determinants of infant mortality: how far are conceptual frameworks really modelled?

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Abstract

To explore whether theory is adequately translated into statistical models for measuring and explaining the widely acknowledged effect of « maternal education on infant or child survival », a systematic compilation of articles dealing explicitly with the statistical analysis of this relationship and published since 1990 in a selected sample of scientific journals was performed.

The models used and the interpretation of the results were evaluated in reference to the Mosley & Chen's analytical framework for the study of child survival in developing countries and to Caldwell's 'theory' regarding the role of the mother's education in this field.

The analysis concludes to a promising evolution towards the use of more adequate statistical models, especially when several levels of observation or sequences of causal factors are to be considered. However, theory per se is seldom present in the selected papers: it is often invoked in the interpretation or the discussion of the results, but not as a support for the design of the survey or of the statistical modelling process.

Keywords:

child survival,
maternal education,
theory,
statistical model,
developing countries

Introduction

The infant mortality rate (IMR) defined as the risk for a live born child to die before its first birthday is known to be one of the most sensitive and commonly used indicators of the social and economic development of a population (Masuy-Stroobant & Gourbin, 1995). The association between deprivation and poor survival in infancy was already documented with survey data as early as 1824 (Villermé, 1830 quoted by Lesaëge-Dugied, 1972). The association between socio-economic factors and infant mortality was further reinforced when improvements in overall infant mortality levels over time ran parallel with general social and economic development in most industrialised countries during the twentieth century. Furthermore, since the Second World War, corroboration of the strong inverse relationship between socio-economic development and mortality rates has been found repeatedly among countries and areas within countries. At the individual level, significant social inequalities are repeatedly recorded, even when the overall IMR reaches very low levels (Haglund et al., 1993). Links between individual-level social inequalities and regional (aggregate-level) differences are partly explained by relatively high spatial concentration of the deprived and of populations of lower social class (United Nations, 1953; Masuy-Stroobant, 1983).

To explore how demographers have tried to theorise infant mortality as a social phenomenon and the way these theoretical assays are actually translated into statistical models for explaining the widely acknowledged effect of maternal education on infant or child survival, I have reviewed part of the recent demographic literature dealing explicitly with the statistical analysis of this relationship.

From the identification of determinants to the design of conceptual frameworks

The high mortality levels experienced by European populations in the past (IMRs ranging from 80‰ to 250‰ by 1900) and the less developed countries today (with populations still experiencing IMRs above 140‰, like Guinea-Bissau, Sierra Leone or Afghanistan as estimated by the US Population Reference Bureau for 1997: Boucher, 1997) show some similarities: their causes of death were and are mainly of infectious origin, and the high mortality levels experienced during the first year tend to continue, although at lower levels, during childhood (i.e. until age five).

Historical studies on infant mortality brought about the quite general observation that a good deal of its decline could be achieved before efficient preventive and curative medication (vaccination against measles, whooping cough, tetanus... and antibiotics) was made available: « the historical evidence is consistent with the view that medical interventions could only have affected mortality in general and infant mortality in particular after 1930 » (Palloni, 1990a, p.191).

Even though death is a biological event, mainly caused by a specific disease, the demographic study of the determinants of infant and child mortality will concentrate on the (cultural, environmental, social and behavioural) factors, which may influence the likelihood of ill health, disease and death in early infancy. Research on the historical decline of infant and child mortality in Europe have thus identified retrospectively a wide series of determinants which are also known to explain the present-day situation in high mortality populations. Climatic and seasonal variations in mortality by diarrhoea have shown the importance of *ecological conditions*; significant spatial correlations between regional IMRs and *infant feeding practices* (whether the infants were breast-fed, bottle fed, currently receiving foster care….) were also abundantly documented; *social factors* as indicated by the excess mortality of illegitimate infants, or the striking rural-urban differences observed during the industrialisation process (Naomi Williams and Chris Galley, 1995, p.405 explain the nineteenth century urban disadvantage by the « urban-sanitary-diarrhoeal effect » due to poor sanitation, overcrowded housing, poverty …) played also an important role in European history; finally, the *high fertility patterns* we have known, did also exert an effect on infant and child survival, through shortened birth intervals, family size, etc.

Infant mortality started its decline in Europe and the USA by 1900, several decades after a decline in early childhood and general mortality had begun. Nutritional improvements (McKeown, Brown and Record, 1972), sanitary reforms (i.e. the provision of sewage disposal and clean water sup-

ply systems in towns) and improved personal hygiene (Ewbank and Preston, 1990) were put forward to explain the decrease in general and in childhood mortality. Infant mortality appears to resist to these improvements until quite similar « Child Welfare Movements » were organised in most European countries and the USA (Masuy-Stroobant, 1983) by the very end of the nineteenth-beginning of the twentieth century. Their health education activities were built on an increasing awareness of the germ theory of disease (Louis Pasteur in the 1880s) and the growing agreement « *that the mother needed education in proper infant care practice* » especially regarding feeding practices. Major emphasis was thus placed on breast-feeding, on providing clean and adequate food to the non breast-fed infant – heating of milk and sterilisation of bottles were important innovations in this regard – and on keeping the baby and its direct environment clean. At first based on private initiatives, various educational activities aimed at mothers were progressively implemented through the organisation of Milk Depots (in French, « Gouttes de Lait » ensuring the distribution of ready-to-use clean and bottled milk to the poorer mothers who could not breast-feed their infant), Infant Consultations, where the babies were weighted and examined by a medical doctor, networks of Home Visiting Nurses and Midwives. Educational efforts were also aimed at schoolgirls: they were taught « … the value of domestic hygiene, the dangers of filth, and what to do about infectious diseases » (Ewbank & Preston 1990, p.127). Mass education campaigns were also organised by the Red Cross during the First World War to teach mothers the basic principles of the 'new' child care practices by means of public demonstrations. The content of the information / education provided did not vary much from one country to another since International Congresses were held to exchange information and experiences gained in the different countries (Congrès Internationaux des Gouttes de Lait, Paris 1903; Bruxelles 1906; Berlin 1912) in order to improve the action. These often local initiatives were later on (around the First World War) institutionalised and generalised in Europe through the Maternal and Child Health Systems, whose main objectives were and are still the development of preventive care through information, education and early detection of health problems.

Training in the 'new' infant care practices seemed thus to be the key to reduce infant mortality. Later evidence however (Boltanski, 1969) worked out in the context of inter-war France has shown that *the general education level of the mother* was more efficient towards adoption of the new infant care practices (and of a more general preventive attitude) than any specific training course in those matters.

Moving towards less developed countries, John C. Caldwell (1979, pp. 408-410) with reference to Nigeria argues that « (…) maternal education cannot be employed as a proxy for general social and economic change

but must be examined as an important force in its own right (…). Furthermore, in Nigeria, as doubtless in much of the Third World, education serves two roles: it increases skills and knowledge as well as the ability to deal with new ideas, and provides a vehicle for the import of a new culture ». He then further develops three main hypotheses on the mechanisms through which maternal education is supposed to exert its effects on the health of children:

> « The first explanation is usually given as the only reason. That is that mothers and other persons involved break with tradition or become less 'fatalistic' about illness, and adopt many of the alternatives in child care and therapeutics that become available in the rapidly changing society.(...)
>
> The second explanation is that an educated mother is more capable of manipulating the modern world She is more likely to be listened to by doctors and nurses. (...) She is more likely to know where the right facilities are and to regard them as part of her world and to regard their use as a right and not as a boon.
>
> There is a third explanation, which may be more important than the other two combined. (...) That is, that the education of women greatly changes the traditional balance of familial relationships with profound effects on child care. »

This paper usually referenced in the demographic literature as Caldwell's « seminal paper » or Caldwell's theory was a few years later completed by a series of analytical frameworks for the study of child survival determinants in developing countries. The frameworks published by Meegama (1980), Garenne & Vimard (1984), Mosley & Chen (1984) and Palloni (1985) have been discussed in an earlier paper (Masuy-Stroobant 1996). For the purpose of this paper I have selected Mosley & Chen's proposal for three reasons: it is the most frequently referenced in subsequent papers dealing with infant or child mortality determinants; it tries to integrate research methods employed by social and medical scientists; it is also closely related to Caldwell's « theory » regarding the role of the mother's education: « Because of her responsibility for her own care during pregnancy and the care of her child through the most vulnerable stages of its life, her educational level can affect child survival by influencing her choices and increasing her skills in health care practices related to contraception, nutrition, hygiene, preventive care and disease treatment. In fact, so many proximate determinants may be directly influenced by a mother's education to radically alter chances for child survival, that one of the authors was prompted to label the process 'social synergy' » (Mosley & Chen, 1984, pp. 34-35).

Basically, their framework provides a clear distinction between socio-economic determinants (on which social science research has devoted

most of its work and which were largely ignored by medical research) and proximate determinants (encompassing indicators of the various mechanisms producing growth faltering, disease and death, most commonly analysed in medical research) of child survival in developing countries:

1. **The dependent variable**: given that « an exclusive focus on mortality handicaps research because death is a rare event » (Mosley & Chen, 1984, p. 29) they propose to combine the level of growth faltering (nutritional status) of the survivors with the level of mortality of the respective birth cohort into a more general health index that can be scaled over all members of the population of interest.
2. **The proximate determinants**: should be measurable in population-based research. They comprise *maternal factors* (age at birth, parity and birth intervals); *environmental contamination* (intensity of household crowding, water contamination, household food contamination or potential faecal contamination); *nutrient deficiency* (nutrient availability to the infant or to the mother during pregnancy and lactation); *injury* (recent injuries or injury-related disabilities); *personal illness control* (use of preventive services as immunisations, malaria prophylactics or antenatal care, and use of curative measures for specific conditions).
3. **The socio-economic determinants**, which are operating through these proximate determinants, are grouped into three broad categories of factors
   - *Individual-level factors*: individual productivity (skills, health and time, usually measured by mother's educational level, whilst father's educational level correlates strongly with occupation and household income); tradition/norms/attitudes (power relationships within the household, value of children, beliefs about disease causation, food preferences).
   - *Household-level factors*: income/wealth effects (food availability, quality of water supply, clothing/bedding, housing conditions, fuel/energy availability, transportation, means to purchase what is necessary for the daily practice of hygienic/preventive care, access to information).
   - *Community-level factors*: ecological setting (climate, temperature, altitude, season, rainfall), political economy (organisation of food production, physical infrastructure like railroad, roads, electricity, water, sewage… political institutions), health system variables.

In doing so, Mosley & Chen parallel the approach used by Davis and Blake (1956) in developing an analytical framework for the study of fertility. But they add «The problems posed by mortality analysis (…) are far more complex because a child's death is the ultimate consequence of a cumulative series of biological insults rather than the outcome of a single

biological event. (…) Thus it appears unlikely that a proximate determinants framework for mortality is easily amenable to a quantification of components contributions to mortality change, like the elegant system Bongaarts (1978) has developed for the fertility model » (Mosley & Chen, 1984, pp. 28-29).

From the analytical framework to statistical modelling: How is the mother's education effect modelled in recent literature?

When defining a 'socio-economic (underlying) → proximate → outcome' approach Mosley & Chen thus clearly specify a sequence of influences which need to be distinguished when analysing infant's survival process. Socio-economic variables are further organised hierarchically according to their level of observation/influence into community – household – and individual-level variables.

For investigating how this well-known analytical framework was translated in current demographic research, I proceeded to a systematic compilation of articles published from 1990 to 1997 dealing explicitly with the statistical analysis of the effect of « maternal education on child or infant survival » (title of the article) in a limited series of scientific journals: *Social Science and Medicine*, a multidisciplinary journal where articles dealing with biological and social factors in relation to health and mortality are found, *Population Studies*, considered by Samuel H. Preston as «(...) the leading publication for demographic research on mortality » (Preston, 1996, p.525) and Health Transition Review (including *Proceedings of International workshops on Health Transition*), which for years and due to its editors, John C. Caldwell and Gigi Santow, focussed on the determinants of infant and child health and mortality. Other journals could be investigated as well, but the objective of this paper was not to proceed to a meta-analysis of all the studies done in this field, but rather to analyse the current way demographers are trying to model this relationship.

Mother's education and its effect on child survival in developing countries: a review of recent literature

References	Data base	Dependent variable	Mother's education	Controls or confounding	Level of analysis	Statistical method	Results	Comments
1. Bourne & Walker (1991)	1981 Census of India	Mortality risks by age (0-5) and sex	5 categories: illiterate/primary/lower secondary/higher secondary/college +	Density measured by rural/urban residence within the Indian states	Individual-level within each state	Median polish for two-way tables for each state in which iterative equations are used	A positive effect of education on child survival with an increasing effect on female children as age at death increases	Education and density effects are additive in the model
2. Bhuiya & Streatfield (1991)	Follow-up of 7,913 live births, Matlab villages, Bangladesh, 1982-1984	Probability of death for survivors at beginning of age interval for 0, 1-5, 6-11, 12-17, 18-35 completed months.	3 categories: no schooling/primary/ some secondary	Mother's age at birth, sex of child, household economic condition, type of health intervention in the village	Individual-level	Hazards model (Cox regression ?) and maximum-likelihood logit model with backward elimination of least-significant variables	A positive effect of mother's education on survival of children but more important for boys	Although control variables pertain to different levels of aggregation, all independent variables are put together into an additive model
3. Akin (1991)	24 months follow-up of 3,080 women having a single live birth, metropolitan area of Cebu, Philippines, 1983-1986	Outcome variables: gestational age and birth weight, growth, morbidity and mortality by age	Formal education in years (continuous variable)	Health related behaviour (feeding practices, health service use, personal hygiene are in one stage considered as effects of education and in the next stage as determinants of children's health	Individual-level	Structural equations distinguishing the impact of education on health behaviour and the impact of health behaviour on the different child's health outcomes. All variables are either continuous either used in binary form	The model allows calculation of the effect of a one-year increase in maternal education through the intermediate action of health behaviour indicators on the incidence of diarrhoea for each two-month period of observation	Using structural equations, this study adequately disaggregates the respective actions of education measured at individual-level and of the proximate behavioural determinants of health according to Mosley & Chen's proposal

4. Victora et al. (1992)	Follow-up of 6,011 births born in three maternity hospitals of Pelotas, Brazil in 1982. Follow-up by home visit in 1984.	Outcome variables: birth weight, perinatal and infant mortality, hospital admissions, nutri-tional status	4 categories: no schooling/ 1-4 years/5-8 years/9+ years	Age of mother, racial group, family income, height of mother, father's education	Individual-level	Multiple logistic regression for dichotomous outcomes, multiple linear regression for continuous ones	In crude associations maternal education is strongly associated with all the consid-ered health outcomes. Birth weight and perinatal mortality are no longer associ-ated after taking controls into account.	All independent (whether control or confounder) variables are put together into simple additive models

5. Bicego & Boerma (1993)	Retrospective data from Demographic & Health Surveys conducted in 17 countries (1987-1990)	Outcome variables: neonatal mortality, and mortality from 1 to 23 completed months, stunting, underweight status, use of tetanus toxoid, use of prenatal care	3 categories: no education/some primary/ some secondary	Control: household economic status Proximate determinants: health services utilisation, pattern of family formation, household exposure (water and latrines) Community: rural-urban setting as indicator of access to health services	Individual-level	Logistic regressions and for postneonatal mortality (by age at death) a Cox hazard regression model. Process of model estimation follows the causal/temporal ordering of factors considered in the conceptual framework.	Postneonatal mortality is more sensitive to mother's education in most countries. The education advantage is more important in urban areas pointing to an interaction between education and access to health services on child survival	The framework derives partly from Mosley & Chen's proposal; The sequence of socio-economic-proximate determinants effects is captured through a progressive introduction of those factors in the regression models. Interpretation is based on changes in coefficients obtained for education during the process. Community variables are considered by introducing an interaction term with education.

6. Dargent-Molina et al. (1994)	6 months follow-up of 2,484 infants surveyed at 6,8,10 and 12 months, in 33 communities of Cebu, Philippines, 1983-1984	Outcome: multiple episodes of diarrhoea during follow-up	3 categories: less than completed primary (0-3 years)/ less than completed high school (4-9 years)/completed high school (10+ years)	Confounder: age of mother. Household assets. Community: economic and communication resources	Individual-level	Multiple (logistic ?) regression analysis including interaction terms between education and community level variables to calculate adjusted risk estimates by maternal education	The protective effect of maternal education on diarrhoea varies according to the resource level of the community, with the least effect in the most disadvantaged communities	Community variables are considered by introducing interaction terms with education in a general additive model.
7. Adetunji (1995)	Retrospective data from the Demographic and Health Survey, Ondo state, Nigeria, 1986-1987	Infant mortality risk	3 categories: no schooling/primary/ secondary +	Maternal age, birth order, duration of breast-feeding	Individual-level	Logistic regression	When the crude relationship between mother's education and infant mortality is not significant, it becomes significant after controlling for duration of breast-feeding	Socio-economic variables and proximate detrminants are analysed concurrently in an additive model

8. Sandiford et al. (1995)	Case-control (3 groups) retrospective study of women aged 25-49, Masaya, Nicaragua.	Infant mortality, health status of under-five children based on anthropometric indicators	Comparison groups are formed on literacy acquisition form: adult education/formal education as a child/illiterate	Household wealth, education of spouse and parents, parity, access to health services, water supply and sanitation	Individual-level	Logistic regression	Women having acquired literacy through adult education showed socio-economic characteristics very similar to those of illiterate women; they however have better survival and health outcomes for their children even after controlling for confounders. Those who benefited as child of formal education fare even better.	This was a unique opportunity to disentangle education effect and often closely linked economic effect on child survival. Results of regression were obtained after controlling for all confounders, mixing socio-economic variables and household sanitation variables.

9. Sastry (1997)	Retrospective data from the Demographic and Health Survey, Brazil 1986, of which 2,946 singleton births of the North Eastern Region occurring during the ten years preceding the survey were analysed	Mortality risks by age: at 0, 1-5, 6-11, 12-23 and 24-59 months	2 categories: less than 3 years/3 years and over	Child's age and sex, maternal age at birth and squared age at birth, birth order and spacing, survival of preceding child, breast-feeding status Belonging to a family (total of 1,051 families), living in a specific community (90 communities)	Individual-level, taking into account the clustering of individuals into the family and of families into communities	Multilevel hazard model with nested frailty effects linked to family clustering and community clustering effects	Risk of death is consistently negatively associated with the mother's education even after controlling for family-level and community-level clustering effects	Beside specific family and community level factors which are introduced stepwise in the model, the other confounders are considered together in the model whether they refer to socio-economic individual-level variables or to proximate determinants (breast-feeding, etc.)

For each of the 9 selected articles, a systematic review of basic information was recorded: these included classically description of the data and material used (type of observation, period, region, number of women/births/children considered), definition of the dependent variable, how mother's education is measured, control variables considered, level of analysis, statistical method used, main conclusions of the research and some brief comments on the way the +eterminants are modelled. Two articles do not exactly meet the selected criteria: Akin's paper (study num. 3) actually deals primarily with an advocacy for the use of structural equations to model the impacts of socio-economic and biomedical factors on child health, but the example he extensively works out deals precisely with the impact of maternal education (Akin, 1991, pp. 419-426); Sastry's paper is primarily interested in the clustering effects of family – and community-level factors on the relationship between maternal education and mortality in childhood, hence 'clustering' was given the first place in the title of his article.

During the late 1970s and the 1980s, the organisation of World Fertility Surveys (WFS), followed in the late 1980s and the 1990s by the Demographic and Health Surveys (DHS) on a standardised format (questionnaire, sample design), together with the availability of new multivariate statistical techniques allowing the analysis of categorical variables (hazards models, logistic regressions, log-linear models), led to an explosion of individual-level analyses of fertility and, later, of infant and childhood mortality in Third World countries (Preston, 1996). Both WFS and DHS surveys collect retrospectively the complete reproductive history of women in childbearing ages, including information on their children's survival; DHS provide additional health related information for children born during the five years preceding the survey (immunisation, prenatal care, birth attendance, episodes of diarrhoea, use of oral rehydration, etc.). Community-level and household-level information is also collected.

Hence the wealth of results showing the positive association between mother's education and survival chances of her children: Caldwell (1989, p. 102) states that the « … most important finding at the individual level was the extraordinary stability of the relationship between maternal education and child survival across the different continents and across enormous differences in societal levels of education and mortality », those findings hold true even after controlling for other socio-economic variables (Hobcraft et al., 1984 on 39 WFS; Rutstein, 1984, quoted by Cleland and Van Ginneken, 1988, p. 1358 on 41 WFS; Hobcraft, 1993 on 25 DHS, etc.). When discussing these findings, Cleland (1990, p. 402) observes that: « there is no threshold; the association is found in all major developing regions; the linkage is stronger in childhood than in infancy; only about half the gross association can be accounted for by material advantages associated

with education; reproductive risk factors play a minor intermediate role in the relationship; greater equity of treatment between sons and daughters is no part of the explanation; the association between mother's education and child mortality is slightly greater than for father's education and mortality ». Attempts to quantify the effect of an additional year of education can also be found: the relationship between maternal education and mortality in childhood is essentially linear, with an average of 7-9% decline in mortality ratios with each one-year increment in mother's education (Cleland and Van Ginneken, 1988, p. 1358).

These results were and are still interesting for research and yet useful for political action in this field. They nevertheless *suffer from the main shortcomings of retrospective surveys*:

- Observed cross-sectionnaly at the time of the survey, socio-economic factors at the individual level and household and community-level factors are retrospectively associated with past infant and child mortality.
- Very poor, if any, information collected on what happened between birth and death for the deceased infants.
- Selective recall problems were encountered concerning reporting of early deaths, and on age-at-death, causing some underscoring of the importance of the relationship between education and mortality: the often reported lesser impact of education on neonatal and infant mortality could be a result of selective (by education) omission or underreporting of early deaths (Bicego & Boerma, 1993, p. 1215). To overcome some of those problems, the DHS restrict recording of more detailed health information to births (and their outcomes) occurring during the five years preceding the survey, but here also the expected inverse relationship between the occurrence of diarrhoea episodes and level of maternal education is not systematically found, due probably to a more accurate reporting of the disease by the better educated, but also to the general bad living conditions in the poorest countries.
- Women in childbearing ages are the observation unit in both surveys, but, when analysing infant mortality a transformation of the data base is often necessary to have children (or births) as unit of analysis: in this case, the information related to the infant's mother being linked to each child (or birth) implies a duplication of the mother's characteristics for each of her children. This may lead to an overrepresentation of parents with high fertility – often the most traditional and poor ones in the transformed files. Multilevel analysis (see below) which provides the possibility to include 'clustering' effects reflecting the fact that some children share the same familial unit offers a solution to this problem.

Some *theoretical problems* may also be put forward: usually the 'net' effect of the mother's education is produced after removing – statisti-

cally – other concurrent effects, such as adjustment for income or father's education. The relationships between the independent variable of interest (mother's education in our case) and 'control' variables are seldom discussed from a mere theoretical point of view. The question of a possible high homogamy – with respect to education – between spouses is not discussed: it may cause multicollinearity problems analogous to what happens in classical multiple regression when introduced into the model without considering those links. And how to interpret the 'net' effect of mother's education when its level is – by social customs – very highly correlated to her husband's? Introduction of income as control has been briefly discussed in Victora et al.'s paper (study num. 4, p. 904): « (...) adjustment for family income greatly reduced the apparent effect of maternal education on some of the child health outcomes. Family income however may be affected by maternal education, as better-educated women would contribute to a higher family income. If this is true, then income would not qualify as a confounding variable as one of the prerequisite for a confounder is not to be an intermediate variable in the causal chain between the risk factor of interest – maternal education in this case – and the health outcome ». The author nevertheless keeps income as a confounder in his model.

One way to overcome this problem through changing the study design may be exemplified by the research conducted by Sandiford et al. (study num. 8) in Nicaragua: their case-control study took advantage of a previous adult literacy campaign to adequately control for income and wealth in their study on the effect of education on child survival. Although retrospective, their study presents some of the advantages of quasi-experimental design where women who did benefit from the adult literacy campaign showed an economic background and situation very similar to that of the illiterates ones. Although less good than those obtained by the group of women who had been educated as children in the formal school system, the women who had benefited from the adult literacy campaign showed significantly better results in health outcomes for their children than their illiterate neighbours.

Quite common in epidemiological study designs, case-control studies are rare in demography and the most usual way is to control for confounders within the statistical model. The absence of conformity to the theoretical time sequence of the hypothesised action of the different variables when having recourse to statistical modelling is also found when authors *mix variables pertaining to different levels of observation or units* (individual – household – and community-level variables) of analysis into a classical additive model. This way-of-doing was still observed in several of the papers we have selected (studies num. 1, 2, 4, 7, 8, see 'comments').

When compared to researches published during the former decades, the studies we have selected for the nineties show a *larger variety of study*

designs: beside the case-control already mentioned, specific follow-up surveys are no more exception (studies num. 2, 3, 4 and 6) and they certainly present the advantage of recording more precise information on the proximate determinants and health indicators identified by Mosley & Chen (health behaviour, illness episodes, nutritional status, etc.). They also overcome the problem of selective omission of early deaths and allow to better understanding the process leading to ill health and later to recovering or death. Another evolution observed in recent research is a *greater diversity in the methodological/statistical treatment of the data*: median polish (study num. 1), hazards models (study num. 2), structural equations (study num. 3), and multilevel hazards model (study num. 9) are found besides the now classical logistic regressions (studies num. 4, 5, 6, 7, 8).

Although Mosley and Chen's framework is frequently and Caldwell's theory systematically referenced in the papers we have selected, *'theory' per se is only seldom present in the researches*: it is often invoked in the interpretation or discussion of the results but not as support for the design of the survey, or of the statistical modelling process. Nevertheless some of the selected studies show interesting attempts to overcome the already discussed problems linked to the mix of several levels of observation or sequences of actions of the considered variables:

– When using *structural equations* Akin (study num. 3) *distinguishes different stages in the sequencing of effects according to Mosley & Chen's proposal*, when he first tries to estimate the effect of education on the proximate behavioural determinants of health then, at a second stage, the effect of proximate variables on diarrhoea episodes, chosen as a health outcome, and finally, gather the results into one model which allows him to describe pathways of influence of mother's education on the selected health outcome. Modelization conforms here to the theoretical framework, but the use of structural equations is at the expense of transforming the variables into either continuous or dichotomies: dichotomization may involve a loss in variability and also in statistical explanation power of the variables.
– Bicego & Boerma (study num. 5), using a *progressive introduction of groups of variables into their logistic regression models, try to follow Mosley & Chen's framework in the selection of variables and the sequencing of their equations*: equation 1 includes only maternal education, equation 2 adds an index of household economic status and the following equations include the proximate determinants (health services use, pattern of family formation and water and latrine facilities within the household) in sequence. A community-level factor is introduced through an interaction term between education and a proxy of access to health services. Although the methodology used does not adequately

capture community and household-level effects, the analysis of the change in the coefficients obtained for education when confounders and proximate determinants are progressively introduced gives interesting results.

– A *multilevel hazard model* is used in Sastry's work (study num. 9) *where the clustering effects of belonging to a specific family and, at a more aggregate level, to a specific community, on the relationship between mother's education and her children's mortality risks are adequately captured*. He unluckily does not conform to Mosley and Chen's framework when he mixes proximate determinants effects (breast-feeding) with socio-economic individual-level variables effects.

To conclude

If the evolution towards more adequate statistical models during the nineties looks promising, the lack of consensus or organised research schemes on the topic of child survival does not allow for easy building of cumulative knowledge, let generalisations about, for example, the key role education plays. Palloni (1990b, p.897) advocates the use of meta-analytic methods to « produce robust inferences by systematically processing the relations and regularities uncovered by studies with disparate designs and samples ». Meta-analytic methods have as objective the cumulation and integration of research findings across studies to establish facts. These facts may then be further organised into a coherent and useful form in order to construct theories (Hunter & Schmidt, 1990). To achieve this objective, a thorough search of all the studies dealing with a specific research topic, including unpublished material, is needed. The located studies should be made available to the meta-analyst and after a careful examination of the quality and validity of the primary researches, he has to obtain, for each of them, a minimum set of informations: sampling, measurement, analysis and the findings. This is often easier to reach in physical or medical sciences where concepts and indicators are standardised as is the format of the written presentation of their researches. A greater heterogeneity is found in the reporting of social science research and even when they are at a varying extent measurable, most social science concepts suffer from a lack of comparability from one research (or context) to another. This might even be the case for one of the key-concepts I am dealing with here: the mother's education. What is really meant by education? Are similar levels of education really comparable across countries? The infant mortality concept can even

suffer from a lack of comparability over time and across countries as was shown repeatedly for Europe (Gourbin & Masuy-Stroobant, 1995).

In recent years, the focus on education has been questioned by Caldwell himself who wrote (1992, p. 205) that research « concentrate disproportionately on the impact of parental education, perhaps because these are measures that are easily quantified and readily available in census and surveys ». The most challenging research question being then 'how' and 'why' the education-health links works. The answers to these key questions may only partly be provided by quantitative data analysis. The study and testing of the mechanisms and processes by which the relationships among variables is generated are only rarely found in quantitative demographic research. It usually rests on « hypothetical explanations » put forward and discussed to make sense of the measured effects or correlations. To observe « how people live and why they act the way they do » (Myntii, 1991, p.227) is usually achieved by means of one or more of the many techniques developed by qualitative researchers. Formerly mainly used during the exploratory and preliminary phase of a more 'serious' (quantitative) survey in order to define concepts and generate hypotheses, qualitative observation is now also used to test hypotheses. Group discussions, biographies, genealogies, open-ended interviews with key-informants, etc., are directed towards either specific groups of interest or on a subsample of a population that was previously surveyed and analysed by means of quantitative standardised methods « in order to provide 'objective' population data to frame and guide subsequent anthropological investigation » (Myntii, 1991, p.227).

Methodology mixes, combining qualitative micro-studies with larger scale quantitative approaches to clarify some critical issue characterise a series of researches aimed at testing Caldwell's hypotheses and their underlying mechanisms. Some examples are a study investigating the literacy skills retained by the mothers in adulthood, their capacity to understand health messages, the quality of mother-health personnel interactions and the health care practices of women having received formal education as a child (LeVine et al., 1994); the father's perception of and involvement in child health (Jahn & Aslam, 1995); the acquisition of specific skills and of an 'identity' associated with 'modern' behaviours through schooling and their effects on child health (Joshi, 1994), etc.

Generalisibility and representativeness of qualitative observations can in most cases only be reached by organising them in the frame of larger scale quantitative standardised observation/survey, given the huge amount of time involved in qualitative observations and their forced limitation to smaller samples. Quantitative techniques and the results they produce are frequently in need of more in depth and comprehensive (qualitative) investi-

gations to make sense of the measured relationships between variables (Silverman, 1993).

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