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Déterminants individuels et contextuels de la mortalité des enfants de moins de cinq ans en Afrique au sud du Sahara. Analyse comparative des enquêtes démographiques et de santé

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Déterminants individuels et contextuels de la mortalité des enfants de moins de cinq ans en Afrique au sud du Sahara. Analyse comparative des enquêtes démographiques et de santé

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Résumé

La santé des enfants demeure une question prioritaire en Afrique sub-saharienne. Les disparités en matière de mortalité entre pays et au sein des pays persistent et se sont fortement accrues durant la dernière décennie. En dépit de solides arguments théoriques voulant que les variables contextuelles soient des déterminants importants de la santé des enfants, ces facteurs, et particulièrement les influences du contexte local, ont été étudiées beaucoup moins souvent que les caractéristiques individuelles.

L'objectif principal de la présente thèse est d’identifier les déterminants individuels et contextuels associés à la mortalité des enfants de moins de 5 ans en Afrique sub-saharienne. L’analyse systématique est basée sur les données les plus récentes des enquêtes démographiques et de santé (DHS/EDS). Deux questions spécifiques sont examinées dans cette thèse. La première évalue la mesure dans la quelle le contexte local affecte la mortalité infanto-juvénile, net des caractéristiques individuelles. La seconde question est consacrée à l’examen de l’effet du faible poids à la naissance sur le risque de décès avant 5 ans.

Par rapport à la première question, les analyses multi-niveaux confirment pour plusieurs pays étudiés l'importance simultanée de l'environnement familial et du contexte local de résidence dans l'explication des différences de mortalité infanto-juvénile. Toutefois, par comparaison au contexte familial, l'ampleur de l'effet de l'environnement local paraît assez modeste. Il apparaît donc que le contexte familial reste un puissant déterminant de la mortalité des enfants de moins de 5 ans en Afrique sub-saharienne. Les résultats indiquent en outre que certains attributs du contexte local de résidence influencent le risque de décès des enfants avant 5 ans, au-delà des facteurs individuels dans plusieurs pays. Cette thèse confirme l'effet contextuel de l'éducation sur la mortalité des enfants. Cet effet s'ajoute, dans certains pays, à l'effet positif du niveau individuel d'éducation de la mère sur la survie de l'enfant. Les résultats montrent aussi que le degré d'homogénéité ethnique de la localité influence fortement la probabilité de mourir avant 5 ans dans certains pays. Globalement, les résultats de cette thèse suggèrent que le défi de réduire la mortalité des enfants va au-delà des stratégies visant uniquement les facteurs individuels, et nécessite une meilleure compréhension de l'influence des facteurs contextuels.

Par rapport à la deuxième question, les résultats montrent également que les facteurs individuels restent aussi très importants dans l'explication des différences de mortalité des enfants dans plusieurs pays étudiés. Nos résultats indiquent que les différences de mortalité selon le poids à la naissance sont significatives dans tous les pays inclus dans l'analyse. Les enfants nés avec un faible poids (moins de 2500 grammes) courent presque 2 à 4 fois plus

de risques de mourir au cours des cinq premières années de vie que les enfants de poids normal, même après correction pour l'hétérogénéité non observée. Ce résultat suggère qu'en plus des mesures visant à réduire la pauvreté et les inégalités de revenus, la réduction de l'incidence du faible poids à la naissance pourrait apporter une contribution majeure aux Objectifs du Millénaire pour le développement; spécialement comme une stratégie efficace pour réduire le niveau de mortalité parmi les enfants de moins de cinq ans.

Mots-clés : Faible poids à la naissance, mortalité infanto-juvénile, analyse de survie, effet individuel, effet communautaire, Afrique sub-saharienne.

Abstract

Child health remains a priority area for health policy in sub-Saharan Africa. Disparities in child mortality between and within countries have persisted and widened considerably during the last few decades. While researchers have devoted considerable attention to the impact of individual-level factors on child mortality, less is known about how community characteristics and institutions affect health outcomes for children, even though they have a prominent role in theoretical models. The aim of this thesis is to identify individual and contextual effects of child mortality by using data from the latest round of Demographic Health Surveys for all countries in sub-Saharan Africa. Two sets of questions are addressed in this research.

First, we evaluate the impact of contextual factors on the risk of dying before age 5 net of the effect of individual factors. The results indicate that some attributes of the community influence the mortality risks of children, over and above the intermediate factors included in this investigation. For instance, in half of the countries under study a 1% increase in the proportion of children fully immunized in the community is associated with a decrease of 17-79% in the odds of dying before age 5. The proportion of women in the community completing secondary school also significantly increases child survival. This effect is, in some countries, in addition to the positive individual-level effect of the child's own mother being educated. Net of individual and household characteristics, higher community-level

ethnic homogeneity is associated with decreased odds of dying before age 5 in some countries. Overall, the results of this study therefore suggest that the challenge to reduce under-five mortality goes beyond addressing individual factors, and requires a better understanding of contextual factors.

Second, the study exploits recent national survey data for nine countries in sub-Saharan Africa to investigate the association of LBW and mortality not only in infancy but also during childhood, using a standardized methodology to adjust missing birth weight data from household surveys while accounting for unobserved family-level factors (genetic or behavioral) that may modify the relationship between birth weight and under-five-years mortality. We find evidence of the impact of birth weight on the risk of dying not only in infancy but also during childhood, which remains strong and significant in all countries even after controlling for potential confounding factors. The main policy implication of our findings is that reducing the incidence of LBW may be an important prevention strategy to combating child mortality in sub-Saharan Africa countries.

Keywords: Child mortality, Low birth weight, Proportional hazard model, Frailty, individual-level effects, community-level effects, multilevel modeling, Sub-Saharan Africa

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Dédicace

À ma mère Ayaba Alice Houdécodji, qui m'a inscrit la première fois à l'école

À la mémoire de mon père Lazare Djakoun Boco

A ma chère et tendre épouse Mathilde Euphrasie Sossou

A mon fils bien-aimé Amoulélo Euphrïm David Dine

A mes frères Nicolas et Cyprien

Je dédie cette thèse marquant la fin de mes études supérieures

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Avant propos

« Partant d'un certain capital-santé à la naissance (potentiel qui peut grossièrement être évalué à l'aide d'indicateurs tels le poids de naissance, la durée de gestation et la présence ou non d'handicaps congénitaux) la capacité de l'enfant à maintenir ou restaurer, s'il a lieu, ce capital, va dépendre de toute une série de facteurs sur lesquels il n'a, en tant que nouveau-né, guère de moyens d'actions propres. Ce sont ce que les démographes, mais aussi les épidémiologistes, appellent les déterminants de la santé ou de la mortalité, périnatale, infantile ou même juvénile » (Masuy-Stroobant 2002a :129).

Chapitre 1 : Introduction générale

1.1 Problématique

La santé des enfants demeure une question prioritaire en Afrique sub-saharienne (Kinney et al. 2010; Lawn 2010) et reste au cœur de plusieurs concertations internationales et gouvernementales (Marmot et al. 2008; Shiffman 2010). La mortalité élevée est toujours considérée comme *un frein sérieux* aux changements de comportements reproductifs et au recul de la fécondité (LeGrand et al. 2003; Montgomery 2000; Singh et al. 2009; Tabutin & Schoumaker 2004). Les disparités en matière de mortalité à l'intérieur des pays et entre pays persistent et se sont fortement accrues durant la dernière décennie (Ahmad et al. 2000; Pison 2010; Rajaratnam et al. 2010; Tabutin & Schoumaker 2004).

La réduction de ces disparités est devenue un objectif majeur des politiques de santé publique dans tous les pays, comme faisant partie des objectifs du Millénaire pour le développement (OMD) (Lawn 2010). Afin de réaliser cet objectif (réduire de deux tiers, entre 1990 et 2015, le taux de mortalité des enfants de moins de 5 ans) (United Nations 2010), il est fondamental de comprendre les facteurs spécifiques associes à ces disparités persistantes de la mortalité des enfants en Afrique sub-saharienne. Une meilleure connaissance des déterminants constitue une base solide à l'orientation des politiques et à la formulation des stratégies d'action (Bennett & Ssengooba 2010; The Bellagio Study Group on Child Survival 2003). L'examen des questions d'inégalités face à la santé des enfants continu donc d'être un défi et un enjeu majeur, notamment pour les politiques et programmes destinés à l'amélioration du bien-être et de la survie des enfants en Afrique sub-saharienne (Fotso 2006; Kinney et al. 2009; Shiffman 2010).

Les facteurs qui affectent la survie des enfants sont à la fois multiples et complexes et relèvent de domaines variés (biologie, économie, social, culturel, environnement etc.) (Caselli et al. 2002; Cutler et al. 2006). Ils exercent leurs influences au niveau individuel, familial, communautaire et national (Masuy-Stroobant 2002a). Ces facteurs varient aussi bien dans l'espace que dans le temps (Tabutin 1999).

La présente étude est entreprise pour contribuer à une compréhension plus large des mécanismes sous-jacents aux inégalités en matière de mortalité des enfants de moins de 5 ans en Afrique sub-saharienne, en lien avec le contexte économique, social, culturel et sanitaire. L'analyse systématique est basée sur les données les plus récentes des enquêtes démographiques et de santé (DHS/EDS).

Notre recherche se focalise donc sur la mortalité infanto-juvénile. Elle est définie comme la probabilité de mourir entre le moment de la naissance et l'âge exact de 5 ans (UNICEF et al. 2007 :10). Ce dernier est largement reconnu comme l'indicateur le plus approprié de l'exposition cumulée au risque de décès durant les cinq premières années de la vie (Ahmad et al. 2000; Reidpath & Allotey 2003). En tant que mesure composite des risques sanitaires dans le jeune âge, le taux de mortalité infanto-juvénile présente un certain nombre d'avantages sur le taux de mortalité infantile (avant un an) (Ahmad et al. 2000 :75). L'intérêt pour la mortalité des enfants de moins de cinq ans se justifie également d'autant plus que, son niveau et son évolution, sont considérés, en général, comme des révélateurs très performants du niveau de développement d'un pays, de l'état de santé d'une population, et du fonctionnement du système de santé, notamment dans les pays en développement (McGuire 2006; United Nations Children's Fund 2008). On peut donc tirer des leçons qui vont au-delà du seul problème de la mortalité des jeunes enfants. Dans cette étude, il sera question de dégager les variables individuelles et contextuelles importantes dans l'explication des différences de mortalité infanto-juvénile dans les pays d'Afrique sub-saharienne et d'ouvrir des pistes pour des analyses plus approfondies.

Les études prenant en compte plusieurs pays permettraient de mieux faire ressortir la diversité des situations, de dégager les tendances réelles indépendamment des contextes locaux et nationaux, et peut-être de mieux préciser les relations entre la mortalité des enfants et ses déterminants (Gakidou et al. 2010; Kuate-Defo & Diallo 2002; Rutstein 2000).

1.2 Objectifs de recherche

Notre recherche s'inscrit dans le courant explicatif en démographie[1] qui vise à évaluer l'influence des facteurs à différents niveaux d'analyse sur le risque de décès des jeunes enfants. En dépit de leur contribution notable, les facteurs explicatifs dans les études sur les inégalités de mortalité en Afrique sub-saharienne reposent en grande partie sur les caractéristiques individuelles (enfant, mère). Dans la présente étude on ajoute simultanément des effets de contexte (au niveau de la famille et de la localité de résidence) pour améliorer le modèle classique des déterminants de la mortalité des enfants dans les pays en développement. Ainsi, on se propose d'identifier les facteurs individuels et contextuels associés au risque de décès avant cinq ans en Afrique au sud du Sahara. Plus précisément, les deux objectifs poursuivis sont :

[1] Il y a un intérêt croissant pour l'étude des influences du contexte sur les comportements démographiques depuis plus de 30 ans (Courgeau & Baccaini 1998; Entwisle 2007; Parr 1999). Depuis les années 1980, nombreuses études utilisent les modèles multi-niveaux pour scruter le rôle du contexte géographique local dans les mécanismes sous-jacents à la fécondité (Casterline 1987; Entwisle et al. 1984; Freedman 1974; Hirschman & Guest 1990; Mason et al. 1983; Schoumaker & Tabutin 1999), la migration (Bilsborrow et al. 1987; Ezra 2003) ou, ce qui nous intéresse plus particulièrement ici, la mortalité des enfants (Al-Kabir 1984; Bolstad & Manda 2001; Kuate-Defo & Diallo 2002; Manda 1998; Matteson et al. 1998; Pickett & Pearl 2001; Sastry 1996).

1. Examiner la mesure dans la quelle le risque de décès des enfants de moins de 5 ans varie entre les ménages et les communautés en Afrique sub-saharienne, et déterminer si les caractéristiques des enfants, des familles et des localités de résidence peuvent expliquer ces différences.

2. Explorer de façon explicite la relation entre le poids à la naissance et le risque de décès avant cinq ans, en contrôlant pour les principaux autres cofacteurs (socio-économiques, comportements reproductifs, recours aux soins prénatals) et pour l'hétérogénéité non observée.

Ces deux objectifs sont atteints en utilisant une approche par articles distincts. Néanmoins, du fait que les deux articles utilisent le même cadre conceptuel et sources des données, ces derniers sont présentés de façon préliminaire dans les chapitres 2 et 3, respectivement.

Ensuite, le chapitre 4 porte sur l'analyse des effets individuels et des effets contextuels, ainsi que de leur importance relative sur la mortalité des enfants de moins de cinq dans 28 pays d'Afrique sub-saharienne. Ce chapitre vise à répondre spécifiquement pour chaque pays inclus dans cette recherche aux trois questions suivantes. Dans quelle mesure le risque de décès des enfants de moins de cinq ans varie entre contexte local et environnement familial? Quelle est la contribution de l'environnement familial et du contexte local de résidence aux différentielles de mortalité des enfants, après contrôle pour les caractéristiques individuelles, familiales et communautaires? Quelles sont les caractéristiques communautaires associées au risque de décès avant cinq ans, net des facteurs individuels?

Le chapitre 5 est consacré à l'examen de l'effet du faible poids à la naissance sur le risque de décès dans les cinq premières années de vie dans une dizaine de pays d'Afrique sub-saharienne. Dans ce chapitre l'accent est particulièrement mis sur l'effet de l'interaction entre la durée d'exposition et le faible poids à la naissance sur le risque de décès. On tente de répondre aux deux questions suivantes. Dans quelle mesure le poids à la naissance affecte le risque de décès avant 5 ans. Y a t-il une différentielle dans l'effet du poids à la naissance sur le risque de décès avant cinq ans selon l'âge de l'enfant?

Enfin, le chapitre 6 présente la conclusion, laquelle fournit une présentation suivie de discussion des principaux résultats, et de leurs implications. On y indique également quelques pistes pour les recherches futures.

Chapitre 2 : Cadre conceptuel général

2.1 Schémas et facteurs explicatifs de la mortalité des enfants dans les pays en développement

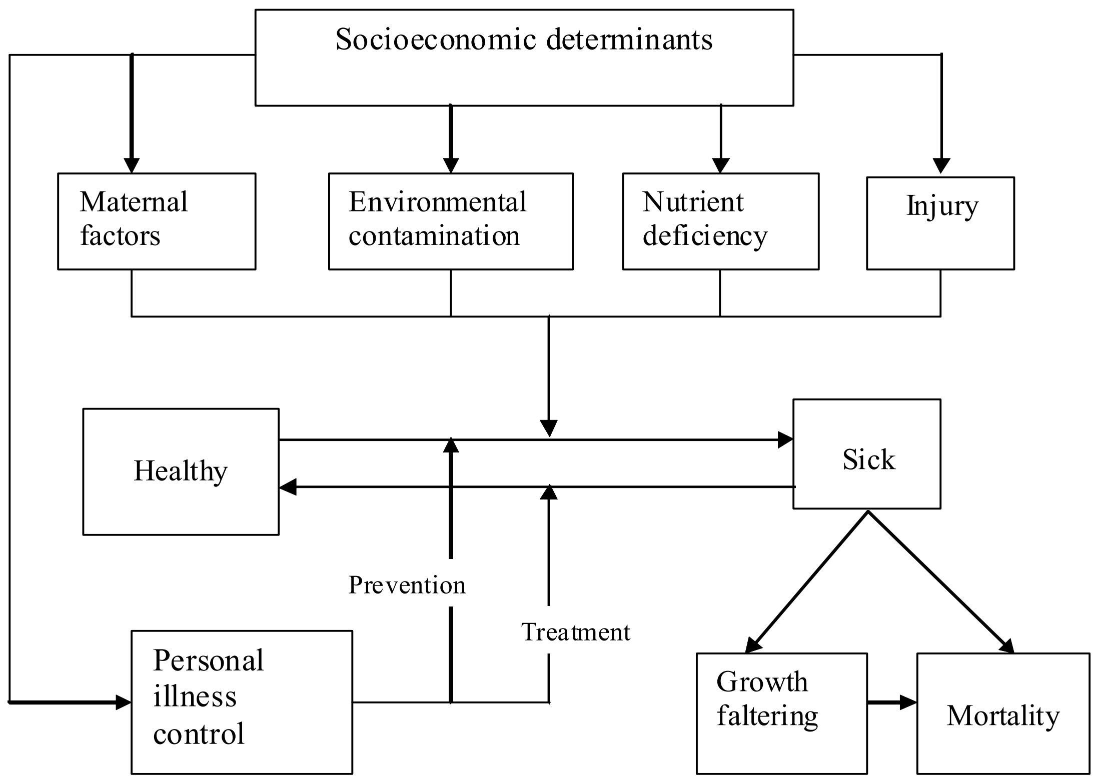
Des recherches antérieures –fondées sur différents paradigmes –suggèrent que le risque de décès d'un enfant dépend d'un ensemble de facteurs très complexes, de nature biologique, économique, politique, sociale, culturelle, écologique, psychologique, souvent interactifs, et exercent leurs influences au niveau individuel, familial, communautaire et national (Caselli et al. 2002; Cutler et al. 2006; Tabutin 1999).

Plusieurs schémas explicatifs ont été développés dans la littérature démographique pour définir et articuler les liens directs et indirects entre les facteurs potentiels pouvant affecter la santé et la mortalité des enfants (Masuy-Stroobant 2002b; Millard 1994; Mosley & Chen 1984; Tabutin 1995; Vallin 1989). Mais leur mécanisme de construction ne varie pas énormément d'un auteur à un autre; chacune de ces approches théoriques se distingue essentiellement des autres par le poids relatif qu'elle accorde à chaque facteur explicatif de la mortalité (Tabutin 1995).

Le cadre conceptuel de Mosley & Chen (1984) a été d'un grand apport dans l'identification des variables explicatives pour l'étude de la mortalité des enfants dans les pays en développement. Depuis sa publication en 1984, ce cadre a servi de base à la formulation de questionnaires pour la collecte des données pertinentes en matière de santé dans de nombreuses grandes enquêtes démographiques, notamment les EDS (Boerma 1996; Hill 2003). Le schéma explicatif de Mosley & Chen reste à ce jour le cadre conceptuel le plus complet et le plus utilisé dans les recherches sur les déterminants de la morbidité et de la mortalité des enfants dans les pays en développement (Hill 2003). Ce schéma représentera donc l'ossature principale du cadre conceptuel de la présente étude.

Mosley et Chen (1984) ont développé un cadre d'analyse de la mortalité des enfants dans les pays en développement qui clarifie l'influence des déterminants socio-économiques et culturels et ceux du système de santé. L'idée centrale de ces auteurs était que les variables socio-économiques et culturelles influencent indirectement les chances de survie, leurs effets opèrent à travers les variables intermédiaires ou déterminants proches qui influencent directement, les risques de morbidité et de mortalité (figure 1).

Figure 1: Schéma explicatif de Mosley & Chen pour l'analyse des déterminants de la mortalité des enfants dans les pays en développement



Source: Mosley & Chen (1984:29). An Analytical Framework for Study of Child Survival in Developing Country.

Mosley et Chen (1984 :3) situent les déterminants socio-économiques à trois niveaux d'observation: individuel, ménage et communautaire. Au niveau individuel, on retient entre autres, le niveau d'instruction des parents, la valeur de l'enfant, les croyances au sujet des maladies, et les normes et attitudes. Quant au niveau du ménage, on a le revenu, la disponibilité de la nourriture, la qualité de l'eau, les vêtements et la propreté, l'état du logement, la disponibilité en source d'énergie, les modalités du transport, la pratique quotidienne d'hygiène préventive et l'accès à l'information. Enfin au niveau communautaire les auteurs distinguent comme variables, les caractéristiques géo-physiques, les structures politiques et économiques, et les caractéristiques du système des soins de santé.

Quant aux variables intermédiaires, les auteurs ont identifié 14 déterminants proches regroupés en 5 catégories. Il s'agit de : (i) facteurs liés à la fécondité de la mère (âge, parité, intervalle entre naissances); (ii) contaminations de l'environnement (l'air, nourriture/l'eau/mains, peau/sol/objets inanimés, piqûres d'insectes); (iii) déficiences nutritionnelles (calories, protéines, micronutriments/vitamines/minéraux); (iv) blessures (accidentelles ou fortuites, volontaires ou intentionnelles); (v) facteurs de contrôle sur les maladies personnelles (mesures préventives personnelles, traitements curatifs) (Mosley & Chen 1984 : 32-33).

En résumé, Mosley et Chen (1984) présentent les déterminants socio-économiques comme des variables qui opèrent nécessairement à travers une série de variables comportementales, ou déterminants proches, pour influencer les chances de survie de l'enfant. Ces déterminants proches tels que la nutrition et l'utilisation des services de santé ont un impact biologique sur la santé (Mosley & Chen 1984 : 27).

Par ailleurs, Venkatacharya & Teklu soulignent à propos de l'opérationnalisation des schémas explicatifs que « l'une des questions pertinentes liées a la mise au point d'un cadre efficace pour l'étude de la mortalité et de la santé des enfants est l'écart qui existe entre la connaissance désirée et notre capacité à en faire un usage approprié » (Venkatacharya & Teklu 1988 :13). Le sentiment d'échec de certaines stratégies ou interventions montre que les chaînes causales de la surmortalité des enfants en Afrique sub-saharienne demeurent quelque peu mal comprises. En dépit de sa relative complétude et sa clarté conceptuelle, le schéma explicatif de Mosley et Chen présente un certain nombre de limites que plusieurs auteurs ont soulignées (Barbieri 1991; Hill 2003; Macassa et al. 2011).

Une première limite concerne sa mise en œuvre opérationnelle. L'application de ce modèle pose des difficultés pratiques avec les données standards provenant par exemple des EDS. Il est vraisemblable que la modélisation des facteurs intermédiaires fournit une indication des mécanismes à travers lesquels les déterminants socio-économiques agissent. Toutefois, en absence de certaines variables (omises ou non mesurées), les estimations statistiques peuvent produire des paramètres biaisés (Hill 2003). On note que certaines variables intermédiaires présentées dans le modèle de Mosley & Chen sont difficiles à mesurer ou ne sont pas collectées lors de la plupart des enquêtes démographiques et de santé.

Par exemple, les carences nutritionnelles (teneur des aliments en minéraux et vitamines) ne sont pas facilement mesurables. Ces mesures requièrent le plus souvent des analyses biochimiques des aliments disponibles ou, lors des enquêtes, la cueillette des données suffisamment détaillées sur les fréquences et la composition des aliments consommés par les enfants (Brown 1984; Wander et al. 2009).

De même, la mesure de la *valeur de l'enfant* est complexe (Friedman et al. 1994). La valeur de l'enfant est un concept multidimensionnel qui varie selon le contexte socio-culturel et économique (van de Kaa 1996 :418). S'il est possible de mesurer la qualité de l'enfant à travers son capital humain potentiel (instruction, expérience professionnelle, salaire), la valeur de l'enfant quant à elle dépend de plusieurs éléments *subjectifs* comme le bonheur, l'affection, la sécurité, la satisfaction, le statut social, etc. que procure l'enfant à ses parents (Hoffman 1975 :431).

Une deuxième limite de l'application du schéma de Mosley et Chen est l'existence d'un risque potentiel d'endogénéité d'inclure dans les modèles statistiques certaines variables intermédiaires sans précaution (Guilkey & Riphahn 1998; Schultz 1984). Les biais d'endogénéité sont des problèmes fréquemment rencontrés avec des variables dont le résultat est motivé par une décision ou un choix personnel (exemples : recours aux soins prénatals, connaissance ou choix des méthodes de planification familiale) (Briscoe et al. 1990). Une fréquence élevée des visites prénatales par exemple peut être le résultat d'une grossesse perçue comme difficile (sur la base de l'état de santé antérieur); laquelle peut donner lieu à un accouchement à haut risque pour l'enfant. Les mères qui expérimentent de hauts risques de complications pendant la grossesse sont susceptibles d'effectuer plus de visites prénatales que les autres (Schultz 1984). Si on ne tient pas compte de la perception des femmes sur leur état de santé dans ce cas précis, l'effet estimé de la fréquence des visites prénatales sur la survie des enfants peut s'avérer erroné (Briscoe et al. 1990). Plusieurs options ou approches statistiques sont proposées dans la littérature pour contrôler les problèmes d'endogénéité (nous y reviendrons dans les sections suivantes sur l'option méthodologique adoptée pour tenir compte des problèmes endogénéité potentiels dans notre étude).

Enfin, une dernière limite importante du schéma de Mosley & Chen concerne l'ambigüité dans la spécification des niveaux auxquels les facteurs socio-économiques agissent sur la mortalité des enfants. Les différents mécanismes ne semblent pas clairement identifiés sur le schéma proposé par les auteurs. Tels que présentés dans le modèle, les facteurs socio-économiques au niveau communautaire exercent un effet indépendant sur les déterminants proches, lesquels à leur tour affectent la survie des enfants. Toutefois, les caractéristiques du contexte local de résidence peuvent affecter la santé et la survie des enfants indépendamment des caractéristiques individuelles ou en modifiant le statut socio-économiques du ménage, aussi bien les comportements de la mère qui sont susceptibles d'exposer directement l'enfant au risque de contracter une maladie ou le conduire à la mort (Fotso & Kuate-Defo 2005a; Huie 2001; Robert 1999). Robert montre que les caractéristiques socio-économiques du lieu de résidence influencent directement l'état de santé des individus sans modifier l'effet des caractéristiques socio-économique du ménage (Robert 1999). Le fait pour un enfant de résider dans une région ou un milieu écologique déterminé expose celui-ci à un ensemble de facteurs externes favorables ou défavorables à son état de santé et par conséquent détermine son risque de décéder avant l'âge de 1 an ou de 5 ans (Balk et al. 2004). En d'autres termes, les ressources collectives définissent le plus souvent le contexte dans lequel les individus vivent et influencent l'exposition aux facteurs de risque (Frenk et al. 1994). Les caractéristiques physiques de l'environnement telles que la qualité de l'eau, du sol ou de l'air, la latitude, le climat ou le bruit sont reconnues comme étant directement responsables de plusieurs maladies dans la population (Sartor 2002). De même, les infrastructures en eau potable et assainissement diminuent les risques de contamination et d'épidémie de certaines maladies infectieuses (Esrey 1996). Globalement, les ressources collectives, associées au niveau de développement social et économique d'une communauté influencent directement les états de santé des individus en créant un environnement *promoteur de santé* ou à l'inverse favorise l'exposition au risque (Martin 2006 :54). Une localité équipée des infrastructures communautaires adéquates offre vraisemblablement un environnement promoteur de santé (Martin 2006 :57). Par exemple, la présence d'un centre de santé favorise la prévention à travers les activités de vaccination systématique.

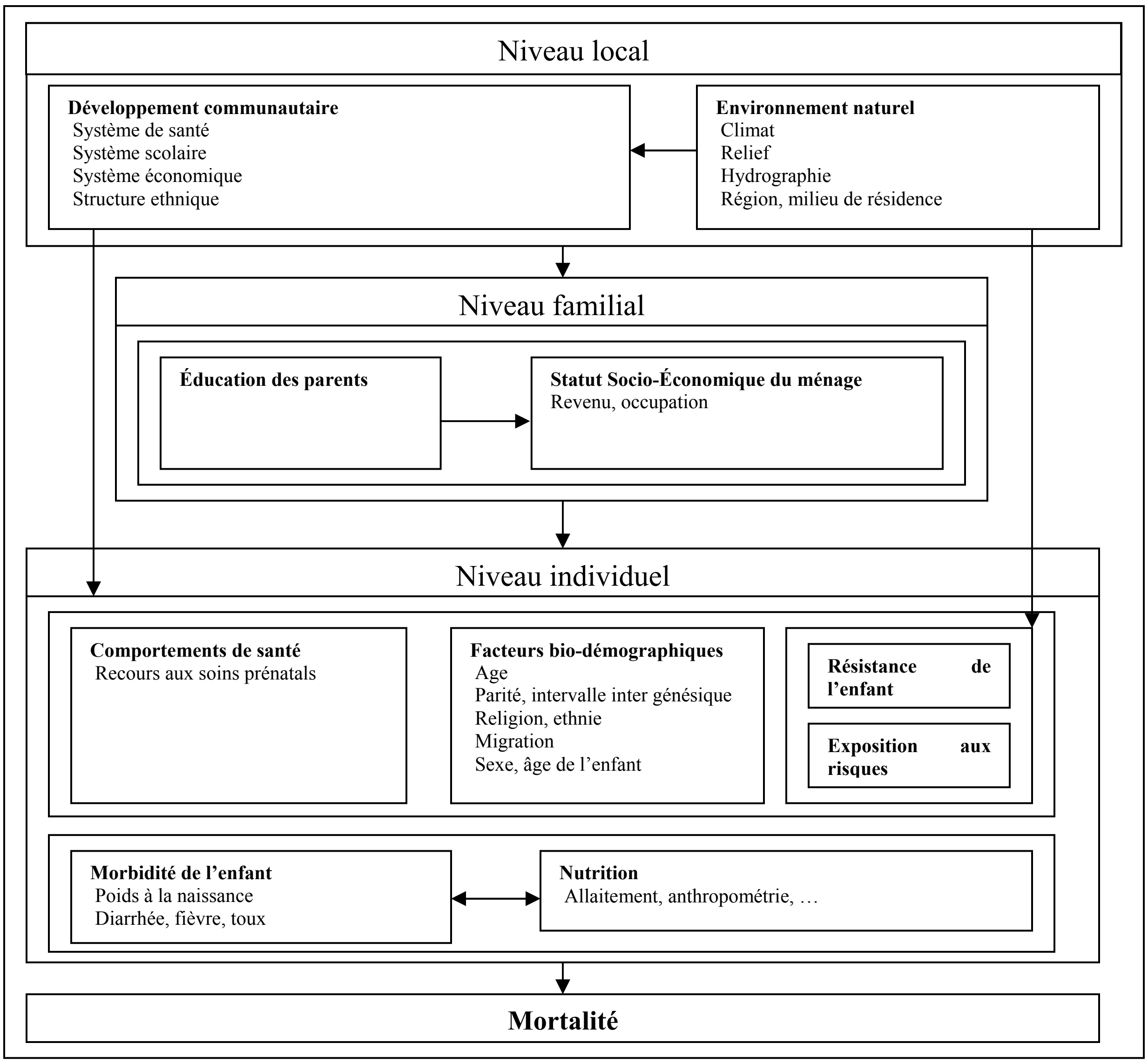
Prenant en compte l'ensemble des mécanismes possibles de l'effet du contexte local sur la survie des enfants, nous faisons une extension au schéma explicatif de Mosley & Chen (1984). Notre modèle théorique d'analyse (voir figure 2) est donc inspiré du cadre conceptuel des déterminants de la mortalité des enfants dans les pays en développement de Mosley & Chen (1984:29) présenté précédemment (voir figure 1), et tient compte de nos objectifs de recherche et les hypothèses que nous nous proposons de vérifier.

2.2 Cadre conceptuel de l'étude

Le modèle proposé pour l'étude des déterminants individuels et contextuels de la mortalité des enfants en Afrique sub-saharienne se fonde sur les connaissances actuelles relatives aux déterminants de la mortalité des enfants et reprend le squelette du schéma explicatif de Mosley & Chen (1984 :29). En adoptant une démarche multi-niveau (sous l'hypothèse que l'environnement et l'individu interviennent de façon synergique dans l'occurrence des problèmes de santé ou conduit au décès) (Huie 2001), nous avons développé un cadre logique hiérarchique des déterminants de la mortalité des enfants. Nous avons spécifié et distingué clairement sur notre schéma les niveaux d'observation des variables. Notre cadre intègre à la fois les facteurs bio-démographiques, sanitaires, socio-économiques, et communautaires du risque de décès de l'enfant. En particulier, le cadre montre aussi bien les facteurs observables empiriquement ou observés (dont l'impact sur la mortalité des enfants est robuste au regard de la littérature) que les facteurs dont le rôle est connu, mais dont on ne saurait évaluer l'impact par insuffisance ou absence de données.

La figure 2 présente le cadre théorique de la présente recherche. Il distingue trois (3) niveaux d'analyse. Hiérarchiquement, du haut vers bas, on retrouve le niveau du contexte local, le niveau familial, et enfin le niveau individuel où les caractéristiques de la mère et de l'enfant sont observées. À l'intérieur de chaque bloc de variables et entre bloc, on trouve des relations de causalité (flèches à sens unique) et des relations corrélationnelles (indiquées par les flèches à double sens).

Figure 2 : Cadre conceptuel pour l'analyse des déterminants de la mortalité infanto-juvénile et principaux liens entre les groupes de variables utilisées dans cette recherche



2.2.1 Le niveau local

En amont de la figure 2, on trouve les variables discriminantes de la mortalité des enfants. Elles sont regroupées en deux principaux groupes de facteurs : les facteurs naturels et les facteurs structurels. Ces variables n'ont pas de raison d'avoir un effet direct sur la mortalité, mais à partir de celle-ci il est classique d'étudier la mortalité différentielle (Garenne & Vimard 1984 :308). Les facteurs naturels tels l'aridité, la climatologie locale (précipitation, température) et le relief sont difficilement contrôlables et influencent plus ou moins fortement les facteurs structurels. Les facteurs structurels indiquent le niveau de développement communautaire. Il s'agit du système de santé, du système scolaire, de l'organisation économique et des structures sociales et culturelles. Tous ces facteurs lointains, mesurés au niveau local, en interaction ou individuellement, vont moduler les conditions socio-économiques des communautés.

Le **système de santé** se réfère à la disponibilité et à l'accessibilité (y compris la qualité) de l'offre des soins de santé. Il regroupe plus particulièrement les infrastructures sanitaires et la technologie médicale, les mesures préventives et la réactivité, la subvention des prix des biens et services, la promotion des services de santé et des pratiques bénéfiques à la santé des enfants. De nombreuses études montrent que les différences de mortalité constatées entre le milieu urbain et le milieu rural s'expliquent en partie par la concentration des ressources sanitaires et médicales dans la zone urbaine (Gakidou & King 2002; Lalou & LeGrand 1997; Sastry 1997c; Van de Poel et al. 2009). Des études ont également montré que le système de santé a un impact direct sur la capacité des enfants à résister aux infections et sur le comportement des parents en matière de santé (Fournier et al. 2009; Gage 2007; Lavy et al. 1996; Magnani et al. 1996; Moisi et al. 2010; Rutherford et al. 2010). Dans la présente recherche, on s'attend à ce que le risque de décès soit relativement faible dans les localités où l'offre de santé est adéquate, suffisante et accessible (les niveaux d'utilisation des services de santé infantiles sont relativement plus élevés).

Au niveau du **système de l'éducation**, on trouve les infrastructures scolaires et la qualité de l'éducation offerte à la population. Ces éléments déterminent le niveau d'éducation moyen de la population. Les mécanismes d'influence de l'éducation contextuelle sur la santé des enfants sont nombreux. L'éducation contextuelle peut affecter la santé et la survie des enfants à travers les modèles de diffusion, fondés entre autres sur l'observation et l'imitation (Desai & Alva 1998; Lindenbaum 1990; Montgomery 2000). Il apparaît que si une personne non instruite reste en contact avec d'autres personnes instruites dans une communauté, il en résulte un partage d'informations sur les comportements favorables, notamment les mesures d'hygiène, les risques de morbidité et l'utilisation des services de santé (Andrzejewski et al. 2008; Montgomery 2000). La mise en évidence de l'effet contextuel de l'éducation sur la survie de l'enfant conduit à évaluer l'existence ou non d'un effet additionnel du niveau d'éducation communautaire, en plus de l'effet de l'éducation de la mère (Kravdal 2004). Suivant Kravdal (2004), on s'attend à ce que les enfants des localités dont le niveau moyen d'éducation est relativement élevé présentent un faible risque de mortalité par rapport aux autres enfants, indépendamment du niveau d'éducation individuel de la mère.

L'organisation économique de la communauté se réfère à la quantité et à la qualité des infrastructures de production des biens et services pour le bien-être de la population (Barbieri 1991; Ciccone & Hall 1996). Les variables économiques agissent indirectement sur la survie des enfants en créant un environnement qui favorise des situations à risque et qui ne permet pas toujours de faire profiter aux enfants des soins adéquats. Le développement économique et social d'une communauté est souvent déterminé par la qualité de son réseau routier et de communication, la présence des marchés, des banques, la proportion des commerçants, le taux d'urbanisation, la proportion des agriculteurs, la disponibilité des terres, la modernisation de l'agriculture et l'importance des cultures de rentes, etc. (Barbieri 1991 :28-29).

Dans plusieurs pays l'organisation économique dans une localité est tributaire du contexte économique national. Particulièrement, la production à l'*échelle de la communauté locale* est influencée par la politique du gouvernement en matière de prix des produits alimentaires et subvention et taxation dans le secteur agricole (Barbieri 1991 : 29). Le mécanisme de l'effet de l'instabilité macroéconomique sur la survie des enfants est relativement documenté (Barbiéri 1996; Ensor et al. 2010; Falagas et al. 2009; Guillaumont et al. 2009; Waltisperger & Meslé 2005). Les crises économiques peuvent provoquer des hausses de la mortalité par manque de nourriture consécutive à la hausse des prix des denrées alimentaires ou la réduction des programmes spéciaux en vers les cibles vulnérables.

L'organisation économique et sociale détermine aussi en partie la densité de la population, laquelle peut avoir des conséquences sur la prévalence des maladies infectieuses à travers divers mécanismes, notamment la promiscuité et l'hygiène publique (Esrey 1996; Root 1997).

La structure politique est un élément fondamental dans l'organisation économique et peut affecter la survie des enfants. Navia et Zweifel (2003) ont comparé les niveaux de mortalité infantile selon le régime politique des États en utilisant les données de 138 pays sur la période de 1950 à 1990. Le résultat montre que le risque de décès avant un an est significativement faible dans les pays qui expérimentent la démocratie comparé aux pays où la dictature est en vigueur (Navia & Zweifel 2003).

De même, l'instabilité politique suivie d'un conflit interethnique peut affecter l'efficacité économique, et par ricochet déterminer le niveau de mortalité des enfants dans un contexte donné (Garenne 1997). La destruction des infrastructures d'un pays (y compris les centres de santé) en situation de conflit armé représente un obstacle à l'accès aux soins de santé et ceci peut largement contribuer à un surcroît de mortalité dans la période pendante (Garenne & Gakusi 2006; WHO 2005), comme c'est le cas en Angola (Agadjanian & Prata 2003), au Rwanda (Garenne & Gakusi 2006), en Éthiopie (Kiros & Hogan 2001), en Guinée-Bisao (Sodemann et al. 2004), au Mozambique (Cutts et al. 1996) et très récemment au Kenya (Kithakye et al. 2010).

La composition ethnique de la population peut également influencer la survie des enfants (Weeks et al. 2006). Les mécanismes d'action de la structure ethnique locale sur le comportement individuel en matière de santé sont multiples. Le degré de fragmentation ethnique est une variable typique de contexte local (Fearon 2003). Il est reconnu que la fragmentation ou une forte diversité ethnique représente une source potentielle d'instabilité politique et de conflits (Posner 2004). Easterly & Levine (1997) ont rapporté que la fragmentation ethnique est un frein à la croissance des économies en Afrique, et par conséquent affecterait considérablement la survie des enfants (Collier 1998).

Par ailleurs, la structure ethnique peut agir sur la santé des individus via le processus de diffusion des normes et croyances sur l'origine des maladies et les thérapies appropriées (Adams et al. 2002; LeClere et al. 1997; Retherford & Palmore 1983). Il y a aussi le principe de solidarité au sein du groupe ethnique (Huie et al. 2002; Wu et al. 2003). Finalement, l'influence de la structure ethnique locale sur la santé des résidents peut se faire à travers un effet d'imitation, de renforcement ou du « *groupe de référence* », au sens où la propension à adopter un comportement varierait en fonction de la prévalence du même comportement dans la localité (Manski 1995 :1). Le principe est basé sur une approche purement économique de l'interaction sociale selon laquelle le comportement individuel dépend du comportement moyen dans le groupe, des attributs exogènes des membres du groupe et d'autres caractéristiques (Manski 1993; Manski 2000).

En résumé, le rythme de propagation des croyances et des pratiques en matière de santé dépend du degré d'homogénéité culturelle. Plus ce dernier est élevé, plus la diffusion est rapide (Retherford & Palmore 1983). Il est alors possible que dans une localité, les normes et les comportements de santé de l'ethnie majoritaire deviennent des références auxquelles adhèrent les populations appartenant aux minorités ethniques (Soura 2009 :42). L'Afrique est caractérisée par une mosaïque d'ethnies avec une diversité remarquable dans les pratiques en matière de soins aux enfants (Fearon 2003; Obono 2003). Compte tenu de la diversité des contextes locaux et régionaux en terme de composition ethnique dans plusieurs pays inclus dans cette étude, nous nous attendons à ce que le degré d'homogénéité ethnique des localités de résidence soit associé au risque infanto-juvénile de mortalité.

Les **organisations sociales** y compris les associations populaires (syndicats, coopératives, partis politiques) jouent également un rôle important sur la santé des enfants. La responsabilité des autorités locales, l'obstruction dont ont fait preuve les élites traditionnelles menacées, l'inertie des administrations impliquées, le manque de volonté politique ainsi que la répartition des ressources budgétaires et le degré de priorité accordé à la santé expliquent en partie le succès ou l'échec de tel ou tel programme de santé mis en œuvre au niveau national ou à l'échelle communautaire (Barbieri 1991; Mosley & Chen 1984). En particulier, les groupements villageois de femmes peuvent jouer un rôle de réseaux sociaux où l'information sur les bonnes pratiques sanitaires est partagée (Adams et al. 2002; Andrzejewski et al. 2008; Behrman et al. 2002; Kawachi et al. 2008; Valente et al. 1997). Quelques fois ces organisations locales représentent des relais pour de nombreux programmes mis en place au niveau national, en particulier les programmes de santé et de planification familiale (Gage 1995; Steele et al. 2001; Udvardy 1998). Des études empiriques ont montré qu'en Asie, la participation des femmes à des organisations locales (notamment celles de Microfinance et autres activités génératrices de revenus) est associée à l'état de santé et à la mortalité des enfants, notamment en Inde (Ranjit 1999), aux Philippines (Arguillas 2008), au Bangladesh (Ashton 1999), en Indonésie (Frankenberg et al. 2005) et au Vietnam (Harpham et al. 2006). En Afrique du Sud, Carter & Maluccio ont montré le rôle important du capital social, notamment des réseaux sociaux sur le statut nutritionnel des enfants (le retard de croissance) (Carter & Maluccio 2003)

Les **facteurs géo-climatiques** sont également associés à la mortalité des enfants de 0-5 ans (Balk et al. 2004; Curtis & Hossain 1998). Des études antérieures ont rapporté un différentiel de mortalité avant 5 ans selon le niveau de précipitation des régions dans plusieurs pays d'Afrique sub-saharienne (Balk et al. 2004; Dos Santos & Henry 2008; Ndiaye et al. 2001). Les conditions climatiques peuvent influencer considérablement la santé des enfants en favorisant la prolifération des agents infectieux ou de leurs vecteurs, en déterminant le type et la quantité des ressources alimentaires ou en déterminant la régulation thermique, la répartition et la mobilité de la population (Githeko et al. 2000).

En résumé, plusieurs caractéristiques physiques et socio-sanitaires de la communauté peuvent affecter la survie des jeunes enfants, indépendamment de leur attribut individuel et familial. Adoptant une *approche holistique* dans la conceptualisation du contexte local de résidence, cette recherche vérifie l'existence de l'effet de plusieurs dimensions de l'environnement communautaire en tant que déterminant potentiel de la mortalité infanto-juvénile. Nous testons l'hypothèse qu'il existe un différentiel de risque de mortalité parmi les enfants de moins de 5 ans selon le milieu de résidence (urbain/rural), le niveau de couverture vaccinale, la concentration de la pauvreté (faible niveau de vie), le niveau d'éducation moyen et le degré d'homogénéité ethnique des localités.

2.2.2 Le niveau familial

Au second niveau du schéma présenté dans la figure 2, en considérant le modèle complet du haut vers le bas, on trouve les variables relatives au statut socio-économique (SSÉ) du ménage. Elles sont considérées comme la cause des variables intermédiaires (au sens de Mosley et Chen) de la mortalité des enfants. Ce bloc comprend essentiellement le revenu du ménage et l'éducation des parents. Particulièrement importantes sont la scolarisation de la mère, la place accordée à la femme dans les communautés en question et la disponibilité des structures et infrastructures éducatives (Ghuman 2003; Ngnie-Teta 2005; Subbarao & Raney 1995). Le niveau d'éducation des parents, en général, va conditionner le type de l'emploi qu'occupe chacun et partant le revenu du ménage (Card 1999). Ceci explique la flèche à sens unique entre le SSÉ du ménage et le niveau d'éducation. De façon très directe, le SSÉ et le niveau d'éducation des parents vont déterminer leur comportement en matière santé de reproduction et les conditions de salubrité et d'hygiène dans les ménages (Mosley & Chen 1984).

Les mécanismes par lesquels l'instruction au niveau individuel affecte la santé et la survie des enfants sont nombreux et complexes (Joshi 2004). Plusieurs recherches rapportent l'existence d'une forte corrélation entre le niveau d'instruction du père et son revenu (Brockerhoff & DeRose 1994; Cochrane et al. 1982; Fotso & Kuate-Defo 2005a). L'instruction du père est donc très souvent considérée comme un indicateur du SSÉ des ménages et elle agirait à travers les déterminants proches de la santé des enfants (Fotso & Kuate-Defo 2005a :193). En Afrique sub-saharienne, très peu d'études portant sur la mortalité des enfants ont pris en compte l'éducation du père, probablement faute de données fiables (Baya 1998; Brockerhoff & DeRose 1994; Irié 2002; O'Toole & Wright 1991). En revanche, il existe une assez bonne documentation sur la mortalité différentielle parmi les enfants selon le niveau d'instruction des femmes (voir: Caldwell & Santow 1989; Cleland & van Ginneken 1988; Desai & Alva 1998; Gakidou et al. 2010; Hobcraft 1993; Preston 1989). L'instruction devrait permettre aux femmes d'avoir un emploi qualifié qui augmente leur revenu; d'améliorer leur statut social, ce qui renforce leur autonomie; d'avoir des connaissances nécessaires qui conduisent à des comportements favorables liés à des soins préventifs, la nutrition, l'hygiène, l'allaitement maternel, la parité et l'intervalle entre les naissances (Mosley & Chen 1984).

Le SSÉ conditionne également l'exposition au risque des maladies, de leur existence (prévalence, incidence) et de leur transmission (endémiques ou épidémiques) (Garenne &

Vimard 1984). L'environnement sanitaire dans le ménage est un facteur essentiel de survie des enfants, car il détermine la probabilité d'entrer en contact avec un agent pathogène dans tous les cas de transmission dite fécale-orale de maladie, au premier rang desquelles figurent les maladies gastro-intestinales (Bartram & Cairncross 2010; Gakidou et al. 2007; Mosley & Chen 1984). Toutes choses égales par ailleurs, les enfants des ménages sans assainissement adéquat (manque des moyens hygiéniques de traitement des excréments) courent un risque élevé de décès comparé aux autres enfants (Bartram & Cairncross 2010; Woldemicael 2000).

2.2.3 Le niveau individuel

En aval de la figure 2, on trouve les variables intermédiaires de la mortalité des enfants. Toute action sur la survie de l'enfant ou sur la cause de son décès se fait essentiellement à travers ce groupe de variables. Ces dernières concernent aussi bien les caractéristiques individuelles de la mère et de l'enfant. Directement influencées par le SSÉ du ménage, elles peuvent, individuellement ou en interaction, conduire à la maladie ou au décès de l'enfant. Il s'agit des variables bio-démographiques, du comportement en matière de santé et de reproduction, de l'état nutritionnel et de morbidité, de l'exposition au risque et de la résistance de l'enfant.

Les variables relatives aux **comportements des parents en matière de santé** regroupent les connaissances des méthodes thérapeutiques efficaces, le recours aux soins prénatals, les attitudes envers la santé des enfants, les pratiques des soins de santé, l'utilisation adéquate des services de soins de santé, incluant, l'ensemble des vaccinations (Ahmed & Mosley 2002; Stephenson et al. 2006). Comme l'indique la figure 2, ces comportements sont influencés par le niveau SSÉ du ménage, le niveau d'éducation des parents, mais aussi directement par le contexte local de résidence. Les femmes scolarisées vont être plus attentives à ce qu'elles mangent et à ce qu'elles offrent comme repas à leurs enfants; plus réceptives aux campagnes d'hygiène et de salubrité. Elles sont aussi plus promptes à consulter et à faire vacciner leurs enfants ainsi qu'à soigner ces derniers dans des centres appropriés. Cette prise en charge sanitaire plus significative de l'enfant par les femmes scolarisées est facilitée par le fait qu'à priori, elles ont un meilleur SSÉ que les femmes non scolarisées c'est-à-dire les moyens pour s'offrir des aliments sains et des soins de santé appropriés (Ngnie-Teta 2005 :61).

Les **caractéristiques bio-démographiques** de la mère (âge à la naissance de l'enfant, intervalle inter génésique, parité, religion, ethnie, statut migratoire, statut matrimonial) et sa survie sont aussi identifiées, dans la littérature, comme de puissants déterminants de la mortalité des enfants dans les pays en développement (Brockerhoff & Hewett 2000; Gyimah 2007; Kuate Defo & Palloni 1995; Ronsmans et al. 2010; Rutstein 2000).

Les variables comportementales déterminent l'état de morbidité et nutritionnel de l'enfant, qui en interaction, apparaissent dans la figure 2 comme le déterminant ultime ou immédiat du risque de décès des enfants de moins de 5 ans. Le décès d'enfant est souvent le résultat d'un processus complexe qui peut rarement être résumé par une cause de décès (Chevalier et al. 1996; Mosley & Chen 1984), celle qui est inscrite en principe sur le certificat de décès (Garenne & Vimard 1984 :308).

L'état nutritionnel est directement interelié à l'alimentation et à des maladies infectieuses telles que la diarrhée, les infections respiratoires aiguës, la malaria et la rougeole (Black et al. 2008). Plusieurs études ont documenté le lien entre malnutrition (insuffisance pondérale) et risque de décès des enfants (voir la recension critique de Pelletier et al. 1995). Le risque de décès augmente de manière croissante chez les enfants qui souffrent de malnutrition légère, modérée et grave (Pelletier et al. 1995). En moyenne, un enfant présentant une insuffisance pondérale grave est 8,4 fois plus susceptible de mourir des suites de maladies infectieuses qu'un enfant bien nourri (Pelletier et al. 1994 :2106S).

Le virus de l'immunodéficience humaine/syndrome d'immuno-déficience aquise (Vih/Sida) est reconnu, depuis quelques années, comme l'une des plus importantes causes infectieuses directes de décès des jeunes enfants en Afrique au sud du Sahara (Newell et al. 2004), notamment dans les pays où la prévalence est relativement élevée (> 1%) (exemples : Butswana, Zimbabwe, Malawi) (Adetunji 2000). Le principal mécanisme est lié à la transmission du Vih de la mère à l'enfant pendant la grossesse, au cours de l'accouchement ou par l'allaitement (Kuhn & Aldrovandi 2010).

Les autres déterminants immédiats sont chez l'enfant ses caractéristiques démographiques et biologiques (âge, sexe, gémellité) et son état de santé à la naissance ou « capital santé ». Ce dernier regroupe l'héritage génétique, le rang de naissance, le poids à la naissance, la durée de gestation, et la présence ou non de handicaps congénitaux (Masuy-Stroobant 2002a). Le sexe et l'âge jouent un rôle important en ce qui concerne la résistance de l'enfant et de son exposition (Waldron 1998).

Le faible poids à la naissance est un indicateur clé *du capital santé* de l'enfant (Masuy-Stroobant 2002a). La présente étude s'intéresse particulièrement à l'effet du faible poids à la naissance sur le risque de décès avant 5 ans. À la suite des études antérieures (Carlo et al. 2010; Ewbank & Gribble 1993; Kuate Defo 1997), nous nous attendons à ce que *les* *nouveau-nés de poids inférieur à la normale courent des risques plus élevés de mortalité que les autres enfants.*

Notre énumération des *variables explicatives* déjà longue *est bien loin* d'être exhaustive. Comme l'a souligné Masuy-Stroobant, « ceci reflète néanmoins l'intérêt que suscite la recherche des causes de la mort des petits enfants, mais aussi la complexité de la causalité de ce phénomène et sans doute la difficulté de son analyse, dans la mesure où les différents niveaux d'explication et d'observation sont en étroite interdépendance » (Masuy-Stroobant 2002a :136), tel que présenté dans notre cadre conceptuel à la figure 2.

Chapitre 3 : Sources des données et enjeux méthodologiques

3.1 Les Enquêtes Démographiques et de Santé

L'étude est basée sur les données les plus récentes des Enquêtes Démographiques et de Santé du programme MEASURE DHS[2]. La dernière enquête disponible est sélectionnée pour chaque pays étudié (voir tableau 1 aux chapitres 4 et 5, respectivement). Les 28 EDS utilisées ont été réalisées entre 2000 et 2009. Une description exhaustive de la méthodologie d'enquête est publiée dans les rapports pays, disponibles sur le site web dédié aux enquêtes : http://www.measuredhs.com.

En effet, la seule source qui nous permet d'examiner les différentiels sociaux et géographiques de la mortalité des enfants au sein des pays en développement dans une approche comparative est celle du Programme des Enquêtes démographiques et santé (Bicego & Ties Boerma 1993; Desai & Alva 1998; Gakidou et al. 2007; Hobcraft et al. 1984; Rutstein 2000; Sullivan et al. 1994; Timæus & Jasseh 2004; Van de Poel et al. 2007).

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[2] DHS pour Demographic and health surveys. Les EDS s'inscrivent dans un vaste programme mondial de collecte, d'analyse et de diffusion des données démographiques de qualité portant, en particulier, sur la fécondité, la planification familiale et la mortalité, et des données sur la santé de la mère et de l'enfant (Vaessen et al. 2005). Théoriquement, les EDS sont réalisées tous les cinq ans afin de permettre la comparaison au fil du temps. Le programme MEASURE DHS est actuellement exécuté par ICF Macro et financé principalement par l'Agence des États-Unis pour le développement international (USAID). Démarré depuis 1984, ce programme est le 3ième initié par l'USAID (après les World Fertility Surveys et les Contraceptive Prevalence Surveys).

Les enquêtes rétrospectives, conduites sur des échantillons représentatifs au niveau national, voire régional, fournissent les données nécessaires à l'estimation des taux de mortalité infanto-juvénile selon de nombreuses variables socio-économiques, culturelles et géographiques. De plus, les EDS sont représentatives de la population. Le nombre de ménages enquêtés par enquête se situe le plus souvent entre 5000 et 30000. Les EDS sont basées sur un sondage par grappes stratifiées à deux degrés. Elles présentent un plan de sondage comparable dans chaque pays. La grappe de sondage correspond généralement à une zone de dénombrement de recensement. Une grappe en général est composée d'un ou de quelques villages dans le milieu rural, ou un quartier dans le milieu urbain.

En particulier, les EDS fournissent des données pertinentes sur l'histoire de maternité des femmes en âge de procréer[3]. Elles recueillent aussi des données sur de nombreuses variables utiles à l'analyse de la mortalité et de ses déterminants. Les enquêtes sélectionnées ont recueilli des informations sur un certain nombre de variables socio-économiques et socioculturelles relatives à l'enfant, concernant la santé et le recours aux soins (sur les naissances des trois ou cinq dernières années avant l'enquête) et le

[3] Pour chaque femme enquêtée, on enregistre toutes les naissances vivantes, en précisant le sexe, la date de naissance (mois et année), l'état de survie, et le cas échéant l'âge au décès (au jour près, pour les décès de moins d'un mois, au mois près, pour ceux de moins de deux ans, et en années, pour les décès survenus à deux ans ou plus).

comportement reproductif des mères. Toutes ces variables sont susceptibles d'influencer le risque de mortalité infanto-juvénile (Mosley & Chen 1984).

L'utilisation de questionnaires standards, et de plan d'échantillonnage et de collecte similaires d'un pays à l'autre fait des EDS une source unique de données représentatives au plan national qui se prête aisément à la comparaison entre pays et entre périodes au sein d'un même pays, et ce pour une vaste gamme d'indicateurs de santé (Bicego & Ties Boerma 1993; Fotso & Kuate-Defo 2005b; Gage et al. 1997; Griffiths et al. 2004; Ronsmans et al. 2006; Sommerfelt & Piani 1997; Stallings 2004; Timæus & Jasseh 2004; Van de Poel et al. 2007). D'une façon générale, les données collectées par les EDS ont été jugées pertinentes et de bonne qualité pour l'étude de la mortalité des enfants et ses déterminants (Bicego & Ahmad 1996; Byass et al. 2007; Curtis 1995; Macro International 1993; Masanja et al. 2008; Pullum 2006; Pullum 2008; Rutstein 2000; Stanton et al. 2000; Timæus & Jasseh 2004; UNICEF et al. 2007).

Les EDS présentent toutefois des faiblesses pour la plupart liées à leur nature transversale. En effet, comme toute enquête se basant sur les observations rétrospectives à passage unique, les EDS sont soumises aux problèmes d'omissions d'événements ou d'imprécisions des informations collectées et des erreurs de déclaration d'âges et des dates, notamment en ce qui concerne la naissance et le décès des enfants (Boerma & Sommerfelt 1993; Manesh et al. 2008; Pullum 2008; Tabutin 2006; Timæus & Jasseh 2004). On peut aussi soupçonner un biais de sélectivité dû au fait que les EDS ne fournissent aucune information sur la survie ou le décès des enfants dont la mère était décédée au moment de l'interview (Ahmad et al. 2000). Finalement, il peut y avoir un effet de troncature lié au fait qu'on n'interroge qu'uniquement les femmes d'un certain âge (15-49 ans). Il est évident que ces limites structurelles peuvent affecter les estimations dans l'étude de la mortalité des enfants utilisant comme matériel l'histoire génésique des femmes (Johnson et al. 2005; Pullum & Sullivan 2008).

Les problèmes de qualité des données EDS varient néanmoins d'un pays à l'autre, d'une phase d'enquêtes à l'autre et bien sûr, d'un type de données à l'autre (Tabutin 2006). Sullivan et al. (1990) ont montré que les limites méthodologiques inhérentes à l'historique des naissances et les risques d'erreurs ou d'imprécisions de collecte n'induisent, en général, qu'une très faible marge d'erreur dans les mesures des événements récents. Des recherches antérieures sur l'estimation des tendances de la mortalité des enfants montrent que les risques de biais liés à la datation des événements sont négligeables notamment pour les histoires de maternité plus récentes (Johnson et al. 2005; Pullum & Sullivan 2008; Rutstein et al. 2009).

Pour limiter l'ampleur de ses biais potentiels, les données que nous utilisons sont restreintes aux naissances vivantes survenues dans les cinq dernières années précédant l'enquête. L'utilisation d'une période d'observation récente favorise aussi un meilleur lien temporel entre les données sur les caractéristiques de la mère, du ménage ainsi que de la communauté et l'exposition au risque de décéder pour les enfants (Kuate Defo 1997; Macro International 1993). De plus, au-delà de cette période, les EDS ne fournissent pas des données sur les conditions sanitaires des enfants.

Par ailleurs, la collecte de certaines données au moment de l'enquête est aussi considérée comme une limite des EDS (exemple : le statut matrimonial de la mère). Plusieurs auteurs soulignent l'importance de la temporalité dans l'analyse causale à travers le respect du *principe de la priorité temporelle de la cause sur l'effet* (Hertzman et al. 1996; Moffitt 2005). Ainsi, « le décalage dans le temps entre certains facteurs et le moment du décès de l'enfant (certains de ces facteurs n'étant pas antérieurs au décès, ni même contemporains avec le décès de l'enfant) constitue l'une des limites sérieuses à l'utilisation de ce type d'enquête [EDS] » (Noumbissi 1996 :14). Toutefois, Wunsch et al. (2010) font remarquer très récemment que la possibilité d'établir des relations de cause à effet ne dépend pas tant de l'utilisation de données longitudinales ou transversales, mais plutôt de savoir si la stratégie de modélisation est d'ordre structurel ou non. En tout état de cause, une extrême prudence sera requise dans l'interprétation des résultats de nos analyses.

3.2 Les enjeux méthodologiques

La variable d'intérêt dans notre étude est la probabilité de survivre (ou le risque pour un enfant né vivant de mourir) avant 5 ans. Plusieurs problèmes méthodologiques se posent et doivent être pris en compte lors des modélisations afin de contrôler d'éventuels biais dans les estimations statistiques (Normand 2008). En particulier, les paramètres estimés dans les modèles d'analyse sont sujets à des biais en raison de l'hétérogénéité non observée (facteurs non-observables ou non mesurés) au niveau des ménages et des communautés, l'endogénéité possible de certaines variables, et l'effet de grappe ou l'effet de "*clustering*" des observations. Ces problèmes sont classiques et pour la plupart liés à la nature des données en jeu et au processus qui conduit à l'occurrence du phénomène étudié (Angeles et al. 2005; Diez Roux 2004; Do & Finch 2008; Kuate Defo 1997; Magnani et al. 1996).

L'hétérogénéité non observée : *« l'hétérogénéité est le fait des variables mesurées et non mesurées qui diffèrent selon les individus et sont susceptibles de différer dans le temps pour le même individu »* (Kuate Defo 1997 :18). La présence de déterminants non observés comme les variations dans l'utilisation des services de santé imputables aux différences dans la dotation biologique en santé ou dans les préférences pour l'enfant sont particulièrement importantes pour la survie de l'enfant (Schultz 1984). Si aucune correction pour l'hétérogénéité n'est effectuée, cela conduit à des estimations biaisées des paramètres des modèles d'analyse multivariée (Kuate Defo 1997 :18).

L'importance des problèmes liés aux déterminants non observés a mené de nombreuses études à introduire de manière explicite les facteurs non observables dans les analyses, pour lesquels on spécifie une distribution particulière ne dépendant pas des paramètres du modèle (Box-Steffensmeier & Bradford 2004 :Chapter 9; Guo & Rodriguez 1992; Sastry 1997b). En particulier, l'hétérogénéité non mesurée peut être prise en compte en modifiant la fonction de risque par un facteur de proportionnalité (fragilité), spécifique à chaque enfant (fragilité individuelle) ou à la famille (fragilité partagée) (Gutierrez 2002). L'approche paramétrique adoptée dans de nombreuses études suppose de définir à priori une forme fonctionnelle[4] de la distribution de l'hétérogénéité non observée (Box-Steffensmeier & Bradford 2004 : Chapter 9; Rodríguez 1994; Vaupel et al. 1979). Pour faire face aux problèmes engendrés par ces facteurs non mesurés dans notre étude, et suivant la démarche adoptée dans de nombreuses études antérieures (voir: Guo & Rodriguez 1992; Gyimah 2007; Omariba et al. 2007; Sastry 1997b), nous avons évalué *la*

[4] On peut également utiliser une estimation alternative par l'approche non-paramétrique qui ne nécessite aucune hypothèse sur la forme des intensités de transition(pour un complément de détails techniques, voir Aassve 2003; Heckman & Singer 1984; Kiefer 1988). En dépit de cet avantage, l'approche exige de disposer d'un nombre important d'observations. En raison de cette difficulté pour certains pays nous avons préféré l'approche paramétrique pour sa flexibilité.

sensibilité de nos estimations à une possible hétérogénéité non mesurée en utilisant des modèles de risques à fragilité (simple et partagée), contrôlant pour l'hétérogénéité non observée spécifique à chaque enfant et à chaque famille (voir chapitre 5 de notre étude). Ici, l’hétérogénéité non observée (ou omise) est prise en compte sous la forme d’une composante aléatoire, indépendante des covariables (ou hétérogénéité observée).

Les problèmes d’endogénéité : Deux éléments sont à l'origine de plusieurs de ces problèmes : *(i) le fait que des variables qui influencent la survie des enfants ne soient pas observées, et (ii) le fait que certaines d'entre elles soient corrélées aux variables explicatives observées* (Do & Finch 2008; Duncan & Magnuson 2004; Schoumaker 2001). Le *défaut* de mesurer directement une quelconque caractéristique de l’environnement familial introduira un biais dans l’estimation des effets des contextes de la famille ou de la localité de résidence dans la mesure où : (i) la caractéristique de la famille omise est un déterminant important de la survie de l’enfant, et (ii) *ce facteur est en corrélation avec les éléments de la famille ou de la localité que l’on tente d’évaluer* (Duncan & Magnuson 2003 :246).

Les sources d'endogeneité sont multiples et prennent plusieurs formes selon qu'elles concernent le contexte familial[5] ou la localité de résidence[6]. Par exemple, il est reconnu que pour de nombreuses raisons le choix de localisation des individus n'est pas aléatoire (Duncan & Magnuson 2003). Le fait que les familles aient *une latitude de choix* quant à la localité dans laquelle elles vivent peut induire un biais d'endogénéité. En effet, si des caractéristiques non mesurées des familles les conduisent *à la fois* à sélectionner certains types de localité et à avoir des enfants qui connaissent tel ou tel problème de santé (ou décèdent), alors l'effet apparent de la localité de résidence sur celui-ci, tel qu'il est appréhendé dans les modèles classiques, est susceptible de surévaluer ou de sous-évaluer l'effet « vrai » et il est impossible de prédire *a priori* la direction de ce biais (Duncan et al. 1997; Vallet 2005). Autrement dit, l'orientation du biais dans les modèles qui omettent d'importantes caractéristiques du contexte de la famille ou des enfants peut être négative ou positive (Do & Finch 2008 :611; Duncan & Magnuson 2003 :246). Les résultats seront surestimés par exemple s'il existe une hétérogénéité non observée des capacités familiales ou communautaires à promouvoir la santé des enfants (compétence à apporter des soins adéquats, réactivité face aux maladies, localité salubre). De même si les parents ont des

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[5] Suivant Fotso & Kuate-Defo (2005b :206), nous utilisons dans cette thèse le terme environnement « familial » pour désigner également le « ménage ».

[6] Dans cette étude le contexte local se réfère aux unités primaires de sondage (ou grappes) dans les enquêtes sélectionnées. Les effets contextuels sont évalués à l'échelle des ces grappes. Il s'agit des communautés reconnues pertinentes pour inférer des interventions (Diez Roux 2001). Schoumaker et al. (2006 :1) résument le concept de contexte local comme étant un *espace de vie quotidienne*, c'est-à-dire l'espace dans lequel la plupart des interactions sociales ont lieu et où les effets de la disponibilité ou de l'absence de services et infrastructures sont les plus forts.

préférences distinctes dans l'arbitrage entre leur niveau de vie et la santé de leurs enfants ou s'il existe des différences non observées dans l'accès aux soins de santé.

Une autre source d'endogénéité est liée à la répartition non-aléatoire des infrastructures communautaires au sein des pays (Angeles et al. 2005; Duncan et al. 1997). L'implantation des services et infrastructures communautaires (services socio-sanitaire, routes, politiques, programmes ciblés,…) est fréquemment faite dans des zones ou la demande serait relativement forte (prévalence élevée de morbidité) (Rosenzweig & Wolpin 1986) ou relève des actions de lobbies (Burgard 2002 :777; Frankenberg 1995 :149; Sastry 1996 :213).

Le problème de l'implantation non-aléatoire des services communautaires est parfois traité comme le problème de l'hétérogénéité non observée (variables omises ou facteur non-observés) dans les modèles statistiques. Cette question est discutée dans la littérature sur l'évaluation de l'impact des programmes et est aussi considérée comme une source potentielle de biais d'estimation (Angeles et al. 1998; Pitt et al. 1999; Rosenzweig & Wolpin 1986; Strauss & Thomas 1995). Le problème résumé dans certaines études est donc le suivant : "*si les décisions d'implantation sont faites sur la base de facteurs qui ne sont pas contrôlés dans le modèle statistique, on risque d'obtenir une estimation biaisée de l'impact du programme*" (Angeles et al. 1998 :886; Bertrand et al. 1996 :56).

Le risque d'endogénéité est quasiment omniprésent dans notre étude des déterminants de la mortalité infanto-juvénile, au moins sous deux (2) formes. En premier, comme nous l'avons souligné précédemment, il est presque impossible de mesurer avec le matériel que nous utilisons (les EDS) toutes les données susceptibles d'expliquer la mortalité infanto-juvénile (phénomène complexe) (Mosley & Chen 1984). Il est possible que le risque de décès des enfants et les variables mesurées et retenues soient simultanément influencés par des caractéristiques inobservables spécifiques aux familles et communautés. Dans le cas échéant, on aboutirait alors à une relation factice entre ces variables, ne permettant pas de conclure à un éventuel lien de causalité. Deuxièmement, il existe un risque de causalité inverse entre la mortalité infanto-juvénile et certaines variables sélectionnées, tels que le nombre de consultations prénatales et le statut de vaccination. En particulier,

> « le mauvais état de santé d'un enfant ou sa fragilité peuvent inciter les parents à un usage accru des services de santé. Les effets estimés du comportement des parents sur la santé de l'enfant peuvent s'avérer erronés si l'on ignore l'effet inverse à savoir que l'état de santé précaire de l''enfant influence de son côté les motivations des parents » (Baya 1993 :69).

En résumé, le lien de *causalité* entre certaines variables et la survie de l'enfant (variable dépendante) est à double sens et de plus, chacune d'elle est déterminée par des facteurs qui sont également susceptibles d'affecter la survie de l'enfant, ce qui constitue une source de biais de simultanéité.

En raison de la présence de différentes sources potentielles d'endogénéïté, l'utilisation de méthodes astucieuses apparaît alors nécessaire afin d'estimer l'impact net des attributs contextuels de la famille et de la localité de résidence sur la survie des enfants. Nous cherchons à obtenir des estimations non biaisées des effets d'éléments importants du contexte de la famille et de la communauté sur le risque de décès avant cinq ans. Il convient de développer des méthodologies rigoureuses pour arriver à identifier empiriquement le rôle exact et les mécanismes par lesquels les conditions contextuelles de la famille et de la localité affectent la survie des enfants.

Plusieurs approches sont développées dans la littérature sur les déterminants de la santé des populations pour tenir compte des biais d'endogénéité (exemples : méthodes des variables instrumentales, modèle Biprobit, modèle de régression conditionnelle à effet fixe, méthode des groupes appariés, appariement par scores de propension, estimation par équations structurelles...) (Babalola & Kincaid 2009; Guilkey & Riphahn 1998; Kawachi & Subramanian 2007; Normand 2008; Pritchett & Summers 1996). Le choix de l'une ou l'autre de ces méthodes dépend en général de la nature des données en jeux (transversale, longitudinale, panel...), de la taille de l'échantillon, et des ressources informatiques disponibles (logiciels, programmes...) (Carle 2009). De plus, il n'est pas facile de trouver des variables instrumentales valides, particulièrement avec des données fournies par les EDS (Sastry 1996 :214; Wang 2003 :286).

Récemment plusieurs études ont montré que l'utilisation des variables instrumentales peut devenir problématique en ce sens qu'il est difficile de s'assurer d'un *bon* instrument (Bollen et al. 1995; Bound et al. 1995; Greenland 2000; Wang 2003). Le choix et la validité des instruments sont souvent discutables d'une étude à une autre (Lavy et al. 1996; Pritchett & Summers 1996; Wang 2003). En résumé, il apparaît que « *les méthodes statistiques actuelles ne règlent pas la question de l'endogénéité de façon satisfaisante* » (Kuate Defo 2005 :21).

Dans la mesure où il est difficile d'établir une supériorité de l'une ou l'autre et reconnaissant une certaine complémentarité de ces méthodes citées plus haut (une propriété manquante dans l'une est présente dans l'autre), l'une des solutions, celle que nous avons adoptée dans notre étude (voir chapitre 4), est d'estimer nos modèles de régression avec plusieurs approches : elle permet de comparer la robustesse des effets associés aux variables incluses dans nos modèles, ainsi que nos conclusions (Angeles et al. 1998; Arceneaux & Nickerson 2009; Austin et al. 2003; Kravdal 2004; Tan et al. 2007).

Le "*clustering*" des observations : le troisième problème concerne l'estimation des erreurs-types pour les paramètres de régression où les variables ont été mesurées à deux niveaux ou plus (Angeles et al. 2005; Deaton 1997; Magnani et al. 1996). Les données EDS que nous analysons présentent une structure hiérarchique, en se sens que, les enfants sont nichés chez les mères, ces dernières nichées dans les ménages et les ménages nichés dans les communautés (Verma & Le 1996). Cette nature des données introduit une possibilité de corrélation entre les observations de même niveau, ce qui viole l'hypothèse d'indépendance à la base de la plupart des modèles d'analyse à un seul niveau (Courgeau 2004; Fotso 2004).

Parce que les facteurs au niveau communautaire sont communs à tous les individus dans une communauté donnée, les observations au sein de chaque communauté ne sont pas indépendantes. Les enfants et leurs familles, vivant dans une même communauté, sont exposés à un climat, un environnement physique, des agents pathogènes et fréquentent des infrastructures identiques. Ces familles adoptent en général des comportements et pratiques similaires, hérités de leur processus de socialisation et des modèles culturels dominants en vigueur dans leur communauté (Diallo 2001 :86).

Cette corrélation lorsqu’elle n’est pas prise en compte, peut réduire l’efficacité de l’échantillon et sous-estimer les erreurs standards des coefficients. Il existe plusieurs solutions pour tenir compte des problèmes de corrélation et corriger les écarts-types des coefficients dans des modèles plus complexes (méthode de Huber-White-Sandwich, les procédures *Bootstrap, Jackknife, Generalized Estimating Equations (GEE) approach, Taylor-series linearization approach* …) (Burgard 2002; Efron 1982; Guo & Rodriguez 1992; Hanley et al. 2003; Huber 1967; Rogers 1993; Rust & Rao 1996; Schoumaker 2001; Vonesh et al. 2001). Les modèles multi-niveaux sont l'une des solutions possibles; ils offrent en outre des possibilités intéressantes permettant de *profiter de la nature multi-niveau plutôt que de la considérer comme une simple nuisance* (Angeles et al. 2005; Courgeau 2004; Goldstein & Silver 1989; Schoumaker 2001; Snijders & Bosker 1999). De façon générale, les intérêts des modèles multi-niveaux sont aussi bien substantifs que statistiques (Schoumaker & Tabutin 1999 :305).

L'apport et les enjeux de l'analyse multi-niveau dans l'explication de la survie des enfants dans les pays en développement sont bien établis (Kravdal 2004; Madise et al. 2003; Sastry 1996; Sear et al. 2002; Tuo 2002). Les analyses multi-niveaux nous conduisent incontestablement vers une appréhension plus fine de la structure hiérarchique des données contextuelles et apporte une solution à la non-indépendance des observations (Chaix & Chauvin 2002).

L'intérêt des modèles multi-niveaux dans notre étude est donc de tenir compte de cette corrélation en introduisant dans les équations de régression un ou plusieurs termes d'erreur au niveau contextuel (Raudenbush & Bryk 2002). Ainsi, l’approche multi-niveau permet non seulement de dépasser le niveau individuel, mais aussi de mesurer la part du phénomène étudié dont l’explication réside dans chacun des niveaux considérés (famille, communauté). Nous pouvons donc tester la présence d’hétérogénéité, telle la variabilité du risque de décéder avant 5 ans entre famille et communauté; ce que les modèles classiques ne peuvent réaliser. Enfin, ces méthodes ont en outre l'avantage de fournir des estimations plus valides du fait de la sous-estimation des erreurs-types par les méthodes classiques (Goldstein 2003; Longford 1993).

Chapitre 4. Article 1 – Individual and Community Level Effects on Child Mortality: An Analysis of 28 Demographic and Health Surveys in Sub-Saharan Africa

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Abstract

While researchers have devoted considerable attention to the impact of individual-level factors on child mortality, less is known about how community characteristics affect health outcomes for children, even though they have a prominent role in theoretical models. Using data from the latest round of Demographic Health Surveys (DHS) for all countries in sub-Saharan Africa, this study uses multivariate and multilevel discrete-time event history analysis to systematically examine the impact of contextual factors on the risk of dying before age five, and their relative importance in relation to individual factors. The results indicate that some attributes of the community influence the mortality risks of children, over and above the intermediate factors included in this investigation. For instance, in half of the countries under study a 1% increase in the proportion of children fully immunized in the community is associated with a decrease of 17-79% in the odds of dying before age five. The proportion of women in the community completing secondary school also significantly increases child survival. In some countries, this effect is in addition to the positive individual-level effect of the child's own mother being educated. Net of individual and household characteristics, higher community-level ethnic homogeneity is associated with decreased odds of dying before age five, in some countries. Overall, the results of this study suggest that the challenge to reduce under-five mortality goes beyond addressing individual factors, and requires a better understanding of contextual factors.

Keywords: child mortality; individual-level effects; community-level effects; multilevel modeling; sub-Saharan Africa

4.1 Introduction

Disparities in child health between and within countries have persisted and widened considerably during the last few decades (Bryce et al. 2006; Moser et al. 2005). The reduction of these disparities is a key goal of most developing countries' public health policies, as outlined in the Millennium Development Goals 2015 (Lawn et al. 2007). It is well recognized that disparities in child health outcomes may arise not only from differences in the characteristics of the families that children are born into but also from differences in the socioeconomic attributes of the communities where they live (Fotso & Kuate-Defo 2005a; Griffiths et al. 2004; Kravdal 2004; Ladusingh & Singh 2006; Montgomery & Hewett 2005; Robert 1999; Sastry 1996). Indeed, the incorporation of community-level factors in the analysis of child mortality provides an opportunity to identify the health risks associated with particular social structures and community ecologies, which is a key policy tool for the development of public health interventions (Pickett & Pearl 2001; Stephenson et al. 2006).

Nonetheless, while researchers have devoted considerable attention to the impact of individual-level factors on child mortality, less is known about how community characteristics affect health outcomes for children, even though they have a prominent role in theoretical models (most notably Mosley & Chen 1984; Schultz 1984). Existing studies generally have a limited focus (a single country) and are quite heterogeneous in the data, definitions, and methods adopted (Rajaratnama et al. 2006; Schaefer-McDaniel et al. 2010). To my knowledge, there are no recent studies that systematically examine contextual influences on child mortality cross-nationally.

The present study takes advantage of the most recent national survey data to reexamine the issue of contextual effects on childhood mortality in sub-Saharan Africa. In doing so, it contributes to the literature that explores the implications of contextual factors for child mortality by examining the effects of community context on the risk of dying before age five, net of the effect of individual factors. In many respects, the analysis updates previous work by Desai and Alva (1998), Gakidou and King (2002), and Rutstein (2000). However, it adds importantly to this stream of literature by providing consistent and comparable results from a multilevel analysis of the factors associated with child mortality in sub-Saharan Africa.

4.2 Literature Review

Despite the insights provided by the rare analyses of African data (Balk et al. 2004; Gakidou & King 2002), scientific knowledge on how community-level factors influence child survival remains fragmentary. Existing studies have been restricted to the analysis of clustering at a single level (family or community), and thus have ignored the complete hierarchical structure of the data (Gibbons & Hedeker 1997). I go beyond previous efforts in this field by developing a multilevel model to quantify the magnitude and importance of clustering mortality risks at the family and community levels. My model explicitly accounts for the unobserved heterogeneity by using—simultaneously—family and community random effects with a cross-level correlation structure (Manda 1998).

In this section, I summarize the literature that indicates how the community environment matters for the health of children. I also discuss the possibility of endogeneity bias when analyzing this relationship and provide an overview of the ways in which endogeneity has been addressed in the literature.

4.2.1 Community-Level Effects on Child Mortality

Mosley and Chen's (1984) well-known framework of the proximate causes of child mortality links outcomes to socioeconomic determinants at individual, household, and community levels. Several theoretical and practical considerations support the idea that the community where a child is born is important for the child's health and survival, particularly in Africa (Ellen et al. 2001; Entwisle et al. 2007; Huie 2001; Robert 1999).

In many areas of African countries, families cannot easily access routine health services, and health outcomes depend on community-based services and norms (WHO 2005). It follows that “place and health are intimately linked, given that goods and services, exposure to hazards, and the availability of opportunities are all spatially distributed” (Do & Finch 2008). Generally, community is considered to be spatially-referenced and bounded, and its role in determining the health of individuals who live in a community becomes evident, as most government and non-government activities are spatially organized (Arguillas 2008). Provision of health care and other public services, such as water supply, electricity, and sanitation are implemented at the level of a geographically defined community. The availability of a health infrastructure in the community has the potential to improve the survival chances of young children, because it provides more opportunities for health care and reduces the costs of obtaining health-related goods and services (The Cebu Study Team 1991). The prevailing norms and attitudes about health behaviors could also influence the health care decisions made by individuals (Rutenberg & Watkins 1997). Similarly, the quality of the physical environment in the community where children live has important consequences for their health.

Studies during the past two decades have increasingly used multilevel methods to examine the independent effect of contextual factors on child mortality, as distinct from the more widely investigated individual factors. In particular, communities’ educational and literacy levels have been found to have a strong effect on children’s health outcomes (Kravdal 2004; Parashar 2005). The level of socioeconomic development also appears to have a positive effect on child health and nutritional status (Boyle et al. 2006; Fotso & Kuate-Defo

2005a; Montgomery & Hewett 2005), as well as on access to health care and health infrastructure (Andes 1989; Macintyre et al. 2002; Matteson et al. 1998; Pickett & Pearl 2001). Finally, variation in child health outcomes can be framed by contextual issues relating to culture (Say & Raine 2007), such as ethnic composition (Weeks et al. 2006) and polygyny (Omariba & Boyle 2007).

In sum, several physical and social attributes of the community have been shown to affect the health of young children, regardless of the household context that the children are born into (Arguillas 2008). Thus, in this analysis I take a holistic approach by simultaneously examining several dimensions of the community environment that have the potential to influence the risk of a child dying before age five (Kravdal 2004; Macintyre et al. 2002; Matteson et al. 1998; Mosley & Chen 1984; Stephenson et al. 2006).

4.2.2 Methodological Issues and Endogeneity Bias

Separating the variations in health outcomes that may be due to area-level factors from those that may be due to the characteristics of individuals and families requires appropriate modeling, and poses methodological challenges (Angeles et al. 2005; Diez Roux 2004). The primary methodological challenge in estimating the causal effect of community-level characteristics on individual health status is the endogeneity of residential location for health outcomes (Do & Finch 2008). This is because community characteristics are determined by the individual characteristics of their residents (Diez Roux 2004: 1956). An additional source of endogeneity is that certain community characteristics, such as a developed infrastructure or the availability of health services, may be purposively placed in areas with particularly poor health, or where there is higher demand for services, and more influence over governmental decisions (Burgard 2002).

It is widely recognized that cross-sectional studies of community context and health are subject to upward biases due to unobserved heterogeneity, and to downward biases due to over-adjustment for potential mediators in the pathway between community context and individual health (Do & Finch 2008: 611). A number of options are available to address the biasing effect of endogeneity (Kawachi & Subramanian 2007). For instance, Pritchett and Summers have carried out extensive econometric analysis using a range of instrumental variables to identify the "pure" income effect on infant and child mortality, isolated from reverse causation or incidental association (Pritchett & Summers 1996). Other analytic methods that have been used to adjust for endogeneity bias in cross-sectional analysis include propensity score matching (Do & Finch 2008) and structural model estimation (Guilkey & Riphahn 1998).

These techniques are beyond the scope of the present analysis and the readily available software. Rather, I compare three practical approaches that researchers can choose to produce a more accurate estimate of their standard errors: clustered robust estimation, fixed-effects modeling, and multilevel modeling (Allison 2009; Rabe-Hesketh & Skrondal 2006). This is in order to overcome the bias due to unobserved heterogeneity at the household and community levels, and to take into account the hierarchical structure in the data. I advocate using these three methods together because they complement one another, and each one contributes evidence that is missing from the other two (described in detail in the next section). Comparative analysis will reveal the robustness of the results.

4.3 Data and Methods

4.3.1 Data Sources

The study uses data from all most recent Demographic and Health Surveys (DHS) available (as of July 2010) for sub-Saharan Africa: Benin (2006), Burkina Faso (2003), Cameroon (2004), Chad (2004), Congo Brazzaville (2005), Congo Democratic Republic (2007), Ethiopia (2005), Gabon (2000), Ghana (2008), Guinea (2005), Kenya (2008-2009), Lesotho (2004), Liberia (2007), Madagascar (2008-2009), Malawi (2004), Mali (2006), Mozambique (2000-2001), Namibia (2003), Niger (2006), Nigeria (2008), Rwanda (2003), Senegal (2005), Sierra Leone (2008), Swaziland (2006-2007), Tanzania (2004-2005), Uganda (2006), Zambia (2007), and Zimbabwe (2005-2006).

For all 28 countries, information on child mortality is derived from full birth histories collected from women of reproductive age. The analysis is restricted to children born in the five-year period before the survey, because of the availability of information on maternal and child health. Details regarding sample design and data collection procedures can be found in the individual country reports. The number of children included in the analysis ranges from 2,829 in Swaziland to 28,100 in Nigeria (Table 1). Table 1 also gives the average number of births per family and community, by country.

[Table 1 about here]

4.3.2 Analytical Strategy

In this study I attempt to separate individual-level and household-level factors from contextual factors associated with child survival by using multivariate and multilevel event history models to account for right-censoring in the estimation of exposure time (Allison 1982; Reardon et al. 2002; Sear et al. 2002). The outcome variable of interest is the risk of death in childhood (0-59 months), measured as the duration from birth to the age at death, or censored. Children who were still alive at the time of the interview were right censored. Since in the DHS age at death (reported in days and months) is subject to heaping at certain ages, a discrete formulation of time is preferred to a continuous one. Discrete-time hazard models require that episodes be split into periods of risk (Singer & Willett 2003). Five exposure periods are defined here: 0, 1-5, 6-11, 12-23, and 24-59 months.

The analytical strategy for the study relies on estimating three sets of models for each country (Table 2).

[Table 2 about here]

First, I estimate "naïve" logistic regression models predicting children's probability of dying by their fifth birthday, accounting for within-cluster correlation by using the Huber-White procedure (Huber 1967; Rogers 1993)[7]. The basic formulation of the standard discrete-time model is:

$$\text{Logit}[p_{ti}] = \alpha_t + \beta X_{ti}$$

where pti is the probability of having an event (i.e., death) at time t, given that the event has not occurred before t. The logit function of p_{ti} is modeled by predictors X_{ti} and corresponding coefficients β. In this step, covariates include only individual-level characteristics, as in many previous studies. This "naïve" model provides a baseline against which to compare the results of more complex models, to be estimated as indicated below.

[7] The Huber-White procedure produces results identical to those of the svylogit procedure (not shown), which is the specific Stata routine recommended to account for the DHS complex survey design.

In the second step, I estimate cluster-level fixed-effects models, which include a linear effect for unobserved community-level factors on the risk of dying before age five. The fixed-effects approach has been used to analyze the role of individual, family, and community factors in determining infant mortality in other social contexts, using DHS data (Desai & Alva 1998; Frankenberg 1995). In their study exploring the causal effect of mother's education on infant mortality, Desai and Alva (1998) used a fixed-effects logit model in order to understand the potential biases from omitted community unobservables. I follow the same approach in this step. The model is given by:

$$\text{Logit}[p_{tij}] = a_j + \alpha_{tj} + \beta X_{tij}$$

Here, j indexes clusters (i.e. the primary sampling units (PSUs)), i (i=1, 2) indexes matched children within each cluster, and a_j represents cluster effects (i.e. the effects of all unmeasured variables that are specific to each cluster but constant over time). Note that no time-invariant covariates are included in the model, as their effects are absorbed into the a_j term. An indication of the extent to which the data for the present analysis are clustered is that each family contributes more than one child to the samples. As can be seen in Table 1, in 23 of the 28 countries included in the analysis the average number of births per family is about two. Overall, the average number of births per community ranges from 7 in Ghana to 36 in Mali (Table 1).

PSUs, or clusters, are administratively-defined areas used as proxies for "neighborhoods" or "communities" (Diez Roux 2001), and are relevant when the hypothesis involves policies (Pearl et al. 2001: 1874). They are small and designed to be fairly homogenous units with respect to the population's social and demographic characteristics, economic status, and living conditions, and they are made up of one or more enumeration areas (EAs), which are the smallest geographic units for which census data are available in the country (Montgomery & Hewett 2005: 402). Generally, a rural community spans one village or settlement, whereas an urban community is a part of a city (Montgomery & Hewett 2005). As do Desai and Alva (1998: 73), I use the terms communities and clusters interchangeably.

One important question about community-level effects that motivates this paper is whether they have a significant impact on the risk of death in poorly-equipped contexts, as in sub-Saharan Africa (WHO 2005). The fixed-effects logit estimates proposed here provide information with which to answer that question, conditional on the underlying specification. The fixed-effects models clarify which community variables affect mortality, the direction of the effects, and the magnitude of the effects on relative mortality risks (Frankenberg 1995). This specification allows for the possibility that unobserved heterogeneity affects child survival (Sastry 1997b).

I estimate fixed effects logit regressions by relying on conditional logits (Allison 2009). This method is also known as the case-control technique (Chamberlain 1980), which requires that we must first pair children within clusters. Thus I randomly selected pairs of children from each cluster, consisting of one death reported during five years preceding the survey (cases) and one birth that survived during the same time period (controls). All pairs in which both children had an identical value for the dependent variable (death or alive), therefore, are excluded from the estimation of the fixed-effects logit model. Such exclusion leads to a reduction in the sample size, which can be quite substantial and may affect the precision of the estimated effects of the covariates. Here, the comparison of more than one estimation method indicates that the results are robust in spite of this issue. In addition, because of this approach, the effect of any variable that does not vary between children in the cluster (for example, urban/rural residence) cannot be estimated in this model.

By using DHS data, it is possible to construct appropriate community-level measures for selected covariates of interest, and, in some cases, the surveys even directly provide information on community-level characteristics (Van de Poel et al. 2009). On the basis of these measures (described in detail in the next section), in the final step of the analysis I apply logit discrete-time models with three-level random intercept to correctly account for the hierarchy in the DHS data, and properly assess the impact of community-level factors on child mortality net of individual-level factors. The hierarchical structure of the data presents children (level 1), as nested within mothers (level 2), who are in turn nested within communities (level 3).

The multilevel modeling strategy accommodates the hierarchical nature of the data and corrects the estimated standard errors to allow for clustering of observations within units (Goldstein 2003). A significant random effect may represent factors influencing the outcome variable that cannot be quantified in a large-scale social survey. A random effects model thus provides a mechanism for estimating the degree of correlation in the outcome that exists at the family level and community level, while also controlling a range of child-level, family-level, and community-level factors that may potentially influence the outcome.

Assuming a logit link between the hazard rate and the explanatory variable, the three-level random-effects discrete-time hazard model can be expressed as:

$$\text{Logit}[\,(p_{tijk}/(1- p_{tijk})] = \alpha_t + X_{tijk}\beta + \mu_{jk} + \nu_k$$

where p_{tijk} is the probability that child i in household j in community k observed in the time interval t dies within that interval; X_{tijk} is a vector of community and family-child level explanatory variables; β is a vector of unknown regression parameters associated with the explanatory variables X_{tijk}; α_t is a function of time and is defined for age; and μ_{jk} [$\sim N(0,\sigma^2_\mu)$] and ν_k [$\sim N(0,\sigma^2_\nu)$] are error terms at the mother and community levels, respectively, that give an indication of the variation after controlling for the individual-level characteristics (Manda 1998). The error terms are standardized to have mean zero and variance of σ^2_μ and σ^2_ν, respectively, and are assumed to be uncorrelated. In this paper, the variances can be interpreted in terms of intra-class correlations (ρ_ν and ρ_μ; for the community and family, respectively) in a latent variable reflecting the unobserved factors that are shared among children in the same community or in the same family[8]. (See Manda (1998) for an explanation of how this expression for the intra-class correlation is derived.) The estimated variance represents the extent to which children in the same community are exposed to the same conditions (sanitation, hygiene, availability of services) even if they have different individual characteristics (Larsen & Merlo 2005). We can then interpret this as evidence of differential mortality levels between groups, for instance births in poor communities relative to rich communities. The higher the estimated variance, the higher is the level of inequality between groups.

The analytical strategy in the case of multilevel analysis consists of applying three models for each country. The first model is the empty model, i.e., a model without covariates fitted to test random variability in the intercept and to estimate the intra-class correlation coefficient. The second model includes only the individual-level variables as predictors. The third model includes both the individual-level and the community-level variables. This approach allows the sequential measurement of the relative contributions of each set of variables to the community-level variance. Reduction in the intra-class correlations (ICC)

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[8] These intra-class correlations (ICC) are defined as $\rho_v = \sigma_v^2/[\sigma_v^2 + \sigma_\mu^2 + 3.29]$ and $\rho_\mu = (\sigma_v^2 + \sigma_\mu^2)/[\sigma_v^2 + \sigma_\mu^2 + 3.29]$ at the community and family levels, respectively; where σ^2_μ and σ^2_v represent the variance at the family and community levels, respectively, and 3.29 represents the fixed individual variance, which is $\pi^2/3$ (Snijders & Bosker 1999).

relative to unadjusted analysis is evidence for explaining geographic variation by the variables included in a multilevel model.

Fixed effects models are fitted using Stata 11.1 (Stata Corporation 2009). MLwiN version 2.16 is used for the multilevel analysis. The multilevel logistic regression models are estimated with Markov Chain Monte Carlo (MCMC) methods in MLwiN. The MCMC procedure is used to fit multilevel models because it produces less biased estimates of variance parameters than quasi-likelihood methods for binary response models (Browne 2009). The default settings in MLwiN are used for the analyses, i.e., chains of length 5000 after a burn-in of 500. Bayesian deviance information criterion (DIC) is used to estimate the goodness of fit of consecutive models. Spiegelhalter et al. (2002) proposed using the DIC as a Bayesian equivalent of Akaike's Information Criterion (AIC)[9] for hierarchical models. A lower value on DIC indicates a better fit of the model (Spiegelhalter et al. 2002). As suggested by Browne, I fitted the model using first-order marginal quasi-likelihood (MQL) to generate starting values for the MCMC process (Browne 2009: 6).

Fixed estimates presented in the results section are those of the full models. The β coefficients (standard errors) have been converted into odds ratios and are presented

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[9] The AIC is appropriate for comparing non-nested models such as those estimates here. The AIC is calculated as -2 (loglikelihood of fitted model) +2p, where p is number of parameters in the model. The AIC values for each model are compared and the model with the lowest value is considered the better one (Maddala 1988).

alongside 95% confidence intervals. Estimates for the three analytical methods are presented side by side in the tables to facilitate comparisons.

4.3.3 Individual-Level and Community-Level Control Variables

Individual-level and household-level factors considered in this study are a set of standard covariates that have been identified by previous studies as important determinants of child mortality, and that are available for all countries considered (Hobcraft et al. 1985; Rafalitnanana & Westoff 2000; Rutstein 2000; Rutstein & Kiersten 2004). They include: the age of the child (in months); the child's sex; the duration of the preceding birth interval; the mother's age at the child's birth; the mother's education; whether the birth of the index child received skilled attendance (doctor, nurse, or midwife) at delivery; and household wealth.

Community-level characteristics are not directly available for most surveys included in the analysis. Instead, they are constructed by aggregating individual-level and household-level characteristics at the cluster level (i.e. the primary sampling units for the DHS). They include: the type of place of residence (urban/rural); the cluster's socioeconomic status (defined as the proportion poor in the cluster); the proportion of women in the cluster with secondary or higher education; the cluster's level of ethnic fractionalization (defined as the probability that two individuals selected at random from a cluster will be from different ethnic groups) (Fearon 2003); and the percentage of children who are fully immunized in the community (that is, who have received BCG, measles, and three doses of DPT and polio vaccines)[10]. The last predictor is a continuous variable, whereas all others variables at the community level are dummy variables, representing discrete factors coded using the reference cell method. All variables and their operational definitions are described in detail in Appendix Table 1.

[10] It is not possible to include individual-level indicators of variables like immunization status and nutrition as predictors of mortality, since values are missing for deceased children. Rather, the DHS questionnaire collects information on vaccination status, height, and weight of each surviving child who was born in the 3/5 years before the survey date.

4.4 Results

4.4.1 Levels of Under-Five Mortality Rates and Samples' Characteristics

Table 1 reports observed under-five mortality rates (U5MR) for each country included in the analysis, in the most recent five-year period. Globally, child mortality rates remain higher in sub-Saharan Africa (SSA) than in other regions. Within SSA, however, there is a large variation in U5MR among countries, from a high of 197.6 deaths per 1,000 live births in Niger to a low of 69.4 deaths per 1,000 live births in Namibia. Overall, the highest SSA child mortality levels are in West Africa, except for Ghana, where the U5MR is 80.0 deaths per 1,000 live births. Other countries with relatively low child mortality rates include Gabon, Madagascar, and Zimbabwe, all with U5MR below 100 deaths per 1,000 live births.

Disparities in U5MR at the national level between countries probably reflect the socioeconomic and health care contexts of the countries. Appendix Table 2 presents country-specific demographic, socioeconomic, and health behavior data relevant to the analysis, providing a picture of the broader context for the 28 countries. The figures presented are weighted percentages, with weighted column totals presented at side. As shown in Appendix Table 2, there are large differences in the covariates between countries, but these differences seldom form clear regional patterns. In many countries most of the children live in rural areas (more than 60% in 24 out of 28 countries). There is substantial variation across countries in the use of health services. The proportion of births attended by a skilled health provider (doctor, nurse, or midwife) ranges from under 6% in two countries—Chad and Ethiopia—to 81.6% in Namibia. The proportion of births in the five years before the survey delivered in a health facility ranges from 5.7% in Ethiopia to 87.1% in Gabon. Levels of education remain relatively low in most sub-Saharan countries. In 9 of the 28 countries studied, the majority of children were born to uneducated mothers, and in 17 of the countries, more than 50% of children live in communities where the level of women's education is low.

4.4.2 Unobserved Heterogeneity at Family and Community Levels in Under-Five Mortality

Table 3 shows the estimates of the family and community level variances, together with the intra-family and intra-community correlation coefficients for the 28 separate models, after adjusting for the child-level, family-level, and community-level characteristics. This analysis supports the numerous other studies that have found that children of the same family have correlated probabilities of survival. The between-family variance is highly significant (p-value <0.01) in almost all countries. It is less significant in Rwanda (p-value

<0.05) and Cameroon (p-value <0.10). The intra-family correlation coefficients range from 2% (Cameroon) to 38% (Lesotho). This result suggests that a significant unobserved heterogeneity exists in the under-five mortality risks between families. Overall, unobserved mother heterogeneity explains a substantial part of the random variance in the child mortality across countries. For instance, the intra-family correlation is 0.33 in Zambia, indicating that 33% of the variation in mortality risks is the result of unobserved family-level factors.

[Table 3 about here]

The community variance is significant at the 5% level or lower in half of the countries under study. Intra-community variation associated with the risk of dying before age five ranges from below 5% in 11 countries to 7% in Sierra Leone. Overall, the results show that the variance between communities is smaller than the variance between families.

The community variance and the family variance are jointly significant in 14 of the 28 countries, providing evidence that the variation in under-five mortality in a number of countries in sub-Saharan Africa is produced by the interaction between the family and geographic environment of the children. Thus the variation in mortality risks in these countries is simultaneously attributed to unobserved heterogeneity at the household and community levels, after accounting for child-level, household-level, and community-level characteristics.

The much larger magnitude of the intra-family correlations than the intra-community correlations suggests that residence in a particular community may be a less important determinant of child survival across sub-Saharan African countries than is membership in a particular family.

4.4.3 Individual-level and Community-level Effects on the Risk of Dying before Age Five

Table 4 presents the adjusted odds ratios and 95 percent confidence intervals of predictor variables on the risk of dying before age five, in the three sets of models fitted for each country.

As one would expect, fixed-effects discrete-time models (model 2) show a better adjustment than "naïve" discrete-time hazard models (model 1). In all countries, the AIC (at the bottom of the Table 4) of fixed-effects models is smaller, suggesting that the conditional logit estimation approach is probably better. This empirical finding demonstrates the need to take context into account while examining factors affecting child survival. However, this fixed-effects approach does not take into account the possibility that one particular community factor might influence child mortality. As mentioned above, these latter two sets of estimates, which include only individual variables, serve the purpose of comparing methods.

This study is focused on contextual effects, and it addresses an important related question: what characteristics of the community are associated with the risk of child death, net of individual characteristics? Thus discussion of the results is based only on the multilevel discrete-time hazard models (model 3), which include both individual-level and community-level variables, and family and community random effects.

The results reveal that individual-level and community-level effects on the risk of dying before age five vary across the 28 countries.

[Table 4 about here]

At the individual level, the results show that in many countries, consistent with earlier studies, the child's birth order and preceding birth interval are significantly associated with under-five mortality. The combination of a higher birth order and a shorter birth interval increases the odds of dying before age five. Fourth or higher-order births preceded by an interval of less than 24 months have a higher mortality risk than first births; this effect is significant in 11 of the 28 countries studied. Correspondingly, children of second and third birth order and a preceding birth interval of 24+ months have a risk of dying before age five that is 17-42% lower than first-born children (ORs are significant in 19 of 28 countries). The results show a systematically higher mortality for male children compared to females in all countries except Sierra Leone, and the relationship is significant in 14 of 28 countries. In Sierra Leone, males have 16% lower odds than females of dying before age five ($p < 0.10$).

Mother's older age at birth reduce the odds of the child's dying during the first five years, in 10 of the 28 countries. Older mothers tend to be more experienced than younger mothers and better able to care for a newborn. Children born to mothers age 20–34 have on average 13-35% lower odds of dying in childhood compared to children born to mothers below age 20. In Lesotho and Madagascar, however, children born to mothers age 35 or older are 72% and 38% more likely, respectively, to die before age five than children born to mothers under age 20.

The results show a consistent inverse relationship between maternal education and child mortality—the more schooling a mother has, the less likely her child is to die before age five. Children of mothers who attended primary school are less likely to die young than children of mothers with no education, and children of mothers with a secondary and higher education are the least likely to die before age five. Among the 28 countries, this effect is statistically significant in 4 countries for primary education, and in 13 countries for secondary or higher education. The two education variables are jointly significant only in Ethiopia.

The results also show that maternal education is not significantly associated with under-five mortality in several countries (Burkina Faso, Congo, Ghana, and Lesotho). Many past studies (as in my model 1) have concluded that maternal education is a significant predictor of child survival in these countries (see: Desai & Alva 1998; Gakidou et al. 2010; Hobcraft et al. 1985). Most of those studies, however, have failed to account for many important variables, including household-level and community-level heterogeneity, and community context variables including community-level maternal education. This present study suggests that failure to account for those factors probably has led to overestimated effects of maternal own education on child survival.

The effect of wealth status is relevant in 11 countries, where children from the richest households have a risk of dying before age five that is 24-57% lower than children from the poorest households.

Regarding the effects of use of health care services, the presence of a skilled attendant at the child's delivery is significantly associated with child survival in 5 of the 28 countries examined. Children delivered by health professionals have an odds of dying before age five that is 17-25% lower than children delivered by others or born at home ($p < 0.05$ in Congo Democratic Republic, Gabon, Malawi, Mali, and Zimbabwe).

This research also contributes to the literature on the implications of community-level factors for child mortality. The results show that in a number of countries some attributes of the community influence mortality risks of children, over and above the intermediate factors included in this investigation. The results are mixed concerning the association between urban residence and the odds of dying before age five. Urban residence is significant in seven countries. In Chad, Malawi, Nigeria, and Rwanda, mortality is lower in urban areas than in rural areas. In Namibia, Sierra Leone, and Zambia, however, urban residence increases the odds of under-five mortality.

The results show that in most countries community-level poverty is not associated with increased risk of dying before age five. In Kenya and Nigeria, clusters with a higher percentage of mothers living in poor households are significantly associated with increased odds of under-five deaths.

Health care context appears to play a major role in child survival in most countries. A 1% increase in the proportion of children fully immunized in the community is associated with a significant decrease of 17-79% in the odds of dying before age five, in 11 of 28 countries under study. The results also show that, even when household-level and community-level factors are controlled, the influence of community-level maternal education on child survival is robust. In Congo, Ghana, and Nigeria, clusters with a higher proportion of women with secondary or higher education are significantly associated with reduced odds of under-five deaths.

The results reveal that, in 7 of 28 countries, the ethnic composition within the community affects mortality risk. In Chad, Kenya, Mali, and Niger, higher levels of community ethnic concentration are significantly associated with decreased odds of dying before age five. In Mozambique, Nigeria, and Zambia, however, higher community-level ethnic homogeneity is significantly associated with increased odds of child mortality.

Finally, in Guinea, Lesotho, Liberia, Madagascar, and Swaziland, none of the community-level factors considered in this analysis is significantly associated with under-five mortality.

4.5 Discussion and Conclusions

In this paper I have examined the effects of child, family, and community characteristics on the risk of dying before age five, across 28 sub-Saharan African countries. Following the recent applications in this field, this paper develops a new empirical conceptualization of childhood mortality research to explain the strong heterogeneity of mortality risks between families and communities across the sub-Saharan countries. This study is the first, to my knowledge, to have an intra-continental scope, comparing determinants of under-five mortality simultaneously at three levels (child, family, and community) across sub-Saharan Africa countries, using DHS data from the most recent national surveys.

The estimates obtained from the analysis show that under-five mortality is jointly determined by the observed individual demographic and socioeconomic characteristics of the child and mother, and by community-level covariates, as well as unobserved household-level and community-level effects, in most of the countries under study.

The results indicate large residual family-level effects and moderately large and statistically significant community-level effects on the risk of dying before age five, even after controlling for a range of child-level, family-level, and community-level variables. I found systematic evidence of higher child mortality clustering at the family-level compared with the community-level. These results suggest that membership in particular families and in particular communities is a major determinant of the risk of dying before age five, in most countries in sub-Saharan Africa.

Because children's contact with institutions outside of the family during the first five years of life (especially < 2 years) is fairly limited, it is not surprising that very few community attributes are associated with the individual-level mortality risks of children (Arguillas 2008). It also is well recognized that household environment is an important determinant of whether young children are exposed to pathogens and other physical risk factors for ill health (David 1999). At this age, the child is kept within the household and often with the mother. Therefore, family-level effects are stronger than community effects, since the child does not have much exposure to the community's culture, customs, and environment (Manda 1998: 154).

The relative importance of family-level random effects observed in child mortality is not uncommon in health research (Bolstad & Manda 2001; Griffiths et al. 2004; Madise et al. 1999; Van de Poel et al. 2009). Like the present study, Bolstad and Manda (2001) used 1992 Malawi DHS data to investigate the existence of variation in under-five mortality risks at both the household level and community level. They estimated the intra-family correlation of child mortality to be about 28% (variance at the family level was 0.843), and the intra-community correlation to be 18% (variance at the community level was 0.417), after controlling for a large number of observed characteristics of individuals and families (Bolstad & Manda 2001:18). In an investigation of the determinants of weight-for-age among young children in six sub-Saharan countries, Madise et al. (1999:339) reported intra-family correlations that ranged from 24% to 40%, while the intra-community correlation ranged from 1% to 6%.

The finding of this present study, which is robust, implies that there are unmeasured or unmeasurable factors other than those included in my analysis that are causing the clustering of child mortality in some families and communities. In general, unobserved effects reflect a diversity of factors that can be broadly classified as genetic, behavioral, and environmental, occurring at individual, family, and community levels (Omariba et al. 2007; Sastry 1997a). Particularly, the explanations for this clustering have centered on childcare practices, use of health services, and personal attitudes of the mothers (Bolstad & Manda 2001; Curtis et al. 1993; Das Gupta 1990; Madise et al. 1999; Pebley et al. 1996; Sastry 1997a). In addition, the unobserved family-level factors could include cultural practices and such household environmental factors as personal hygiene and general cleanliness (Van Poppel et al. 2002).

Finally, while information on birth weight, breastfeeding, delivery care, and immunization is unavailable for the majority of children, these also are part of the unobserved behavioral factors at the family level (Omariba et al. 2007). Other factors that were not measured but that may have helped to reduce the unobserved household heterogeneity in mortality risk include details of specific practices of the mother regarding childcare and hygiene (for example, changes, if any, in the food or water given to children suffering from fever or diarrhea, regular use of soap after defecation, and frequency of bathing). The introduction of HIV as a factor at the community level also may improve the models in countries with relatively high HIV prevalence (DeRose & Kulkarni 2005; Stanecki et al. 2010).

Despite the presence of both unobserved family and community effects, there are different mechanisms that might also predict variation in under-five mortality risks across countries. Results reveal that the standard relationships between child mortality risks and individual and household covariates hold in the countries examined. I discuss below the key findings concerning the effects of some individual-level and community-level factors.

This study found that child's birth order and preceding birth interval, in combination, are strongly associated with under-five mortality. This association is consistent with findings elsewhere that short preceding birth intervals and high parity largely increase child mortality risk, after accounting for unobserved heterogeneity (Bolstad & Manda 2001; Curtis et al. 1993; Miller et al. 1992; Sastry 1997a). This could be related to maternal depletion syndrome and resource competition between siblings, in addition to a lack of care and attention experienced by high-order children (Rutstein 2005; Zenger 1993).

This point is important because short birth intervals remain relatively common in many sub-Saharan countries (Ngianga-Bakwin & Stones 2005). In addition, use of modern contraceptive methods is quite low—often less than 10%—in many countries, especially in Middle and Western Africa (Population Reference Bureau & African Population and Health Research Center 2008:3). Thus the use of contraception to space births could make an important contribution to reducing the risks of child mortality (Curtis et al. 1993). Recently, one multi-country analysis of pregnancy outcomes found that 12 months of contraception-only coverage in the preceding birth interval can reduce the mortality risk for the next newborn by 31%, while 12 months of contraceptive use overlapping with breastfeeding reduces the risk by 68% (Tsui & Creanga 2009).

Child survival to a large extent also depends on mother's age at the time of the child's birth, in several developing countries studied (Bolstad & Manda 2001; Ladusingh & Singh 2006; Sastry 1997a). The present analysis found that in the most of the 28 countries under study the older the mother, the better the child's probability of survival. A similar result is reported by Forste (1994) who found that, in Bolivia, mother's age at childbirth reduced the risk of death during the first two years. The relationship between mother's age at birth and child mortality is sometime difficult to understand. A variety of relationships have been reported and a number of mechanisms have been proposed to account for them (Hobcraft et al. 1985). Forste (1994:506) has pointed out that older mothers tend to be more experienced and better able to care for a newborn, than younger mothers.

The results show systematically that male children have higher mortality risks than female children. This finding seems to confirm the theory of male biological disadvantage in early life (Waldron 1998) in sub-Saharan Africa.

Findings regarding the effects of maternal education on child mortality generally indicate a negative relationship between the educational attainment of the mother and her risk of experiencing an infant and child death (see, e.g., Desai & Alva 1998; Kravdal 2004; Ladusingh & Singh 2006). The results of the present analysis confirm the strong relationship between increased maternal education and improved child survival, even after accounting for other measures of individual-level, child-level, and mother-level demographic and socioeconomic characteristics, and community-level covariates. That is, a strong association remains between the level of maternal education and the odds of child survival, independent of wealth. It appears that more educated mothers can use limited resources more effectively than mothers with less education. More educated mothers may also have better information on health and nutrition-related practices that translate to better survival chances for children (Griffiths et al. 2004). There are a number of plausible mechanisms that could link the level of maternal education to under-five mortality, including both mediation and moderation effects (Cleland & van Ginneken 1988; Thrane 2006).

As would be expected, and has been found in a previous study (Fotso & Kuate-Defo 2005a), this study also observed a negative association between household wealth and child mortality. Compared to children from the poorest households, children from richer households are less likely to die before their fifth birthday, in more than 10 of the 28 countries studied.

The present analysis provides empirical support that, in many countries under study, uptake of safe delivery practices protects children from dying before age five. As would be expected, medical assistance by skilled medical personnel significantly lowers the risk of under-five mortality (WHO 2005). This finding points to the need to continue to invest resources in health care services that promote child health-seeking behavior.

One of the findings of this study is that certain characteristics of the mother's community have independent effects on the survival chances of their children, even after individual and household factors are accounted for. In the most of the countries under study, as in other previous findings (Van de Poel et al. 2009), urban residence lowers child mortality risks. In some countries, however, urban residence increases the odds of under-five mortality. While it is widely recognized that child health outcomes are better in urban than in rural areas of developing countries (Van de Poel et al. 2007), recent evidence suggests that infant and child mortality rates are increasing in many urban areas in sub-Saharan Africa (Fotso et al. 2007; Garenne 2010).

The drivers of excess urban mortality are multiple, and may vary over time and across geographic areas (Sastry 2004; Van de Poel et al. 2009). They are probably the result of growing urban poverty in the context of rapid and unplanned urbanization (Brockerhoff & Brennan 1998). In this analysis, Sierra Leone is illustrative, "primarily because of a worsening economic situation in urban areas, in the context of a dramatic recession following the 1991–2002 civil war" (Garenne 2010:4). Vorster et al. reported that the "African population is experiencing rapid urbanization characterized by a double burden of disease in which non-communicable diseases become more prevalent and infectious diseases remain undefeated" (Vorster et al. 1999:341). Historians and demographers have long debated the existence, causes, and consequences of historical differences between urban and rural mortality levels (Woods 2003). The debate continues, because a number of pertinent questions remain unresolved. Many studies have pointed out that the way in which mortality is measured may influence the apparent extent of the differential, as may the way in which "urban" and "rural" are defined (Bloom et al. 2010; Woods 2003).

Some of the effects of the other community-level variables are difficult to understand. For instance, in many of the countries studied, poverty concentration within a community is not significantly associated with increased under-five mortality. Although this finding is consistent with other research (Chen et al. 2007), it is an unexpected result. A study by Chen et al. (2007:174) highlights that the weakness of the relationship between community characteristics and child deaths is probably due to more frequent underreporting of child deaths in poor communities.

As has been found elsewhere (Kravdal 2004), this present research confirms the presence of the community-level effect of mother's education on child mortality, in three of the countries studied. Residence in areas where levels of education are generally high is associated with decreased odds of dying before age five. In Nigeria, this effect is in addition to the positive individual-level effect of the child's own mother being educated. Most interestingly, even children whose own mothers have little education appear to benefit from the education of other mothers in the community, providing evidence of positive externality (spillover effect) of community-level maternal education in shaping child survival. The effect of community education may operate through a wide range of variables related to health and health care (Kravdal 2004:190). In addition, Gage (2007:1680) highlights the role that high levels of social capital can play as a plausible mechanism through which an area's education level can influence maternal health care-seeking behavior.

This study shows that in some countries an ethnic concentration within a community is predictive of child mortality risks, although it appears likely that neighborhood ethnic composition is a surrogate for neighborhood socioeconomic status and/or other contextual factors (Wight et al. 2010) not examined in this study. Because of higher ethnic diversity in sub-Saharan Africa (Fearon 2003; Obono 2003), the effects of the ethnic composition of the community on child mortality are complex and sometimes difficult to understand. Brockerhoff and Hewett (1998:5) have pointed out that "ethnic child mortality differences probably reflect the heterogeneity of social and ecological settings in Africa." In addition, in many countries child survival is also affected indirectly by the prominence of ethnic groups in the national political economy (Brockerhoff & Hewett 1998:7).

In a number of countries, results of the present study agree with the observations made by Kravdal (2004) in India that low mortality is indicated for children who live in communities where relatively many are members of the same ethnic group (e.g.: scheduled castes or tribes) (Kravdal 2004: 186). However, in some countries my results show that higher community-level ethnic homogeneity is associated with increased odds of child mortality.

Possible explanations for such findings are generally centered on cultural models and social mechanisms (Adams et al. 2002; Brockerhoff & Hewett 1998; Rutenberg & Watkins 1997; Weeks et al. 2006). Cultural factors may play a role in shaping women’s decisions about child delivery and related medical care. Studies have demonstrated the existence of ethnic variation in attitudes and norms surrounding childbirth and medicine that have direct effects on maternal and infant mortality outcomes (Glei & Goldman 2000).

In more than half of the 28 countries studied, having a high proportion of children fully immunized in a community is associated with lower under-five mortality. This finding highlights that the importance of preventive health measures such as vaccination in improving child survival (WHO 2005). A country-specific estimate of immunization coverage has been considered to be a proxy for availability and accessibility of maternal and child health services (Ahmed & Mosley 2002). Previous studies have shown that individual maternal and child health-seeking behaviors are strongly influenced by the practices of others in the community (Stephenson et al. 2006).

In Guinea, Lesotho, Liberia, Madagascar, and Swaziland, none of the community-level factors considered in this analysis has a statistically significant effect on the risk of under-five mortality. This finding is not surprising, since the full multilevel models show non-significant community-level random effects for these countries. It suggests either that the individual-level covariates are relatively more important than the community-level factors, or that the variables used in the models are not able to capture the contextual effect. Robert (1999) has stated that, "if the association between community socioeconomic context and health simply reflects the sum of relationships at the individual level, we might choose to improve health by targeting individuals with lower socioeconomic position rather than targeting communities with lower socioeconomic profiles" (Robert 1999: 490-491).

This research has inherent limitations that should be noted when interpreting the results. As discussed in other analyses, using DHS data and considering primary sampling units (clusters) as the community level (Montgomery & Hewett 2005), results may be biased toward a well-functioning population, due to both endogeneity and selection effects (Kravdal 2004:190; Wight et al. 2010:212) (as detailed in the literature review section of this paper). In addition, the use of cross-sectional individual-level data restricts the inferences to associations between independent and dependent individual-level variables, not causal relationships.

There are also limitations associated with the community-level characteristics used in this analysis. With the exception of "urban-rural residence," all community-level variables are constructed by aggregating individual-level and household-level characteristics at the community level (the primary sampling units). That is, the community contextual variables are actually compositional variables, aggregated upwards. There are two potential problems with this approach (Rajaratnama et al. 2006). First, it could result in multicolinearity, since the same variables used to derive the "contextual" variables are also included as individual variables. Second, the approach is subject to atomistic fallacy, or the problem of making inferences at a higher level based on data collected at a lower level (Duncan et al. 1998).

In addition, the lack of adequate measurement of community-level data (such as distance and travel time to a health facility) has probably reduced the predicting models' power, and hence has contributed to the weakness of the community-level effects on child mortality observed in certain countries.

Finally, although this is a comparative study, the 28 countries could not be fitted with a common statistical model. Each country is unique in its demographic and cultural characteristics, and the DHS data differ significantly by some variables across the countries (e.g., the ethnicity variable was not included in models in seven countries). The lack of the same variables in all the data sets primarily limited our analytical attempts. For this reason, the countries could not be easily compared.

Notwithstanding these limitations, these findings represent a further step toward an improved understanding of the complex determinants of child survival in sub-Saharan Africa. The present study provides empirical evidence for the thesis that information about family and community is essential for a better understanding of inequalities in child mortality. Specially, this study demonstrates that there is no single community influence on child mortality, and the significant community-level factors vary across the 28 study settings, as community-level indicators reflect the socioeconomic context and the health care context, as well as culturally and contextually specific practices. This finding has both theoretical value and important policy implications. Finally, this research suggests that the challenge to reduce under-five mortality goes beyond addressing individual factors, and requires a better understanding of contextual factors.

4.6 Tables

Table 1: Total number of births, average number[1] of births in families and communities, and under-five mortality rate: DHS in 28 countries in sub-Saharan Africa, 2000-2009

Country and Region	Year of survey	Total number of births during the 5 years before the survey[1]	Average number of births[1]		Under-five mortality (5q0)*
			Family	Community	
Western Africa					
Benin	2006	15929	1.7	21.4	124.9
Burkina Faso	2003	10852	1.9	27.0	183.7
Ghana	2008	2909	1.5	6.9	80.0
Guinea	2005	6370	1.8	21.8	163.2
Liberia	2007	5594	1.6	19.5	109.5
Mali	2006	14420	1.8	35.9	190.5
Niger	2006	9954	1.9	29.1	197.6
Nigeria	2008	28100	1.8	30.8	156.9
Senegal	2005	10530	2.2	27.0	121.3
Sierra Leone	2008	5811	1.6	16.6	139.8
Middle Africa					
Cameroon	2004	8097	1.8	17.6	143.6
Chad	2004	5989	1.8	32.3	190.6
Congo Brazzaville	2005	4948	1.6	23.2	116.6
Congo Democratic Republic	2007	8999	1.8	30.8	147.9
Gabon	2000	4031	1.8	15.8	88.6
Eastern Africa					
Ethiopia	2005	11163	1.6	20.4	123.5
Kenya	2008-2009	5852	1.6	15.1	114.6
Madagascar	2008-2009	12686	1.6	21.2	93.9
Malawi	2004	10771	1.5	18.7	133.2
Mozambique	2000-2001	10620	1.6	16.8	152.4
Rwanda	2003	8715	1.6	18.9	152.4
Tanzania	2004-2005	8725	1.7	18.0	112.0
Uganda	2006	8423	1.8	23.1	127.6
Zambia	2007	6435	1.7	20.1	118.7
Zimbabwe	2005-2006	5231	1.4	13.1	82.5
Southern Africa					
Lesotho	2004	3572	1.3	8.6	112.8
Namibia	2003	5003	1.5	10.4	69.4
Swaziland	2006-2007	2829	1.6	10.7	119.9

[1] Weighted.

Note: * Probability of dying between birth and age 5, refer to a 5-year period before the survey, and they are expressed as a rate per 1,000 live births.

Source: Macro International Inc, 2010. MEASURE DHS STATcompiler. http://www.measuredhs.com, April 26 2010.

Table 2: Summary of procedure and decision rules for variables entered and included in the multivariate and multilevel event history models

Model	**Estimation Technique**	**Independent Variables**	**Procedure and Software**
Model 1	Standard logit discrete-time model accounting for within-cluster correlation by using the Huber-White procedure	Conventional logistic regression predicting children's probability of dying by their fifth birthday with only individual-level variables as predictors.	*logit in Stata*
Model 2	Conditional logit discrete-time model or fixed-effects logit model	Model 2 adds to Model 1 cluster-level fixed effects to control for unobserved community-level characteristics. The covariates are same as in Model 1.	*clogit in Stata*
Model 3	Multilevel discrete-time logit models with three-level (community, family, child) random intercepts	The multilevel analysis uses a sequential approach to model building. First, I created an unconditional model (model 3a) in order to determine the proportion of variance in the outcome that is attributed to within- and between-group differences. Then, in model 3b I added individual-level variables (child and family characteristics) as predictors. Finally, in model 3c I added community-level characteristics.	*Markov Chain Monte Carlo (MCMC) procedure in MLwin (version 2.16)*

Table 3: Variance estimates between family and community, and intra-correlations coefficients for the discrete-time multilevel models of probability of dying before age 5, by country

Country	Variance and Level of significance				Intra-unit correlations[a]	
	Family		Community		Family	Community
Benin	0.480	***	0.141	***	0.159	0.036
Burkina Faso	0.533	***	0.141	***	0.170	0.036
Cameroon	0.002	*	0.056	ns	0.017	0.017
Chad	0.580	**	0.113	**	0.174	0.028
Congo (Brazzaville)	1.198	***	0.063	ns	0.277	0.014
Congo Demo. Rep.	0.794	***	0.230	***	0.237	0.053
Ethiopia	0.833	***	0.113	**	0.223	0.027
Gabon	1.129	***	0.139	ns	0.278	0.030
Ghana	1.152	***	0.216	ns	0.294	0.046
Guinea	0.582	***	0.061	ns	0.163	0.016
Kenya	1.627	***	0.273	**	0.366	0.053
Lesotho	1.976	***	0.044	ns	0.380	0.008
Liberia	1.140	***	0.039	ns	0.264	0.009
Madagascar	1.205	***	0.085	ns	0.282	0.019
Malawi	0.740	***	0.085	**	0.200	0.021
Mali	0.888	***	0.126	***	0.236	0.029
Mozambique	0.953	***	0.039	ns	0.232	0.009
Namibia	0.719	***	0.020	ns	0.183	0.005
Niger	0.377	***	0.130	***	0.134	0.034
Nigeria	0.949	***	0.084	***	0.239	0.019
Rwanda	0.436	**	0.167	***	0.155	0.043
Senegal	0.480	***	0.141	***	0.159	0.036
Sierra Leone	0.654	***	0.304	***	0.226	0.072
Swaziland	1.171	***	0.034	ns	0.268	0.008
Tanzania	0.582	***	0.128	**	0.178	0.032
Uganda	0.475	***	0.040	ns	0.135	0.011
Zambia	1.608	***	0.012	ns	0.330	0.002
Zimbabwe	1.340	***	0.052	ns	0.297	0.011

ns = not significatif at 10%; + p-value < 0.10; * p-value < 0.05; ** p-value < 0.01; *** p-value < 0.001.

a: Intra-group correlation coefficients measure the degree of clustering and include random intercepts with both individual- and community-level as predictors. Intra-community correlation (ρ_v), which measures the proportion of the total variance which is between communities, expresses similarity of children in probability of dying before age 5 from the same community. Intra-family correlation coefficient (ρ_μ) expresses similarity of children in probability of dying before age 5 from the same household (and by definition, from the same community). These intra-class correlations (ICC) are calculated as $\rho_v = \sigma_v^2/[\sigma_v^2 + \sigma_\mu^2 + \sigma_e^2]$ and $\rho_\mu = (\sigma_v^2 + \sigma_\mu^2)/[\sigma_v^2 + \sigma_\mu^2 + \sigma_e^2]$ at the community and family levels, respectively; where σ_v^2 denotes community-level variance, σ^2_μ denotes family-level variance and σ_e^2 denotes individual-level variance, with this latter variance set to $\pi^2/3$ (equal to 3.29).

Table 4: Odds ratios and 95 percent confidence intervals (95% CIs) for the effect of individual-level and community-level factors on under-five mortality, by country

	Benin						Burkina Faso					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.47	0.40 - 0.57	0.48	0.40 - 0.58	0.49	0.41 - 0.58	0.80	0.64 - 1.00	0.81	0.65 - 1.02	0.83	0.70 - 0.99
6–11 months	0.64	0.53 - 0.76	0.66	0.55 - 0.78	0.67	0.57 - 0.78	0.85	0.66 - 1.10	0.88	0.68 - 1.13	0.92	0.77 - 1.10
12–23 months	0.58	0.48 - 0.70	0.62	0.51 - 0.74	0.62	0.53 - 0.73	1.39	1.14 - 1.69	1.45	1.20 - 1.76	1.40	1.18 - 1.65
24+ months	0.68	0.56 - 0.82	0.73	0.60 - 0.88	0.74	0.62 - 0.88	1.43	1.13 - 1.82	1.55	1.22 - 1.96	1.58	1.32 - 1.88
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.34	1.04 - 1.72	1.15	0.88 - 1.50	1.25	0.98 - 1.59	1.27	0.89 - 1.81	1.17	0.80 - 1.70	0.99	0.74 - 1.31
2-3 and 24+ months	0.74	0.61 - 0.90	0.70	0.57 - 0.86	0.71	0.60 - 0.84	0.90	0.71 - 1.13	0.90	0.71 - 1.15	0.83	0.68 - 1.02
4+ and < 24 months	1.39	1.08 - 1.79	1.19	0.92 - 1.55	1.28	1.01 - 1.60	1.59	1.21 - 2.09	1.45	1.10 - 1.93	1.32	1.01 - 1.73
4+ and 24+ months	0.88	0.72 - 1.07	0.80	0.65 - 0.99	0.83	0.69 - 0.99	0.87	0.66 - 1.15	0.86	0.65 - 1.15	0.75	0.60 - 0.93
Child's sex												
Female[ref]												
Male	1.10	0.98 - 1.23	1.14	1.01 - 1.28	1.10	0.99 - 1.22	1.00	0.88 - 1.13	1.00	0.88 - 1.14	1.00	0.88 - 1.13
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.94	0.77 - 1.14	1.01	0.83 - 1.23	0.96	0.79 - 1.16	0.85	0.67 - 1.06	0.90	0.71 - 1.14	0.82	0.66 - 1.01
35 years or more	0.92	0.70 - 1.22	1.03	0.76 - 1.39	0.93	0.71 - 1.21	0.88	0.65 - 1.20	0.96	0.70 - 1.32	0.90	0.69 - 1.17
Mother's education												
No education[ref]												
Primary	1.06	0.90 - 1.24	1.07	0.89 - 1.28	1.07	0.91 - 1.27	0.81	0.64 - 1.03	0.84	0.66 - 1.07	0.92	0.72 - 1.16
Secondary or higher	0.67	0.48 - 0.96	0.71	0.49 - 1.03	0.69	0.50 - 0.95	0.72	0.47 - 1.10	0.86	0.54 - 1.37	0.72	0.47 - 1.10
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.01	0.84 - 1.21	0.99	0.82 - 1.20	1.04	0.88 - 1.23	0.95	0.76 - 1.18	1.00	0.80 - 1.24	0.96	0.80 - 1.15
3rd quintile	1.10	0.93 - 1.31	1.01	0.84 - 1.23	1.08	0.91 - 1.29	0.83	0.66 - 1.03	0.83	0.66 - 1.04	0.84	0.70 - 1.01
4th quintile	0.95	0.78 - 1.16	0.96	0.74 - 1.23	0.93	0.76 - 1.15	0.82	0.65 - 1.04	0.85	0.66 - 1.08	0.91	0.73 - 1.12
5th quintile (Richest)	0.69	0.53 - 0.89	0.71	0.49 - 1.02	0.73	0.55 - 0.96	0.73	0.53 - 1.01	0.84	0.55 - 1.30	0.73	0.54 - 0.98
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.88	0.76 - 1.03	0.95	0.79 - 1.13	0.92	0.80 - 1.06	0.93	0.78 - 1.10	1.01	0.84 - 1.23	0.94	0.80 - 1.10
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.90	0.77 - 1.05					0.87	0.65 - 1.18
Proportion of households poor[a]												
Low[ref]												
High					0.89	0.76 - 1.05					1.01	0.86 - 1.19
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.99	0.84 - 1.16					1.17	0.93 - 1.46
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					1.04	0.90 - 1.21					0.97	0.83 - 1.12
Proportion of children fully immunized[d]					0.63	0.44 - 0.91					0.49	0.34 - 0.70
Intercept	-3.24	-3.49 - -2.99			-3.33	-3.64 - -3.02	-3.13	-3.41 - -2.86			-3.19	-3.46 - -2.93
AIC/DIC (multilevel model) of full models	12919		10568		12955		11853		9714		11273	

Table 4: Cont'd

	Cameroon						Chad					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.64	0.51 - 0.82	0.66	0.52 - 0.83	0.65	0.54 - 0.80	0.68	0.51 - 0.89	0.69	0.52 - 0.90	0.63	0.50 - 0.79
6–11 months	0.96	0.76 - 1.20	0.99	0.79 - 1.24	0.91	0.76 - 1.11	0.89	0.65 - 1.21	0.91	0.67 - 1.25	1.00	0.80 - 1.24
12–23 months	0.97	0.78 - 1.21	1.03	0.83 - 1.28	0.96	0.79 - 1.17	0.85	0.61 - 1.19	0.90	0.65 - 1.25	0.90	0.71 - 1.13
24+ months	0.92	0.70 - 1.20	1.00	0.77 - 1.31	0.83	0.66 - 1.04	1.05	0.78 - 1.41	1.13	0.84 - 1.51	1.12	0.87 - 1.44
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.45	1.07 - 1.97	1.46	1.04 - 2.05	1.40	1.06 - 1.83	0.91	0.64 - 1.30	0.83	0.57 - 1.22	0.82	0.58 - 1.14
2-3 and 24+ months	0.80	0.63 - 1.03	0.82	0.63 - 1.08	0.85	0.68 - 1.06	0.69	0.53 - 0.90	0.67	0.50 - 0.89	0.65	0.49 - 0.87
4+ and < 24 months	1.17	0.83 - 1.67	1.06	0.73 - 1.55	1.19	0.88 - 1.61	1.36	0.93 - 1.99	1.29	0.84 - 1.98	1.13	0.81 - 1.59
4+ and 24+ months	0.82	0.62 - 1.08	0.80	0.59 - 1.10	0.85	0.66 - 1.10	0.56	0.40 - 0.80	0.54	0.38 - 0.78	0.57	0.41 - 0.78
Child's sex												
Female[ref]												
Male	1.04	0.89 - 1.21	1.02	0.86 - 1.20	1.08	0.94 - 1.24	1.24	1.04 - 1.47	1.25	1.04 - 1.50	1.12	0.95 - 1.31
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.88	0.71 - 1.10	0.92	0.72 - 1.18	0.86	0.71 - 1.05	0.91	0.70 - 1.20	0.91	0.67 - 1.22	0.86	0.68 - 1.09
35 years or more	1.12	0.83 - 1.53	1.21	0.85 - 1.72	1.10	0.81 - 1.49	1.09	0.75 - 1.58	1.08	0.70 - 1.65	0.96	0.66 - 1.40
Mother's education												
No education[ref]												
Primary	1.19	0.96 - 1.47	1.25	0.96 - 1.64	1.23	1.01 - 1.48	1.23	0.92 - 1.64	1.21	0.91 - 1.60	1.00	0.80 - 1.26
Secondary or higher	0.98	0.75 - 1.26	1.11	0.81 - 1.53	1.02	0.79 - 1.32	0.93	0.61 - 1.44	0.93	0.58 - 1.48	0.71	0.47 - 1.07
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	0.88	0.70 - 1.11	0.88	0.69 - 1.12	0.87	0.72 - 1.07	1.23	0.91 - 1.66	0.84	0.49 - 1.45	1.33	0.97 - 1.82
3rd quintile	0.92	0.73 - 1.15	0.93	0.69 - 1.26	0.90	0.72 - 1.13	0.91	0.63 - 1.30	0.61	0.32 - 1.18	0.95	0.67 - 1.35
4th quintile	0.87	0.67 - 1.12	0.95	0.65 - 1.40	0.94	0.72 - 1.24	1.35	1.02 - 1.80	0.89	0.50 - 1.58	1.43	1.01 - 2.02
5th quintile (Richest)	0.65	0.47 - 0.89	0.68	0.42 - 1.10	0.75	0.53 - 1.05	1.03	0.77 - 1.39	0.66	0.33 - 1.34	1.20	0.77 - 1.89
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.88	0.72 - 1.07	1.01	0.79 - 1.28	0.90	0.76 - 1.07	0.85	0.54 - 1.36	1.03	0.67 - 1.59	1.10	0.74 - 1.62
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.84	0.67 - 1.05					0.65	0.46 - 0.92
Proportion of households poor[a]												
Low[ref]												
High					0.89	0.70 - 1.14					0.88	0.64 - 1.20
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.93	0.76 - 1.14					1.30	1.01 - 1.68
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					0.95	0.78 - 1.15					0.77	0.58 - 1.01
Proportion of children fully immunized[d]					0.63	0.43 - 0.93					0.44	0.18 - 1.09
Intercept	-3.32	-3.60 - -3.05			-3.08	-3.43 - -2.73	-3.21	-3.57 - -2.84			-3.19	-3.70 - -2.68
AIC/DIC (multilevel model) of full models	7531		6245		7678		6671		5362		6178	

Table 4: Cont'd

	Congo (Brazzaville)						Congo Democratic Republic					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.63	0.41 - 0.97	0.65	0.42 - 0.98	0.53	0.40 - 0.71	0.55	0.42 - 0.70	0.56	0.43 - 0.72	0.72	0.60 - 0.87
6–11 months	0.66	0.46 - 0.95	0.69	0.48 - 0.98	0.59	0.44 - 0.81	0.64	0.50 - 0.83	0.68	0.53 - 0.87	0.82	0.68 - 0.99
12–23 months	0.48	0.34 - 0.68	0.51	0.36 - 0.73	0.59	0.43 - 0.81	0.54	0.41 - 0.72	0.58	0.43 - 0.77	0.74	0.60 - 0.91
24+ months	0.40	0.23 - 0.70	0.44	0.25 - 0.76	0.44	0.29 - 0.66	0.52	0.36 - 0.75	0.56	0.38 - 0.81	0.69	0.54 - 0.87
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	0.85	0.52 - 1.42	0.83	0.47 - 1.44	0.77	0.46 - 1.31	1.08	0.76 - 1.54	1.01	0.71 - 1.45	0.77	0.58 - 1.04
2-3 and 24+ months	0.78	0.54 - 1.12	0.87	0.59 - 1.28	0.69	0.50 - 0.95	0.67	0.49 - 0.91	0.66	0.47 - 0.91	0.67	0.52 - 0.85
4+ and < 24 months	1.04	0.60 - 1.82	1.01	0.57 - 1.79	0.68	0.37 - 1.24	1.31	0.91 - 1.91	1.18	0.81 - 1.70	1.16	0.89 - 1.53
4+ and 24+ months	0.73	0.44 - 1.19	0.80	0.47 - 1.34	0.79	0.55 - 1.15	0.63	0.45 - 0.90	0.58	0.41 - 0.83	0.60	0.46 - 0.77
Child's sex												
Female[ref]												
Male	1.00	0.79 - 1.26	1.00	0.80 - 1.26	1.09	0.88 - 1.36	1.22	1.04 - 1.43	1.21	1.02 - 1.44	1.10	0.96 - 1.27
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	1.01	0.72 - 1.43	0.92	0.63 - 1.33	0.98	0.71 - 1.36	0.98	0.71 - 1.34	1.13	0.80 - 1.60	1.01	0.80 - 1.27
35 years or more	1.27	0.75 - 2.16	1.05	0.60 - 1.86	1.07	0.65 - 1.76	1.19	0.71 - 1.97	1.40	0.84 - 2.34	1.27	0.93 - 1.73
Mother's education												
No education[ref]												
Primary	0.86	0.59 - 1.25	0.91	0.60 - 1.38	1.07	0.72 - 1.58	0.80	0.63 - 1.02	0.74	0.57 - 0.96	0.90	0.75 - 1.08
Secondary or higher	0.59	0.40 - 0.85	0.67	0.43 - 1.05	0.73	0.50 - 1.08	0.68	0.48 - 0.97	0.74	0.52 - 1.05	0.79	0.62 - 1.00
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.21	0.93 - 1.56	1.46	1.05 - 2.03	1.09	0.76 - 1.56	0.99	0.71 - 1.38	1.07	0.73 - 1.57	0.99	0.79 - 1.25
3rd quintile	0.97	0.68 - 1.37	1.21	0.80 - 1.82	1.13	0.74 - 1.72	0.77	0.53 - 1.12	0.84	0.55 - 1.26	0.88	0.69 - 1.14
4th quintile	0.92	0.57 - 1.47	1.52	0.81 - 2.83	1.20	0.72 - 2.00	0.97	0.68 - 1.38	0.98	0.65 - 1.49	1.07	0.79 - 1.45
5th quintile (Richest)	0.75	0.47 - 1.19	0.90	0.44 - 1.87	0.94	0.53 - 1.66	0.60	0.40 - 0.89	0.63	0.30 - 1.31	0.65	0.44 - 0.97
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	1.08	0.82 - 1.42	1.03	0.76 - 1.39	0.95	0.74 - 1.22	0.76	0.60 - 0.97	0.86	0.65 - 1.15	0.84	0.71 - 0.99
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.95	0.64 - 1.40					0.77	0.56 - 1.06
Proportion of households poor[a]												
Low[ref]												
High					1.22	0.83 - 1.79					0.98	0.75 - 1.28
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.75	0.54 - 1.04					1.11	0.87 - 1.42
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					1.05	0.53 - 2.06					1.09	0.86 - 1.39
Proportion of children fully immunized[d]					0.88	0.45 - 1.73					0.57	0.34 - 0.94
Intercept	-2.97	-3.45 - -2.50			-3.68	-4.24 - -3.12	-2.72	-3.20 - -2.24			-3.31	-3.75 - -2.88
AIC/DIC (multilevel model) of full models	3966		3048		3640		8400		7171		8308	

Table 4: Cont'd

	Ethiopia						Gabon					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.62	0.50 - 0.76	0.64	0.52 - 0.79	0.69	0.57 - 0.82	0.46	0.31 - 0.70	0.49	0.33 - 0.73	0.58	0.42 - 0.81
6–11 months	0.36	0.26 - 0.49	0.38	0.28 - 0.51	0.39	0.31 - 0.49	0.44	0.29 - 0.66	0.47	0.32 - 0.71	0.54	0.38 - 0.77
12–23 months	0.32	0.23 - 0.44	0.34	0.24 - 0.47	0.36	0.28 - 0.47	0.44	0.28 - 0.68	0.48	0.32 - 0.74	0.54	0.37 - 0.79
24+ months	0.47	0.34 - 0.65	0.52	0.37 - 0.72	0.60	0.47 - 0.75	0.57	0.34 - 0.96	0.65	0.39 - 1.08	0.67	0.45 - 1.01
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.21	0.86 - 1.71	1.25	0.85 - 1.84	1.09	0.80 - 1.48	0.66	0.36 - 1.23	0.53	0.27 - 1.04	0.70	0.39 - 1.26
2-3 and 24+ months	0.53	0.39 - 0.72	0.49	0.35 - 0.69	0.58	0.45 - 0.76	0.77	0.50 - 1.19	0.72	0.45 - 1.15	0.69	0.45 - 1.04
4+ and < 24 months	1.80	1.25 - 2.60	1.72	1.15 - 2.56	1.53	1.14 - 2.06	1.29	0.70 - 2.38	1.06	0.49 - 2.32	1.10	0.63 - 1.92
4+ and 24+ months	0.67	0.49 - 0.91	0.64	0.45 - 0.91	0.63	0.48 - 0.83	0.63	0.36 - 1.07	0.57	0.29 - 1.11	0.54	0.33 - 0.87
Child's sex												
Female[ref]												
Male	1.23	1.03 - 1.47	1.28	1.05 - 1.56	1.34	1.16 - 1.56	1.38	1.05 - 1.82	1.48	1.09 - 2.00	1.33	1.02 - 1.74
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.66	0.49 - 0.88	0.70	0.51 - 0.96	0.66	0.53 - 0.83	0.92	0.60 - 1.40	0.96	0.56 - 1.65	1.05	0.70 - 1.59
35 years or more	0.74	0.48 - 1.12	0.75	0.48 - 1.18	0.81	0.59 - 1.12	1.34	0.72 - 2.51	1.51	0.73 - 3.11	1.38	0.76 - 2.52
Mother's education												
No education[ref]												
Primary	0.74	0.55 - 1.00	0.79	0.59 - 1.06	0.78	0.61 - 0.99	0.75	0.41 - 1.36	0.83	0.44 - 1.59	0.87	0.52 - 1.45
Secondary or higher	0.35	0.20 - 0.63	0.39	0.19 - 0.80	0.56	0.34 - 0.91	0.87	0.46 - 1.65	0.84	0.42 - 1.69	0.83	0.48 - 1.42
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.14	0.88 - 1.48	1.05	0.79 - 1.40	1.12	0.88 - 1.44	1.35	0.95 - 1.91	1.05	0.65 - 1.69	1.33	0.91 - 1.93
3rd quintile	1.34	1.06 - 1.69	1.26	0.96 - 1.65	1.25	0.97 - 1.61	1.10	0.74 - 1.64	1.08	0.56 - 2.07	1.42	0.81 - 2.48
4th quintile	1.12	0.88 - 1.42	0.98	0.72 - 1.34	1.11	0.85 - 1.45	1.13	0.68 - 1.86	1.09	0.50 - 2.36	1.25	0.68 - 2.32
5th quintile (Richest)	0.89	0.65 - 1.23	0.67	0.43 - 1.05	0.70	0.48 - 1.01	0.68	0.39 - 1.18	0.76	0.34 - 1.74	0.83	0.40 - 1.72
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	1.63	1.07 - 2.49	1.96	1.14 - 3.37	0.99	0.69 - 1.42	0.50	0.36 - 0.68	0.47	0.32 - 0.67	0.44	0.32 - 0.61
Community-level variable												
Place of residence												
Rural[ref]												
Urban					1.14	0.77 - 1.68					1.27	0.84 - 1.91
Proportion of households poor[a]												
Low[ref]												
High					0.81	0.66 - 1.00					1.49	0.92 - 2.41
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.96	0.74 - 1.24					1.36	0.98 - 1.89
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					1.04	0.86 - 1.25					0.77	0.47 - 1.26
Proportion of children fully immunized[d]					0.60	0.34 - 1.06					0.19	0.04 - 0.81
Intercept	-2.89	-3.22 - -2.57			-3.28	-3.64 - -2.93	-2.92	-3.69 - -2.15			-4.00	-4.79 - -3.21
AIC/DIC (multilevel model) of full models	8377		6220		7704		2773		2115		2777	

Table 4: Cont'd

	Ghana						Guinea						
	Model 1		Model 2		Model 3		Model 1			Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI		OR	95% CI	OR	95% CI
Individual-level variables													
Age of the child													
< 1 month[ref]													
1–5 months	0.34	0.22 - 0.54	0.38	0.24 - 0.58	0.40	0.27 - 0.61	0.65	0.52 - 0.82	0	0.66	0.53 - 0.83	0.60	0.48 - 0.75
6–11 months	0.30	0.18 - 0.48	0.33	0.20 - 0.54	0.30	0.19 - 0.48	0.58	0.46 - 0.74	0	0.60	0.47 - 0.76	0.59	0.46 - 0.74
12–23 months	0.33	0.20 - 0.54	0.38	0.24 - 0.63	0.37	0.23 - 0.60	0.59	0.46 - 0.77	0	0.63	0.49 - 0.80	0.58	0.46 - 0.74
24+ months	0.27	0.14 - 0.51	0.34	0.18 - 0.64	0.33	0.18 - 0.59	0.73	0.54 - 0.99	0	0.77	0.57 - 1.05	0.76	0.59 - 0.98
Birth order and preceding birth interval													
First birth[ref]													
2-3 and < 24 months	0.94	0.43 - 2.07	0.69	0.29 - 1.62	0.59	0.25 - 1.37	1.13	0.78 - 1.65	0	0.95	0.65 - 1.39	1.12	0.72 - 1.74
2-3 and 24+ months	0.71	0.44 - 1.16	0.73	0.41 - 1.30	0.71	0.43 - 1.17	0.60	0.44 - 0.83	0	0.56	0.40 - 0.79	0.65	0.48 - 0.89
4+ and < 24 months	1.64	0.81 - 3.34	0.93	0.40 - 2.15	1.50	0.73 - 3.08	1.10	0.74 - 1.61	0	0.92	0.61 - 1.38	1.13	0.76 - 1.69
4+ and 24+ months	0.70	0.41 - 1.20	0.64	0.32 - 1.29	0.72	0.41 - 1.26	0.73	0.54 - 0.98	0	0.68	0.49 - 0.94	0.76	0.56 - 1.04
Child's sex													
Female[ref]													
Male	1.10	0.78 - 1.55	1.12	0.74 - 1.67	1.11	0.82 - 1.51	1.26	1.08 - 1.49	0	1.24	1.05 - 1.47	1.23	1.05 - 1.44
Mother's age at child's birth													
Less than 20 years[ref]													
20-34 years	1.14	0.60 - 2.18	1.17	0.57 - 2.40	1.14	0.66 - 2.00	1.02	0.75 - 1.39	0	1.09	0.79 - 1.50	0.97	0.74 - 1.26
35 years or more	1.82	0.80 - 4.12	2.22	0.85 - 5.78	1.77	0.86 - 3.63	1.26	0.88 - 1.82	0	1.39	0.95 - 2.06	1.20	0.86 - 1.68
Mother's education													
No education[ref]													
Primary	1.19	0.77 - 1.83	1.35	0.79 - 2.29	1.03	0.67 - 1.61	1.01	0.73 - 1.39	0	1.18	0.84 - 1.66	1.02	0.74 - 1.41
Secondary or higher	0.79	0.49 - 1.26	1.03	0.58 - 1.84	0.85	0.51 - 1.42	0.64	0.37 - 1.10	0	0.61	0.33 - 1.14	0.71	0.43 - 1.17
Household wealth Index													
1st quintile (Poorest)[ref]													
2nd quintile	0.75	0.46 - 1.22	0.62	0.31 - 1.25	0.74	0.44 - 1.25	0.82	0.65 - 1.04	0	0.83	0.64 - 1.09	0.86	0.67 - 1.10
3rd quintile	1.17	0.71 - 1.94	0.71	0.26 - 1.90	0.82	0.42 - 1.61	0.83	0.65 - 1.06	0	0.77	0.57 - 1.03	0.87	0.67 - 1.12
4th quintile	0.93	0.52 - 1.66	0.65	0.23 - 1.86	0.78	0.37 - 1.61	0.94	0.75 - 1.19	0	1.05	0.76 - 1.45	1.01	0.73 - 1.41
5th quintile (Richest)	0.89	0.45 - 1.77	0.66	0.19 - 2.23	0.81	0.33 - 1.95	0.61	0.40 - 0.91	0	1.26	0.67 - 2.35	0.68	0.42 - 1.10
Skilled attendant at delivery													
Other (incl. none)[ref]													
Doctor, nurse, or midwife	1.06	0.72 - 1.57	0.95	0.58 - 1.57	0.95	0.65 - 1.40	0.96	0.75 - 1.23	0	0.92	0.69 - 1.21	0.92	0.73 - 1.15
Community-level variable													
Place of residence													
Rural[ref]													
Urban					0.89	0.54 - 1.48						0.97	0.69 - 1.35
Proportion of households poor[a]													
Low[ref]													
High					0.51	0.30 - 0.87						0.92	0.73 - 1.16
Proportion of women aged 15-49 in the community with secondary or higher education[b]													
Low[ref]													
High					0.64	0.40 - 1.02						0.96	0.76 - 1.22
Ethnic Homogeneity[c]													
Not homogenous[ref]													
Totally homogenous					1.04	0.73 - 1.49						1.01	0.84 - 1.21
Proportion of children fully immunized[d]					0.69	0.30 - 1.56						0.70	0.42 - 1.18
Intercept	-3.50	-4.22 - -2.77			-3.20	-4.02 - -2.38	-2.98	-3.28 - -2.68	0			-3.13	-3.50 - -2.75
AIC/DIC (multilevel model) of full models	1784		1241		1914		6306		0	5275		6299	

Table 4: Cont'd

	Kenya						Lesotho					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.41	0.28 - 0.59	0.43	0.30 - 0.61	0.48	0.36 - 0.64	0.62	0.46 - 0.84	0.66	0.49 - 0.89	0.66	0.49 - 0.88
6–11 months	0.27	0.17 - 0.43	0.28	0.18 - 0.46	0.35	0.25 - 0.49	0.45	0.31 - 0.66	0.49	0.34 - 0.72	0.49	0.35 - 0.70
12–23 months	0.39	0.26 - 0.60	0.43	0.28 - 0.65	0.45	0.33 - 0.63	0.22	0.14 - 0.35	0.25	0.15 - 0.39	0.32	0.21 - 0.49
24+ months	0.17	0.10 - 0.30	0.19	0.11 - 0.34	0.23	0.14 - 0.39	0.19	0.10 - 0.34	0.22	0.12 - 0.39	0.22	0.13 - 0.38
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.85	1.17 - 2.93	1.78	1.10 - 2.88	1.56	0.98 - 2.50	2.12	1.27 - 3.55	1.70	0.91 - 3.18	1.69	0.98 - 2.89
2-3 and 24+ months	1.12	0.70 - 1.80	1.16	0.70 - 1.95	1.18	0.80 - 1.74	0.82	0.55 - 1.22	0.77	0.50 - 1.19	0.78	0.54 - 1.12
4+ and < 24 months	1.68	0.93 - 3.01	1.54	0.79 - 3.00	1.78	1.06 - 2.97	1.27	0.55 - 2.92	1.05	0.45 - 2.44	1.00	0.47 - 2.11
4+ and 24+ months	1.11	0.65 - 1.90	1.18	0.64 - 2.16	1.41	0.90 - 2.20	0.66	0.39 - 1.11	0.61	0.34 - 1.09	0.58	0.37 - 0.90
Child's sex												
Female[ref]												
Male	1.33	1.00 - 1.78	1.44	1.07 - 1.93	1.34	1.06 - 1.69	1.02	0.79 - 1.34	1.04	0.78 - 1.39	1.09	0.83 - 1.43
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.65	0.44 - 0.95	0.69	0.43 - 1.09	0.72	0.50 - 1.04	1.09	0.76 - 1.55	1.06	0.70 - 1.62	1.19	0.80 - 1.79
35 years or more	1.09	0.57 - 2.08	1.12	0.55 - 2.28	0.95	0.55 - 1.61	1.55	0.83 - 2.90	1.62	0.82 - 3.17	1.72	0.98 - 3.01
Mother's education												
No education[ref]												
Primary	1.02	0.66 - 1.57	0.70	0.33 - 1.46	1.23	0.83 - 1.82	0.56	0.32 - 0.98	0.50	0.26 - 0.96	0.56	0.28 - 1.14
Secondary or higher	0.97	0.59 - 1.61	0.77	0.38 - 1.54	1.20	0.74 - 1.94	0.50	0.27 - 0.92	0.60	0.28 - 1.26	0.53	0.25 - 1.13
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	0.86	0.59 - 1.27	0.75	0.49 - 1.15	1.12	0.75 - 1.68	1.13	0.77 - 1.65	1.40	0.90 - 2.20	1.17	0.78 - 1.74
3rd quintile	0.96	0.60 - 1.55	0.92	0.54 - 1.58	1.24	0.80 - 1.92	1.34	0.91 - 1.99	1.89	1.11 - 3.21	1.70	1.03 - 2.80
4th quintile	0.54	0.32 - 0.93	0.69	0.37 - 1.29	0.76	0.45 - 1.28	1.28	0.84 - 1.95	1.58	0.87 - 2.88	1.79	1.04 - 3.09
5th quintile (Richest)	0.89	0.52 - 1.54	1.51	0.65 - 3.50	1.00	0.55 - 1.82	1.13	0.73 - 1.75	1.45	0.72 - 2.90	1.74	0.95 - 3.19
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	1.17	0.85 - 1.59	1.22	0.87 - 1.70	1.07	0.81 - 1.41	0.96	0.70 - 1.32	0.83	0.57 - 1.21	0.84	0.62 - 1.14
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.77	0.48 - 1.23					1.22	0.78 - 1.91
Proportion of households poor[a]												
Low[ref]												
High					0.83	0.57 - 1.20					1.42	0.91 - 2.20
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.94	0.66 - 1.34					0.90	0.64 - 1.27
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					0.91	0.68 - 1.22						
Proportion of children fully immunized[d]					0.46	0.21 - 1.04					1.08	0.57 - 2.06
Intercept	-3.44	-4.16 - -2.73			-4.23	-4.89 - -3.57	-2.73	-3.40 - -2.07			-4.01	-5.09 - -2.93
AIC/DIC (multilevel model) of full models	4881		3520		4398		3065		2191		2919	

Table 4: Cont'd

	Liberia						Madagascar					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.66	0.47 - 0.93	0.68	0.48 - 0.95	0.68	0.53 - 0.88	0.47	0.36 - 0.60	0.48	0.37 - 0.62	0.51	0.41 - 0.63
6–11 months	0.49	0.35 - 0.70	0.52	0.36 - 0.74	0.56	0.42 - 0.75	0.49	0.38 - 0.62	0.51	0.40 - 0.65	0.54	0.44 - 0.68
12–23 months	0.44	0.30 - 0.65	0.47	0.32 - 0.68	0.54	0.40 - 0.73	0.24	0.17 - 0.34	0.25	0.18 - 0.36	0.30	0.22 - 0.41
24+ months	0.31	0.20 - 0.48	0.33	0.21 - 0.51	0.42	0.29 - 0.60	0.44	0.31 - 0.63	0.47	0.33 - 0.67	0.45	0.34 - 0.60
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.18	0.64 - 2.15	1.10	0.57 - 2.13	1.30	0.87 - 1.95	1.06	0.77 - 1.47	0.98	0.70 - 1.39	0.85	0.61 - 1.20
2-3 and 24+ months	0.84	0.51 - 1.39	0.87	0.52 - 1.47	0.80	0.59 - 1.10	0.80	0.59 - 1.08	0.80	0.58 - 1.10	0.70	0.53 - 0.91
4+ and < 24 months	1.70	0.95 - 3.05	1.51	0.82 - 2.75	2.05	1.38 - 3.04	1.42	0.98 - 2.05	1.33	0.88 - 1.99	1.18	0.86 - 1.63
4+ and 24+ months	0.92	0.54 - 1.58	0.87	0.50 - 1.53	0.92	0.66 - 1.30	0.85	0.60 - 1.21	0.83	0.57 - 1.20	0.76	0.57 - 1.01
Child's sex												
Female[ref]												
Male	1.21	0.96 - 1.52	1.27	0.97 - 1.67	1.20	0.98 - 1.47	1.08	0.88 - 1.33	1.12	0.89 - 1.41	1.19	1.02 - 1.40
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.58	0.36 - 0.95	0.55	0.33 - 0.90	0.65	0.47 - 0.89	0.94	0.69 - 1.27	0.94	0.68 - 1.31	0.89	0.69 - 1.15
35 years or more	0.71	0.40 - 1.27	0.72	0.40 - 1.29	0.66	0.43 - 1.02	1.54	1.02 - 2.31	1.61	1.05 - 2.47	1.38	0.98 - 1.95
Mother's education												
No education[ref]												
Primary	0.95	0.71 - 1.28	1.09	0.78 - 1.52	0.96	0.76 - 1.23	1.05	0.83 - 1.34	0.97	0.74 - 1.26	1.09	0.88 - 1.35
Secondary or higher	1.00	0.63 - 1.58	1.13	0.67 - 1.92	0.90	0.62 - 1.29	1.05	0.67 - 1.63	0.92	0.59 - 1.43	0.97	0.69 - 1.36
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	0.78	0.56 - 1.10	0.63	0.44 - 0.91	0.93	0.67 - 1.28	0.96	0.74 - 1.25	1.02	0.75 - 1.37	1.09	0.86 - 1.38
3rd quintile	0.84	0.56 - 1.25	0.71	0.43 - 1.18	1.02	0.70 - 1.49	0.86	0.63 - 1.16	0.89	0.61 - 1.30	0.99	0.74 - 1.34
4th quintile	0.94	0.64 - 1.38	0.81	0.47 - 1.38	0.96	0.62 - 1.49	0.81	0.59 - 1.12	0.99	0.68 - 1.43	1.11	0.80 - 1.54
5th quintile (Richest)	0.79	0.48 - 1.30	0.69	0.36 - 1.30	0.91	0.54 - 1.54	0.82	0.52 - 1.30	1.37	0.70 - 2.67	1.14	0.72 - 1.81
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.99	0.72 - 1.35	1.00	0.66 - 1.50	0.91	0.73 - 1.15	0.87	0.70 - 1.08	0.90	0.70 - 1.17	0.85	0.70 - 1.04
Community-level variable												
Place of residence												
Rural[ref]												
Urban					1.24	0.91 - 1.68					0.95	0.68 - 1.33
Proportion of households poor[a]												
Low[ref]												
High					0.88	0.65 - 1.19					1.21	0.95 - 1.54
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.91	0.68 - 1.23					0.88	0.70 - 1.11
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					0.83	0.62 - 1.11						
Proportion of children fully immunized[d]					0.78	0.40 - 1.50					1.12	0.72 - 1.76
Intercept	-2.99	-3.43 - -2.56			-3.60	-4.11 - -3.09	-3.65	-3.99 - -3.31			-4.43	-4.82 - -4.05
AIC/DIC (multilevel model) of full models	4352		3500		4411		3525		2353		3094	

Table 4: Cont'd

	Malawi						Mali					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.87	0.71 - 1.06	0.89	0.73 - 1.09	0.81	0.68 - 0.97	0.53	0.44 - 0.64	0.54	0.44 - 0.65	0.52	0.45 - 0.60
6–11 months	0.92	0.76 - 1.11	0.96	0.80 - 1.16	0.95	0.79 - 1.13	0.58	0.48 - 0.70	0.59	0.49 - 0.71	0.59	0.51 - 0.68
12–23 months	0.76	0.60 - 0.96	0.81	0.64 - 1.02	0.75	0.61 - 0.91	0.72	0.59 - 0.88	0.74	0.60 - 0.91	0.75	0.65 - 0.87
24+ months	0.66	0.50 - 0.88	0.71	0.54 - 0.95	0.63	0.48 - 0.81	0.95	0.79 - 1.14	0.98	0.81 - 1.18	1.01	0.86 - 1.18
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.19	0.87 - 1.62	0.98	0.70 - 1.36	0.97	0.73 - 1.31	0.96	0.76 - 1.22	0.94	0.74 - 1.21	0.88	0.70 - 1.10
2-3 and 24+ months	0.70	0.56 - 0.87	0.62	0.48 - 0.79	0.68	0.55 - 0.83	0.66	0.54 - 0.81	0.67	0.54 - 0.82	0.65	0.53 - 0.78
4+ and < 24 months	1.57	1.15 - 2.16	1.23	0.87 - 1.72	1.31	0.97 - 1.78	1.22	0.97 - 1.53	1.15	0.91 - 1.46	1.14	0.91 - 1.42
4+ and 24+ months	0.63	0.48 - 0.83	0.55	0.41 - 0.74	0.60	0.48 - 0.75	0.71	0.55 - 0.90	0.69	0.53 - 0.89	0.66	0.54 - 0.81
Child's sex												
Female[ref]												
Male	1.24	1.08 - 1.44	1.24	1.06 - 1.45	1.30	1.14 - 1.48	1.02	0.91 - 1.15	1.02	0.90 - 1.15	1.09	0.98 - 1.21
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.92	0.74 - 1.13	0.97	0.77 - 1.22	0.87	0.71 - 1.06	0.85	0.70 - 1.03	0.83	0.67 - 1.03	0.87	0.73 - 1.03
35 years or more	0.92	0.67 - 1.28	1.03	0.74 - 1.45	0.88	0.65 - 1.18	0.80	0.61 - 1.07	0.79	0.58 - 1.07	0.88	0.70 - 1.11
Mother's education												
No education[ref]												
Primary	0.85	0.72 - 1.00	0.79	0.65 - 0.95	0.88	0.76 - 1.03	0.91	0.74 - 1.13	0.95	0.76 - 1.18	0.95	0.78 - 1.16
Secondary or higher	0.59	0.40 - 0.88	0.56	0.37 - 0.85	0.62	0.45 - 0.84	0.54	0.34 - 0.86	0.57	0.34 - 0.94	0.52	0.35 - 0.75
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.04	0.83 - 1.30	0.99	0.77 - 1.28	0.99	0.80 - 1.21	1.03	0.87 - 1.21	1.06	0.88 - 1.26	0.99	0.83 - 1.17
3rd quintile	1.01	0.82 - 1.25	1.02	0.81 - 1.28	0.97	0.79 - 1.20	0.89	0.74 - 1.06	0.89	0.73 - 1.08	0.82	0.69 - 0.98
4th quintile	0.90	0.71 - 1.14	0.86	0.66 - 1.12	0.90	0.72 - 1.14	0.93	0.78 - 1.11	0.98	0.82 - 1.17	0.89	0.73 - 1.07
5th quintile (Richest)	0.80	0.56 - 1.15	0.93	0.65 - 1.34	0.89	0.65 - 1.20	0.65	0.51 - 0.84	0.96	0.69 - 1.32	0.73	0.55 - 0.96
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.83	0.70 - 0.97	0.78	0.65 - 0.93	0.84	0.72 - 0.96	0.86	0.69 - 1.07	0.96	0.77 - 1.19	0.83	0.70 - 0.98
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.70	0.51 - 0.97					0.92	0.74 - 1.14
Proportion of households poor[a]												
Low[ref]												
High					0.96	0.81 - 1.13					1.16	0.99 - 1.37
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					1.01	0.85 - 1.19					0.93	0.79 - 1.11
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					0.93	0.75 - 1.14					0.75	0.61 - 0.92
Proportion of children fully immunized[d]					1.06	0.66 - 1.71					1.38	0.97 - 1.98
Intercept	-3.18	-3.49 - -2.88			-3.41	-3.76 - -3.06	-2.63	-2.86 - -2.40			-3.20	-3.46 - -2.93
AIC/DIC (multilevel model) of full models	9324		7925		9677		15774		13388		14837	

Table 4: Cont'd

	Mozambique						Namibia					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	1.00	0.82 - 1.22	1.03	0.84 - 1.25	1.04	0.88 - 1.23	0.49	0.34 - 0.69	0.52	0.37 - 0.72	0.59	0.43 - 0.81
6–11 months	0.73	0.58 - 0.91	0.77	0.61 - 0.96	0.86	0.72 - 1.03	0.45	0.31 - 0.67	0.48	0.33 - 0.71	0.54	0.38 - 0.77
12–23 months	0.50	0.40 - 0.64	0.55	0.43 - 0.69	0.67	0.55 - 0.83	0.49	0.33 - 0.72	0.53	0.36 - 0.78	0.59	0.42 - 0.84
24+ months	0.52	0.38 - 0.69	0.58	0.43 - 0.78	0.60	0.47 - 0.76	0.35	0.21 - 0.59	0.39	0.23 - 0.65	0.47	0.30 - 0.73
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.06	0.79 - 1.44	0.87	0.62 - 1.21	1.01	0.79 - 1.31	1.75	0.86 - 3.55	1.35	0.61 - 3.01	1.35	0.78 - 2.35
2-3 and 24+ months	0.59	0.47 - 0.75	0.55	0.43 - 0.71	0.59	0.48 - 0.71	1.35	0.91 - 2.01	1.40	0.92 - 2.12	1.08	0.78 - 1.51
4+ and < 24 months	1.40	1.05 - 1.88	1.31	0.94 - 1.82	1.23	0.92 - 1.64	2.05	0.93 - 4.50	1.79	0.86 - 3.71	1.44	0.76 - 2.75
4+ and 24+ months	0.61	0.47 - 0.79	0.57	0.43 - 0.76	0.56	0.44 - 0.71	1.84	1.12 - 3.02	1.67	1.04 - 2.68	1.36	0.89 - 2.07
Child's sex												
Female[ref]												
Male	1.05	0.91 - 1.20	1.04	0.89 - 1.21	1.08	0.95 - 1.23	1.34	1.03 - 1.75	1.36	1.02 - 1.82	1.26	1.00 - 1.61
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.79	0.66 - 0.96	0.88	0.71 - 1.08	0.81	0.66 - 0.99	0.71	0.42 - 1.22	0.69	0.40 - 1.20	0.77	0.53 - 1.12
35 years or more	0.70	0.50 - 0.99	0.71	0.50 - 1.01	0.72	0.54 - 0.96	0.74	0.39 - 1.40	0.80	0.43 - 1.50	0.98	0.58 - 1.64
Mother's education												
No education[ref]												
Primary	0.86	0.72 - 1.04	0.87	0.70 - 1.07	0.90	0.77 - 1.05	1.59	0.93 - 2.71	1.20	0.64 - 2.26	1.59	1.01 - 2.52
Secondary or higher	0.68	0.41 - 1.13	0.82	0.46 - 1.48	0.86	0.58 - 1.27	1.53	0.85 - 2.75	1.12	0.55 - 2.29	1.45	0.87 - 2.40
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.18	0.94 - 1.48	1.01	0.78 - 1.31	1.09	0.89 - 1.34	0.89	0.59 - 1.32	0.89	0.53 - 1.49	0.92	0.63 - 1.36
3rd quintile	1.11	0.90 - 1.36	0.83	0.63 - 1.08	0.99	0.80 - 1.24	1.01	0.67 - 1.52	1.03	0.58 - 1.83	1.03	0.68 - 1.54
4th quintile	0.94	0.73 - 1.22	0.70	0.50 - 0.98	0.92	0.71 - 1.19	0.77	0.48 - 1.24	0.70	0.33 - 1.47	0.69	0.41 - 1.15
5th quintile (Richest)	0.85	0.62 - 1.16	0.68	0.42 - 1.11	0.60	0.43 - 0.83	0.52	0.28 - 0.97	0.45	0.17 - 1.15	0.58	0.31 - 1.07
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.93	0.73 - 1.17	1.04	0.80 - 1.37	0.94	0.79 - 1.13	0.89	0.61 - 1.28	0.72	0.47 - 1.11	0.76	0.54 - 1.05
Community-level variable												
Place of residence												
Rural[ref]												
Urban					1.15	0.93 - 1.42					1.37	0.95 - 1.96
Proportion of households poor[a]												
Low[ref]												
High					0.83	0.66 - 1.04					1.04	0.73 - 1.49
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					1.03	0.83 - 1.28					1.12	0.82 - 1.54
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					1.28	1.10 - 1.49					1.15	0.86 - 1.54
Proportion of children fully immunized[d]					0.75	0.50 - 1.13					1.31	0.67 - 2.54
Intercept	-2.82	-3.11 - -2.54			-3.14	-3.50 - -2.79	-4.11	-4.81 - -3.42			-4.70	-5.43 - -3.97
AIC/DIC (multilevel model) of full models	10323		8379		7704		2964		2148		3113	

Table 4: Cont'd

	Niger						Nigeria					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.61	0.46 - 0.81	0.62	0.46 - 0.82	0.64	0.52 - 0.77	0.43	0.38 - 0.49	0.44	0.39 - 0.50	0.46	0.41 - 0.51
6–11 months	0.75	0.58 - 0.99	0.77	0.59 - 1.01	0.74	0.61 - 0.90	0.44	0.39 - 0.50	0.45	0.40 - 0.51	0.50	0.44 - 0.56
12–23 months	1.19	0.96 - 1.47	1.24	1.00 - 1.53	1.17	0.97 - 1.40	0.81	0.71 - 0.91	0.84	0.74 - 0.95	0.92	0.83 - 1.02
24+ months	1.26	1.00 - 1.58	1.33	1.06 - 1.68	1.37	1.12 - 1.68	0.82	0.72 - 0.94	0.87	0.76 - 0.99	0.99	0.89 - 1.11
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.14	0.82 - 1.59	1.05	0.75 - 1.46	1.02	0.76 - 1.37	1.60	1.37 - 1.87	1.52	1.29 - 1.79	1.37	1.17 - 1.60
2-3 and 24+ months	0.81	0.62 - 1.06	0.77	0.59 - 1.00	0.79	0.63 - 1.01	0.84	0.73 - 0.98	0.85	0.73 - 0.99	0.76	0.67 - 0.87
4+ and < 24 months	1.74	1.20 - 2.52	1.60	1.13 - 2.26	1.48	1.12 - 1.95	1.99	1.71 - 2.33	1.84	1.55 - 2.18	1.67	1.43 - 1.94
4+ and 24+ months	0.99	0.68 - 1.43	0.96	0.69 - 1.34	0.87	0.67 - 1.12	1.04	0.90 - 1.21	0.99	0.84 - 1.15	0.92	0.80 - 1.06
Child's sex												
Female[ref]												
Male	1.02	0.90 - 1.16	1.00	0.88 - 1.14	1.13	0.98 - 1.29	1.12	1.04 - 1.22	1.14	1.05 - 1.24	1.18	1.09 - 1.28
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.68	0.48 - 0.96	0.72	0.53 - 0.97	0.69	0.55 - 0.87	0.71	0.62 - 0.81	0.76	0.67 - 0.87	0.77	0.68 - 0.87
35 years or more	0.67	0.44 - 1.02	0.73	0.49 - 1.07	0.72	0.52 - 0.98	0.83	0.70 - 0.99	0.89	0.74 - 1.07	0.89	0.75 - 1.05
Mother's education												
No education[ref]												
Primary	1.00	0.78 - 1.29	0.94	0.70 - 1.27	1.08	0.85 - 1.38	0.94	0.84 - 1.05	1.04	0.90 - 1.19	0.99	0.87 - 1.12
Secondary or higher	0.69	0.33 - 1.43	0.79	0.40 - 1.55	0.67	0.42 - 1.06	0.84	0.73 - 0.97	0.90	0.75 - 1.08	0.85	0.72 - 1.01
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	0.98	0.77 - 1.26	0.94	0.72 - 1.24	1.10	0.87 - 1.39	0.92	0.82 - 1.03	0.87	0.76 - 0.99	0.97	0.87 - 1.08
3rd quintile	0.97	0.76 - 1.24	0.97	0.74 - 1.27	1.09	0.86 - 1.38	0.88	0.77 - 1.01	0.93	0.78 - 1.10	1.03	0.90 - 1.19
4th quintile	1.12	0.90 - 1.41	1.04	0.79 - 1.36	1.22	0.97 - 1.55	0.74	0.64 - 0.85	0.88	0.72 - 1.07	0.94	0.78 - 1.12
5th quintile (Richest)	0.81	0.58 - 1.11	1.00	0.68 - 1.47	0.92	0.66 - 1.29	0.52	0.41 - 0.65	0.73	0.54 - 0.98	0.73	0.59 - 0.91
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.78	0.62 - 0.99	0.94	0.74 - 1.19	0.89	0.70 - 1.14	1.05	0.94 - 1.18	1.24	1.09 - 1.42	1.10	0.97 - 1.24
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.76	0.55 - 1.06					0.85	0.74 - 0.98
Proportion of households poor[a]												
Low[ref]												
High					1.05	0.86 - 1.28					1.17	1.02 - 1.33
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.89	0.70 - 1.14					0.87	0.75 - 1.00
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					0.80	0.67 - 0.97					1.11	1.00 - 1.23
Proportion of children fully immunized[d]					1.00	0.59 - 1.67					0.93	0.65 - 1.33
Intercept	-3.09	-3.37 - -2.80			-3.42	-3.74 - -3.11	-2.94	-3.08 - -2.79			-3.62	-3.81 - -3.42
AIC/DIC (multilevel model) of full models	9762		7339		8596		26983		23628		26471	

Table 4: Cont'd

	Rwanda						Sengal					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.65	0.53 - 0.80	0.67	0.54 - 0.81	0.62	0.51 - 0.75	0.35	0.27 - 0.44	0.36	0.28 - 0.45	0.49	0.41 - 0.58
6–11 months	0.67	0.53 - 0.84	0.70	0.55 - 0.88	0.66	0.54 - 0.80	0.36	0.28 - 0.46	0.38	0.29 - 0.48	0.67	0.57 - 0.78
12–23 months	0.62	0.49 - 0.79	0.66	0.52 - 0.85	0.63	0.51 - 0.78	0.36	0.27 - 0.46	0.37	0.29 - 0.48	0.62	0.53 - 0.73
24+ months	0.60	0.47 - 0.76	0.66	0.52 - 0.84	0.63	0.49 - 0.81	0.75	0.57 - 0.98	0.79	0.60 - 1.04	0.74	0.62 - 0.88
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.01	0.76 - 1.34	0.98	0.72 - 1.33	1.00	0.77 - 1.31	0.79	0.58 - 1.09	0.69	0.49 - 0.97	1.25	0.98 - 1.59
2-3 and 24+ months	0.72	0.57 - 0.91	0.74	0.57 - 0.95	0.75	0.59 - 0.94	0.63	0.47 - 0.84	0.65	0.48 - 0.88	0.71	0.60 - 0.84
4+ and < 24 months	1.18	0.88 - 1.58	1.13	0.83 - 1.52	1.19	0.91 - 1.56	0.97	0.71 - 1.32	0.83	0.59 - 1.18	1.28	1.01 - 1.60
4+ and 24+ months	0.58	0.45 - 0.75	0.59	0.44 - 0.77	0.63	0.50 - 0.80	0.64	0.49 - 0.84	0.61	0.45 - 0.82	0.83	0.69 - 0.99
Child's sex												
Female[ref]												
Male	1.01	0.88 - 1.16	0.99	0.85 - 1.15	1.03	0.89 - 1.18	1.24	1.07 - 1.43	1.28	1.10 - 1.49	1.10	0.99 - 1.22
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.75	0.57 - 1.00	0.74	0.55 - 1.00	0.66	0.50 - 0.87	0.78	0.61 - 1.00	0.86	0.64 - 1.16	0.96	0.79 - 1.16
35 years or more	0.83	0.59 - 1.17	0.84	0.58 - 1.21	0.72	0.51 - 1.01	1.13	0.81 - 1.57	1.29	0.87 - 1.91	0.93	0.71 - 1.21
Mother's education												
No education[ref]												
Primary	0.88	0.74 - 1.03	0.89	0.75 - 1.06	0.89	0.75 - 1.04	0.63	0.47 - 0.83	0.60	0.43 - 0.82	1.07	0.91 - 1.27
Secondary or higher	0.62	0.42 - 0.91	0.62	0.41 - 0.94	0.61	0.41 - 0.88	0.92	0.53 - 1.60	0.84	0.45 - 1.56	0.69	0.50 - 0.95
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	0.83	0.67 - 1.01	0.82	0.66 - 1.01	0.83	0.67 - 1.03	0.98	0.79 - 1.21	0.96	0.76 - 1.22	1.04	0.88 - 1.23
3rd quintile	0.71	0.57 - 0.89	0.74	0.58 - 0.95	0.73	0.57 - 0.94	0.82	0.60 - 1.13	0.82	0.58 - 1.15	1.08	0.91 - 1.29
4th quintile	1.02	0.82 - 1.26	1.03	0.81 - 1.29	1.08	0.87 - 1.35	0.68	0.49 - 0.94	0.57	0.36 - 0.91	0.93	0.76 - 1.15
5th quintile (Richest)	0.62	0.46 - 0.83	0.74	0.53 - 1.04	0.70	0.52 - 0.94	0.47	0.31 - 0.71	0.35	0.18 - 0.67	0.73	0.55 - 0.96
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.79	0.65 - 0.96	0.89	0.71 - 1.10	0.89	0.74 - 1.08	0.99	0.79 - 1.23	1.04	0.82 - 1.32	0.92	0.80 - 1.06
Community-level variable												
Place of residence												
Rural[ref]												
Urban					0.70	0.54 - 0.91					0.90	0.77 - 1.05
Proportion of households poor[a]												
Low[ref]												
High					1.08	0.89 - 1.32					0.89	0.76 - 1.05
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.99	0.83 - 1.17					0.99	0.84 - 1.16
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous											1.04	0.90 - 1.21
Proportion of children fully immunized[d]					0.49	0.29 - 0.83					0.63	0.44 - 0.91
Intercept	-2.49	-2.82 - -2.17			-2.32	-2.80 - -1.83	-2.78	-3.03 - -2.53			-3.33	-3.64 - -3.02
AIC/DIC (multilevel model) of full models	8156		6432		7988		7895		6501		7773	

Table 4: Cont'd

	Sierra Leone						Swaziland					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.64	0.48 - 0.85	0.66	0.50 - 0.88	0.66	0.52 - 0.84	1.89	1.34 - 2.66	1.94	1.39 - 2.72	1.96	1.44 - 2.69
6–11 months	0.67	0.50 - 0.89	0.71	0.54 - 0.95	0.72	0.56 - 0.92	0.95	0.65 - 1.40	1.04	0.71 - 1.52	1.04	0.72 - 1.52
12–23 months	0.48	0.35 - 0.66	0.52	0.38 - 0.72	0.56	0.42 - 0.76	0.75	0.45 - 1.23	0.84	0.51 - 1.38	0.70	0.44 - 1.10
24+ months	0.48	0.32 - 0.73	0.54	0.36 - 0.82	0.51	0.35 - 0.73	0.56	0.30 - 1.03	0.65	0.35 - 1.18	0.67	0.40 - 1.14
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.22	0.80 - 1.86	1.21	0.76 - 1.93	1.17	0.82 - 1.68	0.92	0.47 - 1.81	0.82	0.45 - 1.51	0.79	0.42 - 1.49
2-3 and 24+ months	0.58	0.42 - 0.80	0.58	0.41 - 0.80	0.58	0.43 - 0.78	0.78	0.52 - 1.16	0.77	0.50 - 1.19	0.78	0.53 - 1.14
4+ and < 24 months	1.56	1.02 - 2.38	1.49	0.94 - 2.37	1.67	1.18 - 2.38	1.33	0.79 - 2.26	1.24	0.67 - 2.33	1.34	0.73 - 2.48
4+ and 24+ months	0.78	0.55 - 1.12	0.70	0.48 - 1.01	0.77	0.57 - 1.04	0.83	0.50 - 1.36	0.75	0.44 - 1.28	0.77	0.49 - 1.20
Child's sex												
Female[ref]												
Male	0.88	0.72 - 1.08	0.86	0.70 - 1.06	0.84	0.70 - 1.00	1.00	0.78 - 1.28	1.00	0.75 - 1.35	1.01	0.78 - 1.30
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.85	0.61 - 1.18	0.93	0.66 - 1.31	0.77	0.58 - 1.02	1.13	0.76 - 1.69	1.14	0.73 - 1.76	1.17	0.80 - 1.71
35 years or more	1.01	0.64 - 1.60	1.16	0.73 - 1.85	0.94	0.64 - 1.38	0.86	0.46 - 1.60	0.93	0.47 - 1.83	0.77	0.40 - 1.47
Mother's education												
No education[ref]												
Primary	1.16	0.81 - 1.66	1.14	0.76 - 1.71	1.14	0.86 - 1.50	0.90	0.54 - 1.50	0.99	0.60 - 1.63	0.98	0.62 - 1.56
Secondary or higher	1.11	0.76 - 1.64	1.10	0.71 - 1.70	1.01	0.73 - 1.40	0.73	0.44 - 1.23	0.92	0.56 - 1.52	0.76	0.46 - 1.25
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	0.57	0.39 - 0.82	0.55	0.37 - 0.81	0.63	0.46 - 0.87	0.85	0.54 - 1.34	1.01	0.61 - 1.68	0.77	0.48 - 1.23
3rd quintile	0.76	0.55 - 1.05	0.74	0.49 - 1.11	0.86	0.63 - 1.18	1.07	0.70 - 1.62	0.96	0.59 - 1.55	0.89	0.54 - 1.44
4th quintile	0.70	0.48 - 1.00	0.58	0.33 - 1.00	0.70	0.48 - 1.03	1.28	0.78 - 2.09	0.95	0.56 - 1.64	0.91	0.54 - 1.52
5th quintile (Richest)	0.87	0.59 - 1.28	0.65	0.34 - 1.25	0.80	0.52 - 1.23	1.19	0.76 - 1.86	0.81	0.46 - 1.45	0.81	0.45 - 1.45
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.81	0.64 - 1.01	0.85	0.65 - 1.11	0.89	0.70 - 1.12	1.00	0.75 - 1.33	1.05	0.77 - 1.42	0.92	0.68 - 1.26
Community-level variable												
Place of residence												
Rural[ref]												
Urban					1.73	1.22 - 2.46					1.27	0.84 - 1.91
Proportion of households poor[a]												
Low[ref]												
High					1.00	0.70 - 1.42					0.80	0.55 - 1.18
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.73	0.55 - 0.98					0.87	0.63 - 1.20
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					0.86	0.66 - 1.13						
Proportion of children fully immunized[d]					1.12	0.60 - 2.08					0.65	0.28 - 1.48
Intercept	-2.71	-3.07 - -2.36			-3.14	-3.75 - -2.53	-3.63	-4.23 - -3.02			-3.61	-4.26 - -2.96
AIC/DIC (multilevel model) of full models	4803		3816		4844		2527		1834		2520	

Table 4: Cont'd

	Tanzania						Uganda					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.57	0.45 - 0.72	0.59	0.46 - 0.74	0.56	0.46 - 0.70	0.75	0.59 - 0.95	0.76	0.60 - 0.97	0.80	0.65 - 0.98
6–11 months	0.52	0.40 - 0.69	0.55	0.42 - 0.72	0.54	0.44 - 0.67	0.82	0.64 - 1.04	0.84	0.66 - 1.07	0.94	0.77 - 1.15
12–23 months	0.52	0.38 - 0.72	0.56	0.41 - 0.76	0.57	0.45 - 0.72	0.93	0.73 - 1.18	0.98	0.77 - 1.24	1.00	0.80 - 1.24
24+ months	0.59	0.43 - 0.81	0.64	0.46 - 0.88	0.60	0.46 - 0.78	0.51	0.37 - 0.70	0.54	0.40 - 0.74	0.51	0.38 - 0.69
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	0.94	0.62 - 1.43	0.88	0.55 - 1.38	0.86	0.59 - 1.23	1.09	0.77 - 1.54	1.03	0.71 - 1.51	1.17	0.86 - 1.59
2-3 and 24+ months	0.96	0.72 - 1.28	0.99	0.73 - 1.33	0.90	0.68 - 1.20	0.80	0.59 - 1.09	0.79	0.56 - 1.09	0.76	0.57 - 1.01
4+ and < 24 months	1.56	1.08 - 2.27	1.43	0.97 - 2.12	1.40	0.97 - 2.03	1.20	0.86 - 1.68	1.13	0.78 - 1.63	1.09	0.81 - 1.48
4+ and 24+ months	0.79	0.56 - 1.12	0.82	0.57 - 1.19	0.78	0.56 - 1.08	0.74	0.55 - 0.99	0.72	0.53 - 0.98	0.71	0.54 - 0.95
Child's sex												
Female[ref]												
Male	1.09	0.91 - 1.31	1.11	0.91 - 1.36	1.17	0.98 - 1.38	1.25	1.07 - 1.47	1.27	1.07 - 1.49	1.31	1.13 - 1.52
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	0.83	0.61 - 1.14	0.79	0.57 - 1.10	0.74	0.56 - 0.98	0.87	0.67 - 1.15	0.93	0.69 - 1.26	0.96	0.74 - 1.24
35 years or more	0.96	0.62 - 1.49	0.83	0.54 - 1.28	0.81	0.55 - 1.21	1.13	0.79 - 1.61	1.19	0.81 - 1.74	1.23	0.87 - 1.75
Mother's education												
No education[ref]												
Primary	0.84	0.68 - 1.03	0.78	0.60 - 1.00	0.91	0.75 - 1.10	0.90	0.71 - 1.14	0.97	0.76 - 1.24	0.98	0.81 - 1.19
Secondary or higher	0.69	0.37 - 1.27	0.70	0.35 - 1.40	0.58	0.38 - 0.88	0.70	0.47 - 1.04	0.77	0.50 - 1.19	0.68	0.49 - 0.95
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.36	1.07 - 1.74	1.26	0.96 - 1.67	1.22	0.95 - 1.55	0.97	0.77 - 1.23	0.99	0.74 - 1.32	0.88	0.71 - 1.10
3rd quintile	1.26	0.97 - 1.64	1.24	0.91 - 1.67	1.13	0.87 - 1.48	0.86	0.67 - 1.12	0.88	0.63 - 1.24	0.78	0.59 - 1.02
4th quintile	0.93	0.69 - 1.26	0.96	0.67 - 1.36	0.93	0.69 - 1.25	0.98	0.75 - 1.28	1.01	0.69 - 1.48	0.86	0.66 - 1.13
5th quintile (Richest)	0.95	0.66 - 1.37	0.99	0.51 - 1.91	0.79	0.53 - 1.18	0.87	0.62 - 1.21	0.86	0.55 - 1.34	0.77	0.53 - 1.11
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	1.05	0.85 - 1.31	1.03	0.77 - 1.37	1.02	0.84 - 1.23	0.90	0.76 - 1.08	0.92	0.76 - 1.12	0.94	0.79 - 1.11
Community-level variable												
Place of residence												
Rural[ref]												
Urban					1.05	0.77 - 1.43					1.05	0.77 - 1.44
Proportion of households poor[a]												
Low[ref]												
High					0.99	0.77 - 1.27					0.95	0.76 - 1.18
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.98	0.78 - 1.24					0.90	0.75 - 1.08
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous												
Proportion of children fully immunized[d]					0.63	0.37 - 1.07					0.45	0.21 - 0.99
Intercept	-3.29	-3.60 - -2.97			-3.35	-3.85 - -2.84	-3.32	-3.72 - -2.92			-3.49	-3.93 - -3.05
AIC/DIC (multilevel model) of full models	6984		5318		6710		7109		6009		7271	

Table 4: Cont'd

	Zambia						Zimbabwe					
	Model 1		Model 2		Model 3		Model 1		Model 2		Model 3	
	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI	OR	95% CI
Individual-level variables												
Age of the child												
< 1 month[ref]												
1–5 months	0.49	0.37 - 0.66	0.50	0.38 - 0.68	0.58	0.45 - 0.75	1.03	0.77 - 1.38	1.07	0.80 - 1.43	1.05	0.81 - 1.37
6–11 months	0.52	0.39 - 0.69	0.53	0.40 - 0.71	0.62	0.47 - 0.80	0.55	0.39 - 0.76	0.59	0.42 - 0.83	0.61	0.44 - 0.84
12–23 months	0.51	0.38 - 0.69	0.53	0.40 - 0.71	0.65	0.50 - 0.86	0.44	0.30 - 0.66	0.49	0.33 - 0.73	0.50	0.35 - 0.73
24+ months	0.60	0.44 - 0.83	0.63	0.46 - 0.88	0.65	0.47 - 0.89	0.41	0.26 - 0.65	0.45	0.29 - 0.71	0.50	0.33 - 0.77
Birth order and preceding birth interval												
First birth[ref]												
2-3 and < 24 months	1.40	0.91 - 2.15	1.20	0.75 - 1.93	1.01	0.66 - 1.54	2.40	1.44 - 4.01	1.94	1.13 - 3.32	1.69	1.03 - 2.78
2-3 and 24+ months	0.74	0.54 - 1.00	0.68	0.49 - 0.94	0.69	0.50 - 0.93	0.92	0.59 - 1.46	0.92	0.56 - 1.51	0.97	0.70 - 1.34
4+ and < 24 months	1.17	0.74 - 1.84	0.95	0.61 - 1.48	0.79	0.50 - 1.23	3.52	1.76 - 7.05	3.50	1.74 - 7.04	2.29	1.32 - 3.97
4+ and 24+ months	0.63	0.43 - 0.92	0.56	0.37 - 0.84	0.56	0.41 - 0.78	1.03	0.60 - 1.76	1.15	0.65 - 2.04	0.96	0.64 - 1.44
Child's sex												
Female[ref]												
Male	1.23	1.01 - 1.50	1.18	0.96 - 1.45	1.26	1.04 - 1.53	1.02	0.80 - 1.30	1.07	0.82 - 1.39	1.18	0.94 - 1.49
Mother's age at child's birth												
Less than 20 years[ref]												
20-34 years	1.07	0.79 - 1.43	1.07	0.78 - 1.46	1.08	0.80 - 1.45	0.82	0.54 - 1.24	0.82	0.53 - 1.27	0.89	0.63 - 1.26
35 years or more	1.34	0.87 - 2.07	1.36	0.87 - 2.12	1.29	0.81 - 2.04	0.86	0.45 - 1.64	0.88	0.45 - 1.75	1.04	0.59 - 1.83
Mother's education												
No education[ref]												
Primary	1.08	0.80 - 1.46	1.39	0.97 - 1.99	1.05	0.76 - 1.45	1.23	0.65 - 2.32	1.46	0.67 - 3.16	1.12	0.58 - 2.16
Secondary or higher	0.89	0.60 - 1.33	1.18	0.73 - 1.92	0.97	0.64 - 1.46	1.46	0.73 - 2.91	1.73	0.82 - 3.63	1.16	0.58 - 2.31
Household wealth Index												
1st quintile (Poorest)[ref]												
2nd quintile	1.04	0.76 - 1.42	1.25	0.88 - 1.79	1.11	0.81 - 1.52	1.11	0.75 - 1.65	1.06	0.73 - 1.55	1.07	0.76 - 1.50
3rd quintile	1.11	0.82 - 1.49	1.36	0.95 - 1.95	1.28	0.90 - 1.82	1.05	0.66 - 1.66	0.95	0.59 - 1.53	1.08	0.73 - 1.61
4th quintile	1.35	0.97 - 1.89	1.62	0.98 - 2.67	1.54	0.99 - 2.41	0.92	0.60 - 1.40	0.71	0.42 - 1.20	0.81	0.46 - 1.42
5th quintile (Richest)	1.21	0.85 - 1.72	1.01	0.53 - 1.95	1.38	0.81 - 2.34	0.91	0.55 - 1.50	0.71	0.32 - 1.60	0.81	0.40 - 1.66
Skilled attendant at delivery												
Other (incl. none)[ref]												
Doctor, nurse, or midwife	0.97	0.76 - 1.24	0.96	0.72 - 1.29	0.96	0.77 - 1.20	0.75	0.57 - 0.99	0.67	0.47 - 0.95	0.73	0.57 - 0.94
Community-level variable												
Place of residence												
Rural[ref]												
Urban					1.55	1.07 - 2.23					1.04	0.61 - 1.76
Proportion of households poor[a]												
Low[ref]												
High					1.17	0.82 - 1.68					0.98	0.69 - 1.41
Proportion of women aged 15-49 in the community with secondary or higher education[b]												
Low[ref]												
High					0.68	0.51 - 0.90					1.10	0.80 - 1.52
Ethnic Homogeneity[c]												
Not homogenous[ref]												
Totally homogenous					1.34	0.95 - 1.89						
Proportion of children fully immunized[d]					0.82	0.35 - 1.93					0.75	0.40 - 1.38
Intercept	-3.48	-3.92 - -3.04			-4.33	-4.93 - -3.72	-3.84	-4.63 - -3.05			-4.34	-5.22 - -3.46
AIC/DIC (multilevel model) of full models	5301		4155		5034		3529		2673		3544	

Table 4: Cont'd

Note: ref = refernce category for each variable. n/a = no data available

Model 1: Ordinary discrete-time logistic regression predicting children's probability of dying by their fifth birthday with only individual-level variables as predictors (Age of the child ; Birth order and preceding birth interval; Child's sex; Mother's age at child's birth; Mother's education; Skilled attendant at delivery; Household wealth Index).

Model 2: Conditional discrete-time logistic, adds to Model 1 cluster-level fixed effects to control for unobserved community-level characteristics. The covariates are same as in Model 1.

Model 3: Multilevel logit discrete-time model with three-level random intercept: child (level 1), family (level 2) and cluster (level 3). Included as predictors, both individual- and community-level covariates. The Models were fitted using the Markov Chain Monte Carlo (MCMC) procedure in MLwin (version 2.16). To implement estimation using MCMC procedure, the first-order marginal quasi-likelihood (MQL) model is used to obtain initial start values for the parameter estimates.

a: Proportion of households poor (two lowest wealth quintiles) in the community.

b: Dichotomous variables indicating whether the proportion of women aged 15-49 in the community with secondary or higher education is high or low (cut-off at mean proportion).

c: Based on the measures of the ethno-linguistic fractionalization index (EFL), defined as the probability that two individuals selected at random from primary sampling unit, will be from different ethnic groups. Theoretically, for each cluster, the scale goes from 0 (totally homogenous) to 1 (complete diversity). For the purposes of the present analysis, the resulting scale ethno-linguistic fractionalization Index was then classified into dichotomous variables indicating whether the ethnic composition of the community is totally homogenous (ELF equal 0) categorized as 1; if cluster is not totally homogenous (EFL more than 0), then categorized as 0.

d: Percentage of children who received full immunization in the community (Child has received BCG, measles, and three doses of DPT and polio vaccines).

APPENDIX Table 1: Description of variables used in the analysis (variables names and definition)

Names	Description
Individual-level variable	
Age of the child in months	Number of months from time of birth until time of death or censoring (interview) (categorized as 1= 0 months; 2 = 1 to 5 months; 3=6 to 11 months; 4 =12 to 23 months; 5 = 24 to 59 months).
Sex	Whether the child is male or female (1 = male; 0 = female).
Birth order and preceding birth interval	Birth order and preceding birth interval were combined in one variable and is classified as follows: first birth, birth order 2-4 with short birth interval (< 24 months), birth order 2-4 with medium birth interval (24 – 47 months), birth order 2-4 with long birth interval (48+ months), birth order 5+ with short birth interval (< 24 months), birth order 5+ with medium birth interval (24 – 47 months), birth order 5+ with long birth interval (48+ months).
Mother's age at child birth	Respondent's age (in years) at child birth (1 = less than 20 years; 2 = 20-34 years; 3 = greater than 35 years.
Mother's education	Categorical variable indicating highest educational level that respondents completed (1 = no education; 2 = primary; 3 = secondary or higher education).
Household wealth Index	Index provided with the dataset is used. DHS program provides a composite index of household amenities based on the principal component analysis (PCA) and classified the population into quintiles: (1st quintile (Poorest); 2nd quintile; 3rd quintile; 4th quintile and 5th quintile (Richest). A quintile is assigned to each household as a measure of its relative socioeconomic level (for details see Rutstein and Johnson, 2004).
Place of delivery	Whether the place of delivery is in a health facility categorized as 1; if place of delivery is in home or other then as 0.
Skilled attendant at delivery	Deliveries assisted by either doctor, nurse/midwife categorized as 1; if no assistance then categorized as 0.
Community-level variable	
Urban	Whether the cluster is urban community according the definition of the country categorized as 1; if cluster is rural community then categorized as 0.
Community-level socio-economic status	Proportion of households poor (two lowest wealth quintiles) in the community.
Community-level education	Dichotomous variables indicating whether the proportion of women aged 15-49 in the community with secondary or higher education is high or low (cut-off at mean proportion).
Community-level Ethnic Homogeneity	Measure based on the concept of the index of Ethno-linguistic fractionalization (ELF). Ethno-linguistic fractionalization is the probability that two people randomly drawn from the population are from distinct ethnic groups (Fearon, 2003: 208). This Index is calculated as $ELF = 1 - \sum_i$ (Proportion of Ethno-linguistic group$_i$ in the population)^2. Theoretically, for each primary sampling unit, the scale goes from 0 (totally homogenous) to 1 (complete diversity). For the purposes of the present analysis, the resulting scale ethno-linguistic fractionalization Index was then classified into dichotomous variables indicating whether the ethnic composition of the community is totally homogenous (ELF equal 0) categorized as 1; if cluster is not totally homogenous (EFL more than 0), then categorized as 0.
Community child immunization coverage	Percentage of children who received full immunization in the community (Child has received BCG, measles, and three doses of DPT and polio vaccines).

APPENDIX Table 2: Number and percentage[1] of children by selected characteristics and country: births in the five years preceding the survey

Characteristics	Benin		Burkina Faso		Cameroon		Chad		Congo (Brazzaville)		Congo Democratic		Ethiopia		Gabon		Ghana		Guinea	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Number of children	15929	100.0	10852	100.0	8097	100.0	5989	100.0	4948	100.0	8999	100.0	11163	100.0	4031	100.0	2909	100.0	6370	100.0
Individual-level variables																				
Birth order and preceding birth interval																				
First birth	3058	19.3	2053	18.9	1902	23.6	1039	17.4	1271	25.8	1850	20.6	1933	17.3	1083	27.0	688	23.7	1098	17.3
2-3 and < 24 months	790	5.0	473	4.4	591	7.3	445	7.4	271	5.5	705	7.9	754	6.8	297	7.4	157	5.4	211	3.3
2-3 and 24+ months	4804	30.3	2948	27.2	2112	26.2	1385	23.2	1707	34.6	2171	24.2	2593	23.2	1063	26.5	946	32.6	1751	27.6
4+ and < 24 months	1025	6.5	690	6.4	755	9.4	817	13.7	212	4.3	1141	12.7	1219	10.9	332	8.3	153	5.3	392	6.2
4+ and 24+ months	6194	39.0	4673	43.1	2707	33.6	2291	38.3	1474	29.9	3106	34.6	4661	41.8	1243	30.9	961	33.1	2899	45.6
Child's sex																				
Female	7901	49.6	5303	48.9	4060	50.1	2931	48.9	2434	49.2	4589	51.0	5440	48.7	1979	49.1	1399	48.1	3075	48.3
Male	8028	50.4	5549	51.1	4038	49.9	3058	51.1	2514	50.8	4410	49.0	5723	51.3	2052	50.9	1510	51.9	3294	51.7
Mother's age at child's birth																				
Less than 20 years	1890	11.9	1667	15.4	1843	22.8	1277	21.3	1009	20.4	1454	16.2	1715	15.4	1069	26.5	333	11.5	1140	17.9
20-34 years	12013	75.4	7260	66.9	5368	66.3	4013	67.0	3320	67.1	6090	67.7	7702	69.0	2566	63.6	2079	71.4	4128	64.8
35 years or more	2026	12.7	1924	17.7	886	10.9	699	11.7	619	12.5	1455	16.2	1746	15.6	397	9.8	497	17.1	1103	17.3
Mother's education																				
No education	11940	75.0	9574	88.2	2397	29.6	4580	76.5	443	8.9	2117	23.5	8838	79.2	268	6.6	952	32.7	5546	87.1
Primary	2829	17.8	862	7.9	3462	42.8	1164	19.4	1796	36.3	3770	41.9	1855	16.6	1697	42.1	722	24.9	524	8.2
Secondary or higher	1161	7.3	416	3.8	2238	27.6	245	4.1	2710	54.8	3112	34.6	470	4.2	2066	51.3	1232	42.4	300	4.7
Household wealth Index																				
1st quintile (Poorest)	3550	22.3	2100	19.3	2058	25.4	1019	17.0	1182	23.9	1873	20.8	2440	21.9	811	20.1	744	25.6	1563	24.5
2nd quintile	3248	20.4	2297	21.2	1648	20.3	1356	22.6	1119	22.6	2035	22.6	2356	21.1	926	23.0	641	22.0	1376	21.6
3rd quintile	3320	20.8	2900	26.7	1681	20.8	1187	19.8	1060	21.4	1864	20.7	2486	22.3	857	21.3	549	18.9	1323	20.8
4th quintile	3206	20.1	1972	18.2	1489	18.4	1333	22.3	856	17.3	1844	20.5	2222	19.9	784	19.4	560	19.3	1164	18.3
5th quintile (Richest)	2605	16.4	1583	14.6	1221	15.1	1093	18.3	732	14.8	1383	15.4	1660	14.9	653	16.2	415	14.3	943	14.8
Place of delivery																				
Home/Other	3433	21.6	6655	61.4	3237	40.2	5153	86.2	811	16.5	2503	28.2	10502	94.3	510	12.9	1223	42.2	4378	69.1
Health facility	12462	78.4	4187	38.6	4824	59.8	827	13.8	4111	83.5	6382	71.8	635	5.7	3454	87.1	1675	57.8	1960	30.9
Skilled attendant at delivery																				
Other (incl. none)	4083	25.7	6741	62.2	3293	40.8	5839	97.5	3404	68.8	5135	57.8	10505	94.3	671	16.8	1302	45.0	4502	71.1
Doctor, nurse, or midwife	11777	74.3	4104	37.8	4773	59.2	147	2.5	1545	31.2	3756	42.2	635	5.7	3330	83.2	1594	55.0	1828	28.9
Community-level variables																				
Place of residence																				
Rural	10480	65.8	9466	87.2	4547	56.2	4866	81.2	2691	54.4	5509	61.2	10348	92.7	1069	26.5	1806	62.1	4932	77.4
Urban	5450	34.2	1386	12.8	3550	43.8	1123	18.8	2258	45.6	3490	38.8	815	7.3	2962	73.5	1104	37.9	1438	22.6
Community-level socio-economic status[a]																				
Low	8297	52.1	5291	48.8	4041	49.9	2222	37.1	2122	42.9	4560	50.7	5893	52.8	2710	67.2	1719	59.1	3352	52.6
High	7632	47.9	5561	51.2	4057	50.1	3766	62.9	2826	57.1	4439	49.3	5270	47.2	1322	32.8	1190	40.9	3017	47.4
Proportion of women aged 15-49 in the community with secondary or higher education[b]																				
Low	9015	56.6	8227	75.8	4373	54.0	3779	63.1	2805	56.7	4078	45.3	8825	79.1	1666	41.3	1336	45.9	4150	65.1
High	6915	43.4	2625	24.2	3724	46.0	2210	36.9	2143	43.3	4921	54.7	2338	20.9	2365	58.7	1573	54.1	2220	34.9
Community-level ethnic homogeneity[c]																				
Not totally homogenous (EFL more than 0)	11646	73.1	6252	57.6	6525	80.6	4018	67.1	4817	97.3	2841	31.6	4923	44.1	3740	92.8	1655	56.9	4140	65.0
Totally homogenous (ELF equal 0)	4283	26.9	4600	42.4	1572	19.4	1970	32.9	132	2.7	6158	68.4	6240	55.9	291	7.2	1254	43.1	2229	35.0
Community-level child immunization coverage[d]																				
Low	5294	33.2	4086	37.7	2893	35.7	2733	45.6	1826	36.9	3212	35.7	3304	29.6	1214	30.1	1255	43.1	2250	35.3
Middle	5439	34.1	3518	32.4	2433	30.0	2068	34.5	1632	33.0	2914	32.4	4841	43.4	1274	31.6	649	22.3	2114	33.2
High	5197	32.6	3248	29.9	2772	34.2	1188	19.8	1490	30.1	2873	31.9	3018	27.0	1543	38.3	1005	34.6	2005	31.5

APPENDIX Table 2 Continued

	Kenya		Lesotho		Liberia		Madagascar		Malawi		Mali		Mozambique		Namibia		Niger		Nigeria	
Characteristics	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Number of children	6102	100.0	3572	100.0	5594	100.0	12686	100.0	10771	100.0	14420	100.0	10620	100.0	5003	100.0	9954	100.0	28100	100.0
Individual-level variables																				
Birth order and preceding birth interval																				
First birth	1469	24.1	1238	34.8	1266	22.7	2845	22.5	2530	23.5	2536	17.6	2303	21.7	1608	32.3	1544	15.5	5371	19.1
2-3 and < 24 months	534	8.8	145	4.1	326	5.8	969	7.7	622	5.8	1009	7.0	599	5.7	271	5.4	603	6.1	2324	8.3
2-3 and 24+ months	1634	26.8	1178	33.1	1582	28.3	3375	26.6	3299	30.7	3385	23.5	3037	28.6	1770	35.5	2146	21.6	6969	24.8
4+ and < 24 months	526	8.6	100	2.8	436	7.8	1281	10.1	613	5.7	1578	11.0	758	7.1	182	3.7	1142	11.5	3071	10.9
4+ and 24+ months	1929	31.7	901	25.3	1974	35.3	4196	33.1	3684	34.3	5894	40.9	3909	36.9	1148	23.1	4503	45.3	10324	36.8
Child's sex																				
Female	2992	49.0	1737	48.6	2682	48.0	6222	49.0	5390	50.0	7104	49.3	5379	50.6	2434	48.7	4853	48.8	13811	49.2
Male	3110	51.0	1834	51.4	2911	52.0	6465	51.0	5381	50.0	7316	50.7	5241	49.4	2569	51.3	5101	51.2	14289	50.8
Mother's age at child's birth																				
Less than 20 years	1070	17.5	727	20.3	956	17.1	2673	21.1	2205	20.5	2901	20.1	2380	22.4	793	15.9	1848	18.6	4159	14.8
20-34 years	4287	70.3	2290	64.1	3702	66.2	8038	63.4	7321	68.0	9494	65.8	6865	64.6	3482	69.6	6653	66.8	19636	69.9
35 years or more	745	12.2	555	15.5	935	16.7	1975	15.6	1246	11.6	2026	14.0	1375	12.9	728	14.5	1452	14.6	4305	15.3
Mother's education																				
No education	938	15.4	94	2.6	2729	48.9	3219	25.4	2785	25.9	12334	85.5	4906	46.2	553	11.1	8709	87.5	13071	46.5
Primary	3901	63.9	2318	64.9	1951	34.9	7010	55.3	6860	63.7	1452	10.1	5315	50.0	1436	28.7	934	9.4	6521	23.2
Secondary or higher	1263	20.7	1160	32.5	906	16.2	2457	19.4	1127	10.5	634	4.4	399	3.8	3014	60.2	311	3.1	8508	30.3
Household wealth Index																				
1st quintile (Poorest)	1509	24.7	746	20.9	1254	22.4	3270	25.8	2099	19.5	2958	20.5	2822	26.6	1072	21.4	2144	21.5	6525	23.2
2nd quintile	1271	20.8	861	24.1	1332	23.8	2839	22.4	2426	22.5	2985	20.7	2050	19.3	956	19.1	1989	20.0	6395	22.8
3rd quintile	1159	19.0	638	17.9	1197	21.4	2539	20.0	2446	22.7	3025	21.0	2286	21.5	1121	22.4	1903	19.1	5417	19.3
4th quintile	1032	16.9	721	20.2	1137	20.3	2252	17.8	2091	19.4	2939	20.4	1775	16.7	1041	20.8	2100	21.1	5003	17.8
5th quintile (Richest)	1131	18.5	605	17.0	673	12.0	1787	14.1	1709	15.9	2514	17.4	1687	15.9	813	16.3	1818	18.3	4760	16.9
Place of delivery																				
Home/Other	3584	58.9	1623	45.9	3411	61.7	8082	64.0	3164	29.4	7783	54.3	5370	50.7	933	18.7	8168	82.6	17437	62.7
Health facility	2498	41.1	1913	54.1	2113	38.3	4539	36.0	7593	70.6	6550	45.7	5214	49.3	4055	81.3	1722	17.4	10377	37.3
Skilled attendant at delivery																				
Other (incl. none)	3545	58.3	1556	44.0	2965	53.9	7058	55.9	4702	43.8	10450	73.0	8499	80.4	919	18.4	8101	82.2	18045	65.1
Doctor, nurse, or midwife	2536	41.7	1978	56.0	2539	46.1	5571	44.1	6042	56.2	3864	27.0	2077	19.6	4071	81.6	1757	17.8	9660	34.9
Community-level variables																				
Place of residence																				
Rural	4959	81.3	3069	85.9	3900	69.7	11309	89.1	9347	86.8	10529	73.0	7533	70.9	2926	58.5	8451	84.9	19741	70.3
Urban	1143	18.7	503	14.1	1694	30.3	1377	10.9	1425	13.2	3891	27.0	3087	29.1	2077	41.5	1503	15.1	8359	29.7
Community-level socio-economic status[a]																				
Low	2868	47.0	1995	55.8	2848	50.9	6771	53.4	5499	51.1	6983	48.4	4556	42.9	2484	49.6	4146	41.7	15483	55.1
High	3234	53.0	1577	44.2	2745	49.1	5915	46.6	5272	48.9	7438	51.6	6064	57.1	2519	50.4	5808	58.3	12617	44.9
Proportion of women aged 15-49 in the community with secondary or higher education[b]																				
Low	3096	50.7	1733	48.5	2901	51.9	6235	49.1	5363	49.8	8811	61.1	8233	77.5	2329	46.5	7616	76.5	13075	46.5
High	3006	49.3	1839	51.5	2693	48.1	6451	50.9	5408	50.2	5609	38.9	2387	22.5	2674	53.5	2337	23.5	15025	53.5
Community-level ethnic homogeneity[c]																				
Not totally homogenous (EFL more than 0)	3004	49.2	3572	100.0	4433	79.3	12686	100.0	8784	81.5	12639	87.6	6298	59.3	2703	54.0	6509	65.4	16963	60.4
Totally homogenous (ELF equal 0)	3098	50.8	3572	100.0	1160	20.7	12686	100.0	1988	18.5	1782	12.4	4322	40.7	2300	46.0	3445	34.6	11137	39.6
Community-level child immunization coverage[d]																				
Low	1996	32.7	1127	31.5	1761	31.5	3798	29.9	3688	34.2	4779	33.1	4199	39.5	1707	34.1	4387	44.1	9029	32.1
Middle	2153	35.3	1350	37.8	1709	30.6	4231	33.4	3560	33.1	5299	36.7	3418	32.2	1621	32.4	3251	32.7	8980	32.0
High	1952	32.0	1095	30.7	2124	38.0	4657	36.7	3524	32.7	4343	30.1	3003	28.3	1675	33.5	2316	23.3	10091	35.9

APPENDIX Table 2 Continued

Characteristics	Rwanda		Senegal		Sierra Leone		Swaziland		Tanzania		Uganda		Zambia		Zimbabwe	
	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Number of children	8715	100.0	10530	100.0	5811	100.0	2829	100.0	8725	100.0	8423	100.0	6435	100.0	5231	100.0
Individual-level variables																
Birth order and preceding birth interval																
First birth	1616	18.6	2299	21.9	1148	19.8	890	31.6	1922	22.1	1450	17.2	1270	19.8	1654	31.7
2-3 and < 24 months	802	9.2	741	7.0	366	6.3	160	5.7	503	5.8	658	7.8	348	5.4	208	4.0
2-3 and 24+ months	2079	23.9	2767	26.3	1785	30.8	904	32.1	2620	30.1	1749	20.8	1866	29.1	1988	38.1
4+ and < 24 months	841	9.7	845	8.0	459	7.9	141	5.0	586	6.7	1097	13.0	437	6.8	159	3.1
4+ and 24+ months	3353	38.6	3860	36.7	2038	35.2	725	25.7	3072	35.3	3458	41.1	2496	38.9	1210	23.2
Child's sex																
Female	4287	49.2	5109	48.5	2931	50.4	1401	49.5	4347	49.8	4243	50.4	3231	50.2	2563	49.0
Male	4428	50.8	5421	51.5	2880	49.6	1428	50.5	4377	50.2	4180	49.6	3204	49.8	2668	51.0
Mother's age at child's birth																
Less than 20 years	533	6.1	1669	15.8	977	16.8	661	23.4	1502	17.2	1436	17.0	1102	17.1	1070	20.5
20-34 years	6366	73.1	7236	68.7	4002	68.9	1852	65.5	6153	70.5	5857	69.5	4485	69.7	3668	70.1
35 years or more	1815	20.8	1625	15.4	832	14.3	315	11.1	1070	12.3	1131	13.4	849	13.2	492	9.4
Mother's education																
No education	2470	28.3	7577	72.0	4443	76.5	263	9.3	2318	26.6	1910	22.7	870	13.5	213	4.1
Primary	5513	63.3	2194	20.8	713	12.3	992	35.1	6020	69.0	5358	63.6	4089	63.5	1922	36.7
Secondary or higher	732	8.4	759	7.2	655	11.3	1574	55.6	387	4.4	1155	13.7	1477	22.9	3096	59.2
Household wealth Index																
1st quintile (Poorest)	1845	21.2	2425	23.0	1327	22.8	572	20.2	1974	22.6	1893	22.5	1524	23.7	1296	24.8
2nd quintile	1794	20.6	2332	22.1	1220	21.0	603	21.3	1857	21.3	1900	22.6	1445	22.4	1093	20.9
3rd quintile	1785	20.5	2238	21.3	1288	22.2	554	19.6	1866	21.4	1676	19.9	1351	21.0	911	17.4
4th quintile	1742	20.0	1908	18.1	1102	19.0	554	19.6	1681	19.3	1604	19.0	1227	19.1	1091	20.9
5th quintile (Richest)	1548	17.8	1627	15.5	873	15.0	546	19.3	1347	15.4	1351	16.0	889	13.8	839	16.0
Place of delivery																
Home/Other	6139	70.6	3916	37.4	4172	73.8	715	25.3	4599	52.8	4870	57.9	3325	51.8	1627	31.2
Health facility	2553	29.4	6550	62.6	1479	26.2	2110	74.7	4115	47.2	3539	42.1	3092	48.2	3595	68.8
Skilled attendant at delivery																
Other (incl. none)	6212	71.5	5780	55.2	3892	68.6	873	30.9	5030	57.8	4889	58.1	3491	54.4	1637	31.4
Doctor, nurse, or midwife	2479	28.5	4683	44.8	1783	31.4	1951	69.1	3677	42.2	3526	41.9	2924	45.6	3583	68.6
Community-level variables																
Place of residence																
Rural	7487	85.9	6688	63.5	4226	72.7	2199	77.7	7034	80.6	7470	88.7	4553	70.7	3718	71.1
Urban	1228	14.1	3842	36.5	1585	27.3	630	22.3	1691	19.4	953	11.3	1883	29.3	1513	28.9
Community-level socio-economic status[a]																
Low	4152	47.6	5686	54.0	2671	46.0	1445	51.1	4174	47.8	4421	52.5	2969	46.1	2767	52.9
High	4563	52.4	4843	46.0	3140	54.0	1384	48.9	4551	52.2	4002	47.5	3466	53.9	2464	47.1
Proportion of women aged 15-49 in the community with secondary or higher education[b]																
Low	4523	51.9	5459	51.8	3414	58.8	1384	48.9	6361	72.9	4125	49.0	3407	52.9	2489	47.6
High	4192	48.1	5071	48.2	2397	41.2	1445	51.1	2364	27.1	4298	51.0	3028	47.1	2742	52.4
Community-level ethnic homogeneity[c]																
Not totally homogenous (EFL more than 0)	8715	100.0	9224	87.6	3512	60.4	2829	100.0	8725	100.0	8423	100.0	5664	88.0	5231	100.0
Totally homogenous (ELF equal 0)	8715	100.0	1306	12.4	2299	39.6	2829	100.0	8725	100.0	8423	100.0	771	12.0	5231	100.0
Community-level child immunization coverage[d]																
Low	2875	33.0	3670	34.9	2164	37.2	926	33.8	2944	33.7	2811	33.4	2276	35.4	1999	38.2
Middle	2914	33.4	3501	33.2	1788	30.8	946	33.4	2924	33.5	2827	33.6	2066	32.1	1575	30.1
High	2926	33.6	3359	31.9	1860	32.0	2828	100.0	8725	100.0	8423	100.0	2093	32.5	5231	100.0

Note: Percentages may not add to 100 because of missing values.

1: Weighted percentage. Figures were calculated using appropriate individual country weights.

n/a = Not available. Item not measured

a: Proportion of households poor (two lowest wealth quintiles) in the community.

b: Dichotomous variables indicating whether the proportion of women aged 15-49 in the community with secondary or higher education is high or low (cut-off at mean proportion).

c: Based on the measures of the ethno-linguistic fractionalization index (EFL), defined as the probability that two individuals selected at random from primary sampling unit, will be from different ethnic groups. Theoretically, for each cluster, the scale goes from 0 (totally homogenous) to 1 (complete diversity). For the purposes of the present analysis, the resulting scale ethno-linguistic fractionalization Index was then classified into dichotomous variables indicating whether the ethnic composition of the community is totally homogenous (ELF equal 0) categorized as 1; if cluster is not totally homogenous (EFL more than 0), then categorized as 0.

d: Tiers based on the percentage of children who received full immunization in the community (Child has received BCG, measles, and three doses of DPT and polio vaccines).

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Chapitre 5. Article 2 – Is birth weight a good predictor of child mortality in less developed countries? Results from recent national surveys in sub-Saharan Africa

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Abstract

Low birth weight (LBW) has been found to be the strongest predictor of infant mortality, especially in the neonatal period. Yet little attention has been paid to the relationship between LBW and the risk of dying before age 5. To fill this gap, we exploit recent national survey data for nine countries in sub-Saharan Africa to investigate the association of LBW and mortality not only in infancy but also during childhood, using a standardized methodology to adjust missing birth weight data from household surveys while accounting for unobserved family-level factors (genetic or behavioral) that may modify the relationship between birth weight and under-five-years mortality. We find evidence of the impact of birth weight on the risk of dying not only in infancy but also during childhood, which remains strong and significant in all countries even after controlling for potential confounding factors.

Key Words: Low birth weight; Child mortality; Proportional hazard model; Frailty; Sub-Saharan Africa

5.1 Introduction

More than 20 million infants worldwide are born with low birth weight (LBW), that is, weighting less than 2500 grams (5.5 pounds) at birth according to the definition of the World Health Organization (World Health Organization 1992). The majority (95.6%) of low birth weight infants are found in less developed countries, and low birth weight levels in sub-Saharan Africa are around 15% (United Nations Children's Fund & World Health Organization 2004: 1).

Preterm birth (before 37 weeks of gestation) or restricted foetal (intrauterine) growth are the main causes of LBW (Kramer 1987). In turn, the factors that affect the duration of gestation and foetal growth may relate to the infant, the mother, or the physical environment (World Health Organization 2006). In deprived socio-economic conditions an infant’s LBW stems primarily from the mother’s poor nutrition and health over a long period of time, including during pregnancy, the high prevalence of specific and non-specific infections, or from pregnancy complications, underpinned by poverty (United Nations Children's Fund & World Health Organization 2004: 1).

It is well-known that LBW contributes to a range of poor health outcomes later in life as it may limit growth during childhood and increase the risk of adult diseases such as diabetes, hypertension and cardiovascular diseases (Bhalotra & Rawlings 2011; Cunningham et al. 2010; Harder et al. 2007; Schooling et al. 2010; Smith et al. 2010). Children born underweight also tend to have cognitive disabilities and a lower IQ, affecting their performance in school and their job opportunities as adults (McCormick 1985; Paneth 1995; United Nations Children's Fund 2008). The goal of reducing LBW incidence by at least one third between 2000 and 2010 is thus one of the major goals in the Declaration and Plan of Action, which was adopted by the United Nations General Assembly Special Session on Children in 2002 (United Nations 2002).

LBW has also been found to be the strongest predictor of infant mortality, especially in the neonatal period (Ashworth 1998; Bobossi-Serengbe et al. 1999; Diallo et al. 1998; Engmann et al. 2009; Kabore et al. 2009; Mathews et al. 2007; McCormick 1985; Mendes et al. 2006; Shoham-Yakubovich & Barel 1988; Susser et al. 1972; United Nations Children's Fund & World Health Organization 2004; Victora et al. 1987; Yasmin et al. 2001). Nonetheless little attention has been paid to the specific relationship between LBW and the risk of dying before age 5. Indeed, birth weight is seldom taken into account by the numerous demographic studies that have examined the determinants of child mortality. To fill this gap, in this paper we exploit several recent national surveys to evaluate whether LBW is associated with an increased risk of child mortality in sub-Saharan Africa.

5.2 Background

It has been recognized for several decades that LBW is an important marker of morbidity and mortality in newborns, especially during the first year of life (McCormick 1985). According to at least few authors, infants who weight between 2000 and 2499 grams at birth have a risk of death during the neonatal period four times higher than infants who weight between 2500 and 2999 grams. This risk would be ten times higher than that of infants who weight between 3000 and 3499 grams at birth (Ashworth 1998; Bobossi-Serengbe et al. 1999; Diallo et al. 1998; Engmann et al. 2009; Kabore et al. 2009; Mathews et al. 2007; McCormick 1985; Mendes et al. 2006; Shoham-Yakubovich & Barel 1988; Susser et al. 1972; Victora et al. 1987; Yasmin et al. 2001).

If the association between LBW and neonatal and infant mortality is well-known, there are few studies that have quantified the relative contribution of LBW to under-five-years mortality, particularly in developing countries, for two main reasons. First, in less developed countries reliable data on LBW remain limited, since a large proportion of babies are born at home and without a skilled attendant, and in these circumstances they are rarely weighed (Robles & Goldman 1999). Even when babies are weighed at birth, their weight is not always measured accurately, or recorded, reported and tabulated correctly (United Nations Children's Fund & World Health Organization 2004: 3). In addition, in household surveys, the availability of information on birth weight importantly decreases with birth order, so that children born further away from the survey date generally have more incomplete information on birth weight. The second reason for the limited number of studies linking birth weight to child mortality is that after the neonatal period it may be difficult to disentangle genetic from environmental factors that affect a child's chances of survival. Some women tend to have low-birth-weight babies and difficult labors, and their children are at a high risk of mortality during the first year of life. When this effect is seen in later childhood, it may be an indication that environmental variables, such as socioeconomic status or childcare, are the basis of differential child mortality among women (Das Gupta 1990).

The current study is the first to investigate the association of LBW and mortality not only in infancy but also during childhood, using a standardized methodology to adjust missing birth weight data from household surveys while accounting for unobserved family-level factors (genetic or behavioral) that may modify the relationship between birth weight and under-five-years mortality. We begin our investigation by comparing the characteristics of children with normal and low birth weight. Next, we calculate life table estimates of the risk of dying before age 5 by birth weight in each country selected for the analysis. Finally, we estimate multivariate piecewise exponential hazards models with frailty to assess the influence of birth weight status on the risk of dying before age 5, controlling for a number of socio-economic characteristics, access to health care as well as the effect of unobserved individual and family-level characteristics, that is, genetic or behavioral factors that are shared by children of the same mother.

5.3 Data

5.3.1 Data sources and country selection

We use data from the most recent Demographic and Health Surveys (DHS) from the following nine countries in sub-Saharan Africa, which were carried out between 2000 and 2007: Benin, Cameroon, Congo (Brazzaville), Congo Democratic Republic, Gabon, Lesotho, Namibia, Swaziland, and Zimbabwe. The DHS are nationally-representative probability samples of women aged 15–49 years. They use standardized questionnaires across countries to collect information on the sampled respondents' basic socio-demographic characteristics, as well as on their birth histories and on their children's health. The sampling design and survey implementation procedures for each country are described in detail in the individual country reports (Central Statistical Office (CSO) [Swaziland] & Macro International Inc 2008; Central Statistical Office (CSO) [Zimbabwe] & Macro International Inc 2007; Centre National de la Statistique et des Études Économiques [Congo] (CNSEE) & ORC Macro 2006; Direction Générale de la Statistique et des Études Économiques (DGSEE) [Gabon] & ORC Macro 2001; Institut National de la Statistique (INS) & ORC Macro 2004; Institut National de la Statistique et de l'Analyse Économique (INSAE) [Bénin] & Macro International Inc 2007; Ministère du Plan [Congo] & Macro International 2008; Ministry of Health and Social Services (MoHSS) [Namibia] & Macro International Inc 2008; Ministry of Health and Social Welfare (MOHSW) [Lesotho] et al. 2005).

The selection of the countries to be included in the analysis was guided by the availability of information on birth weight, since the DHS do not contain missing data on children's age at death. The DHS questionnaire collects information on birth weight for the respondent's children who were born in the five years preceding the survey. For each of these children, the DHS records the mother's report of the child's weight at birth (numerical weight in grams or pounds) as well as her assessment of the child's size when born (very small, small, average, large, very large). As indicated earlier, there are a number of limitations inherent to survey data on birth weight from household surveys in developing countries such as the DHS, mainly arising from the fact that infants are often born at home or without a skilled attendant and thus are not weighed at birth. Indeed, the proportion of children with missing information on numerical birth weight varies considerably across DHS that were carried out in sub-Saharan African countries and it can be quite high, especially for children born the furthest away from the date of the survey (see Appendix Table 1). For the purposes of the present analysis, we choose to include only countries where the proportion of children (singleton births[11]) with missing information on numerical birth weight is 45% or less. To correct for missing birth weight data, we then apply a standardized procedure that is described in the next section.

In the countries selected for the analysis, infant mortality varies from 46.1 deaths per 1,000 births in Namibia to 91.8 deaths per 1,000 births in Congo Democratic Republic, and under five mortality ranges from 82.5 deaths per 1,000 births in Zimbabwe to 147.9 deaths per 1,000 births in Congo Democratic Republic (Table 1).

[Table 1 about here]

[11] The analysis is limited to singleton births since the exceedingly high risks of death associated with multiple births may otherwise contaminate our results (Curtis et al. 1993; Guo & Grummer-Strawn 1993).

5.3.2 Adjustment of information on birth weight

Studies based on birth weight data collected from surveys in less developed countries have demonstrated that biases are likely to result from restricting estimates of the frequency of LBW or its determinants to the selected subsample of women who report birth weight information. They also indicate that the use of mothers' subjective assessments of birth weight such as the relative size of the infant at birth, along with numerical birth weight where available, can reduce these biases (Blanc & Wardlaw 2005; Boerma et al. 1996; Eggleston et al. 2000; Magadi et al. 2006; Robles & Goldman 1999; Rutstein 2008).[12] The mother's assessment of the child's size at birth is generally available for the majority of children of interviewed mothers (see Appendix Table 1). UNICEF and the World Health Organization (2004) indeed rely on adjustments of recorded birth weight based on the mother's assessment of size at birth to estimate the prevalence and incidence of LBW at the country, regional and global level.

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[12] A check of the mothers' reports of the size of the baby at birth against the birth weight where it was available revealed that in general, the mothers' reports were consistent with the recorded birth weights (Boerma et al. 1996; Magadi et al. 2001).

We follow the same approach and we begin by drawing from the mother's assessment of the child's size at birth to infer the numerical birth weight if the latter is missing.[13] To do so, for mothers who reported both the child's numerical birth weight and self-assessed size at birth, in Figure 1 we compare the mean numerical birth weight by different categories of the mother's assessment of the child's size at birth (the corresponding figures are presented in Appendix Table 2). This comparison suggests that, if the mother reports that the child's size was very small or smaller than average at birth, in all countries included the analysis this systematically corresponds to a low numerical birth weight (less than 2500 grams). We thus classify as low birth weight children with missing numerical birth weight but who are assessed to have been small or very small at birth.[14]

[Figure 1 about here]

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[13] In their estimates of the prevalence and incidence of LBW, UNICEF and the World Health Organization (United Nations Children's Fund & World Health Organization 2004) reclassify as LBW one-quarter of the births recorded as exactly 2,500 g to take into account heaping at 2,500 g, the cut-off point for low birth weight. To verify whether heaping may influence our results, we ran the analyses reclassifying as LBW all births recorded as exactly 2,500 g. Since our results are unaffected by this reclassification, for simplicity we present the results that take into account only the adjustment for missing information on recorded birth weight.

[14] In a preliminary analysis, we compared the performance of this adjustment procedure with the results of multiple imputation models on missing birth weight (Rubin 1987; Schafer 1997; StataCorp LP 2009; van Buuren et al. 1999). The results of the two adjustments were remarkably similar and they lead to the same results.

5.4 Methods

5.4.1 Analytical strategy

We begin with a descriptive analysis that compares children with normal weight (2500 grams or more) and those with low birth weight (less than 2500 grams) according to a number of demographic and socioeconomic factors traditionally known to affect child mortality (Hobcraft et al. 1985; Rafalitnanana & Westoff 2000; Rutstein 2000). These are: birth spacing, the child's sex, the mother's age at birth of the child, the mother's education, household wealth status, and place of residence. As regards birth spacing, previous birth intervals are combined with parity to examine whether birth of higher parities which follow short birth intervals increase the child's risk of death and whether lower parities with close birth intervals decrease the risk, as it has been done in other studies (Forste 1994: 502). We also compare normal and low birth weight children on the basis of two variables that capture access to health care services and that have been shown to influence child mortality: the number of prenatal visits and the presence of a skilled attendant (doctor, nurse or midwife) at the child's delivery. Differences between normal and low birth weight children are evaluated by using the chi square statistics.

Next, we use the life table method to calculate the probability of dying before age 5 by age at death and country. We stratify these findings by birth weight status (normal vs. low birth weight) and we compare them graphically by using the logrank test statistics.

Lastly, we evaluate the association between birth weight (measured as indicated above) and the risk of dying before age 5 controlling for potential confounding factors, as it is described in detail in the next section.

Since information on prenatal care (a key determinant of infant and child mortality) is available only for the last birth, the analyses are carried out for two groups of children. The first group includes all three most recent singleton births during the five years preceding the survey in each country, for which no information on prenatal care is available. The number of children included in this group ranges from 2670 in Swaziland to 14892 in Benin (Table 2). Of these, the proportion of children with low birth weight ranges from 7.5% in Swaziland to 15.4% in Cameroon, and it is overall 9.7% in all countries. The second group of children includes only the most recent singleton birth in the five years before the survey for all countries pooled together. Pooling of observations in this case is necessary because the number of observations in each country is not sufficient to carry out meaningful analyses. The number of children included in this group is 41960, of which 9.0% weighed less than 2500 grams at birth. Descriptive statistics for all variables included in the analyses for these two groups of children are presented in Appendix (Tables 3 and 4).

[Table 2 about here]

5.4.2 Event-history models

We use multivariate event history regression models with heterogeneity to evaluate the association between birth weight and the risk of dying before age 5 controlling for potential confounding factors. We apply an event history model to account for right-censoring in the estimation of exposure time, since not all children had the chance to survive to the oldest age under investigation by the time of interview.

Specifically, we use a proportional hazard model with a piecewise constant baseline hazard by dividing the child's first five years into three exposure periods (0-1 months, 1-11 months, and 12-59 months[15]) and assuming that the baseline hazard is constant within each period. The dependent variable is the risk of death in childhood (0–59 months), measured

[15] These intervals conform to established conventions and assure that there are enough cases in each of them.

as duration from birth to the age at death (in months)[16] or censored. The control variables included in the event history models are the characteristics that we have selected for the descriptive analysis presented in the previous section. To test whether birth weight status has a differential impact on the risk of dying by age 5 by duration of exposure, we include also a series of dichotomous control variables to capture the interaction between exposure time to the risk of dying before age 5 (0-1 months, 1-11 months, and 12-59 months) and birth weight status.

The standard piecewise exponential model is built on the assumption of independence of observations. The DHS children file has a hierarchical structure, with children nested within mothers (Gyimah 2007). Some women thus contribute more than one child to the sample: across the countries included in our analysis, 18% to 34% of women count more than one child. Mortality risks for children of the same mother are expected to be correlated because of shared genetic and environmental factors between siblings beyond those included as explicit covariates in the models, as it been found in earlier studies (e.g. Curtis et al. 1993; Das Gupta 1990; Guo & Rodriguez 1992; Gyimah 2007; Sear et al. 2002).

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[16] The DHS collect age at death for nonsurviving children in three scales: for children who died at less than one month, age in days is collected. For nonsurviving children dying within two years of birth, age at death in number of months is collected. The number of years survived is used for children who died at an age of two or more years since birth. Dates of birth of children are given in calendar year and month (Rutstein 2008: 23). For the purposes of the present analysis, we converted age at death for all children on an individual month scale.

These unobserved family-level factors could include childcare practices, cultural practices, and household environmental factors such as personal hygiene and general cleanliness (Omariba et al. 2007; Ronsmans 1995; Van Poppel et al. 2002). Information on breastfeeding, delivery care, and immunization is unavailable for the majority of children and it also forms part of the unobserved behavioral factors at the family level (Omariba et al. 2007).

If there is a correlation between the survival probabilities of children with the same mother, then observations in our data are not independent. Without accounting for within-mother correlation of mortality risks, the standard piecewise exponential model is thus misspecified and parameter estimates can be inconsistent, standard errors can be wrong, and estimates of duration dependency can be misleading (Gyimah 2007: 6). The large number of families in the data does not allow us to estimate fixed family effects to control for such unobserved family-specific variations in the data. Instead, we add frailty effects (or random effects) to our survival models. This is equivalent to say that children of the same mother share an unobservable random covariate that acts multiplicatively on the hazard (Sastry 1997b).[17]

[17] The main difference between shared and individual frailty models is the assumption about how frailty is distributed in the data. Shared frailty models assume that similar observations share frailty, even though frailty may vary from group to group.

Specifically, we estimate a piecewise exponential models with shared frailty, which can be formalized as follows (Guo & Rodriguez 1992: 970). Let T_{i1}, …, $T_{in_{ij}}$ denote random variables representing the n_i survival time in family i and let $\mathbf{x}_{ij}$ represent a vector of covariates associated with the jth child of the ith family. We assume that, conditional on a family-specific random effect W_i, the survival times are mutually independent and their conditional marginal distributions have hazard functions $h(t_{ij}|w_i;\ \mathbf{x}_{ij})$ satisfying the multiplicative frailty model:

$$h(t_{ij}|w_i; \mathbf{x}_{ij}) = w_i\, h_0\, (t_{ij})\, \exp(\beta \mathbf{x}_{ij})$$

where w_i is the realized value of the random effect, h_0 (t_{ij}) represents the baseline hazard, and □ is a vector of estimated coefficients. The frailty (random) effect is assumed to follow a gamma distribution[18] with mean 1 and variance theta (Cleves et al. 2004; Jenkins 1995; Jenkins 1997; Sastry 1997a). Large values of theta therefore reflect greater variability between sub-groups and a strong association among sub-group members. If the variance estimate is significantly different from zero, it can be concluded that there are unmeasured

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[18] Past research has made extensive use of this distribution because of its flexible shape and analytical tractability (Oakes 1982; Sastry 1996), and because estimates do not seem to be too sensitive to the choice of the distribution for the random effect (Guo & Rodriguez 1992; Omariba et al. 2007; Sastry 1997b; Van Poppel et al. 2002). Indeed, a recent study shows that, in a large class of hazard models with proportional unobserved heterogeneity, the distribution of the heterogeneity among survivors converges rapidly to a gamma distribution (Abbring & Van Den Berg 2007).

and unmeasurable factors shared by siblings that affect the risk of dying, and thus that siblings' survival risks are correlated (Omariba et al. 2007: 304).

We perform all analyses using Stata 11.0 (Stata Corporation 2009). Descriptive analyses take into account the DHS complex survey design through the appropriate use of individual country weights or pooled weights for all countries. We do not use survey weights for multivariate analyses because they cannot be meaningfully incorporated in event history models with frailty (Sastry 1997b).

5.5 Results

5.5.1 Comparison of children with normal and low birth weight

Table 3 compares children with normal and low birth weight according to a number of selected characteristics, by country for the last three births during the five years before the survey as well as for all countries for the last birth. All differences are statistically significant at the 10% level except where indicated.

[Table 3 about here]

Overall, in the univariate analysis of the last three births during the five years before the survey differences by birth weight are statistically significant in all countries for age at death, birth order, and the child's sex. At all ages, the proportion of deaths is higher among low birth weight children than among normal weight children. The difference is largest for the neonatal period (less than one month of age), but it diminishes over time so that the proportion of deaths at 12-59 months is similar among low and normal weight children, albeit the difference between the two remains statistically significant. The proportion of low birth weight children who are first births is also higher than the corresponding proportion of normal weight children in all countries except Lesotho. In addition, in all countries the proportion of low birth weight children who are third or higher rank births is higher than the corresponding proportion of normal weight children. Finally, the proportion of low birth weight girls is higher than the proportion of normal weight girls, whereas the opposite is true for boys.

Differences between low and normal birth weight children by mother's age at the child's birth are significant in all countries but Lesotho and Namibia. There is a larger proportion of low than normal birth weight children among mothers who were less than 20 years old at the birth of their child, and there is a correspondingly lower proportion of low than normal birth weight children among mothers who were 20-34 years old at the birth of their child. Differences by mother's education (which are significant in all countries but Benin) indicate that the proportion of low birth weight children of mothers with no or primary education is higher than for normal weight children.

The presence of a skilled attendant at delivery (doctor, nurse or midwife) is associated with a higher proportion of normal than low birth weight children, and this finding is significant in all countries except Congo Brazzaville.

Concerning household wealth, we find that there is a higher proportion of low birth weight children in the poorest households and a lower proportion in the richest households, than the corresponding proportions of normal weight children. The difference between low and normal weight children by household wealth status is significant in all countries but Gabon and Swaziland. On the contrary, differences by type of place of residence (urban/rural) are significant in only in 4 of the 9 countries included in the analysis. In these cases, the proportion of low birth weight children who live in rural areas is higher than the corresponding proportion of normal weight children.

Similar patterns can be found for the last birth during the five years before the survey when data for all countries are pooled together. In addition, in this case we find that prenatal care importantly and significantly discriminates between low and normal weight children: the proportion of low birth weight children whose mothers did not receive prenatal care is double the proportion of normal weight children whose mothers did.

5.5.2 Life table estimates of the probability of dying before age 5 by birth weight status

In Figure 2 we plot life table estimates of the proportion of children surviving at each age (in months) by birth weight status for each country included in the analysis. The figure clearly indicates that LBW is associated with a higher probability of dying not only in infancy but also during childhood. At each age, the proportion surviving is significantly higher among children whose weight is normal, particularly after the first year of life. Overall, the difference in survival probabilities at age 5 between normal and low birth weight children varies from 2% in Benin to 12% in Swaziland. This provides a first indication of the differential impact of birth weight by duration of exposure on the risk of dying during infancy and childhood.

[Figure 2 about here]

5.5.3 Influence of birth weight status on the risk of dying before age 5: last 3 births in the five years before the survey

Table 4 shows the results of the multivariate piecewise exponential model with gamma-shared frailty for the last three singleton births occurred during the five years before the survey in each country included in the analysis.

[Table 4 about here]

The model with frailty provides a good fit to the data: in all models, the null hypothesis that the effect of the frailty (theta) is zero is rejected ($p \leq 0.05$ in all countries). This indicates that factors at the family level, which were not included in the model, are important for the risk of dying before age 5. In other terms, children of the same mother share relevant characteristics for their mortality risk during infancy and childhood, and it is important to account for such dependence. Our analysis supports the numerous other studies that have found that the children of any one mother have correlated probabilities of survival (e.g. Curtis et al. 1993; Das Gupta 1990; Guo 1993; Guo & Rodriguez 1992; Gyimah 2007; Sear et al. 2002).

As concerns birth weight, the main result of the analysis is that, in all countries, LBW is a very strong predictor of mortality risk not only in infancy but also in the postneonatal period. In particular, the statistical significance of the interaction between birth weight status and exposure time confirms that the influence of birth weight status on the risk of dying before age 5 conceals differences based on exposure time.

To facilitate the interpretation of the interaction terms in Table 4, Table 5 shows the interaction effects for exposure time and birth weight status on the risk of dying before age 5, controlling for the effect of the same covariates as in Table 5.[19] In this table, the reference category is the risk of dying during the neonatal period (less than 1 month of age) for children with normal birth weight. Consistently with the existing literature, we find that across the countries included in the analysis the risk of dying during the neonatal period for children with low birth weight is 2 to 4 times the risk of dying for children with normal birth weight. Yet we also find that, regardless of birth weight status, exposure time has a significantly negative relationship with the risk of dying before age 5 except for Namibia and Swaziland. Mortality declines sharply after the first month of life and continues to gradually decline thereafter thought infancy and childhood, but the magnitude of this effect importantly differs by birth weight status. The risk of dying for normal weight children is

[19] To calculate and interpret the interaction effects, the coefficients from the full model are summed and exponentiated to assess changes in risks. Hazard ratios are calculated to assess relative differences in risks between relevant groups within the sample. We test the null hypothesis that the hazard ratio is equal to 1 using the "lincom" command in Stata software (Stata Corporation 2009). This command is used to compute point estimates and p-values given linear combinations of coefficients and to assess whether the risk of dying before age 5 differs between children with selected characteristics.

63% to 87% lower during infancy (1-11 months of age) than during the neonatal period (less than 1 month of age). For low birth weight children, during infancy the risk of dying is lower than in the neonatal period, but it is still 23% to 91% higher than the risk of dying of normal birth weight children during the first month of life. Low birth children recover their mortality disadvantage compared to normal birth weight children only by the end of their fifth year of life. During childhood (1-5 years), the risk of dying for low birth weight children decreases to become only 3% to 25% lower than the risk of dying of normal birth weight children during the neonatal period.

[Table 5 about here]

Consistently with earlier studies (DaVanzo et al. 2008; Manda 1999; Reid 2001; Rutstein 2005; Rutstein 2008), one of the two covariates that are significantly associated with the risk of dying before age 5 after controlling for birth weight and unobservable family-level characteristics is the child's birth order and preceding birth interval. This could be related to maternal depletion syndrome and resource competition between siblings, in addition to a lack of care and attention experienced by high-order children (Rutstein 2005; Zenger 1993). In general, our results indicate that the combination of a higher birth order and a shorter interval increases the risk of dying. Second and third or higher order births preceded by an interval of less than 24 months have a higher mortality risk than first births, although this effect is not significant in all countries. Correspondingly, children of third or higher birth order and preceding birth interval of 36+ months have a risk of dying before age 5 that is

29 to 47% lower than children of the first birth order ($p < 0.05$ in Benin, Congo, Cameroon, and Congo Brazzaville; $p < 0.10$ in Gabon and Lesotho).

The other covariate that is significantly associated with the risk of dying before age 5 in our model is the presence of a skilled attendant at the child's delivery. Delivery by a health professional is a significant independent contributor to under-five mortality after controlling for birth weight, other socio-demographic factors, and unobserved family-level factors. Children who were delivered by health professionals have a risk of dying before age 5 that is 13 to 56% lower than children who were delivered by others or at home ($p < 0.05$ in Benin, Congo Democratic Republic, Gabon, and Zimbabwe; $p < 0.10$ in Cameroon and Namibia).

On the contrary, controlling for birth weight and for unobserved family-level factors in the analysis of the last three births crucially alters the effect of several variables that have been found to influence child mortality in earlier studies. The influence of the child's sex, wealth status and place of residence on the risk of dying before age 5 is generally in the expected direction but is significant only in a handful of countries included in the analysis. The child's sex is significantly associated at the 5% level with the risk of dying before age 5 only in Gabon and Namibia (at the 10% level in Congo Democratic Republic), where it shows higher mortality for males than females. The effect of wealth status is relevant just in

Benin and Congo Democratic Republic, where children from the richest households have a risk of dying before age 5 that is 36 to 39% lower than children from the poorest households ($p < 0.05$). Urban residence is associated with a lower risk of dying only in Benin and Cameroon ($p < 0.10$).

The effect of mother's education on the risk of dying before age 5 is reversed in most countries, and its expected negative effect is found to be significant in only two cases (Congo Democratic Republic and Lesotho).

Finally, mother's age at birth is not significantly associated with the risk of dying before age 5 in any country included in the analysis, although it is generally well known that the mother's age at birth is an important factor for child mortality (Hobcraft et al. 1985). Younger women under the age of 20 are likely to experience a greater risk of pregnancy and delivery complications and their children an increased risk of having LBW and prematurity (Arokiasamy & Gautam 2008). In our models, controlling for low birth weight and unobservable family-level factors seems, however, to completely remove this effect, as it has been observed in rural Gambia (Sear et al. 2002) and Bolivia (Forste 1994).

5.5.4 Influence of birth weight status on the risk of dying before age 5: last birth in the five years before the survey

Table 6 shows the results of the multivariate piecewise exponential model with individual frailty for the last singleton birth occurred during the five years before the survey in the pooled dataset for all countries included in the analysis. Table 7 presents the interactions effects between birth weight status and exposure time for ease of interpretation.

[Table 6 and 7 about here]

The results for birth weight status confirm the findings of the earlier models for the last three births occurred in the five years before the survey (see Table 4 and 5). LBW results, once again, an important predictor not only of neonatal but also of post-neonatal and child mortality; the interaction terms between birth weight status and exposure time allow quantifying the differential impact of birth weight for the risk of dying before age 5 based on exposure time.

As concerns the other covariates included in the model, birth order and skilled attendant at delivery are two important factors influencing the risk of dying before age 5 as it was the case in the earlier models. In the pooled dataset, third or higher order births preceded by an interval of more than 36 months have a risk of dying that is 28% lower than first births. The presence of a skilled attendant at delivery implies a risk of dying that is 14% lower than children who were delivered at home.

For the last birth in the five years before the survey, we find, however, different results concerning the other covariates. The child's sex, which had an inconsistent effect in the earlier models, here is a factor significantly associated with our outcome of interest: males have a risk of dying that is 9% higher than females ($p < 0.05$). The effect of household wealth, which in the models for the last three births was significant and in the expected directions for at least few countries, is insignificant in the model for the last birth. On the contrary, there is an important effect of place of residence: children who reside in urban areas have a risk of dying before age 5 that is 11% lower than children residing in rural areas ($p < 0.05$). The influence of mother's age at birth on the risk of dying before age 5 is now significant, but the direction of this effect is opposite than that found in other studies: children whose mothers were 35 years or older have a risk of dying that is 29% higher than that of children whose mother were less than 20 years old. This is also the case for maternal education.

The model for the last birth allows appreciating the impact of prenatal care on the risk of dying before age 5, which we could not take into account in the models for the last three births before the survey. The potential contribution to child survival of health care provision during pregnancy and delivery has been well documented in less developed countries (Berg 1995; Brockerhoff & Derose 1996; Claeson & Waldman 2000). If the primary effect of prenatal care is to increase the mothers' health and survival, it can also have a strong impact of the foetal health through better dietetic nutrition, vitamin A, monitoring, early detection of health, and pregnancy problems (Berg 1995). Our findings about prenatal care indeed confirm that under-five mortality declines with the number of visits for antenatal care during pregnancy. Children whose mothers were visited 1 to 3 times during pregnancy have a risk of dying before age 5 that is 17% lower than children whose mothers were not visited ($p < 0.05$). If the mother was visited 4 or more times, the risk of dying before age 5 is 26% lower than if the mother was not visited ($p = 0.000$).

5.6 Conclusion

The idea that birth weight affects survival is nothing new, although the focus of the existing literature has mainly been on infant mortality. In the past forty years, numerous studies have quantified the risk of morbidity and mortality among low birth weight infants relative to the risk in infants of normal birth weight. At least few authors have also identified the proportion of all mortality and morbidity in infancy attributable to or accounted for by LBW. Yet there is a paucity of research on the influence of LBW on under-five-years mortality, especially in developing countries. Such an omission is particularly unfortunate since the majority of low birth weight children as well as the highest child mortality rates are found in this region. Against this backdrop, our study exploits recent national survey data for nine countries in sub-Saharan Africa to explore whether LBW is associated with increased risk of mortality not only in the neonatal but also in the postneonatal period and during childhood.

As concerns neonatal mortality, our findings confirm those of previous studies. Children born with low birth weight are 2-4 more likely to die during the year of life than children born with normal weight, net of demographic and socio-economic factors, health-seeking behavior, and unobservable family-level characteristics. Yet the main novel finding in our study is that the mortality risk associated with LBW remains important even after neonatal period. For low birth weight children, during infancy the risk of dying is lower than in the neonatal period, but it is still 23% to 91% higher than the risk of dying of normal birth weight children during the first month of life. Low birth children recover their mortality disadvantage compared to normal birth weight children only by the end of their fifth year of life. During childhood (1-4 years), the risk of dying for low birth weight children decreases to become only 3% to 25% lower than the risk of dying of normal birth weight children during the neonatal period.

Our study has inherent limitations that should be noted when interpreting the results. A major analytic challenge is the threat to the validity and precision of our results that is posed by missing data. As noted earlier, information on birth weight is missing in many cases, since a large proportion of children were born at home and thus not weighed at birth. In the present study, we use a standardized methodology to adjust for missing birth weight data that relies on the mother's assessment of the child's size at birth. Although we limit the analysis to countries where the proportion of missing values does not exceed 45%, the mothers' subjective assessment of the infant's size at birth remains likely biased. This is because some mothers may report their babies to be smaller if they were failing to thrive or have died, thus exaggerating the association between the infant's size and subsequent mortality. In addition, except for antenatal care, we could not take into account in our analysis the mother's behaviour during pregnancy, which is known to crucially affect the child's weight at birth as well as his/her chances of survival. We also could not account for either details of the circumstances of the individual child (place of delivery and help at delivery; breastfeeding; immunization; number of siblings who died during their first five years of life) or specific practices of the mother regarding child care and hygiene (changes, if any, in the food or water given to children when they suffered from fever or diarrhea, regularity in use of soap after defecation, frequency of bathing).

The main policy implication of our findings is that reducing the incidence of LBW may be an important prevention strategy to combating child mortality in sub-Saharan Africa countries, where it remains a major health challenge (Black et al. 2003; Bryce et al. 2006; Jones et al. 2003; Lee 2003; World Health Organization 2005). In addition to measures targeted at reducing poverty and income inequalities, reducing LBW could thus form an important contribution to the Millennium Development Goal of reducing child mortality.

5.7 Tables and figures

Table 1: Infant and Under-5 mortality rates (number of deaths per thousand births) for the five-year period before the survey in the countries selected for the analysis

Country	Survey year	Infant mortality (1q0)	Under-five mortality (5q0)
Benin	2006	67.0	124.9
Cameroon	2004	74.1	143.6
Congo Brazzaville	2005	75.5	116.6
Congo Democratic Republic	2007	91.8	147.9
Gabon	2000	57.3	88.6
Lesotho	2004	91.0	112.8
Namibia	2006	46.1	69.4
Swaziland	2006	85.5	119.9
Zimbabwe	2005/06	59.9	82.5

Source: Macro International Inc, 2010. MEASURE DHS STATcompiler. http://www.measuredhs.com, March 22 2010.

Table 2: Number and percentage[1] of children with low birth weight[2]: last 3 births and last birth during the five years before the survey, by country and all countries

Country	Survey year	Last 3 births in past 5 years		Last birth in past 5 years	
		Number[3]	% with low birth weight	Number[3]	% with low birth weight
Benin	2006	14892	11.8	10138	11.8
Cameroon	2004	7621	15.4	5139	15.2
Congo Brazzaville	2005	4507	10.6	3361	9.7
Congo Democratic Republic	2007	8469	7.9	5317	6.7
Gabon	2000	3776	12.4	2664	12.3
Lesotho	2004	3405	11.6	2778	11.0
Namibia	2006	4738	13.8	3769	13.7
Swaziland	2006	2670	7.5	2055	7.1
Zimbabwe	2005/06	5010	10.8	3998	10.2
All countries		63502	9.7	41960	9.0

[1] Number and percentages were calculated using appropriate individual country weights and pooled weights for all countries.

[2] Low birth weight: less than 2500 grams. Information on missing numerical birth weight was derived from the mother's assessment of the child's size at birth (see text).

[3] Number of children (singleton births) for whom it was possible to estimate birth weight status, either from the reported numerical birth weight or from the mother's assessment of the child's size at birth.

Table 3: Percentage distribution[1] of children's selected characteristics by birth weight status[2]: last 3 births and last birth during the five years before the survey (singleton births), by country and all countries

	Last 3 births in past 5 years																				Last birth in past 5 years, all countries	
	Benin		Cameroon		Congo Brazaville		Congo Dem. Republic		Gabon		Lesotho		Namibia		Swaziland		Zimbabwe		All countries			
Characteristics	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight	Low birth weight	Normal birth weight
Number of children[3]	1755	13137	1174	6447	478	4029	670	7800	468	3308	394	3011	656	4082	200	2470	539	4472	6161	57340	3767	38192
Age at death																						
< 1 month	4.5	2.0	4.1	1.8	8.0	1.7	10.1	2.4	5.5	1.7	9.2	2.8	4.2	1.6	6.2	1.5	4.8	1.6	7.5	2.2	4.4	1.6
1- 11 months	3.5	2.6	4.7	3.7	6.1	2.7	5.2	3.7	4.1	2.0	5.1	3.5	3.2	1.7	10.0	5.1	3.5	3.0	4.8	3.5	3.1	2.5
12-59 months	2.4	2.3	3.9	3.2	2.8	1.6	2.2	2.6	2.0	1.6	0.4	1.2	2.0	1.0	3.1	1.6	1.3	1.2	2.5	2.5	1.7	1.2
Child is alive	89.6	93.1	87.2	91.3	83.0	94.0	82.5	91.4	88.4	94.8	85.3	92.5	90.5	95.8	80.6	91.9	90.4	94.2	85.2	91.9	90.8	94.7
Birth order and preceding birth interval																						
First birth	26.6	19.0	28.9	23.5	36.8	26.0	30.6	20.2	41.2	26.0	33.9	35.4	34.1	32.7	46.2	31.3	40.6	31.6	31.2	22.0	28.0	21.6
2nd and < 24 months	3.1	2.9	4.5	4.1	3.6	3.1	5.0	4.4	5.0	4.1	1.6	2.9	5.7	2.9	3.2	3.9	2.7	2.3	4.4	4.0	4.1	3.3
2nd and 24-36 months	7.7	7.6	8.2	7.4	5.9	6.1	7.5	6.7	5.3	6.6	5.6	6.2	5.5	6.1	6.7	7.1	7.3	7.5	7.5	6.9	6.9	6.6
2nd and 36+ months	7.4	8.7	5.6	7.7	12.7	14.3	5.6	6.7	6.8	9.8	9.4	14.4	16.2	16.3	10.4	13.4	13.0	16.0	6.9	8.2	7.2	8.8
3rd+ and < 24 months	8.6	8.5	14.0	12.3	5.3	6.2	15.7	15.9	11.5	11.1	9.2	3.5	5.9	5.8	5.5	6.5	3.7	4.7	13.0	13.4	13.0	12.0
3rd+ and 24-36 months	20.5	24.6	21.0	22.5	11.8	15.1	17.7	24.9	13.8	18.3	13.4	9.0	9.7	11.6	12.5	13.4	8.9	10.9	17.5	22.8	17.1	22.5
3rd+ and 36+ months	26.1	28.7	17.7	22.6	23.9	29.2	17.8	21.1	16.3	24.0	26.8	28.6	23.0	24.5	15.5	24.3	23.8	26.9	19.5	22.7	23.7	25.3
Child's sex																						
Female	55.5	48.9	53.9	49.6	53.4	48.1	50.6	50.7	53.6	48.1	53.7	48.2	51.1	48.4	52.1	49.1	55.5	48.2	52.4	50.1	52.1	49.3
Male	44.5	51.1	46.1	50.4	46.6	51.9	49.4	49.3	46.4	51.9	46.3	51.8	48.9	51.6	47.9	50.9	44.5	51.8	47.6	49.9	47.9	50.7
Mother's age at child's birth																						
Less than 20 years	16.6	11.6	31.6	21.8	31.1	20.0	23.1	15.7	35.7	26.1	19.0[a]	20.9[a]	16.7[a]	16.0[a]	31.7	23.5	27.9	19.8	25.1	16.8	21.0	16.0
20-34 years	71.3	75.7	58.9	67.3	56.0	67.8	59.3	68.4	55.2	64.3	62.0[a]	64.5[a]	69.7[a]	69.8[a]	58.7	65.7	63.9	70.8	60.8	68.9	61.4	67.4
35 years or more	12.1	12.7	9.6	10.9	12.9	12.1	17.5	15.9	9.1	9.6	19.1[a]	14.6[a]	13.7[a]	14.2[a]	9.6	10.8	8.2	9.4	14.1	14.3	17.6	16.6
Mother's education																						
No education	77.0[a]	74.7[a]	52.2	26.2	9.7	7.7	27.7	22.8	9.5	6.3	4.6	2.3	14.6	10.1	12.5	8.5	5.3	3.9	34.5	24.7	35.3	23.7
Primary	15.8[a]	17.9[a]	33.2	44.0	39.9	34.3	44.2	41.6	43.3	41.7	67.5	63.8	29.6	28.3	36.4	34.4	42.4	35.7	38.9	39.5	37.1	38.6
Secondary or higher	7.2[a]	7.5[a]	14.5	29.8	50.4	57.9	28.1	35.6	47.2	52.1	27.9	33.9	55.8	61.6	51.1	57.2	52.3	60.3	26.6	35.7	27.5	37.7
Skilled attendant at delivery																						
Doctor, nurse, or midwife	67.6	74.7	35.7	63.2	29.5[a]	31.8[a]	39.1	43.1	83.9	84.1	48.4	57.6	74.6	83.4	67.9	70.6	56.5	71.0	43.7	51.1	46.4	53.2
None or other	32.4	25.3	64.3	36.8	70.5[a]	68.2[a]	60.9	56.9	16.1	15.9	51.6	42.4	25.4	16.6	32.1	29.4	43.5	29.0	56.3	48.9	53.6	46.8
Number of prenatal visits																						
None or unknown	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	20.3	11.2
1-3 visits	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	31.4	32.2
4 visits or more	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	48.3	56.6
Household wealth status																						
1st quintile (Poorest)	27.0	21.7	37.8	23.5	24.0	21.7	28.9	20.0	20.8[a]	19.5[a]	26.9	20.3	23.4	20.5	17.6[a]	19.5[a]	30.4	23.9	30.4	20.9	29.5	20.2
2nd quintile	21.0	20.4	25.5	19.8	20.7	22.3	24.9	21.9	23.2[a]	23.1[a]	26.1	23.5	20.1	18.9	20.5[a]	20.9[a]	20.4	20.9	24.0	21.4	23.4	20.9
3rd quintile	20.4	20.8	18.1	20.9	24.8	21.6	20.8	21.0	20.0[a]	21.4[a]	16.5	17.7	24.7	22.3	20.2[a]	20.0[a]	16.8	17.6	19.9	20.7	18.1	20.9
4th quintile	17.7	20.5	10.8	19.2	15.3	18.6	14.4	21.1	21.1[a]	19.6[a]	21.3	20.2	19.6	21.2	19.0[a]	19.8[a]	17.8	21.1	14.5	20.7	16.3	20.5
5th quintile (Richest)	13.9	16.6	7.8	16.6	15.2	15.7	11.0	16.0	14.9[a]	16.4[a]	9.2	18.3	12.3	17.1	22.8[a]	19.9[a]	14.7	16.4	11.1	16.2	12.7	17.5
Place of residence																						
Rural	68.2	65.3	70.0	54.1	50.2[a]	52.3[a]	69.8	59.8	25.6[a]	26.0[a]	88.4	85.4	60.8[a]	57.6[a]	74.6[a]	77.6[a]	72.3[a]	70.5[a]	69.0	60.2	67.1	59.1
Urban	31.8	34.7	30.0	45.9	49.8[a]	47.7[a]	30.2	40.2	74.4[a]	74.0[a]	11.6	14.6	39.2[a]	42.4[a]	25.4[a]	22.4[a]	27.7[a]	29.5[a]	31.0	39.8	32.9	40.9

[1] Percentages were calculated using appropriate individual country weights and pooled weights for all countries.

[2] Normal birth weight: 2500 grams or more. Low birth weight: less than 2500 grams. Information on missing numerical birth weight was derived from the mother's assessment of the child's size at birth (see text).

[3] Number of children (singleton births) for whom it was possible to estimate birth weight status, either from the reported numerical birth weight or from the mother's assessment of the child's size at birth.

[a] Differences between normal and low birth weight children were not significant even at the 10 per cent level.

Table 4: Multivariate piecewise exponential hazard model with gamma-shared frailty[1] (hazard ratios, HR, and p-value) for the influence of birth weight status and selected characteristics on the risk of dying before age 5: last 3 births during the five years before the survey, by country and all countries

	Benin		Cameroon		Congo Brazzaville		Congo Dem. Republic		Gabon		Lesotho		Namibia		Swaziland		Zimbabwe		All countries	
Characteristics	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue	HR	pvalue
Exposure time																				
< 1 month	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
1- 11 months	0.14	0.000	0.20	0.000	0.14	0.000	0.18	0.000	0.17	0.000	0.14	0.000	0.14	0.000	0.40	0.000	0.19	0.000	0.17	0.000
12-59 months	0.07	0.000	0.09	0.000	0.06	0.000	0.07	0.000	0.07	0.000	0.03	0.000	0.05	0.000	0.07	0.000	0.04	0.000	0.06	0.000
Birth weight status[2]																				
Low birth weight (< 2500 grams)	2.09	0.000	1.91	0.000	4.04	0.000	2.12	0.000	3.59	0.000	3.19	0.000	2.90	0.000	4.22	0.000	2.30	0.001	2.48	0.000
Normal birth weight (>= 2500 grams)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Interaction between exposure time and birth weight status																				
Less than 1 months * normal	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
1-11 months * low birth weight	0.65	0.024	0.69	0.103	0.62	0.109	0.74	0.200	0.50	0.048	0.45	0.014	0.63	0.162	0.48	0.070	0.56	0.084	0.59	0.000
12+ months * low birth weight	0.55	0.004	0.63	0.054	0.48	0.038	0.54	0.029	0.33	0.011	0.12	0.005	0.75	0.438	0.62	0.397	0.50	0.125	0.51	0.000
Birth order and preceding birth interval																				
First birth	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
2nd and < 24 months	1.12	0.514	1.39	0.050	0.71	0.362	0.97	0.855	0.80	0.539	1.66	0.081	1.17	0.643	0.78	0.541	2.17	0.007	1.20	0.022
2nd and 24-36 months	0.73	0.028	0.86	0.361	0.72	0.243	0.68	0.025	0.80	0.431	0.76	0.337	0.80	0.484	0.69	0.233	0.87	0.599	0.77	0.000
2nd and 36+ months	0.62	0.001	0.86	0.373	0.79	0.279	0.63	0.013	0.85	0.558	0.86	0.475	1.21	0.364	1.04	0.857	0.96	0.834	0.81	0.001
3rd+ and < 24 months	1.35	0.011	1.20	0.198	0.86	0.597	1.11	0.405	1.05	0.840	1.38	0.230	0.81	0.535	1.32	0.357	1.98	0.005	1.31	0.000
3rd+ and 24-36 months	0.86	0.167	0.92	0.519	0.94	0.788	0.69	0.004	0.47	0.005	0.50	0.014	0.96	0.876	0.93	0.795	0.91	0.692	0.83	0.001
3rd+ and 36+ months	0.67	0.000	0.66	0.006	0.64	0.035	0.53	0.000	0.65	0.086	0.68	0.057	1.07	0.741	0.71	0.161	0.86	0.448	0.68	0.000
Child's sex																				
Female	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Male	1.09	0.157	1.07	0.390	1.07	0.576	1.13	0.095	1.37	0.017	1.10	0.450	1.29	0.052	1.03	0.843	1.16	0.205	1.11	0.001
Mother's age at child's birth																				
Less than 20 years	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
20-34 years	0.89	0.237	0.84	0.116	0.97	0.870	1.01	0.958	1.17	0.450	1.17	0.394	0.93	0.735	1.10	0.661	0.91	0.602	0.94	0.186
35 years or more	0.94	0.653	1.16	0.356	1.17	0.565	1.27	0.122	1.42	0.242	1.42	0.185	1.28	0.365	0.68	0.263	1.10	0.741	1.10	0.166
Mother's education																				
No education	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Primary	1.09	0.361	1.22	0.046	1.25	0.345	0.93	0.410	0.86	0.575	0.62	0.111	1.86	0.010	1.09	0.726	1.22	0.539	1.04	0.355
Secondary or higher	0.77	0.142	1.08	0.561	0.87	0.575	0.79	0.045	0.94	0.806	0.58	0.098	1.71	0.034	0.76	0.292	1.31	0.428	0.86	0.001
Skilled attendant at delivery																				
Doctor, nurse, or midwife	0.87	0.050	0.85	0.073	0.92	0.550	0.82	0.014	0.44	0.000	0.95	0.687	0.74	0.079	0.98	0.911	0.75	0.034	0.80	0.000
None or other	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Household wealth Index																				
1st quintile (Poorest)	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
2nd quintile	0.99	0.897	0.94	0.549	1.04	0.831	1.04	0.730	1.48	0.033	1.20	0.328	0.96	0.828	0.74	0.196	1.00	0.998	1.04	0.410
3rd quintile	1.09	0.326	0.98	0.841	0.84	0.426	0.95	0.681	1.23	0.385	1.24	0.292	1.10	0.622	0.97	0.882	1.14	0.455	1.09	0.077
4th quintile	0.95	0.595	1.00	0.989	0.86	0.549	1.04	0.735	1.06	0.836	1.42	0.097	0.69	0.139	0.96	0.868	0.95	0.823	1.05	0.373
5th quintile (Richest)	0.64	0.002	0.81	0.250	0.66	0.141	0.61	0.006	0.73	0.317	1.52	0.086	0.61	0.108	0.85	0.534	0.99	0.972	0.85	0.019
Place of residence																				
Rural	1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00		1.00	
Urban	0.88	0.075	0.84	0.092	0.83	0.305	0.88	0.265	1.05	0.770	0.97	0.891	1.27	0.161	1.47	0.033	0.92	0.738	0.89	0.002
Constant	-3.54	0.000	-3.68	0.000	-3.64	0.000	-3.31	0.000	-3.76	0.000	-3.34	0.000	-4.64	0.000	-4.07	0.000	-4.16	0.000	-3.64	0.000
Theta	0.36		0.06		0.91		0.59		0.51		0.67		1.12		1.00		0.85		0.40	
Likelihood X^2 theta = 0	5.63	0.009	0.14	0.354	6.35	0.006	13.38	0.000	1.85	0.087	4.50	0.017	3.78	0.026	5.27	0.011	6.49	0.005	34.12	0.000

[1] Models were run without using survey weights.

[2] Information on missing numerical birth weight was derived from the mother's assessment of the child's size at birth (see text).

Table 5: Interactions effects (hazard ratios) for the risk of dying before age 5 by birth weight status and duration of exposure*, by country and all countries: last 3 births in the five years before the survey

	Exposure time		
	< 1 month	1- 11 months	12-59 months
Benin			
Low birth weight	2.09	1.36	1.15
Normal birth weight	1.00	0.14	0.07
Cameroon			
Low birth weight	1.91	1.32	1.20
Normal birth weight	1.00	0.20	0.09
Congo Brazzaville			
Low birth weight	4.04	2.50	1.94
Normal birth weight	1.00	0.14	0.06
Cong Dem. Republic			
Low birth weight	2.12	1.57	1.14
Normal birth weight	1.00	0.18	0.07
Gabon			
Low birth weight	3.59	1.80	1.18
Normal birth weight	1.00	0.17	0.07
Lesotho			
Low birth weight	3.19[a]	1.44[a]	0.38[a]
Normal birth weight	1.00	0.14	0.03
Namibia			
Low birth weight	2.90	1.83	2.18
Normal birth weight	1.00	0.14	0.05
Swaziland			
Low birth weight	4.22	2.03	2.62
Normal birth weight	1.00	0.40	0.07
Zimbabwe			
Low birth weight	2.3[a]	1.29[a]	1.15[a]
Normal birth weight	1.00	0.19	0.04
All countries			
Low birth weight	2.48	1.46	1.26
Normal birth weight	1.00	0.17	0.06

* Model is presented in Table 3.

[a] The test of the null hypothesis that the hazard ratio is equal to 1 was not significant at the 5 per cent level.

Table 6: Multivariate piecewise exponential hazard model with individual frailty[1] (hazard ratios, HR, and p-value) for the influence of birth weight status and selected characteristics on the risk of dying before age 5: last birth during the five years before the survey, all countries

Characteristics	HR	pvalue
Exposure time		
< 1 month	1.00	
1- 11 months	0.16	0.000
12-59 months	0.07	0.000
Birth weight status[2]		
Low birth weight (< 2500 grams)	2.36	0.000
Normal birth weight (>= 2500 grams)	1.00	
Interaction between exposure time and birth weight status		
Less than 1 months * normal	1.00	
1-11 months * low birth weight	0.56	0.000
12+ months * low birth weight	0.59	0.000
Birth order and preceding birth interval		
First birth	1.00	
2nd and < 24 months	1.06	0.655
2nd and 24-36 months	0.75	0.006
2nd and 36+ months	0.87	0.108
3rd+ and < 24 months	1.09	0.310
3rd+ and 24-36 months	0.78	0.002
3rd+ and 36+ months	0.72	0.000
Child's sex		
Female	1.00	
Male	1.09	0.043
Mother's age at child's birth		
Less than 20 years	1.00	
20-34 years	0.98	0.733
35 years or more	1.29	0.005
Mother's education		
No education	1.00	
Primary	1.19	0.002
Secondary or higher	1.02	0.737
Skilled attendant at delivery		
Doctor, nurse, or midwife	0.86	0.002
None or other	1.00	
Number of prenatal visits		
None or unknown	1.00	
1-3 visits	0.83	0.014
4 visits or more	0.74	0.000
Household wealth status		
1st quintile (Poorest)	1.00	
2nd quintile	1.11	0.125
3rd quintile	1.13	0.083
4th quintile	1.14	0.075
5th quintile (Richest)	0.97	0.771
Place of residence		
Rural	1	
Urban	0.89	0.028
Constant	-3.86	0.000
Theta	0.00	
Likelihood X^2 theta = 0	0.00	1.000

[1] Models were run without using survey weights.

[2] Information on missing numerical birth weight was derived from the mother's assessment of the child's size at birth (see text).

Table 7: Interactions effects (hazard ratios) for the risk of dying before age 5 by birth weight status and duration of exposure*: last birth in the five years before the survey, all countries

	Low birth weight	Normal birth weight
Exposure time		
< 1 month	2.36	1.00
1- 11 months	1.32	0.16
12-59 months	1.39	0.07

* Model is presented in Table 5.

APPENDIX Table 1: Number of children born (singleton births) and proportion of children with missing information on numerical birth weight or on mother's assessment of the child's size at birth[1]: last 3 births and last birth in the five years before the survey: all DHS carried out in sub-Saharan Africa during the period 2000-2007

		Last 3 births in past 5 years			Last birth in past 5 years		
Country	Survey year	Number of children born[2]	% with missing information on numerical birth weight	% with missing information on both numerical birth weight and the mother's assessment of child's size at birth	Number of children born[2]	% with missing information on numerical birth weight	% with missing information on both numerical birth weight and the mother's assessment of child's size at birth
Benin	2006	15010	41.7	0.8	10196	37.3	0.6
Burkina Faso	2003	10533	72.9	1.3	7306	69.5	1.2
Cameroon	2004	7723	44.6	1.3	5186	41.0	0.9
Chad	2004	5828	90.1	0.2	3664	89.5	0.2
Congo Brazzaville	2005	4743	14.7	5.0	3498	12.6	3.9
Congo Democratic Republic	2007	8647	31.5	2.1	5385	29.2	1.3
Ethiopia	2005	10922	96.9	0.4	7238	96.0	0.2
Gabon	2000	3849	11.3	1.9	2707	10.0	1.6
Ghana	2003	3487	71.4	1.0	2585	67.9	0.7
Guinea	2005	6028	59.7	1.8	4322	57.3	1.4
Kenya	2003	5879	55.9	0.6	3980	53.0	0.5
Lesotho	2004	3491	37.4	2.5	2827	34.9	1.7
Liberia	2007	5360	83.7	1.9	3843	79.8	0.7
Madagascar	2003/2004	6156	64.1	1.1	4122	61.9	0.3
Malawi	2004	10381	51.3	2.3	7139	49.5	2.3
Mali	2006	13916	72.9	1.8	8926	70.4	1.6
Mauritania	2000/2001	4905	71.5	1.9	3371	71.2	1.9
Mozambique	2003	10260	53.8	0.5	7041	50.2	0.2
Namibia	2006	4827	24.8	1.8	3824	21.8	1.4
Niger	2006	9535	82.5	0.5	6167	81.6	0.5
Nigeria	2003	5962	86.7	1.3	3820	85.7	0.8
Rwanda	2005	8481	70.0	0.4	5354	69.0	0.2
Senegal	2005	10145	53.7	1.0	6797	50.1	0.5
Swaziland	2006	2752	16.4	3.0	2105	14.8	2.4
Tanzania	2004	8373	50.3	0.3	5662	46.9	0.2
Uganda	2006	8129	64.9	0.9	4944	61.4	0.6
Zambia	2007	6148	52.2	1.4	4038	49.0	1.1
Zimbabwe	2005/06	5067	28.2	0.9	4036	26.5	0.8

[1] Number and percentages were calculated using appropriate individual country weights.

[2] Singleton births only.

APPENDIX Table 2: Mean numerical birth weight[1] (grams) by mother's assessment of the child's size at birth: last 3 births during the 5 years before the survey (singleton births), by country

Country	Mother's assessment of child's size at birth	Number of children[2]	Mean numerical birth weight (grams)	Standard error (mean)
Benin	Total	8749	3051	6
	Very large	697	3573	28
	Larger than average	2743	3272	10
	Average	4098	2957	7
	Smaller than average	1023	2582	15
	Very small	130	2243	61
Cameroon	Total	4276	3370	11
	Very large	824	4040	24
	Larger than average	1035	3671	18
	Average	1884	3159	11
	Smaller than average	306	2573	31
	Very small	218	2355	42
Congo Brazaville	Total	4047	3230	10
	Very large	1100	3743	16
	Larger than average	1518	3362	10
	Average	1070	2829	12
	Smaller than average	266	2386	22
	Very small	84	1915	59
Congo Dem. Republic	Total	5927	3319	9
	Very large	1068	4018	19
	Larger than average	2383	3453	10
	Average	1973	2995	10
	Smaller than average	412	2508	22
	Very small	82	2175	61
Gabon	Total	3413	3152	11
	Very large	872	3620	19
	Larger than average	1035	3343	14
	Average	1094	2879	13
	Smaller than average	248	2483	26
	Very small	150	2209	44
Leshoto	Total	2185	3170	14
	Very large	148	3761	58
	Larger than average	463	3551	29
	Average	1330	3104	13
	Smaller than average	153	2534	45
	Very small	82	2220	58
Namibia	Total	3631	3122	11
	Very large	436	3597	41
	Larger than average	833	3328	23
	Average	1830	3092	12
	Smaller than average	361	2616	30
	Very small	154	2234	52
Swaziland	Total	2301	3224	12
	Very large	103	3890	67
	Larger than average	548	3526	23
	Average	1322	3204	12
	Smaller than average	274	2648	28
	Very small	46	2142	71
Zimbabwe	Total	3639	3128	9
	Very large	425	3497	25
	Larger than average	1018	3354	15
	Average	1712	3088	11
	Smaller than average	355	2569	23
	Very small	122	2160	50

[1] Weighted means. Figures were calculated using appropriate individual country weights.

[2] Number of children (singleton births) for whom both reported numerical birth weight and the mother's assessment of the child's size at birth were available.

APPENDIX Table 3: Number and percentage[1] of children by selected characteristics: last 3 births in the five years preceding the survey (singleton births), by country and all countries

	Benin		Cameroon		Congo Brazaville		Congo Dem. Republic		Gabon		Lesotho		Namibia		Swaziland		Zimbabwe		All countries	
Characteristics	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Number of children[2]	14892	100	7621	100	4507	100	8470	100	3776	100	3405	100	4738	100	2670	100	5010	100	63502	100.0
Birth weight status[3]																				
Low birth weight (< 2500 grams)	1755	11.8	1174	15.4	478	10.6	670	7.9	468	12.4	394	11.6	656	13.8	200	7.5	539	10.8	6161	9.7
Normal birth weight (>= 2500 grams)	13137	88.2	6447	84.6	4029	89.4	7800	92.1	3308	87.6	3011	88.4	4082	86.2	2470	92.5	4472	89.2	57341	90.3
Birth order and preceding birth interval																				
First birth	2963	19.9	1854	24.3	1225	27.2	1782	21	1053	27.9	1198	35.2	1560	32.9	867	32.5	1630	32.5	14553	22.9
2nd and < 24 months	435	2.9	315	4.1	142	3.1	373	4.4	160	4.2	95	2.8	156	3.3	102	3.8	117	2.3	2552	4.0
2nd and 24-36 months	1137	7.6	572	7.5	275	6.1	576	6.8	243	6.4	210	6.2	285	6	190	7.1	375	7.5	4436	7.0
2nd and 36+ months	1274	8.6	564	7.4	637	14.1	563	6.6	357	9.4	470	13.8	772	16.3	351	13.1	787	15.7	5129	8.1
3rd+ and < 24 months	1263	8.5	955	12.5	276	6.1	1347	15.9	420	11.1	141	4.1	276	5.8	172	6.5	231	4.6	8470	13.3
3rd+ and 24-36 months	3594	24.1	1697	22.3	663	14.7	2063	24.4	671	17.8	324	9.5	536	11.3	356	13.3	537	10.7	14134	22.3
3rd+ and 36+ months	4226	28.4	1665	21.8	1289	28.6	1766	20.9	872	23.1	967	28.4	1152	24.3	632	23.7	1332	26.6	14229	22.4
Child's sex																				
Female	7399	49.7	3833	50.3	2194	48.7	4293	50.7	1843	48.8	1662	48.8	2313	48.8	1318	49.4	2455	49	31940	50.3
Male	7493	50.3	3788	49.7	2313	51.3	4177	49.3	1933	51.2	1743	51.2	2425	51.2	1352	50.6	2555	51	31562	49.7
Mother's age at child's birth																				
Less than 20 years	1819	12.2	1775	23.3	955	21.2	1381	16.3	1030	27.3	704	20.7	762	16.1	644	24.1	1037	20.7	11201	17.6
20-34 years	11193	75.2	5029	66	3001	66.6	5732	67.7	2386	63.2	2185	64.2	3308	69.8	1741	65.2	3511	70.1	43254	68.1
35 years or more	1879	12.6	817	10.7	551	12.2	1356	16	360	9.5	516	15.1	668	14.1	285	10.7	463	9.2	9046	14.2
Mother's education																				
No education	11159	74.9	2302	30.2	358	8	1963	23.2	252	6.7	86	2.5	508	10.7	234	8.8	205	4.1	16300	25.7
Primary	2625	17.6	3225	42.3	1573	34.9	3543	41.8	1580	41.9	2188	64.3	1348	28.4	921	34.5	1827	36.5	25064	39.5
Secondary or higher	1107	7.4	2094	27.5	2576	57.1	2963	35	1944	51.5	1131	33.2	2883	60.8	1515	56.7	2979	59.4	22138	34.9
Skilled attendant at delivery																				
Doctor, nurse, or midwife	3875	26.1	3122	41	3084	68.4	4842	57.2	601	16	1479	43.5	844	17.8	790	29.6	1528	30.5	31442	49.6
None or other	10973	73.9	4490	59	1423	31.6	3615	42.8	3168	84	1923	56.5	3889	82.2	1880	70.4	3475	69.5	31967	50.4
Household wealth status																				
1st quintile (Poorest)	3325	22.3	1956	25.7	990	22	1754	20.7	741	19.6	716	21	992	20.9	517	19.4	1231	24.6	13879	21.9
2nd quintile	3044	20.4	1578	20.7	997	22.1	1874	22.1	873	23.1	810	23.8	903	19.1	557	20.9	1045	20.9	13768	21.7
3rd quintile	3096	20.8	1558	20.4	991	22	1778	21	802	21.2	598	17.6	1073	22.6	534	20	879	17.5	13103	20.6
4th quintile	3007	20.2	1366	17.9	824	18.3	1740	20.5	747	19.8	693	20.3	993	21	526	19.7	1041	20.8	12763	20.1
5th quintile (Richest)	2419	16.2	1162	15.3	705	15.6	1323	15.6	613	16.2	588	17.3	777	16.4	536	20.1	814	16.3	9989	15.7
Place of residence																				
Rural	9779	65.7	4310	56.6	2346	52	5133	60.6	981	26	2920	85.7	2751	58.1	2065	77.3	3543	70.7	38786	61.1
Urban	5113	34.3	3311	43.4	2161	48	3336	39.4	2795	74	485	14.3	1987	41.9	605	22.7	1468	29.3	24715	38.9

Note: Percentages may not add to 100 because of missing values.

[1] Number and percentages were calculated using appropriate individual country weights and pooled weights for all countries.

[2] Number of children (singleton births) for whom it was possible to estimate birth weight status, either from the reported numerical birth weight or from the mother's assessment of the child's size at birth.

[3] Information on missing numerical birth weight was derived from the mother's assessment of the child's size at birth (see text).

APPENDIX Table 4: Number and percentage[1] of children by selected characteristics: last birth during the five years preceding the survey (singleton births), by country and all countries

	Benin		Cameroon		Congo Brazaville		Congo Dem. Republic		Gabon		Lesotho		Namibia		Swaziland		Zimbabwe		All countries	
Characteristics	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%	Number	%
Number of children[2]	10138	100.0	5139	100.0	3361	100.0	5317	100.0	2664	100.0	2778	100.0	3769	100.0	2055	100.0	3998	100.0	41960	100.0
Birth weight status[3]																				
Low birth weight (< 2500 grams)	1200	11.8	780	15.2	326	9.7	358	6.7	328	12.3	305	11.0	515	13.7	146	7.1	410	10.2	3767	9.0
Normal birth weight (> 2500 grams)	8939	88.2	4360	84.8	3035	90.3	4959	93.3	2337	87.7	2474	89.0	3254	86.3	1909	92.9	3589	89.8	38193	91.0
Birth order and preceding birth interval																				
First birth	1833	18.1	1208	23.5	860	25.6	1074	20.2	756	28.4	946	34.0	1210	32.1	640	31.1	1231	30.8	9317	22.2
2nd and < 24 months	253	2.5	194	3.8	92	2.7	192	3.6	117	4.4	64	2.3	119	3.2	82	4.0	80	2.0	1407	3.4
2nd and 24-36 months	702	6.9	364	7.1	203	6.0	348	6.5	163	6.1	159	5.7	220	5.8	146	7.1	271	6.8	2784	6.6
2nd and 36+ months	883	8.7	389	7.6	486	14.5	363	6.8	257	9.6	405	14.6	634	16.8	277	13.5	680	17.0	3614	8.6
3rd+ and < 24 months	725	7.2	566	11.0	199	5.9	795	14.9	282	10.6	110	3.9	199	5.3	127	6.2	163	4.1	5055	12.0
3rd+ and 24-36 months	2453	24.2	1131	22.0	496	14.7	1309	24.6	437	16.4	257	9.3	417	11.1	267	13.0	418	10.5	9228	22.0
3rd+ and 36+ months	3288	32.4	1287	25.0	1025	30.5	1235	23.2	652	24.5	838	30.2	969	25.7	516	25.1	1156	28.9	10555	25.2
Child's sex																				
Female	5082	50.1	2558	49.8	1622	48.3	2644	49.7	1317	49.4	1339	48.2	1853	49.2	993	48.3	1952	48.8	20811	49.6
Male	5056	49.9	2582	50.2	1738	51.7	2672	50.3	1347	50.6	1439	51.8	1916	50.8	1062	51.7	2047	51.2	21149	50.4
Mother's age at child's birth																				
Less than 20 years	1133	11.2	1103	21.5	649	19.3	804	15.1	721	27.1	536	19.3	575	15.2	471	22.9	753	18.8	6893	16.4
20-34 years	7444	73.4	3360	65.4	2233	66.4	3502	65.9	1636	61.4	1780	64.1	2618	69.5	1334	64.9	2835	70.9	28060	66.9
35 years or more	1561	15.4	676	13.2	479	14.2	1010	19.0	308	11.6	462	16.6	576	15.3	250	12.2	411	10.3	7007	16.7
Mother's education																				
No education	7404	73.0	1460	28.4	248	7.4	1221	23.0	162	6.1	66	2.4	346	9.2	166	8.1	162	4.1	10382	24.7
Primary	1872	18.5	2129	41.4	1114	33.1	2178	41.0	1052	39.5	1728	62.2	1042	27.7	690	33.6	1399	35.0	16146	38.5
Secondary or higher	863	8.5	1550	30.2	1998	59.5	1917	36.1	1451	54.4	984	35.4	2381	63.2	1199	58.3	2437	61.0	15432	36.8
Skilled attendant at delivery																				
Doctor, nurse, or midwife	2406	23.8	1953	38.0	2264	67.4	2983	56.1	415	15.6	1149	41.4	623	16.5	584	28.4	1167	29.2	19864	47.4
None or other	7714	76.2	3184	62.0	1097	32.6	2331	43.9	2249	84.4	1628	58.6	3143	83.5	1471	71.6	2826	70.8	22068	52.6
Number of prenatal visits																				
None or unknown	1138	11.4	832	16.4	334	10.1	661	12.9	94	3.6	232	8.6	133	3.9	48	2.4	193	4.9	4919	12.1
1-3 visits	2750	27.5	1148	22.6	413	12.4	1966	38.4	814	31.1	500	18.6	582	17.1	312	15.6	907	22.9	13083	32.1
4 visits or more	6120	61.2	3100	61.0	2575	77.5	2492	48.7	1710	65.3	1953	72.7	2686	79.0	1636	82.0	2859	72.2	22750	55.8
Household wealth status																				
1st quintile (Poorest)	2130	21.0	1227	23.9	692	20.6	1081	20.3	479	18.0	527	19.0	744	19.7	371	18.0	905	22.6	8831	21.0
2nd quintile	2009	19.8	1013	19.7	700	20.8	1163	21.9	594	22.3	620	22.3	691	18.3	409	19.9	804	20.1	8874	21.1
3rd quintile	2094	20.7	1038	20.2	726	21.6	1127	21.2	576	21.6	490	17.6	832	22.1	409	19.9	699	17.5	8653	20.6
4th quintile	2107	20.8	980	19.1	676	20.1	1059	19.9	548	20.6	607	21.9	833	22.1	424	20.6	878	22.0	8448	20.1
5th quintile (Richest)	1798	17.7	882	17.2	567	16.9	887	16.7	467	17.5	534	19.2	669	17.7	442	21.5	712	17.8	7154	17.0
Place of residence																				
Rural	6529	64.4	2770	53.9	1650	49.1	3172	59.7	633	23.8	2339	84.2	2104	55.8	1574	76.6	2738	68.5	25112	59.8
Urban	3609	35.6	2369	46.1	1711	50.9	2144	40.3	2031	76.2	439	15.8	1665	44.2	481	23.4	1260	31.5	16847	40.2

Note: Percentages may not add to 100 because of missing values.

[1] Number and percentages were calculated using appropriate individual country weights and pooled weights for all countries.

[2] Number of children (singleton births) for whom it was possible to estimate birth weight status, either from the reported numerical birth weight or from the mother's assessment of the child's size at birth.

[3] Information on missing numerical birth weight was derived from the mother's assessment of the child's size at birth (see text).

Figure 1. Mean numerical birth weight by mother's assessment of the child's size at birth and country

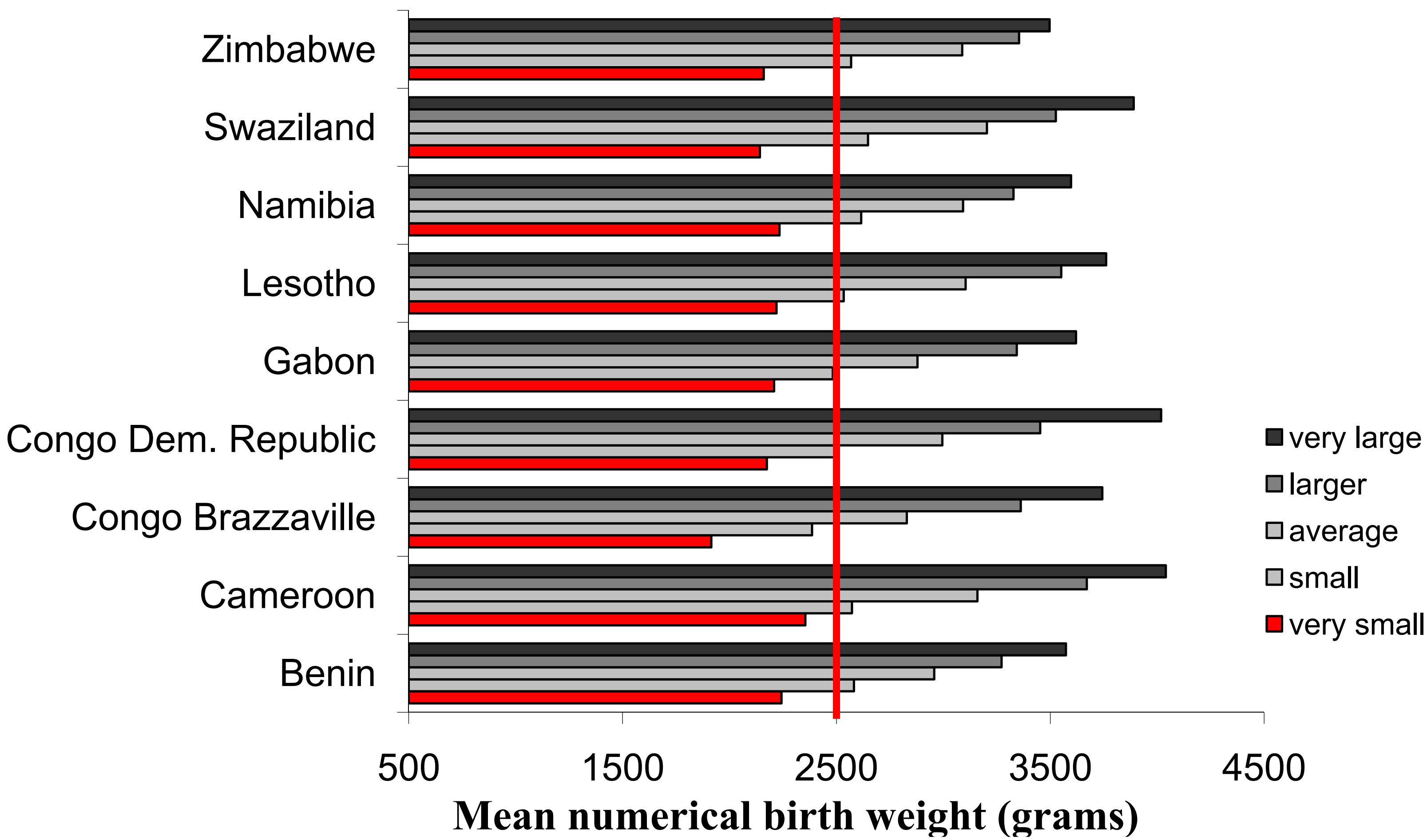
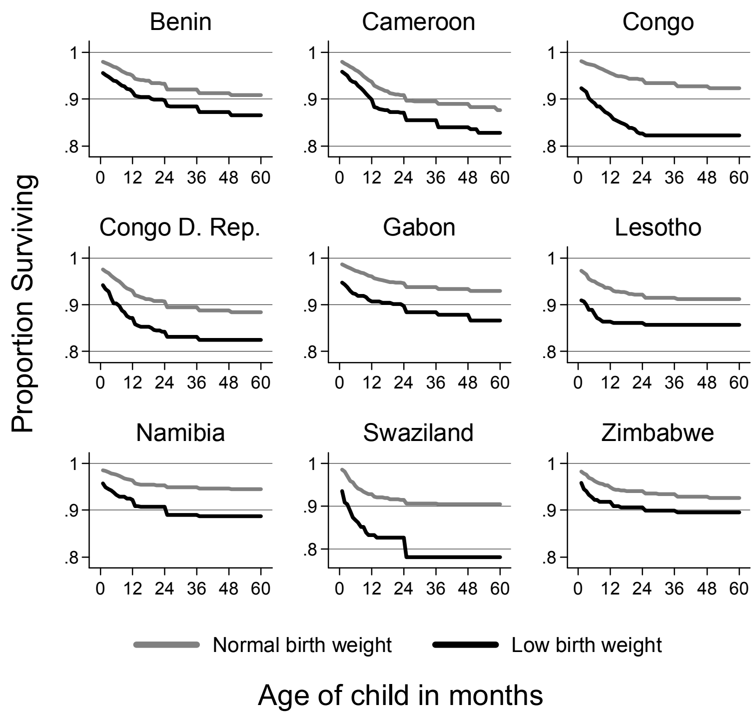


Figure 2. Life table estimates of the proportion of surviving children at each age (in months), by birth weight status and country



Note: Last 3 births in the 5 years before the survey. In all countries, the two curves are statistically significantly different (logrank test statistics, p <.000).

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Chapitre 6 : Conclusion générale

Nous consacrons ce chapitre à la présentation et discussion des principaux résultats auxquels nous sommes parvenus, de leurs implications, et à l'ébauche de quelques pistes pour les futures recherches.

En s'appuyant uniquement sur des données les plus récentes des EDS cette thèse vise à identifier les facteurs individuels et contextuels associés à la mortalité des enfants de moins de cinq ans en Afrique sub-saharienne. Deux grandes questions spécifiques ont été examinées dans cette thèse. La première examine la mesure dans laquelle le risque de décès des enfants de moins de 5 ans varie entre les communautés et les familles, et détermine si les caractéristiques des enfants, des familles et des localités de résidence peuvent expliquer ces différences. Substantiellement, nous avons ajouté des effets de contexte (au niveau de la famille et de la communauté) pour améliorer le modèle classique des déterminants de la mortalité des enfants dans les pays en développement. Cette étude donne pour la première fois un aperçu continental sur l'ampleur de l'effet contextuel de la famille et des communautés dans les inégalités de mortalité parmi les enfants de moins de cinq en Afrique sub-saharienne.

La seconde question est consacrée à l'examen de l'effet du faible poids à la naissance (FPN) sur le risque de décès avant 5 ans. Le FPN (moins de 2500 grammes) est reconnu comme l’une des causes majeures de morbidité et de mortalité dans la petite enfance, tant dans les pays industrialisés que dans les pays en développement. Les études empiriques qui ont évalué l’effet du FPN sur la mortalité des enfants en Afrique sub-saharienne sont très rares. De plus, la majorité des études existantes se sont focalisées sur la période infantile (avant 1 an) et ont utilisé des données non représentatives au niveau national, soit provenant des données transversales rétrospectives de registres des hôpitaux, ou soit d’un suivi longitudinal de la population dans un contexte local donné. Ces études ont également occulté l’effet possible de l’interaction entre le risque associé au faible poids à la naissance et la durée d’exposition. Alors que le risque de décès dans les premières années de vie peut dépendre de la durée d’exposition au risque (l’âge de l’enfant). Enfin, un bon nombre de ces études n’ont pas pris en compte l’hétérogénéité non observée, source potentielle de biais dans l’estimation des paramètres statistiques. Notre étude utilise donc pour la première fois des données collectées à l’échelle nationale dans neuf (9) pays d’Afrique sub-saharienne pour explorer de façon explicite la relation entre le poids à la naissance et le risque de décès avant cinq ans, net des facteurs socio-économiques, des comportements reproductifs et le recours aux soins prénatals, aussi bien de l’hétérogénéité non observée. De plus, notre étude met particulièrement l'accent sur l'effet de l’interaction entre la durée d’exposition (âge de l’enfant) et le FPN sur le risque de décès.

Par rapport à notre première question de recherche, les résultats indiquent une concentration de la mortalité infanto-juvénile parmi les enfants au sein de certaines familles et communautés qui persiste même après contrôle pour les caractéristiques communautaires, familiales et individuelles des enfants, ce qui suggère la présence d'effets contextuels et renforce le rôle de la communauté et de la famille comme source potentielle d'influence sur la survie des enfants dans de nombreux pays d'Afrique sub-saharienne. Les analyses multi-niveaux confirment pour plusieurs pays étudiés l'importance simultanée de l'environnement familial et du contexte local de résidence dans les différences de mortalité infanto-juvénile. Toutefois, l'hétérogénéité non-observée dans le risque de décès des enfants est plus forte entre familles comparée aux communautés; ceci quelque soit le pays étudié. Il apparaît donc que le contexte familial reste un puissant déterminant de la mortalité des enfants de moins de 5 ans en Afrique sub-saharienne.

Dans notre étude, la proportion de la variation du risque de décès infanto-juvénile, attribuable au contexte local de résidence, varie entre moins de 1% et 8%. La proportion attribuable à l'environnement des familles se situe entre 2% et 38%. Globalement, par comparaison au contexte familial, l'ampleur de l'effet de l'environnement local paraît assez modeste. Une partie importante des différences de risque de mortalité parmi les enfants proviendrait donc des caractéristiques individuelles et familiales. Ce résultat semble confirmer l'hypothèse de recherche fréquemment avancée dans plusieurs études qui se sont intéressées à l'analyse de la mortalité ou de la santé en prenant en compte des caractéristiques communautaires : la santé individuelle dépend plus des caractéristiques individuelles et familiales que des caractéristiques contextuelles (Boyle & Lipman 1998; Madise et al. 1999; Manda 1998; Pebley et al. 1996; Robert 1999; Van de Poel et al. 2009).

Il s'avère en effet que les proportions dans la présente étude sont proches de celles observées par Bolstad et Manda (2001) au Malawi et Zourkaleini (1997) au Niger dans leur étude sur la mortalité infanto-juvénile. Plusieurs auteurs soutiennent que cette partie non expliquée de la variance peut être considérée comme celle liée aux effets non observés tels que les pratiques culturelles et la fréquence des maladies infectieuses, etc., qui sont communes aux enfants d'une même communauté, ou encore, à l'incompétence parentale, les facteurs génétiques, etc., qui peuvent aussi être communs aux enfants d'une même famille résidant dans la même communauté (Bolstad & Manda 2001; Curtis et al. 1993; Das Gupta 1990; Madise et al. 1999; Omariba et al. 2008; Pebley et al. 1996; Sastry 1997a; Zourkaleini 1997).

En dépit de la présence d'une forte hétérogénéité non observée au niveau des familles et des communautés, cette étude met en évidence certains attributs du contexte local de résidence qui sont apparus comme étant d'importants prédicteurs du niveau de mortalité des enfants dans plusieurs pays. Ces facteurs affectent de façons indépendantes le risque de décès infanto-juvénile.

En effet, nos résultats confirment pour certains pays étudiés ce qui est suffisamment documenté, à savoir que la résidence en milieu urbain diminue fortement la mortalité des enfants de moins de cinq ans. En revanche, les résultats montrent que les enfants du milieu urbain sont 37% à 73% plus susceptibles de mourir avant cinq ans que les enfants du milieu rural dans certains pays comme la Sierra Leone et la Zambia. Les bénéfices potentiels pour la santé sont bien reconnus pour les enfants qui habitent le milieu urbain en raison –de façon générale– de l'offre de service de santé plus grande et accessible, de la présence et de l'accès à des infrastructures socio-économiques meilleurs, etc. (Lalou & LeGrand 1997; Van de Poel et al. 2007). Toutefois, de récentes études ont rapporté une dégradation de la santé des enfants et une augmentation du risque de décès dans le milieu urbain (Harpham 2009; Sastry 2004). Plusieurs mécanismes sont à l'origine des disparités urbain-rural de la mortalité des enfants dans les pays à faible revenu (Bocquier et al. 2010; Lalou & LeGrand 1997; Sastry 2004; Van de Poel et al. 2009). Elles peuvent être dues à la pauvreté urbaine émergente, résultats d'une urbanisation grandissante et non contrôlée (Harpham 2009), ou dans certains cas dues à des difficultés économiques post conflictuel (Garenne 2010).

Le contexte sanitaire joue un rôle majeur dans la réduction des niveaux de la mortalité infanto-juvénile dans un bon nombre de pays inclus dans l'étude. Pour une douzaine de pays étudiés, une augmentation de 1% de la proportion d'enfants complètement vaccinés dans la communauté est associée à une diminution de 17 à 79% de la probabilité de décéder avant l'âge de 5 ans. Ce résultat suggère que le renforcement et le maintien des stratégies préventives de santé publique comme la vaccination systématique des enfants sont hautement nécessaires dans la réduction des niveaux de mortalité parmi les enfants de moins de cinq ans dans de nombreux pays d'Afrique sub-saharienne.

La composition ethnique joue également un rôle important dans les inégalités de mortalité infanto-juvénile dans certains pays. Les résultats montrent que le degré d'homogénéité ethnique est fortement associé à la probabilité de mourir avant cinq ans dans certains pays d'Afrique de l'Ouest (Mali, Niger, Nigéria, Sénégal), du Centre (Tchad) et de l'Est (Zambia). Ces résultats sont proches des observations de Kravdal (2004) et de Murthi et al. (1995) sur l'Inde où ils ont montré que la structure ethnique communautaire influence le risque de décès de l'enfant indépendamment de l'ethnie de sa mère.

Des recherches antérieures ont rapporté un différentiel de mortalité parmi les enfants de moins de 5 ans selon les groupes ethniques dans plusieurs pays d'Afrique sub-saharienne. Sur la base d'enquêtes réalisées dans les années 1990 dans 11 pays (Côte d'Ivoire, Ghana, Kenya, Mali, Namibie, Niger, Ouganda, République Centrafricaine, Rwanda, Sénégal et Zambie), Brockerhoff et Hewett (2000) montrent que la probabilité de décéder pendant les premiers mois ou avant l'âge de cinq ans varie significativement d'un groupe ethnique à l'autre. Khalfaoui et Waka Modjo (2009) analysent les données récentes des EDS du Niger et montrent que les enfants dont les mères appartiennent à l'ethnie Djerma présentent une faible mortalité infantile comparée aux enfants des autres groupes ethniques, y compris les Haoussa depuis les années 1960 jusqu'au début des années 1990. De même, au Mali, Hill et Randall (1984) ont montré que les enfants Tamasheq ont une mortalité plus faible que les Bambara. Dans le même sens, Kuate-Defo rapporte pour Yaoundé (Cameroun) que les risques de mortalité avant 2 ans (toutes causes) sont plus faibles chez les enfants dont la mère est d'origine Bamiléké que chez les autres enfants (Kuate Defo 1997). L'effet de l'ethnie sur la mortalité des enfants a été aussi examiné au Sénégal où les enfants de mères Peuls ont une faible mortalité par rapport aux autres (Cantrelle et al. 1980). L'avantage des Peuls s'expliquerait par leurs habitudes alimentaires, notamment la consommation du lait qui favorise un bon état nutritionnel et une meilleure santé des enfants (Baya 1993; Cantrelle et al. 1980). En particulier, Modiano (1999) montre qu'au Burkina Faso, les Peuls seraient plus résistants au paludisme qui représente la principale cause de mortalité du pays.

L'importance du facteur ethnie devient donc suggestive dans notre étude. Nous nous y attardons. L'Afrique est caractérisée par une diversité ethnique (Brockerhoff & Hewett

2000; Obono 2003), et il semblerait qu'il existe d'importantes différences en ce qui concerne les usages liés aux soins et à l'élevage des enfants (Akoto 1993; Caldwell 1990; Kuate Defo 1994). Il existe souvent des traditions et des règles culturelles précises qui régulent la pratique de l'allaitement et, plus généralement, les habitudes alimentaires, les normes d'hygiène, le recours aux soins de santé, etc. (Akoto 1993; Kuate Defo 1994; Magadi et al. 2000). Plus particulièrement, certains aliments sont interdits aux femmes enceintes ainsi qu'aux enfants de moins de 5 ans dans presque chaque ethnie dans de nombreux pays en Afrique au sud du Sahara (Akoto 1993; Gyimah 2006).

Le degré d'homogénéité ethnique utilisé dans notre étude est une variable proxy des pratiques culturelles dominantes dans une communauté. Nous pensons être en présence de l'effet des *tendances lourdes* (pratiques persistantes) qui sont perpétuées de génération en génération. On sait que,

> « les traditions et les habitudes en matière de santé résultent d'une dynamique à la fois collective et individuelle. L'attachement aux pratiques traditionnelles, comme le recours systématique à la médecine moderne, sont des attitudes qui, avant d'être propres à l'individu, sont générées, entretenues ou condamnées par l'ensemble de la collectivité. Elles s'interprètent donc en terme de conformité ou de déviance par rapport à la norme collective » (Lalou & LeGrand 1997 :148).

L'appartenance ethnique apparait donc comme un fait anthropologique incontestable où l'identité est consolidée par altérité (De Heusch 2000). En conséquence, les spécificités ethniques conduisent à des représentations différentes de la santé en général, de celle des enfants en particulier (Akoto 1993). À ce titre, l’ethnie met en œuvre des mécanismes qui font obstacles (ou non) à l’accès à l’information et au système sanitaire moderne, compte tenu de l’ethnocentrisme et d’une certaine appréhension à l’égard des pratiques modernes de santé (Sahraoui & Ndiaye 2009 :6). En réalité, l’adoption de pratiques modernes reste généralement partielle et conduit souvent à des pratiques de dualisme médical (soins modernes et traditionnels) qui peuvent être préjudiciables à la santé de l’enfant. Ceci se révèle également dans les pratiques de recours aux soins et leur incidence sur la santé des enfants. Ces considérations, à notre avis, conduisent à des différences de mortalité selon l’appartenance ethnique.

L’éducation est souvent citée au même titre que l’ethnie, la structure familiale et le statut de la femme en tant que reflet de la diversité des cultures en Afrique sub-saharienne (Tabutin 1999). Nos analyses confirment la robustesse de l’effet contextuel de l’éducation sur la survie des enfants dans les pays en développement (voir: Kravdal 2004). Dans la présente étude, l’éducation contextuelle est mesurée par la proportion des femmes ayant un niveau d’instruction secondaire ou plus dans les localités. Nos données montrent un effet contextuel de l’éducation indépendant des conditions socio-économiques contextuelles de la famille et de la communauté. Les enfants des localités de niveau d'éducation communautaire élevée (supérieur à la moyenne nationale) présentent une probabilité infanto-juvénile relativement faible par rapport aux autres enfants dans certains pays. Au Nigéria par exemple, il s'agit d'un effet complémentaire en addition à l'effet positif significatif de l'éducation individuelle de la mère sur la survie de l'enfant. Il est vraisemblable que l'hypothèse d'effet de *débordement* (*spillover effects*) (Desai & Alva 1998 :80) semble se vérifier pour ce pays, suggérant que l'effet total de l'instruction sur la mortalité avant 5 ans ne se limite pas au seul effet individuel (Kravdal 2004). Bien que ce résultat soit robuste, l'effet estimé de l'éducation peut paraître partiel en ce sens que nous n'avons pu tenir compte de l'éducation du père (dans notre modèle théorique, l'instruction du père est considérée comme un indicateur du niveau de vie du ménage).

Néanmoins, le résultat reste hautement suggestif dans la mesure où l'effet contextuel de l'éducation persiste en présence des conditions de vie des ménages et de l'environnement communautaire dans lesquels vivent les enfants. Il existerait donc un effet « localité éduquée » ou «localité non éduquée » qui influence la survie des jeunes enfants dans certains pays d'Afrique sub-saharienne. Cela peut indiquer un phénomène d'entraînement social puisque, toutes choses étant égales par ailleurs, un enfant aura une plus grande probabilité d'être en bonne santé (et de survivre dans les cinq premières années) s'il habite dans une localité où le niveau d'éducation moyen de la communauté est plus élevé.

Au total, notre étude fournit un regard nouveau qui consolide la question des influences contextuelles sur la survie des enfants dans les pays en développement, et suggère entre autres que les politiques et programmes en vue d'améliorer la santé des enfants devraient inclure une dimension communautaire, particulièrement en focalisant davantage l'attention sur l'environnement familial des enfants.

Nos analyses montrent aussi que les facteurs individuels demeurent très importants dans l'explication des différences de mortalité des enfants dans plusieurs pays inclus dans notre étude. Certaines caractéristiques de l'enfant et de la mère sont apparues comme étant d'importants prédicteurs de la mortalité infanto-juvénile (en présence des facteurs contextuels). Il s'agit notamment, de l'éducation de la mère, le sexe de l'enfant, l'intervalle entre naissances précédentes et le rang de naissance. Globalement, les résultats de la présente étude confirment l'importance des facteurs socio-économiques, des comportements reproductifs et du patrimoine génétique et biologique de l'enfant dans la réduction de la mortalité des enfants en Afrique sub-saharienne.

Par rapport à notre deuxième question de recherche, l'étude montre de façon robuste que le poids à la naissance est un déterminant majeur de la survie des enfants aussi bien dans la période néonatale (< 1 mois) que la période post-néonatale (1-11 mois) et juvénile (1-4 ans). Les différences de mortalité infanto-juvénile selon le poids à la naissance sont significatives dans tous les pays inclus dans l'étude. Les enfants nés avec un faible poids à la naissance (FPN) courent presque 2 à 4 fois plus de risques de mourir au cours des cinq premières années de vie que les enfants de poids normal, même après correction pour l'hétérogénéité non observée. Nos résultats confirment constamment ceux des autres études et étaye l'hypothèse suivant laquelle les inégalités en matière de mortalité remontent à la période prénatale (Bhalotra & Rawlings 2011; Ewbank & Preston 1990; Kuate Defo 1997).

Les problèmes de morbidité de l'enfant commencent avant la naissance proprement dite (voir une recension sur ″Intergenerational Persistence in Health in Developing Countries″ dans : Bhalotra & Rawlings 2011). Plusieurs études ont montré que l'état de santé maternelle (aussi bien depuis sa propre naissance et particulièrement durant la période de grossesse) est un important déterminant de l'état de santé à la naissance de ses enfants (Abu-Saad & Fraser 2010; Bhalotra & Rawlings 2011; Conley et al. 2003; Cunningham et al. 2010). Il est reconnu que le manque de suivi médical des grossesses est associé à un faible capital-santé pour le futur nouveau-né (Berg 1995; Gage & Calixte 2006). Pour l'ensemble des pays étudiés, nous avons observé qu'en moyenne 12% des femmes n'ont effectué aucune visite prénatale (voir tableau annexe 4 du chapitre 5). De même, moins d'une femme sur deux (47%) en moyenne accouche en présence d'un professionnel de la santé (médecin, sage-femme, infirmier diplômé). Les enfants de ces femmes qui n'ont consulté aucun professionnel de santé au cours de la grossesse et à l'accouchement sont alors exposés à la prématurité, au retard de croissance intra-utérine (donc au FPN), à l'anémie, à l'infection foetale, etc. Finalement, les risques de morbidité et de mortalité néonatale et infantile de ces enfants seraient donc plus élevés pour cause de mauvais suivi médical de leurs grossesses.

Le désavantage persistant des enfants de FPN peut aussi se comprendre dans un contexte de pauvreté et d'insécurité alimentaire générale (ACC/SCN 2000; UNICEF 1998). Les problèmes de morbidité des enfants de FPN peuvent donc s'aggraver dans un contexte de malnutrition chronique (Chevalier et al. 1996; Rice et al. 2000). On sait que la prévalence de la malnutrition chez les enfants de moins de cinq ans reste en moyenne relativement élevée, et les carences en vitamine A, en fer et en iode, continuent d'être l'un des problèmes majeurs de santé publique dans de nombreux pays d'Afrique sub-saharienne (Fotso 2007; Linnemayr et al. 2008; Ngnie-Teta et al. 2007; Smith et al. 2005). De plus, plusieurs études ont rapporté une association significative entre le FPN et la malnutrition en raison d'une alimentation pauvre en protéine au cours des premiers mois de vie (voir : Tharakan & Suchindran 1999). Ainsi, les enfants de FPN sont plus exposés et accumuleraient un déficit en nutriment dans la période néonatale, et ceux-ci auraient du mal à rattraper leur retard de croissance (Black et al. 2008; Ziegler et al. 2002). Il semble donc évident que les enfants de

FPN qui souffrent de malnutrition protéino-calorique verraient leur risque de décès augmenté au cours de la période néonatale; et il est vraisemblable que ce désavantage persiste durant les cinq premières années de vie ou plus.

Au total, nos résultats suggèrent qu'en plus des mesures visant à réduire la pauvreté et les inégalités de revenus, la réduction de la prévalence liée au FPN pourrait apporter une contribution importante aux Objectifs du Millénaire pour le développement. Spécialement, elle apparait comme une stratégie efficace pour réduire les niveaux de mortalité parmi les enfants de moins de cinq ans.

Il y a lieu de souligner quelques limites de notre recherche. Ces limites, pour la plupart, sont inhérentes aux données disponibles essentiellement quantitatives et transversales. Certaines d'entre elles sont évoquées dans plusieurs études antérieures ayant utilisé les EDS (DeRose & Kravdal 2007; Gage & Calixte 2006; Griffiths et al. 2004; Montgomery & Hewett 2005; Omariba et al. 2008; Sastry 1996; Stephenson et al. 2006). Quant à la présente recherche, nous soulignons trois enjeux interreliés qu'il est fondamental de retenir dans l'interprétation des résultats.

Premièrement, il y a les enjeux conceptuels liés à la définition du contexte local et sa composition. La dimension (limites géographiques et taille) du contexte local est un élément capital dans l'évaluation des effets contextuels du milieu de résidence sur la santé individuelle (Diez-Roux et al. 2001; Reijneveld et al. 2000). Il existe un débat concernant l'unité spatiale d'analyse la plus appropriée pour explorer l'incidence des différences sociales, culturelles et économiques sur la santé des populations (voir par exemple : *Modifiable Areal Unit Problem*) (Gephart 1997; Jelinski & Wu 1996; LeGrand & Barbieri 2002; MacQueen et al. 2001). La règle générale est de rechercher toujours un découpage spatial fin pour garantir un certain degré d'homogénéité interne aux localités, notamment au niveau socio-économique (Schootman et al. 2007).

Le contexte communautaire retenu dans notre étude est l'unité primaire de sondage des enquêtes (ou grappe). Ces grappes sont créées pour les besoins de l'échantillonnage statistique, en général, à partir des zones de dénombrement des recensements de la population (Kravdal 2006; Lê & Verma 1997). Elles peuvent ne pas être pertinentes pour détecter une variation de la mortalité des enfants (Omariba et al. 2008 :316). De plus, elles ne représentent pas forcément une réalité socio-économique. Par exemple, certains clusters sont parfois divisés en deux groupes à partir d'un village si la taille de la population est trop grande. Il devient alors difficile d'interpréter l'effet contextuel des grappes d'échantillonnage. Toutefois, bien que ces unités spatiales apparaissent comme des unités statistiques (elles s'imposent à nous), elles gardent leur intégrité et conservent une certaine réalité socio-culturelle homogène (Pearl et al. 2001).

En gros, le choix d'une échelle spatiale pertinente dépend beaucoup plus des données disponibles. De nombreuses études sont effectuées en utilisant des découpages administratifs parce que les données sont souvent recueillies et publiées à ces niveaux administratifs, en particulier par la plupart des organismes statistiques (Courgeau 2004 :99).

Deuxièmement, il y a les enjeux liés aux mesures (*measurement en anglais)* : la plupart de nos variables contextuelles sont des proxy construits par agrégation des caractéristiques individuelles et des ménages (excepté le milieu de résidence). Par exemple, la proportion des enfants complètement vaccinés est utilisée pour caractériser le contexte sanitaire, notamment l'utilisation des services de santé infantile (Ahmed & Mosley 2002). Le fait que le statut de vaccination individuel de tous les enfants n'est pas inclus dans nos modèles peut conduire à surestimer l'effet de la couverture vaccinale. L'effet estimé peut être un *artéfact statistique* qui met en évidence un simple « effet de composition » (Duncan et al. 1998; Subramanian et al. 2003). D'une façon générale, il est difficile d'interpréter l'effet contextuel d'une variable en présence d'un biais de structure. Ce dernier fait référence « au fait qu'une variable individuelle n'est pas contrôlée, que cette variable influence le comportement étudié, et que sa distribution (la structure) est corrélée à la (ou les) variable contextuelle » (Schoumaker 2001 :57). Toutefois, ce cas est très limité dans notre étude : le problème est contrôlé pour l'éducation où on a distingué l'effet individuel (mère) et l'effet contextuel (au niveau de la communauté).

Enfin, troisièmement, il y a les enjeux liés à la disponibilité des données. La persistance d'une variabilité significative du risque de décès au niveau des familles et des communautés dans plusieurs pays étudiés (après inclusion des variables individuelles et contextuelles), suggère l'absence, dans nos modèles statistiques, des caractéristiques situées à ces différents niveaux qui sont non mesurées ou non mesurables, et qui sont pertinentes pour la survie des enfants de moins de cinq ans. Au niveau du contexte familial, nous pourrions citer par exemple l'éducation du père, les disponibilités alimentaires, la morbidité, des informations fiables sur l'allaitement, le statut nutritionnel et le statut de vaccination de tous les enfants. De même, au niveau communautaire, la disponibilité de certaines données pourrait améliorer les modèles statistiques. Il s'agit par exemple des caractéristiques agro-climatiques et des données épidémiologiques (exemples : prévalence du Vih/Sida, paludisme et autres maladies émergentes), aussi bien que des données sur l'accès aux services de santé (distance, coût, qualité) (Moisi et al. 2010; Stanecki et al. 2010).

Les recherches futures doivent donc chercher à approfondir les mécanismes qui conduisent aux disparités persistantes en matière de mortalité des enfants en documentant davantage les caractéristiques contextuelles de la famille et des localités de résidence. Le défi pour les prochaines générations d'enquêtes (notamment les EDS) est de veiller à (re)intégrer le module des questionnaires communautaires. Un questionnaire communautaire comporte en général une cinquantaine de questions visant à recueillir des informations sur les infrastructures socio-économiques (écoles, marché, transports, route…) et sanitaires (hôpitaux, centre de santé, cliniques…) disponibles dans les communautés. Si les exigences financières ne représentent pas de contraintes majeures, il faudra créer un système d'information intégré (SII) qui combine l'état civil avec l'ensemble des sources quantitatives existantes (recensements, enquêtes ponctuelles). Le principal objectif du SII est d'assurer la maîtrise de la production d'informations harmonisées, utiles, fiables, disponibles et accessibles pour une recherche approfondie en matière de mortalité (Boco 2007). Les données du recensement permettent par exemple une agrégation précise à toutes les échelles géographiques ou sous-groupes socio-économiques (Schootman et al. 2007). Il s'agit d'une alternative fiable par rapport aux données communautaires des EDS (si disponibles) dont la qualité a été souvent critiquée et a aussi été considérée comme l'un des éléments expliquant la relative difficulté à mettre en évidence des effets contextuels sur la santé des enfants (Mensch et al. 1996 :61). Les EDS récentes fournissent rarement des variables contextuelles *intégrales*, c'est-à-dire celles qui sont directement mesurées au niveau des zones de résidence (exemple : la distance de l'hôpital le plus proche) (Courgeau & Baccaini 1998; Hillemeier et al. 2003). Sur une vingtaine d'opérations de collecte réalisées en Afrique sub-saharienne entre 2005 et 2009, aucune enquête ne fournit les données relatives aux infrastructures communautaires. Pourtant, ces dernières sont essentielles à la compréhension des phénomènes démographiques (Schoumaker et al. 2006), y compris l'étude des déterminants de la survie des enfants (Al-Kabir 1984; Arguillas 2008; Boco & Bignami 2008; Moisi et al. 2010). La difficulté de collecter des données communautaires directement mesurées au niveau des localités contraint la majorité des chercheurs à travailler avec des variables agrégées construites à partir des caractéristiques individuelles (Kravdal 2004; Macintyre et al. 2002; Yen & Kaplan 1999) comme nous l'avons fait dans cette recherche.

La recherche qualitative aussi peut être mise à contribution pour approfondir la connaissance du contexte local de résidence des individus, notamment sur la formation des réseaux sociaux, considéré comme un des mécanismes de l'influence contextuelle des comportements individuels en matière de santé (Andrzejewski et al. 2008; Behrman et al. 2002; Gage 2007).

Les données qualitatives sont cruciales pour une bonne compréhension des facteurs sous-jacents à la persistance des inégalités en matière de mortalité des jeunes enfants en Afrique sub-saharienne (Adams et al. 2002; Bozon 2006; Caldwell et al. 1983; Randall & Kopenhaver 2004; Uche 1988). Il y a des situations atypiques difficiles à observer à partir des échantillons aléatoires comme cela se passe dans la plupart des grandes enquêtes démographiques en cours dans les pays du Sud. Les approches anthropologiques permettent le recueil d'informations précises sur certains aspects de la morbidité et de la mortalité des enfants (Randall & LeGrand 2003). Le rôle du réseau social durant la maladie fait rarement l'objet d'études quantitatives. Les données qualitatives peuvent concerner les réactions face à la maladie et le recours aux services sanitaires. Il reste d'actualité qu'en Afrique au sud du Sahara la source supposée de la maladie (naturelle, surnaturelle, d'origine mixte) indique le type de remède à appliquer (Uche 1988). Il peut être aussi question d'examiner *la perception*, *les croyances et les modes de raisonnement des populations* sur le phénomène de mortalité dans leurs stratégies reproductives (Montgomery 2000; Randall & LeGrand 2003).

En gros, suivant l'étude de Randall et LeGrand (2003) sur les stratégies de la reproduction, l'objectif serait de valider les hypothèses/théories démographiques sur la mortalité des enfants à partir des données qualitatives. Cependant, il n'est pas question à notre sens que la démographie se confonde avec l'anthropologie, mais la démographie peut mieux interpréter certains de ces résultats statistiques en s'appuyant sur des contributions qualitatives de bonne qualité. Une collaboration est parfois souhaitée et requise à certaines conditions (Greenhalgh 1990), notamment dans les micro-approches (Caldwell et al. 1983). Assurément, il y a là un vaste champ d'études qui ne demande qu'à être défriché.

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