Human and animal health

in nomadic pastoralist communities of Chad:

zoonoses, morbidity and health services

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Herrn Prof. Dr. Marcel Tanner und Herrn Prof. Dr. Jacques Nicolet

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Prof. Dr. Andreas Zuberbühler

Dekan

Dedicated to my friend and family

and in memory of Kol Dossoum

À la mémoire de Kol Dossoum, qui a grandement
contribué à la réalisation de cette étude,
en souvenir de tous les bons moments passés ensemble.

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Summary

The health of nomadic pastoralists is influenced by factors specific to their way of life. Nomadic pastoralists depend on their livestock for subsistence, especially on the livestock's milk. Veterinary services provide vaccination against feared livestock diseases such as anthrax. Agents transmissible between livestock and humans (zoonotic agents) may have an important impact on the health status of pastoralists because they live in close contact to their animals. However, morbidity of nomadic pastoralists in Chad had not been documented and their everyday use of health services was virtually unknown. A research collaboration between veterinary and public health was implemented to evaluate morbidity of nomadic pastoralists and of their animals simultaneously and to test intersectoral pilot-interventions following the concept of "one medicine". The studies encompassed in this thesis were conducted in the framework of an interdisciplinary research and action programme.

Fulani and Arab cattle breeders and Arab camel breeders were visited during three consecutive samplings, two in the dry season and one in the wet season, between April 1999 and April 2000. A physician clinically examined 1160 women, men and children and completed a survey questionnaire. Sera, sputum and urine samples were collected from humans, as well as sera and milk from 1640 animals. Complementary interviews mainly directed at livestock health were recorded.

Brucellosis and Q-fever were selected to investigate a possible correlation between the occurrence of these zoonoses in livestock and in humans. No active foci of brucellosis were found. The impact of brucellosis and Q-fever on the health status of the three nomadic communities included in the study appeared marginal in comparison to other diseases recorded. Pulmonary diseases were frequent, e.g. bronchitis in children under 5 years of age (18%). Arab cattle and camel breeders were severely diseased by malaria during the wet season. Clinically diagnosed malaria was prevalent during the entire year among Fulani, who stayed in the vicinity of Lake Chad. Human serum retinol concentrations were significantly correlated to livestock milk retinol, illustrating the significance of milk as a dietary component. However, serum retinol levels of women were generally low. A 24-hours dietary recall showed that nomadic pastoralists only rarely consumed fruits and vegetables.

The utilisation study provided an overview on health service utilisation patterns of sick nomadic pastoralists. Participants with respiratory disorders went early to a dispensary for consultation and successively also used more other health services. Dispensaries where anti-malarial drugs were known to be in short supply were rarely visited during the wet season. Our data suggest that young unmarried women and men had fewer opportunities to visit a marabout or a dispensary than other members of the community. Women gave birth assisted by relatives in the camps, and prenatal health care was virtually not used. No fully immunised nomadic child was found in the study population. In contrast, livestock had been vaccinated by veterinarians visiting the nomadic camps during compulsory vaccination campaigns. Breeders observed an increasing inefficacy of anthrax, blackleg and pasteurellosis vaccines. Deaths of cattle after vaccination against contagious bovine pleuropneumonia and visits of veterinarians solely to take blood for rinderpest serosurveillance without treating diseased animals were recurrent complaints of nomadic pastoralists towards veterinary services. Nevertheless, the idea of joint human and animal vaccination campaigns was appreciated because nomadic pastoralists wanted vaccination for their children, especially against measles. To which extent knowledge and experiences with livestock vaccination were transposed to children vaccination remained unclear. A cost analysis of subsequent joint vaccination campaigns showed that the public health sector can save up to 15% of infrastructure and personnel costs when vaccination services for nomadic children and women are delivered together with interventions of the livestock production sector.

Improvement of the quality of dispensary services has a potential to increase the utilisation of dispensaries by nomadic people. Health workers belonging to the nomadic community itself and better able to reach the camps may, nevertheless, be more accessible to women and children. Static or outreach dispensary-based vaccination services do not have the same efficiency to reach nomadic children as mobile vaccination campaigns have. Private veterinarians, who almost exclusively have access to pastoralists in remote areas would be interested in more fully capitalising their transportation infrastructure. Joint human and animal vaccination campaigns should be extended to other services (such as the selling of drugs) and especially to information campaigns. The provision of appropriate information may be as important as health care interventions themselves.

Résumé

La santé des pasteurs nomades est influencée par des facteurs spécifiques à leur style de vie. Leur subsistance repose sur leur bétail, et spécialement sur la production laitière de celui-ci. Les services vétérinaires assurent la vaccination contre des maladies redoutées du bétail, telles que par exemple l'anthrax. Les agents d'infections transmissibles entre humains et animaux (zoonoses) peuvent fortement influencer la santé des nomades, qui vivent en contact étroit avec leur bétail. Cependant, il n'existait aucune donnée sur la morbidité chez les pasteurs nomades du Tchad, et leur façon de recourir aux services de santé dans la vie quotidienne était pratiquement inconnu. Un projet de recherche basé sur la collaboration des secteurs de la médecine vétérinaires et de la santé publique a été mis en place pour évaluer simultanément la morbidité des pasteurs nomade et de leur bétail, et pour tester des interventions-pilote intersectorielles suivant le concept d'«une médecine unie». Les études inclues dans cette thèse ont été réalisées dans le cadre d'un programme de recherche interdisciplinaire et d'intervention.

Des campements d'éleveurs de bovins Fulani et Arabes, ainsi que de chameliers Arabes ont été visité durant trois périodes d'échantillonage, deux pendant la saison sèche et une durant la saison des pluies, d'avril 1999 à avril 2000. Un médecin a examiné 1160 hommes, femmes et enfants, et a rempli un questionnaire de santé avec eux. Chez les humains, des échantillons de sang, de crachats et d'urine ont été collectés, ainsi des spécimens de sang et de lait chez les animaux. Les éleveurs ont, de plus, participé à des interviews centrés surtout sur la santé du bétail.

La brucellose et la fièvre Q ont été choisies pour la recherche d'une éventuelle corrélation entre la présence de ces maladies zoonotiques chez les humains et les animaux. Aucun foyer actif de brucellose n'a pu être mis en évidence. L'impact de la brucellose et de la fièvre Q sur l'état de santé des nomades semble être marginal par rapport à d'autres maladies. Les affections pulmonaires étaient fréquentes, comme par exemple la bronchite chez les enfants moins de 5 ans (18%). Les éleveurs de bovins et de chameaux Arabes étaient sévèrement affectés par la malaria durant la saison des pluies. Les cas cliniques de malaria étaient fréquents en toute saison chez les Fulani qui séjournent à proximité du Lac Tchad toute l'année. Les taux sériques de rétinol des humains étaient corrélés de façon significative avec les taux observés dans le lait du bétail, ce qui souligne l'importance du lait comme source nutritionnelle pour les pasteurs nomades. Cependant, les taux de rétinol étaient bas en général. Les nomades ne consommaient que rarement des fruits et des légumes.

Notre étude a permis d'identifier les habitudes d'utilisation des ressources de santé par les nomades lors de maladies. Les participants du projet atteints de troubles respiratoires se rendaient en général rapidement à un dispensaires et tendaient souvent à recourir à d'autres dispositifs de santé par la suite. Les dispensaires connus pour être souvent à court de médicaments contre la malaria étaient peu visités durant la saison des pluies. Nos résultats suggèrent que les jeunes célibataires (femmes et hommes) avaient moins de possibilités de se rendre chez un marabout ou à un dispensaire que d'autre membres de leur communauté. Les femmes accouchaient dans les campements assistées par des proches, et n'avaient pratiquement aucun recours à la médecine prénatale. Lors de l'étude de morbidité, aucun enfant complètement vacciné n'a pu être identifié dans les campements visités. Par contre, le bétail avait été vacciné par des vétérinaires effectuant les campagnes de vaccination obligatoire. Les éleveurs ont rapporté qu'ils constataient une inefficacité croissante des vaccins contre l'anthrax, la maladie du charbon et la pasteurellose. Les nomades se sont plaints à plusieurs reprises de pertes de bétail après la vaccination contre la péripneumonie contagieuse et de visites de vétérinaires venant uniquement pour des prises de sang dans le cadre de la sérosurveillance pour la peste bovine, et qui repartaient sans traiter les animaux malades. Néanmoins, l'idée de campagnes conjointes de vaccination humaine et animale était apprécié des pasteurs nomades qui désiraient faire vacciner leurs enfants, particulièrement contre la rougeole. Dans quelle mesure leurs connaissances sur les vaccinations du bétail étaient appliquées à celles des enfants n'a pas pu être déterminé avec précision. Une analyse des coûts de campagnes conjointes de vaccinations exécutées par la suite a montré que le secteur de la santé publique pouvait économiser jusqu'à 15% des dépenses d'infrastructure et de personnel si les services de vaccination pour les enfants et les femmes nomades sont intégrés dans des interventions du secteur de la production animale.

Une amélioration de la qualité des services de dispensaire aurait le potentiel d'augmenter leur fréquentation par les nomades. Cependant, des travailleurs de santé appartenant aux communautés nomades elles–mêmes, et donc mieux à même de se rendre dans les campements, pourraient être plus accessibles pour les femmes et les enfants. Des services de vaccination statiques ou de terrain basés sur une structure de dispensaires ne disposeront pas de la même efficacité pour atteindre les enfants nomades que des campagnes de vaccination mobiles. Les vétérinaires privés, qui sont pratiquement les seuls à avoir accès aux campements d'éleveurs nomades dans des contrées retirées, seraient intéressés à optimiser l'usage de leurs moyens de déplacement en prenant part à des interventions de santé couvrant aussi des aspects de médecine humaine. Les campagnes conjointes de vaccination devraient de plus être élargies à d'autres services (tels que la vente de médicaments) et particulièrement à des campagnes d'information. La mise à disposition d'informations appropriées pourrait être aussi importante que les interventions de santé elles-mêmes.

Zusammenfassung

Die Gesundheit von Pastoralnomaden wird von ihrer Lebens- und Wirtschaftsweise beeinflusst. Die Lebensweise von Pastoralnomaden, wiederum, wird von den Bedürfnissen ihrer Tiere bestimmt. Die Tiere liefern die für ihre Ernährung wertvolle Milch und mit den Erlösen aus den Tier- und Milchverkäufen können weitere Konsumgüter der Familie gekauft werden. Da Pastoralnomaden in engem Kontakt zu ihren Nutztieren leben, können zoonotische Erkrankungen bei ihnen eine wichtige Rolle spielen. Die vorherrschenden Krankheiten von Nomaden im Tschad waren aber nicht dokumentiert und ihre Gewohnheiten zur Benutzung von Gesundheitsdiensten beinahe unbekannt. Folgend dem Konzept der einen Medizin für Mensch und Tier – der „one medicine" - untersuchte eine Forschungsgruppe gleichzeitig Krankheiten bei Pastoralnomaden und ihren Tieren sowie testete Pilotinterventionen. Die einzelnen Studien dieser Dissertation wurden im Rahmen eines interdisziplinären Forschungs- und Aktionsprogrammes in enger Zusammenarbeit mit Ärzten, Geographen, Anthropologen und Mikrobiologen durchgeführt.

Während dreier Stichprobenerhebungen, zwei in der Trockenperiode und eine in der feuchten Jahreszeit zwischen April 1999 und April 2000, wurden Fulbe und Araber besucht, die entweder hauptsächlich Rinder oder Kamele mobil halten. Eine tschadische Ärztin hat 1160 Frauen, Männer und Kinder klinisch untersucht und mit ihnen einen Fragebogen ausgefüllt. Von diesen Probanden wurden Serum, Sputum- und Urinproben gesammelt. Gleichzeitig wurden Serum- und Milchproben von 1640 Tieren gesammelt und Interviews über die Tiergesundheit durchgeführt.

Mögliche Beziehungen zwischen dem Vorkommen zweier Zoonosen, der Brucellose und dem Q-Fieber, bei den Nutztieren und beim Menschen wurden geprüft. Es wurden keine aktiven Infektionsherden der Brucellose gefunden. Der Einfluss der Brucellose und des Q-Fiebers auf den Gesundheitszustand der nomadischen Gruppen schien klein im Vergleich zu den anderen vorkommender Krankheiten. Respirationserkrankungen traten häufig auf, beispielsweise wurde eine Bronchitis in 18% der Kinder unter 5 Jahren diagnostiziert. Viele Araber wurden mit einer Malariainfektion während der Regenzeit angetroffen. Malaria wurde bei den Fulbe, die in der Nähe des Tschadsees während der Trockenzeit bleiben, während der Trocken- und der Regenzeit klinisch diagnostiziert. Die Menge von Retinol (Vitamin A) im Serum von

Frauen war signifikant mit Retinolkonzentrationen in der Milch von Nutztieren korreliert, was die Bedeutung der Milch als wichtiger Ernährungsbestandteil aufzeigte. Pastoralnomaden konsumiert gar nie oder sehr selten Früchte und Gemüse in den 24 Stunden vor dem Interview.

Eine Studie über die Benutzung von Gesundheitsdiensten zeigte Benutzungsmuster von kranken Pastoralnomaden auf. Probanden mit einer Respirationserkrankung gingen früh zu einem Gesundheitszentrum und haben in der Folge mehrere andere Dienste in Anspruch genommen. Da antimalaria Mittel in Gesundheitszentren während der Regenzeit knapp waren, haben Nomaden sie in dieser Zeit selten aufgesucht. Unsere Daten zeigten, dass in einem Krankheitsfall unverheiratete Männer und Frauen seltener als andere Mitglieder der Gemeinschaft einen Marabout oder ein Gesundheitszentrum aufgesucht haben. Frauen gebaren in den camps und sie benutzten pränatale Vorsorgeuntersuchungen sozusagen nie. Kein Nomadenkind der Untersuchungsgruppe war vollständig geimpft. Ein gegensätzliches Bild zeigte sich für die Rinder, wo ein Grossteil während obligatorischen Impfkampagnen geimpft worden war. Jedoch beobachteten die Nomaden eine zunehmende Unwirksamkeit der Anthrax-, Rauschbrand- und Pasteurelloseimpfstoffe während den letzten Jahren. Todesfälle von Rindern nach einer Lungenseuchenimpfung und Tierärzte, die nur für eine Blutentnahme bei Rindern im Rahmen der Rinderpestüberwachung in die camps kamen, waren weitere regelmässig genannte Beschwerden der Viehzüchter gegenüber den Veterinärdiensten. Trotzdem wurde die Idee von gemeinsamen Impfdiensten für Mensch und Tier positiv aufgenommen, da Pastoralnomaden Impfungen, im speziellen gegen Masern, für ihre Kinder wünschten. In welchem Ausmass Wissen und Erfahrungen von Tierimpfungen auf die Impfungen von Kindern und Frauen übertragen wurde, konnte nicht vollständig durchleuchtet werden. Gemeinsame Impfkampagnen wurden durchgeführt und eine erste Kostenstudie zeigte, dass der Gesundheitssektor bis zu 15% der Infrastruktur- und Personalkosten einsparen kann, wenn die Impfdienste zusammen mit dem Veterinärsektor durchgeführt werden.

Eine Verbesserung der Qualität der Dienste von Gesundheitszentren kann potentiell die Benutzungsfrequenz von Pastoralnomaden steigern. Dennoch können Gesundheitsberater, die aus der nomadischen Gemeinschaft stammen, zu den camps gehen und sind deshalb eher für Frauen und Kinder zugänglich. Statische Impfdienste haben nicht dieselbe Durchschlagkraft um nomadische Kinder und Frauen zu erreichen wie mobile Impfdienste. Private Tierärzte, die in abgelegenen Gegenden arbeiten, wären sehr interessiert ihre Infrastruktur besser auszunutzen und bei gemeinsamen Impfkampagnen mitzumachen. Den Impfkampagnen für Mensch und Tier können weitere Dienste wie der Verkauf von Medikamenten und vor allem Informationskampagnen angeschlossen werden. Die Verfügbarkeit von guter Information kann für Pastoralnomaden genauso wichtig sein wie die Gesundheitsinterventionen.

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Part I

General Introduction

When the Swiss Tropical Institute initiated a new interdisciplinary research and action programme in nomadic pastoralist settings of Chad, veterinarians were asked to contribute to a project research protocol at the interface of human and animal health. Collaboration between veterinary and public health should focus on agents transmissible between livestock and humans (zoonotic agents), to evaluate health status of nomadic pastoralists and their animals, but also to test pilot interventions with resources shared between the two sectors. The interrelationship between nomadic pastoralists and their livestock is far reaching. Transactions of property and services, as well as social events such as weddings, are commonly realised by exchange of livestock, but, besides providing them with their only source of subsistence, livestock is also an aesthetic pleasure leading to a sense of well-being and the basis of wealth and respect for pastoralists.

In the course of a programme supporting primary health care systems in the Chadian province Chari-Baguirmi of Chad in collaboration with the Swiss Agency for Development and Cooperation, staff of the "Centre de Support en Santé International", faced the problem of reaching nomadic people only insufficiently with static dispensaries, and expressed the need for more appropriate interventions to provide health services to mobile populations. Different studies including the disciplines geography, anthropology, biology, veterinary and human medicine, as well as microbiology were therefore initiated to provide data on transhumance routes, utilisation of health services, perception of ill-health and biomedical morbidity of nomadic pastoralists in two Sahelian provinces of Chad.

Chapter 1 General aspects of health care in nomadic pastoralist communities

Brief introduction to nomadic pastoralism

Pastoralism refers to a livelihood based on livestock raising, and can be undertaken by sedentary or mobile communities. Nomadism refers to the extent of spatial movement of people. Nomadic pastoralism refers to an extensive form of pastoralism with a high degree of mobility. Traditional pastoral production systems of Africa may be classified (in order of increasing mobility) as agro-pastoralism, sedentary pastoralism, semi-sedentary-pastoralism (transhumance) and nomadic or migratory pastoralism (Schwartz, 1993). In general, mobility is used to manage uncertainty and risk (e.g. drought, diseases, raids, insect vectors) in arid and semi-arid ecosystems (Scoones, 1995, cited in Niamir-Fuller, 1999; Thébaud, 1992; Swift *et al.*, 1990). Majok and Schwabe (1996) add the possibility to gather for social events to this list.

The total number of mobile pastoralists in Africa is not defined. Bonfiglioli and Watson (1992), who have estimated a proportion of 16% of mobile breeders among the Sahelian population, are usually cited as the most recent reference. This constellation may have changed slightly since the nineties. In Niger and Mali, as examples for many other Sahelian countries, a shift is recognised from traditional breeding systems towards herds owned by sedentary people which no longer support an entire pastoralist family (Bonfiglioli and Watson, 1992; Thébaud, 1992). Traditional African pastoral societies, mobile for the most part, have supported sizeable human populations under often severe environmental stress in the past (Majok and Schwabe, 1996). In the Sahelian zone, pastoralists, farmers and fishers live side by side with a certain degree of interdependency (Hill, 1985). However, this equilibrium of cohabitation is increasingly disturbed (Thébaud, 1992). The exclusion of pastoralists from more productive pastures (with higher agronomic potential) by farmers and blocking of traditional transhumance routes lead to significant disruption of the annual transhumance cycle increasing the ecological and economic vulnerability of pastoral systems in dryland Africa. Yet, ecological, national economic, egalitarian and humanitarian considerations justify major efforts to encourage nomadic pastoral continuity (White, 1997; Fratkin *et al.*, 1994; Bonfiglioli and Watson, 1992).

Two references summarise first the contrast between possible attitudes and generalisations towards nomadic pastoralism and, secondly, the strong incentive to invest in pastoral development clearly suggested by many authors and summarised in the “mobility paradigm”. Victor Azarya (1996) wrote (while referring to other authors): “…the general picture is one of political and economic deterioration and continuing marginalization [of nomads]. It is striking to see how little difference independence made with respect to the central government’s attitude towards nomadic pastoralists. Nomads continued to be considered impediments to development. They were considered uncivilised and uneducated. Their economy was seen as wasteful and they were blamed for the decline of land fertility and the spread of desertification…. Post-colonial governments’…. encouraged the settlement of pastoralists as they saw in it important economic and political benefits….”. Such stereotypes are often biased through numerous drought reports (McCabe, 1994). The “mobility paradigm” emerged in the 1990s as an alternative for pastoral development. Niamir-Fuller and Turner (1996) wrote about the “mobility paradigm”: “….it probably is the only paradigm available to date that not only gives mobile livestock production a raison d’être, but also tries to redress the imbalance engendered by too much of a focus on intensive production”. The main ideas of the “mobility paradigm”, based on evidence from more recent studies (reviewed in Niamir-Fuller, 1999), can be summarised as follows. The ecological and the anthropic parameters are dynamic and constantly changing in pastoralist settings of Africa. Warm arid ecosystems are characterised by variability, unpredictability, and high resilience, and, therefore, land-use patterns for livestock raising must adapt to the variability and uncertainty of rainfalls using “opportunistic”, flexible and mobile strategies. The drier the ecosystem, the more there is an incentive to manage the natural resources communally in order to minimise the individual risk. The environmental decline of drylands and the role of *extensive* livestock grazing were overestimated in the past. Ecological studies showed that the climate appears to be a more significant factor in determining vegetation structure than grazing. The “mobility paradigm” contends that relatively higher stocking rates can be achieved in arid rangelands if the animals are allowed full and opportunistic mobility.

The sense of community of pastoralists is extended to other groups, whether pastoral or not, in the form of kinship bounds, reciprocity of group favours, interdependence, and political alliances. Pastoral communities depend on gaining access to resources controlled by others in a seasonal, annual or episodic fashion. Access rights are negotiated through appropriate customary institutions – and conflicts can arise. There are important social, managemerial, and economic limitations for territorial expansion, and political limitations can nowadays also be added to this list. Common property management breakdown is due to two main trends: i) increased demand for privatisation of land at the expense of common land, and ii) decrease of the moral authority of local leadership and social cohesion (Niamir-Fuller and Turner, 1996). Furthermore, pastoralists lag behind sedentary people in education in most African countries, leading to a lack of representation in governmental institutions thus often of political empowerment (Majok and Schwabe, 1996).

Many development approaches, such as settlement schemes, implementation of water points, roads, static schools and clinics have failed or at least shown less than expected positive results so far the in mobile pastoralist context of arid and semi-arid Africa. Attempts to replace traditional systems with new production forms underestimated the efficiency of the traditional systems. Pastoral development programmes were based on livestock-productivity ("ranching", water point development) or on multi-sectoral natural-resource-management projects, creating pastoral associations, which in turn only exceptionally included mobile pastoralist communities (Niamir-Fuller, 1999; Majok and Schwabe, 1996; Fratkin *et al*., 1994; Baumann *et al*., 1993; Scholz, 1991).

Informal rules between pastoralists and the settled population could be translated into formal Codes of Law, backed by State institutions, in order to prevent their disappearance. However, it may not be an easy task, as there is a danger of binding them into too static a structure, and therefore not allowing them to adapt to changing needs (Yosko, 2001; Niamir-Fuller and Turner, 1996; Thébaud, 1992; Lachenmann, 1991).

<u>Herds and nutrition</u>

During the Sahelian wet season, enough pasture is available and herders care that their animals gain weight and they try to "increase their herds to their maximum" (Awogbade, 1979). Thirty livestock units (1 cow or 6 sheep or 6 goats) seem to be the minimum for subsistence of one household in semi-arid systems (Niamir-Fuller, 1999). Holter (1988) found that for a young household with two small children, a herd of 30 female camels is necessary. Diversification of livestock species, herd splitting with animals raised in separate places, herd loans (e.g. for social obligations) are strategies to reduce or to distribute the risks of livestock losses due to epidemics or environmental constraints (scarcity of dry season grazing and water supplies, degree of flooding during rains and prevalence of insect vectors) (Fratkin and Smith, 1994). Ruminants and camels, in contrast to humans, are able to metabolise cellulose from Sahel plants to dietary valuable products. A surplus on livestock is sold to buy other necessities of the family.

The preferred food of all pastoral populations is milk and its products. Cereal is the most important staple food. Meat, game and fish are added to the diet at less regular intervals. Animal products are important components of children's diet, as they provide high quality protein and are excellent sources of micronutrients (Davidson, 2002). Milk is an important source of vitamin A for nomadic women of Chad (Zinsstag *et al.*, 2002). In East Africa, pastoralists appear to be close to the lower threshold of reasonable nutritional status at most times - their diet being low in energy, but adequate in protein (Galvin, 1992 and 1994; Loutan, 1989). Sugar has become a new important source of energy for pastoralists (Holter, 1988). Much of the research on African pastoral production has focussed on problems of drought (and economic development) (Fratkin *et al.*, 1994).

In the Sahel, the critical period in terms of adult and child nutrition among pastoralists is often the end of the dry season, characterised by reduced milk production of livestock, high temperatures and aridity, combined with increased energy expenditure associated with pasturing and watering herd animals. Milk is most abundant during the wet season (Nathan *et al.*, 1996; Shell-Duncan, 1995; Hilderbrand, 1985; Loutan and Lamotte, 1984). In contrast, crop purchase prices are highest during the wet season before harvest (Thébaud, 1992).

<u>Zoonoses</u>

Zoonotic infections, transmissible between humans and animals, are closely associated with pastoralism. Worldwide, zoonoses have important impacts on public health and livestock economies. Taylor *et al.* (2001) reported 868 zoonotic infections representing 61% of all infectious organism known to be pathogenic to humans. Some zoonotic diseases such as rabies have been recognised since early history, others such as BSE are only now being recognised for the first time (Hugh-Jones *et al.*, 1995). Vertebrate animals (including humans) are the reservoirs of zoonotic infections, and the disease agents (bacterial, ricketsial, viral, parasitic and fungal) are transmitted directly or indirectly between them. Infection as a result of contact with an infected animal host represents a direct mode of transmission, whereas infection as a result of contact with a vector or vehicle is an indirect mode. Transmission of pathogens from livestock to pastoralists may occur e.g. through consumption of uncooked milk or through obstetric work.

Only after the transmission of bovine tuberculosis through raw milk was recognised and proved, occurrence of the disease could be reduced drastically by pasteurisation of the milk in Europe at the beginning of the last century (Pritchard, 1988). Foodborn diseases such as listeriosis or salmonellosis are monitored, surveyed and controlled in developed countries, whereby slaughterhouses play an important role. The prevalence of many zoonoses could be considerably reduced in these countries. In contrast to Europe, "classical" zoonoses as bovine tuberculosis, brucellosis, anthrax, and rabies are still common and represent the main focus of control in Africa. Humans are not likely to be infected with infections such as anthrax, rabies or brucellosis if the disease does not occur in livestock. Therefore, livestock or pet animal vaccination against anthrax or rabies, respectively, and brucellosis eradication programmes are also public health measures.

Nomadic pastoralism and morbidity

Swift *et al.* (1990) and Loutan (1989) identified five main factors affecting the morbidity patterns in nomadic pastoralists: i) proximity to animals, ii) problems related to a diet rich in milk, iii) mobility and dispersion with subsequent difficulties to get and maintain treatment, iv) factors related to the special environment (hot, dry and dusty zones), and v) socio-economic and cultural factors as well as the presence or absence of traditional healers. Human behaviour and level of education are further factors that may influence health status (Defo, 1996; MacPherson, 1994). Migration may put nomadic pastoralists at periodical risk of infection, especially around water points (Loutan and Paillard, 1992; Rahmann, 1996). The health status of nomadic pastoralists in the Sahel in terms of morbidity and mortality is not well defined (Swift *et al.*, 1990). Rare analytical studies on morbidity compared the frequency of selected diseases among settled agropastoralists to that in nomadic pastoralists (Hilderbrand, 1985; Chabasse *et al.*, 1983).

Utilisation of health and veterinary services

Knowledge on everyday use of health services by nomadic pastoralist populations is insufficient, little experience exists in providing health services to nomads, and only few evaluations of innovative services for nomadic communities have been performed (Swift *et al.*, 1990). Nomads are known to be vulnerable to exclusion from primary health care and education systems (Sheikh-Mohamed and Velema, 1999; Aliou, 1992 and 1995; Omar, 1992). Yet, egalitarian and economic reasons justify efforts to develop innovative and adapted health services for nomadic people (Wyss, 1998a).

In contrast, pastoralists have experience with livestock vaccination provided by veterinary services for decades.

Chapter 2 Livestock production and veterinary services in Chad

Livestock production

The Chadian economy is mainly based on agriculture. Thirty percent of the total export value is attributable to livestock and meat export. This represents the second most important good, after cotton and before arabic gum. Livestock production contributes up to 18% of the gross domestic product (GDP). Yet, this proportion is likely under-estimated, because it does not entirely include other subsistence returns, such as milk, which pastoralists view as being of prime importance. Three-forth of cattle are kept in the Sahelian zone of Chad, about 80% thereof in mobile systems (ME, 1998).

Predominant livestock diseases

Chad experienced severe droughts in 1969-73 and 1983-84. Besides little and unpredictable rainfall, infectious livestock diseases and probably also nutritional and metabolic disorders limit the potential of animal productivity. Highly contagious (list A) livestock diseases are reported by Chadian authorities to the "Office International des Epizooties" (OIE) if there is sufficient evidence of a new outbreak. Data on livestock diseases is collected in some slaughterhouses. The main contagious cattle diseases recorded in five slaughterhouses (1985-1995) were parasitic infections, mainly cysticercosis (0.2%) and echinococcosis (0.05%), as well as mycobacteriosis (0.15%). Cases of anthrax (0.02%) have been reported (Maho *et al.*, 1997). In 1995, a surveillance system for priority livestock diseases (réseau d'épidemiosurveillance des maladies animales au Tchad [REPIMAT)]) has been implemented. Its results are reported in the REPIMAT periodical. Although this system may not cover all zones and is often based on voluntary cooperation of veterinarians, it provides useful information on occurrence and outbreaks of OIE list A and B diseases (Hendrikx *et al.*, 1997). Still, the impact of livestock diseases is largely unknown. Prevalence studies are very rare (ME, 1998; Djimadoum, 1998).

Sollod and Stem (1991) stated that large government-operated surveillance systems are hardly sustainable. They proposed an appropriate animal health information system for nomadic and transhumant livestock by soliciting the participation of pastoralists. Multifactorial disease complexes and unclear diagnoses should be included in the reporting system (Ward *et al.*, 1993).

Rinderpest broke the economic backbone of many prosperous communities in Africa in the late 1800's. It first appeared in Chad in 1913, causing the loss of 30% of cattle (Djimadoum, 1998). The last major epidemic was recorded in 1983 and, thanks to the international effort of the Pan African Rinderpest Campaign (PARC), rinderpest has not been seen in Chad since 1994. The rinderpest campaign was (eventually) a success because enough resources were mobilised to assure eradication of disease (Ward *et al.*, 1993). A new programme, the Pan African Programme for the Control of Epizootics (PACE), replaced the PARC. The main aim of the PACE is the determination of the prevalences and impacts of epidemic livestock diseases on African livestock production. Attention is nowadays focused on a spectrum more or less common of major infectious livestock diseases including contagious bovine pleuropneumonia (CBPP), foot-and-mouth disease, peste des petits ruminants, caprine poxvirosis, anthrax, blackleg, pasteurellosis (hemorrhagic septicemia), Newcastle disease of poultry, African swine fever, brucellosis and tuberculosis (two zoonoses), and on parasitic diseases, particularly trypanosomiasis and helminthosis (intestinal worm parasites, liver fluke).

<u>Formal and informal veterinary services in pastoralist zones</u>

Traditional practises

Because livestock is so important to pastoralists, breeding practises are already taught to youngsters and the recognition of different livestock diseases and their treatment are later learnt from elders (Majok and Schwabe, 1996). Schwabe and Koujok (1981) described traditional healers for both humans and animals in Sudan. Healers provide diagnostic disease services and manual healing arts including bone setting, obstetric manipulations and suturing of wounds. The traditional vaccination against CBPP seems to be widespread across the African continent (Bizimana, 1994; Mesfin and Obsa, 1994; Ba, 1982). Increasing numbers of ethnoveterinary studies aiming at describing local knowledge, concepts and vocabulary of animal diseases are conducted (Catley and Mohammed, 1995; Bizimana, 1994; Mesfin and Obsa, 1994, McCorkle and Matthias-Mundy, 1992; Schwabe and Koujok, 1981). In their theses, Wiese (2002) and Krönke (2001) describe animal health concepts of pastoralists in Chad. Specialists with knowledge of specific treatment for certain affections exist.

"Doctor Choukous"

"Doctor Choukous" are drug-selling peddlers without an official permission. For nomadic pastoralists or for scattered populations in general, they offer a valuable service: their high mobility. These peddlers visit weekly markets in small villages and nomadic camps far away from market centres. The drugs sold are of variable quality (fraud is always present), often expired or originating from doubtful sources outside of Chad (Idriss and Ali Seid, 1998). The relatively bad quality of their products is well known to pastoralists. Nevertheless, due to the lack of access, pastoralists are repeatedly forced to buy drugs for people or livestock from them. A study revealed that about half of the "Doctor Choukous" sell veterinary and human drugs, one third visit nomadic camps directly, and one third have received a training as paraveterinarians (auxiliaires d'élevage) (Ousman, 1999). Arditi and Lainé (1999) proposed to better integrate the "Doctor Choukous" for example into (legalised) agreements with the local population. For the sake of welfare of mobile livestock, their potential should not be neglected.

Paraveterinarians

The ministry of livestock production of Chad trained about 3000 paraveterinarians. Still, only about 5% of pastoralits have access to a paravet (ME, 1998). Two-hundred trained paraveterinarians originate from a transhumant or nomadic setting. Especially their supervision and ongoing education is not guaranteed (Djimadoum, 1998). Paraveterinary programmes seek to complement and extend conventional delivery systems by giving short-term training (one week) in basic western-type veterinary techniques to community members, which are preferably selected by their respective group. Ideally, traditional healers should be included in training programmes and provided with additional knowledge on asepsis and basic drug use, because they are already qualified in diagnosing diseases (McCorkle and Matthias, 1996, Ward *et al*., 1993, Schwabe and Koujok, 1981).

Governmental veterinary system

There is no veterinary faculty in Chad. The ministry of livestock production (Ministère d'élevage) with about 600 officials and 200 temporary workers, includes the national veterinary laboratory "Laboratoroire de recherches vétérinaires et zootechniques de Farcha" (LRVZ) and the principal slaughterhouse in N'Djaména, which has competence for meat inspection. Livestock vaccines (anthrax, pasteurellosis and blackleg) are produced at the

LRVZ, newly including a production of approximately half of CBPP vaccines. The LRVZ also has competences in veterinary and environmental research.

Staffing in many of the 27 veterinary districts includes solely veterinary assistants. A total of 360 trained veterinary assistants are in charge of one of the 143 veterinary posts or are working with the ministry in N'Djaména. Sixty-seven veterinarians work for the ministry of livestock production.

The governmental veterinary service is operating at the limit of its financial, infrastructural and human resources. Pastoral zones are covered insufficiently (ME, 1998). The report of the livestock ministry on priorities to improve livestock production suggested to reinforce the transmission of appropriate information directly to the breeders, to intensify training at all levels, and also to destock a part of the herds and to simultaneously increase breading quality. This report furthermore suggested the definition of a flexible law for transhumance and the creation of pastoral spaces (ME, 1998). Idriss and Ali Seid (1998) have undertaken an initial mission to register the main wishes of pastoralists in view of the creation of a competence centre for mobile livestock production at the LRVZ.

Private veterinarians

In Chad, the process of veterinary privatization started in 1987 and has been supported actively by development projects funded by the European Union, the World Bank and others. Legal regulations stipulate that state veterinarians are required to cease activities in areas where a private veterinarian is installed. After an abrupt implementation, private veterinarians lack nowadays a backing-up by a clearer legal framework as well as more political and economical commitment of the government (Arditi and Lainé, 1999). Both roads and communications are difficult to allow for efficient delivery of public or private veterinary services (Angniman, 1997). Clinical services of veterinarians remain weak (breeders are willing to pay for drugs, but not for proficiency services), and other tasks (mandates) such as compulsory vaccination, surveillance, meat inspection or training seldom fully occupy private veterinarians. Next to sales of veterinary drugs, their almost sole activity is cattle vaccination in a 4-wheel-drive vehicle during the dry season. Private veterinarians vaccinated more than half of Chadian livestock in 1996. Twenty-four private veterinarians were registered in 1999, which represented a decrease in comparison to 1997. Private veterinarians demand a new orientation in providing public health services such as first aid and transport of emergencies to health centres, health education and information on public health actions, or provision of antimalarial drugs (Nahar, 2000).

Chapter 3 The concept of "one medicine"

<u>"One medicine"</u>

The concept of "one medicine" was promoted by the American epidemiologist Calvin Schwabe in the sixties. It describes the intrinsic link between human and veterinary medicine. Western-type human and veterinary medicine share most of the same paradigms, they have their roots in biology and both contribute to the "general medicine", both are dependent on a common pool of knowledge in anatomy, physiology, pathology and aetiology of diseases (Schwabe, 1984).

The underlying concept is traceable to the late 19th century, to contributions of the German pathologist and architect of social medicine Rudolf Virchow (Saunders, 2000). During the 19th century, many others such as Jenner and Koch were "veterinary physicians" due to the necessity of studying animals to progress in applied human medicine. Even earlier, in the 18th century, e.g. in Lyon (France), the idea was raised to introduce bone-setting or obstetrics for humans into the curriculum of veterinary students in order to fulfil the demand of farmers that veterinarians should also be able to treat the people (Driesch, 1989). Roots of the concept can be found in the Egyptian and Greek culture or even further back in history (Schwabe, 1984). During the 20th century, both disciplines of veterinary and human medicine became increasingly specialised fields. Unlike human medicine, delivery of veterinary medicine is also subject to economy (Ward *et al*., 1993).

The practical side of the "one medicine" concept goes beyond the control of zoonoses. It proposes to join veterinary with human heallth services in order to control important public health diseases. Furthermore, the relationship between humans and livestock production needs to consider ethical concerns of animal rights and ecology. Animal diseases having broad consequences on human well-being and public life, as was seen e.g. with the recent eradication of foot-and-mouth disease in the United Kingdom or the anthrax epidemic in Chari-Baguirmi of Chad, demand the definition of social approaches to also take into account social and psychological aspects (Zinsstag and Weiss, 2001).

Intersectoral collaboration between veterinary and other sectors

In contrast to multisectoral (interdisciplinary) research approaches as ecopathology or agroecosystem health (Faye *et al.*, 1997), the purpose of intersectoral intervention collaboration is to combine actions by veterinarians, health professionals, governmental officials and the public, as well as NGOs. Different authors proposed to join veterinary and health services in order to reach pastoralists in remote zones, reduce costs and increase acceptance (Meslin, 1996; review in Swift *et al.*, 1990). Wherever single approaches cannot be achieved (mainly due to financial constraints), all potentially multiuse facilities, personnel and routines of veterinary, education, human health, water and environmental services could be actively shared. Intersectoral collaboration for pastoral development is the main focus of Majok and Schwabe (1996). They state that veterinarians are the most extensively distributed manpower with a higher degree of education and that they are likely to reach livestock owners in most rural areas. When pastoral families can be reached, maximal use should be made of each visit. Yet, so far, only few integrated human and veterinary health care interventions are documented (Ward *et al.*, 1993).

Control of zoonoses, food safety, and disease surveillance

An expanded view of veterinary medicine towards public health issues such as zoonoses and food hygiene, is defined with the term “veterinary public health” (VPH). A VPH unit may be responsible on the basis of a legislation for assuring and coordinating, the control and effective surveillance in the field of major zoonoses, as well as for the safety and quality of animal foodstuffs and by-products, destined either for the local market or for export to other countries. Veterinary and public health services should not only collaborate to collect data and samples, but also share use of the (expensive) diagnostic laboratories (Shears, 2000; Majok and Schwabe, 1996; OIE, 1995).

First aid, vaccination, health education and training

In areas where 4-wheel-drive vehicles are grossly lacking, veterinarians could be in charge of first aid for human patients and transport of emergencies to the next clinic (Nahar, 2000). Nahar also suggests to distribute basic drugs such as antimalarials. Such additional services may improve the acceptance of private veterinarians, who’s reputation is sometimes weakened toward nomadic populations due to their involvement in compulsory vaccination campaigns (Krönke, 2001; Idriss and Ali Seid, 1998).

In Southern Sudan, the WHO/UNICEF shared cold chain equipment with veterinary services for vaccination within the Expanded Programme on Immunization (EPI) in 1980. They found that an increased vaccination coverage for children could be obtained when livestock owners were encouraged to bring their cattle for rinderpest vaccination to the same vaccination location (Ward *et al*., 1993). In return for veterinary cooperation in maintaining viable vaccines, the EPI programme offered assistance of the less-well-financed veterinary services at little additional cost for itself (Majok and Schwabe, 1996). The International Red Cross (ICRC) has implemented joint vaccinations, using the vehicles of veterinarians in Southern Sudan in the nineties (Peterhans, personal communication). Such local initiatives without further documentation and involvement of higher authorities have likely been put into action in many places, especially in relief situations after crises such as droughts or civil wars. To our knowledge, costs and performances of joint vaccinations have not been evaluated so far.

Health education, especially on zoonoses (Ward *et al*., 1993), could be another branch of collaboration between veterinary and public health services. In Africa, a major educational effort has already taken place among pastoralists about the merits of vaccination. That substantial accomplishment could be capitalised by public health officials if the veterinary sector could be convinced to share its acceptance and contact with nomadic pastoralists (Majok and Schwabe, 1996).

The lessons learned with the training and follow-up of paraveterinarians on a large scale in most developing countries, could be extended to the planning of training programmes for community health workers.

Monitoring of environmental factors

Majok and Schwabe (1996) proposed that veterinary services could additionally monitor for variables such as rainfalls, grazing conditions, soil erosion, animal movements, animal productivity and pastoralist’s practises to respond to drought and range management with an early warning system, and to improve pasture and crop production.

Organisation

Cooperation must be mutually beneficial to the programmes of both services. Veterinary services themselves need help to succeed. Decentralised initiatives should be kept formal but flexible. Local management structures for shared resources could be established to provide necessary degrees of accountability and to assure the uninterrupted implementation of each sector's objectives. In general, knowledge about other programmes should be shared more widely (Majok and Schwabe, 1996). Desirable changes will most likely be possible in little steps by taking advantage of, and grafting any new efforts and ideas upon, traditional beliefs and institutions. This will only be achievable if pastoralists participate at all stages (Wyss, 1998a). Local desires and perceived needs must be explored, and local institutional arrangements carefully examined (Majok and Schwabe, 1996). Key to success may also be the recognition of "key persons" within communities.

Chapter 4 Objectives of the study

The main objectives of the present study were to identify predominant health problems of nomadic pastoralists and of their livestock in Chad, with a special focus on zoonoses, to assess their expectations toward public health and veterinary services, in order to design and evaluate joint human and animal health strategies adapted to mobile populations.

<u>Objectives</u>

- Assessment of selected zoonoses in humans and livestock, and identification of risk factors for infection of nomadic pastoralists
- Description of occurring human and animal diseases within seasons and breeding systems
- Evaluation of health services and their utilisation by nomadic pastoralists
- Comparison between perceived illnesses and biomedical results
- Evaluation of pilot interventions in nomadic settings

Structure of the thesis

Chapter 5 and **6** give a brief overview on the context of the study and various collaborations, the study site, the nomadic communities involved and the sampling procedure.

Chapter 7 describes the study on zoonoses and the related risk factors identified for brucellosis and Q-fever seropositivity. In the Annexe, preliminary results on cattle tuberculinisation are presented.

Chapter 8 presents another biomedical measurement of the interrelationship between animals and people. A study on vitamin A (retinol) in the milk of livestock and in the serum of nomadic women was conducted.

Chapter 9 describes morbidity patterns as well as alimentary patterns (with a focus on milk).

Chapter 10 reports utilisation of health services using an epidemiologic approach based on morbidity results and presents vaccination coverage of children.

Chapter 11 assesses the perception of nomadic pastoralists on joint human and animal vaccination campaigns. This intervention approach was defined as a consequence of the nil vaccination rate of nomadic children.

Chapter 12 presents a cost analyses study of joint human and animal vaccination campaigns conducted in nomadic settings.

Chapter 13 to **15** is a general discussion of the methodology used and the results obtained with a concise conclusion and outlook to future research.

The bibliography of the whole thesis is pooled at the end to avoid repeated listing of references.

Part II

Approach

Chapter 5 Collaborations

The study was conducted in the context of the programme “Health for nomads” of the Swiss Tropical Institute (STI). The Swiss National Foundation (SNF) provided financial support.

A research collaboration was established with the Chadian national veterinary laboratory “Laboratoire de Recherche Vétérinaires et Zootechniques (LRVZ) de Farcha” in 1998. The director of the LRVZ is co-supervisor of the study. Mrs. Colette Diguimbaye, microbiologist at the LRVZ and PhD student at the University of Basel, is currently conducting a mycobacteriological study. She was in charge of the serological procedures, the *Brucella* spp. isolation and the lecture of sputum and urine stains for acid fast bacilli, of which the results are presented in this study.

Mrs. Saada Daoud, physician and vice-director of the EPI (Ministry of public health) in Chad, performed the physical examinations, and completed the survey questionnaires. An overview of the morbidity results are presented in her report (2001) “Etat de santé des pasteurs nomades du Chari-Baguirmi et du Kanem au Tchad”, Institut Tropical Suisse, PEV, N'Djaména.

Mr. Mahamat Bechir, biologist and employee of the “Centre de Support en Santé International” (CSSI), the outlet of the STI in Chad, organised the vaccination campaigns and contributed to data collection on the costs of joint campaigns.

A collaboration with the anthropologist Mr. Frank Krönke led to the redaction of the article: Krönke F., Schelling E., Diguimbaye C., Béchir M., Wyss K. and Zinsstag J. (2001). Zoonones among FulBe pastoralists and their livestock in Chad: The interface of cultural epidemiology and social anthropology.

Different aspects of health service utilisation based on the example of nomadic Arab camel breeders will lead to a joint article with Martin Wiese, geographer at the University of Freiburg.

During two workshops on the health of nomadic people in Chad, potential interventions were discussed with stakeholders in January 1998 and December 1999 in N'Djaména. Stakeholders were authorities of both ministries of public health and of livestock production, nomads' associations, nomads' representatives, NGOs working in the field of nomadic health and the Swiss Tropical Institute (Wyss, 1998b; Wyss and Zinsstag, 2000).

Chapter 6 Study site, nomadic communities and sampling

Study site

The study zone in two provinces of Chad, the Chari-Baguirmi in the north and the Kanem in the souths, was typical of the Sahel zone. The Sahel has an average rainfall of around 400 mm (100mm near the Sahara and 700 mm near the Sudan Savanna), which is largely concentrated in a single wet season. The ecosystem of the Sahel is characterised by low net primary productivity, by interannual variability of rainfall and by high variability in ecosystem structure and productivity ("patchiness") (Niamir-Fuller, 1999; Vernet, 1994; Hill, 1985). A detailed description on the geography and ecology of the study area is given by Wiese (2002). Officially, 11% and 4.4% of the rural population of Chari-Baguirmi and Kanem, respectively, are nomads. These numbers are likely underestimated because the census was conducted in a period when many Fulani were in Cameroon and because a certain proportion of the nomads were likely missed in the fields.

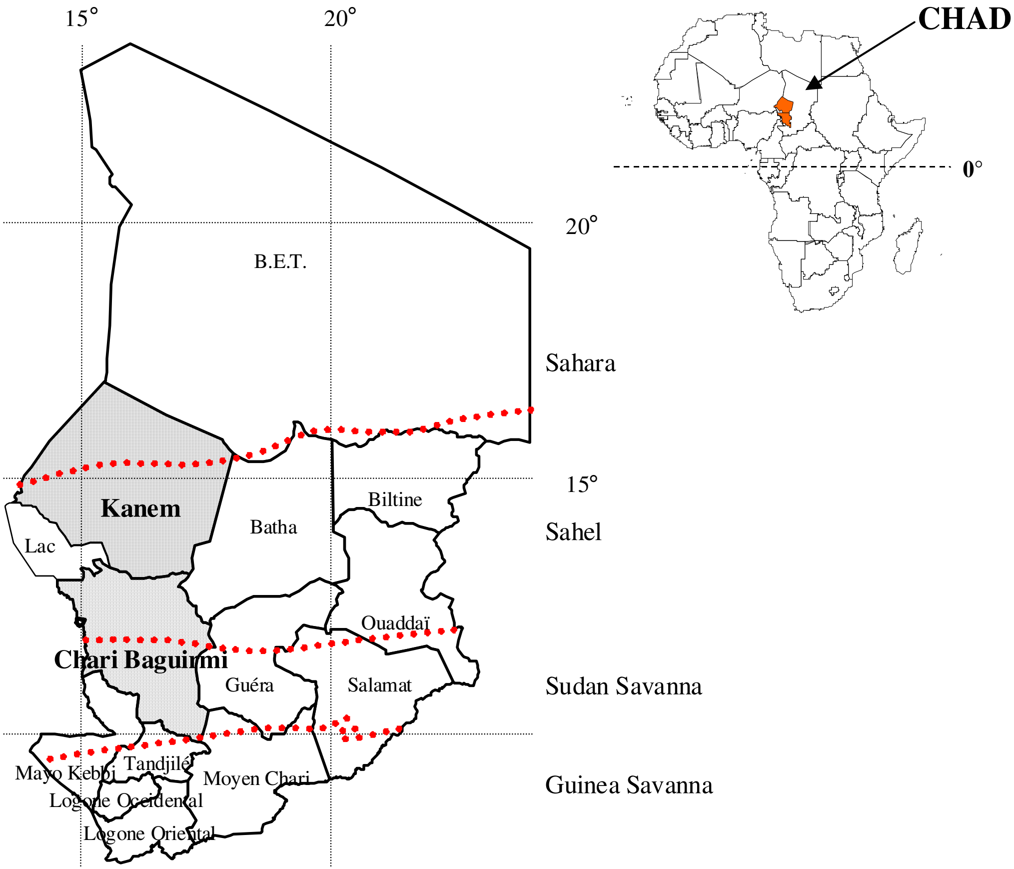

Figure 6.1 The two provinces Chari-Baguirmi and Kanem in Chad. The approximate borders of the zones Sahara-Sahel, Sahel-Sudan Savanna and Sudan Savanna – Guinea Savanna are indicated.

Nomadic communities

Nomadic Fulani cattle breeders and Arab camel or cattle breeders were chosen in order to include two different ethnic groups and two different main livestock kept.

During the wet season, Fulani cattle breeders leave the zone of lake Chad mainly because the pastures at the shore or on the islands are flooded, but also to take advantage of fresh green pastures. They use surface water in the clay plains of Chari-Baguirmi. As soon as the rainfalls stop, approximately three months later, they hurry back to the lake to arrive before access is blocked by cultivated fields. Most Fulani families have some agricultural activity themselves and a small part of Fulani of the lake Chad are in transition to semi-nomadism practising some agriculture or small-scale business, while retaining transhumant livestock breeding as their basic economy (Planel, 1996).

Arab camel breeders leave the zone of the Massenya flood plains (Chari-Baguirmi) after the first rainfalls, and move about 400 kilometres northwards to disperse in the Kanem within three months. In the Kanem, they stay in remote zones far away from villages. Arab cameleers came to the Chari-Baguirmi from Central Chad only after the last severe drought in 1985 and after the civil war. In the Chari-Baguirmi and Kanem they faced severe problems with access to wells due to lack of traditional access rights. They are very rarely involved in agricultural activities. Younger men herd young and non-lactating camels separately, while lactating camels remain with the family.

The group of Arab cattle breeders was the most heterogeneous with regard to sub-ethnic background. From the zone of Massenya (Chari-Baguirmi), they do not move with their cattle as far north as cameleers. Some camps stay all year in the flood plains of Massenya and only the young men go north with the small ruminants and cattle. In contrast to camel breeders, they have already been in that zone for about fifty years. Some Arab cattle breeders collect arabic gum, which they sell with a high profit on the markets.

All three nomadic pastoralist communities are Muslim. Their transhumance routes, socio-economic features and socio-cultural relationships are detailed in Wiese (2002), and specifically for Fulani in Krönke (2001).

Sampling

With the help of nomad representatives, camp elders were contacted randomly. They were asked for participation in the study after they were informed about its objectives and the sampling procedure. Out of a first list including names of those camp elders willing to participate, a second selection was randomly drawn. A unique identification number was allocated for each visited camp, which was retained for all samplings. Sixteen Fulani and 15 Arab camps were visited during a first sampling in May/June 1999 (hot dry season). Twenty-seven of these camps were visited again during a second sampling in October/November 1999 after the annual rainfalls. During this period (wet season), Fulani and Arabs are involved in long transhumance movements. During a third sampling in March/April 2000, six Fulani and four Arab camps were visited for a third time. In addition, 12 Fulani and 11 Arab camps were newly included in the study.

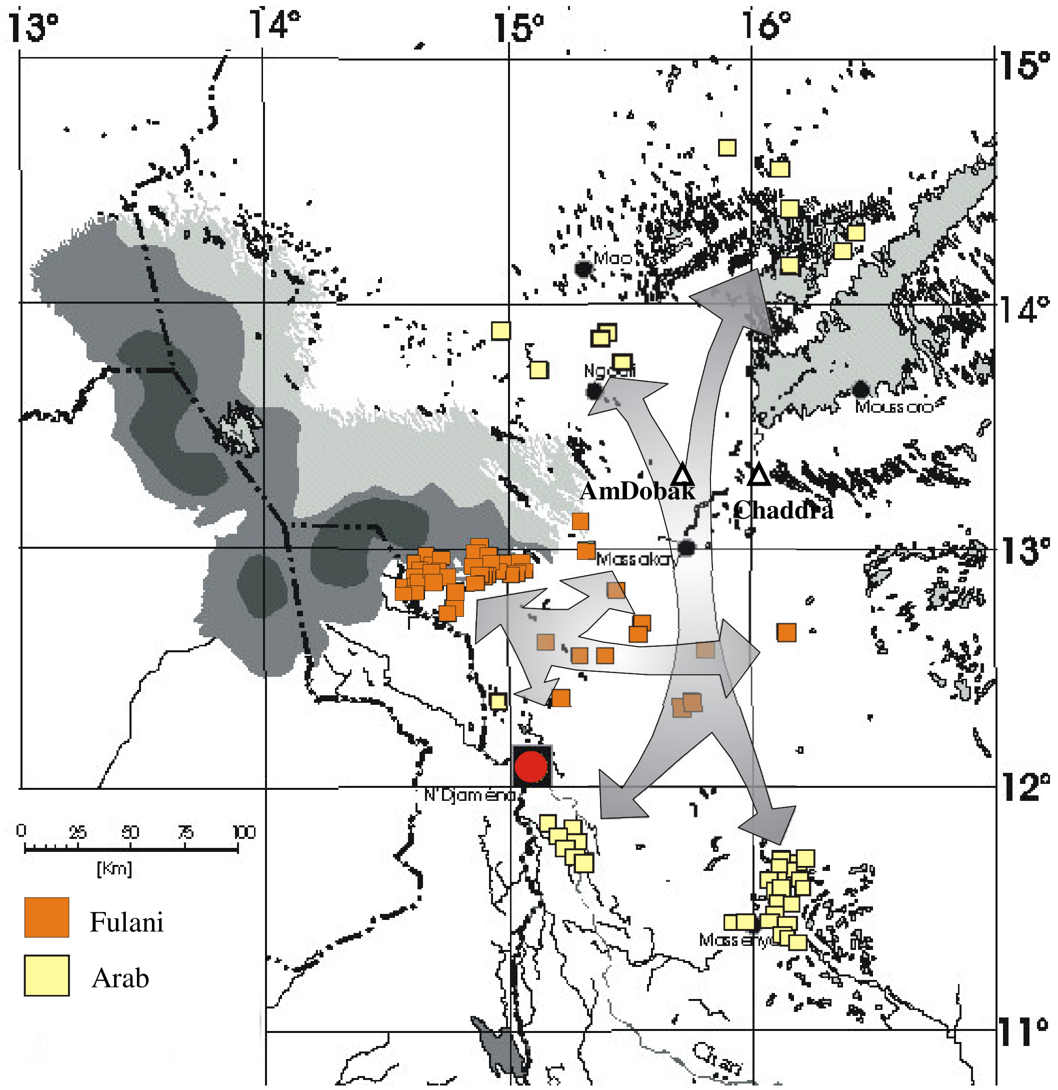

Figure 6.2 Localisation of nomadic camps visited in northern Chari-Baguirmi and southern Kanem (map layer by M. Wiese)

Part III

Zoonoses, Morbidity and Health Services

Chapter 7

Zoonotic infections of nomadic pastoralists and their livestock in Chad

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Submitted to *Preventive Veterinary Medicine*

Abstract

Nomadic pastoralists of Chad are dependent on their camels, cattle and small ruminants for subsistence, and they live in close contact to their animals. The relationship between the prevalences of brucellosis, Q-fever and toxoplasmosis in humans and livestock was evaluated in three nomadic communities of Chad (Fulani cattle breeders and Arab camel and cattle breeders) clustered within camps. Nomad camps were visited three times between April 1999 and April 2000. A total of 911 human and 1637 animal sera were tested for antibodies against *Brucella* spp., 368 human and 613 animal sera for *Coxiella burnetii*, and a random sample of each 125 human and animal sera was tested for *Toxoplasma gondii*. Sixteen brucellosis positive human sera resulted in a seroprevelance of 1.8%. Male participants were significantly more often brucellosis seropositive (OR 4.9) than females. No clear-cut correlation was found between brucellosis serostatus and physical examination or reported symptoms. Positive serology results were distinctively more frequent for cattle (seroprevalence of 7.3%) than for camels and small ruminants, and brucellosis seropositivity was a significant risk factor for abortion in cattle (OR 2.9). No small ruminants seropositive for brucellosis were found in the 13 camps with seropositive humans. Fifteen Q-fever seropositive blood samples were taken from 11 Arab camel and 4 Arab cattle breeders resulting in a seroprevalence below 1%. Being a camel breeder was the only significant risk factor for Q-fever seropositivity in humans with an odds ratio of 12.2. Camels had the highest Q-fever seroprevalence (73.4%) among livestock species. Only one human serum tested positive for toxoplasmosis. With regard to high-risk behaviour towards acquisition of brucellosis and Q-fever from livestock through raw milk consumption (98%) and obstetric work (62%), we conclude that prevalences in humans were low due to very few active foci in livestock. *Brucella* spp. occurrence needs to be further evaluated by strain isolation and characterisation.

1. Introduction

After the transmission of bovine tuberculosis through raw dairy milk was recognised, its occurrence in humans was drastically reduced by pasteurisation of the milk at the beginning of the last century (Pritchard, 1988). Gradually, the protection of consumers of livestock products in Europe concentrated on a few contagious foodborne diseases such as salmonellosis, campylobacteriosis and listeriosis. In 1986, the detection of BSE, despite its very limited impact on human health, created an enormous fear and was controlled by severe measures, costing the lives of hundreds of thousands animals. In contrast to Europe, "classical" zoonoses such as bovine tuberculosis, brucellosis, anthrax, and rabies are still widespread in Africa, causing mostly unknown amounts of human and animal suffering and numbers of causalities (Meslin et al., 2000). Zoonoses are not always recognised as a danger by the population, because the connection between the infection in animals, which may be asymptomatic, and the occurrence of symptoms in humans is not always obvious. The protection of humans from zoonotic diseases depends in many cases on the control and eradication of the disease in livestock.

Brucellosis is considered by the Food and Agriculture Organization (FAO), the World Health Organization (WHO) and the "Office International des Epizooties" (OIE) as one of the most widespread zoonoses in the world. Brucellosis in humans is caused by *Brucella melitensis*, *B. abortus* or *B. suis*, and animals are the almost exclusive source of infection for people. Livestock production losses are the consequences of abortion, reduced fertility, birth of weak offspring and decreased milk production (Bernues et al., 1997). Further economic losses due to human public health hazards are caused by the treatment costs and income loss for people infected with brucellosis (Roth and Zinsstag, 2001).

One forth of nomadic pastoralists of the Malian Gourma had antibodies against the bacterial agent of brucellosis. Of the five pastoralist communities tested, the prevalence was lower than 25% in only one group who had lost its entire livestock in previous years (Chabasse et al., 1983). Another study compared these results with sedentary cultivators in three other settings in Mali. Prevalences ranged from zero to 4% among cultivators (Tasei et al., 1982). These two studies did not attempt to directly correlate the infection in animals with the infection in humans. Gidel et al. (1974) sampled sera from livestock and people in the same villages of different zones and ethnic groups (livestock breeders and crop farmers) in Côte d'Ivoire, Burkina Faso and Niger. However, neither could they demonstrate a relationship in seropositivity between people and livestock, nor was the involvement of different livestock species for the infection of people further analysed.

Antibodies against *Brucella* spp. were repeatedly found in sera of cattle and small ruminants in Chad, however, with large differences between different regions and authors. Prevalences for cattle ranged from 3% up to 30% (Perreau, 1956; Lefèvre et al., 1970; Domenech et al., 1982; ME, 2000). For the human population, a prevalence of 14% was found among slaughterhouse workers, but was zero in a group of urban blood donors (Massenet et al., 1993). Lefèvre et al. (1970) isolated *Brucella* strains (mainly *B. melitensis*, but also *B. abortus*) from 12 patients suspect of brucellosis in Chad.

The rickettsial disease Q-fever caused by *Coxiella burnetii* can be transmitted by ticks to domestic animals. Yet, the transmission pathways from livestock to humans are very similar to those of brucellosis, including the consumption of non-pasteurised dairy products, the contact with diseased animals and carcasses, or with products of livestock births and abortions (most often by aerosols or contaminated dust). Antibodies to Q-fever were found in 3.5% of sera collected in N'Djaména, Chad (Maurice and Gidel, 1968). The authors concluded that this zoonosis may be responsible for a number of undefined cases of fever. During the same study in Chad, positive microagglutination reactions were observed for cattle, sheep, goats and camels. Distinctively higher prevalences (35 to 75%) were found in humans in a study conducted by Giroud et al. (1951) in Southern Chad, but the study population had close contact to livestock (breeders, butchers and meat sellers). Domenech et al. (1985) found a Q-fever seroprevalence of 6.7% in cattle from Southern Chad.

Toxoplasmosis occurs worldwide and may cause stillbirth, blindness, mental retardation and occasional death of congenitally infected infants, or may cause complicated disease in toxoplasmosis-infected immunocompromised patients. This zoonosis is transmitted to humans by the ingestion of oocysts (shed by infected cats, the final hosts of the parasite), by bradyzoites (cysts) in the tissue of animals infected as intermediary hosts, or, eventually, through the consumption of raw milk from infected livestock (Hugh-Jones et al., 1995).

About ten percent of the total population of Chad are nomads, but studies on the health status of nomadic pastoralists in terms of morbidity and mortality are few and dated. The highest density of nomadic pastoralists is found in the dry Sahel zone, south of the Sahara. The present study was directed towards acquisition of knowledge on morbidity of Chadian nomadic pastoralists and development of adapted health care services. Zoonoses may play an important role in the disease burden of these populations since pastoralists live in close contact with their animals. An intersectoral collaboration between public health and livestock production was used to evaluate the relationship between the prevalences of zoonotic diseases in humans and animals of same nomadic camps, and to identify possible sources of exposure of pastoralists to brucellosis, Q-fever and toxoplasmosis. Results on tuberculosis will be reported separately.

2. Materials and Methods

A research team consisting of veterinarians and physicians collaborated with the Ministry of Health in Chad and the National Veterinary Laboratory of Chad (Laboratoire de Recherches Vétérinaires et Zootechniques de Farcha). Furthermore, in the context of a broader research programme on the health of nomadic people in Chad by the Swiss Tropical Institute, the group collaborated with an anthropologist and a geographer. Quality control of the brucellosis and Q-fever serology was conducted at the Institute of Veterinary Bacteriology of the University of Berne, Switzerland and the Valais Central Laboratory, Sion, Switzerland, respectively.

2.1. Sampling and data collection

The study took place in the Chadian provinces Chari-Baguirmi and Kanem. Nomadic Fulani cattle breeders and Arab camel or cattle breeders were included in the study in order to consider two different types of livestock breeding. With the help of nomad representatives and using their knowledge of the geographical distribution of nomadic communities, camp elders were randomly contacted. They were asked for participation in the study after they were informed about the objectives and the sampling procedure. Out of a first list including names of those camp elders willing to participate, a second selection was randomly drawn. Sixteen Fulani and 15 Arab camps were visited during a first sampling in May/June 1999 (hot dry season). Twenty-seven of these camps were visited again up to 400 kilometres further north or east during a second sampling in October/November 1999 after the annual rainfalls. During a third sampling in March/April 2000, six Fulani and four Arab camps were visited for a third time. In addition, 12 Fulani and 11 Arab camps were newly included in the study. A unique identification number was allocated for each visited camp, which was retained for all samplings. The physician and the veterinarian treated sick people or livestock in the camps at no charge. People who could not be treated immediately were referred to local dispensaries.

A cohort of 5 men, 5 women and 5 children was selected with random numbers in each visited camp. After physical examination, an individual questionnaire focused on risk behaviour towards zoonoses and typical signs of brucellosis was completed with participants. In addition, reported symptoms and duration of illness were recorded. Venous blood was taken with 5 ml vacutainer tubes with informed consent of each participant. Whole blood was centrifuged with a mobile centrifuge for ten minutes at 5000 rotations per minute. Serum was transported on ice in 2 ml tubes to the laboratory.

Blood specimens from 10 cattle or 10 camels (*Camelus dromedarius*), as well as from 5 sheep and 5 goats (almost exclusively females in lactation) were obtained by venipuncture with 5 or 10 ml Vacutainer® tubes. Milk samples were collected in sterile 10 ml tubes. A semi-quantitative assessment of tick infestation on animals was done (no ticks, ticks <10, 10 < ticks <100, ticks >100 per animal). The breed, age, name, number of births and number of abortions were registered for each animal on the basis of information from the owner.

2.2. Serological tests

2.2.1 Brucellosis serology

All human and livestock sera were subjected to the rose bengal plate agglutination test (RBT), whereby 30 µl serum and 30 µl antigen (*B. abortus* strain 99, Sanofi Diagnostics Pasteur, Marnes-la-Coquette, France) were mixed and rotated on a glass plate during 4 minutes. Agglutination values were recorded as negative, +, ++, +++ and ++++. Sera with values ≥ ++ (all with time to reaction < 2 minutes) and <++ were classified as positive and negative, respectively.

In addition, a commercially available indirect enzyme linked immunosorbend assay (ELISA) (CHEKIT®-Brucellose, Dr. Bommeli AG, Liebefeld-Bern, Switzerland), registered for ruminants, was used. This assay uses microtiter plates wells precoated with a lipopolysaccharide-phenol extract of the *B. abortus* 99 Weybridge strain and, as conjugate, a monoclonal anti-ruminant-IgG also reacting with IgG of different animal species including man. First, the test's ability to detect antibodies against *Brucella* spp. of camels and humans was evaluated. RBT-positive camel sera from another study derived from a herd with signs of clinical brucellosis were tested. The ELISA remained positive for the seven RBT-positive camel sera and was negative for RBT-negative samples. Two human reference brucellosis sera and two RBT-positive field human sera showed positive correlations ($p<0.05$) between optical densities (OD) obtained with the monoclonal anti-ruminant–IgG–peroxidase–conjugate and anti–human–IgG–peroxidase–conjugate (Sigma) diluted 1:10'000 at 5, 10, 20, and 30 minutes of reaction with the ELISA chromogen (data not shown). It was concluded that the commercial ELISA was convenient to screen human and livestock sera.

The protocol of the ELISA manufacturer was followed with the exception of a shorter time to reaction of the chromogen (stopped after 5 to 10 minutes instead of 25 minutes) due to higher room temperatures observed in Chad compared to Switzerland. Results were expressed as the percentage of the ratio between the corrected optical densities (OD) of the sample by subtracting the OD of the negative control and the corrected OD of the positive control (S/P-ratio). S/P-ratio-values > 100% were used for final classification of brucellosis seropositive livestock sera.

Human sera were evaluated further, due to RBT-positive but ELISA negative results. Seventeen RBT-positive (out of a total of 19 RBT-positive) human sera and a random selection of 40 RBT-negative human sera were tested with the ELISA, now using an anti-human-IgM-peroxidase-conjugate (Sigma™). Of the same samples, 12 and 26 RBT-positive and -negative sera, respectively, were also tested with the complement fixation test (CFT). The same protocol was used for the ELISA with the anti-human-IgM-peroxidase-conjugate (Sigma™) diluted 1:12'000. With regard to the CFT, dilutions of inactivated sera were mixed with *B. abortus* strain 99 (Weybridge) antigen (BGVV, Berlin-Marienfelde) and the complement before incubation at 37°C for 30 minutes. A mixture of sheep red blood cells and haemolytic serum was then added and incubation continued for another 30 minutes. The reactions were read as the degree of haemolysis and results expressed in international complement fixation test units (ICFTU) (OIE, 1996). The threshold for seropositivity was fixed at ≥ 1:20 ICFTU.

For final classification of human seropositive and –negative sera for brucellosis, a threshold value was defined for the ELISA test. Receiver operating characteristic (ROC) analyses with the reference variable consisting of positive (RBT- *or* CFT-positive) and negative (RBT- *and* CFT-negative) samples were compared to ELISA S/P-ratio-values obtained with anti-ruminant-conjugate and anti-human-IgM-conjugate. Thresholds for ELISA anti-ruminant-IgG and anti-human-IgM were set at S/P-ratio-values of 90% and 30%, respectively. Respective specificities were 95% and 100%.

For the milk ring test (MRT), 30 µl of antigen solution (killed *B. abortus* strain 99, BGVV, Berlin-Marienfelde) were thoroughly mixed with 1 ml of individual livestock milk (kept beforehand in 10 ml glass tubes at 4°C for 24 hours). After incubating the tubes at 37°C for one hour, MRT results were recorded as negative (blue milk with white milk cream ring); +/- (milk and cream of the same blue colour); + (cream more blue than underlying milk), ++ (blue cream ring and slightly blue milk), +++ (dark blue cream ring and white milk). The threshold for MRT-positive milk was set at +.

2.2.2. Q-fever serology

The indirect ELISA (CHEKIT®-Q-fever, Dr. Bommeli AG, Liebefeld-Bern, Switzerland) was used to assay for antibodies against *Coxiella burnetii* in blood sera of livestock and humans according to the manufacturer's instructions. Results were recorded as positive when S/P-ratio-values were > 40%. Positive results were confirmed with the indirect immunofluorescence test (IFAT) using phase I and phase II *C. burnetti* antigens (Valais Central Laboratory, Sion, Switzerland). In addition, 43 livestock sera were tested with the complement fixation test (CFT) (OIE, 1996). Rhône Mérieux provided the antigen (prepared from strains of C. burnetti cultured in eggs).

2.2.3. Toxoplasmosis serology

Randomly selected livestock and human samples collected during the first sampling were tested with an indirect ELISA (CHEKIT®-Toxotest, Dr. Bommeli AG, Liebefeld-Bern, Switzerland) for antibodies against *Toxoplasma gondii*. Serum samples with S/P-ratio-values > 30% were classified as positive.

2.3. Culture of milk for brucellosis

A sample of 10 ml of aseptically collected milk was stored at 4°C overnight. A selective supplement for the isolation of *Brucella* species (OXOID™) was added to Columbia agar containing ethyl violet. Supernatant milk cream was spread on the agar and incubated at 37°C in air supplemented with 10% CO_2 for at least 5 days. Presumptive identification of *Brucella* spp. was based on purple coloration of colonies, colony morphology, Gram stain, and agglutination with monospecific antiserum. Further testing included CO_2 requirement, H_2S production and PCR method to determine genus (Herman and de Ridder, 1992). Definite *Brucella* spp. identification was done at the German National Veterinary Medical Reference Laboratory for Brucellosis (BGVV, Berlin-Marienfelde).

2.4. Data analyses

The analyses were carried out in Intercooled STATA 7.0 for Windows (Stata Corporation, Texas, USA). Results of two serological tests with dichotomous recording of positive and negative samples were compared for agreement with Kappa statistic. Random-effects logistic regression models were used to estimate prevalences taking into account clustering within camps and to adjust for confounders. In order to analyse the interaction between infection in people and in livestock within camps, a generalised linear latent and mixed model (STATA command gllamm, Rebe-Hesketh, 2001) was used. This multilevel model allowed for inclusion of the denominator (number of people sampled per camp) in the analysis.

3. Results

3.1. Samples and tests

Brucellosis serology results were available for a total of 1637 animals and 860 humans. A second and third blood sample were taken from 43 and 4 humans, respectively, during consecutive samplings, resulting in a total of 911 human sera. Questionnaire data were not available for 7 children younger than 5 years, for a total of 22 participants in two camps due to loss and for few other single participants due to missing values. A total of 368 human and 613 animal sera was tested for Q-fever. Each of 125 human and livestock sera were serologically tested for *Toxoplasma gondii*. Table 7.1 gives an overview of all sera and milk samples tested, and of questionnaire data within nomadic groups including participants' age classes and livestock species.

Table 7.1 Overview of the samples

[a)] Humans: age, sex, and risk behaviour. Livestock: age, number of births, and history of abortions.

Group		Age class	Brucellosis Serum samples	Brucellosis Milk samples	Brucellosis Questionnaire data[a]	Q-fever Serum samples	Q-fever Questionnaire data[a]	Toxoplasmosis Serum samples
Fulani cattle breeder	Humans	0-4	17		0	16	0	7
		5-14	70		39	36	32	6
		>=15	434		396	158	155	47
	Livestock	Cattle	488	218	465	163	153	28
		Sheep	208	94	160	78	63	17
		Goats	220	113	176	71	61	15
Arab cattle breeder	Humans	0-4	0		0	0	0	0
		5-14	9		8	3	2	2
		>=15	72		68	6	6	3
	Livestock	Cattle	90	60	76	11	8	4
		Sheep	34	22	24	5	3	1
		Goats	30	20	16	4	3	0
Arab camel breeders	Humans	0-4	14		0	10	0	6
		5-14	54		37	33	29	10
		>=15	241		218	106	98	44
	Livestock	Cattle	30	9	18	21	19	6
		Camels	289	73	128	142	26	28
		Sheep	127	51	45	59	12	14
		Goats	129	56	34	59	3	12

Human brucellosis serostatus obtained with the ELISA were compared to the combined results of the RBT and CFT, whereby a moderate agreement (kappa statistic 0.549) was found. A substantial agreement (kappa statistic 0.611) was found between the results of the ELISA and the RBT of livestock field sera. There was moderate agreement between the ELISA and the MRT of livestock (kappa statistic 0.46). Results of the MRT substituted missing results of 16 livestock sera (sampled in two camps) lost to clotting of whole blood samples. Thirteen out of 15 Q-fever ELISA-positive results of human sera were confirmed with the IFAT.

3.2. Seropositive samples, individual and herd prevalences

A total of 16 brucellosis seropositive human samples resulted in a seroprevelance of 1.8% (95% confidence interval 1.1 –2.8%). The 16 seropositive sera derived from 9 Fulani (1 three year-old girl, 1 one year-old boy and 7 men aged 15 to 50 years), 1 male forty year-old Arab cattle breeder and 6 Arab camel breeders (2 women aged 14 - 26 years and 4 men 20 – 50 years old). None of these participants were repeatedly sampled. Five out of the 16 sera were seropositive due to high IgM-antibodies titres indicating a recent infection. Of these five, four were sampled during the first sampling in May/June 1999. Only single brucellosis seropositive human sera were found in 10 out of 13 human seropositive camps (Table 7.2). An overall brucellosis seroprevalence of 2.9% (95% CI 2.0-4.3%) was calculated for the livestock, whereas most seropositive samples were obtained during the first sampling. Positive results were significantly more frequent for cattle (seroprevalence of 7.3%) than for camels and small ruminants (1.4% and 0.5%). Cattle kept by Fulani and Arabs were equally affected. The cattle herd with the highest mean ELISA-values was composed of recently purchased animals (with unknown history of abortion) and owned by an Arab pastoralist. In 14 out of 25 seropositive cattle herds, a single cow alone was seropositive for brucellosis (Table 7.2). Positivity of individual milk ring test ranged from 1.4% to 2.1% for small ruminants and cattle, respectively, whereas no camel milk was ring test positive. Two strains of *Brucella abortus* biovar 6 were isolated from two cow milk samples.

Fifteen Q-fever seropositive blood samples were taken from 11 Arab camel breeders and 4 Arab cattle breeders. The human seroprevalence for Q-fever was below 1% (0.9%, 95% CI 0.2-4.7%). However, two or more Q-fever seropositive camels were found in each camel herd and individual seroprevalence of camels was 73.4% (95% CI 52.0-87.6%). Seroprevalences of other livestock species were significantly lower (4.1%, 9.8%, and 11.9% for cattle, sheep, and goats, respectively) (Table 7.2). Seropositive animals were mainly kept by Arab camel or cattle breeders (111 out of 136, of which 29 were small ruminants) and only 25, of which 14 small ruminants, by Fulani.

Of 125 people tested serologically for toxoplasmosis, only one Fulani man (52 years) was found to be positive. In contrast, all 38 cattle tested and 7 out of 28 camels were seropositive. Only few seropositive small ruminants were identified (Table 7.2).

Table 7.2 Individual and camp seroprevalences of brucellosis, Q-fever and toxoplasmosis.
[a] Prevalences with 95% confidence intervals were calculated with random effect on the camp level.

	Individual				Camp				
						At least 1 pos.		At least 2 pos.	
Brucellosis	N	Pos	Prev.[a]	(95% CI)[a]	N	Pos.	%	Pos.	%
Cattle	608	54	7.3	(4.9-10.7)	39	25	64.1	11	28.2
Camel	288	4	1.4	(0.5-3.6)	17	4	23.5	0	0
Sheep	367	2	0.5	(0.1-2.2)	46	2	4.3	0	0
Goat	374	2	0.5	(0.1-2.1)	49	2	4.1	0	0
Humans	911	16	1.8	(1.1-2.8)	54	13	24.1	3	5.6
Q-fever	N	Pos	Prev.[a]	(95% CI)[a]	N	Pos.	%	Pos.	%
Cattle	195	13	4.1	(1.3-12.1)	19	7	36.8	4	21.1
Camel	142	89	73.4	(52.0-87.6)	14	14	100	14	100
Sheep	142	18	9.8	(4.5-19.8)	28	12	42.9	4	14.3
Goat	134	16	11.9	(7.4-18.6)	28	13	46.4	3	10.7
Humans	368	15	0.9	(0.2-4.7)	32	7	21.9	4	12.5
Toxoplasmosis	N	Pos	Prev.[a]	(95% CI)[a]					
Cattle	38	38	100	(90.7-100)					
Camel	28	7	25.0	(12.4-43.9)					
Sheep	32	2	6.2	(1.6-21.8)					
Goat	27	1	3.7	(0.5-22.1)					
Humans	125	1	0.8	(0.1-5.4)					

<u>3.3. Seropositivity of humans compared to serostatus of the camps' livestock</u>

No brucellosis seropositive small ruminants were found in the 13 camps with at least one seropositive person, but seropositive cattle or camels were present in 9/13 camps. No significant correlation was found between human brucellosis and Q-fever serostatus and camp proportions of seropositive large animals (cattle and camels) and small ruminants.

<u>3.4. Factors influencing human serostatus of *Brucella spp.* and *C. burnetii*</u>

Risk factors for brucellosis and Q-fever seropositivity are presented in table 7.3 and table 7.4. Male participants were more often brucellosis seropositive (odds ratio 4.9, 95% CI 1.1-22.5) than females. Being a camel breeder was the only significant risk factor for Q-fever seropositivity in humans with an odds ratio of 12.2.

Virtually all participants, including children under five years, consumed raw milk (97.7%, 95% CI 96.3-98.6) and 62.1% (58.6-65.6%) said to have direct contact to placentas of livestock from time to time. No differences in the frequency of raw milk consumption or the milk species were observed between genders within the two breeding system camel or cattle. Most (87%) adult camel breeders, consumed small ruminant milk in addition to camel milk and ten percent also consumed cattle milk bought on markets or from neighbouring camps (cattle milk was very much appreciated among camel breeders). Sporadic direct contact to placentas was already reported for 27% (21/77) of children aged from 5 to 14 years and was as high as 66% for adults. Significantly (p>0.001) more men than women reported to have direct contact to livestock placentas and to do obstetric work. In total, 84.4% (80.9-87.9%) of adults did obstetric work.

Table 7.3 Distribution of *Brucella* spp. seropositivity according to breeding system, sex, age class, consumption of raw milk and contact to livestock placenta. Multivariate logistic regression model adjusted to age class, breeding system, raw milk consumption and contact to placenta.

*=p-value ≤ 0.05, ns=non significant

		Neg n=755	Pos n=14	OR	95% confidence interval	Level of signifi-cance
Breeding system	Cattle breeders	506	8			
	Camel breeders	249	6	1.5	(0.5-4.4)	ns
Sex	Females	348	2			
	Males	407	12	4.9	(1.1-22.5)	*
Age class	>15 years	669	13			
	<15 years	83	1	0.6	(0.1-5.1)	ns
Consumption of raw milk	Yes	738	14	1.0		ns
Contact to placenta	Yes	459	10	1.0	(0.3-3.7)	ns

Table 7.4 Distribution of *Coxiella burnetii* seropositivity according to breeding system, sex, age class, consumption of raw milk and contact to livestock placenta. Multivariate logistic regression model adjusted to age class, breeding system, raw milk consumption and contact to placenta.
*=p-value ≤ 0.05, ns=non significant

		Neg n=310	Pos n=12	OR	95% confidence interval	Level of signifi-cance
Breeding system	Cattle breeders	192	3			
	Camel breeders	118	9	12.2	1.1-136.6	*
Sex	Females	147	2			
	Males	163	10	3.9	0.7-20.2	ns
Age class	>15 years	250	9			
	<15 years	60	3	0.9	0.2-4.5	ns
Consumption of raw milk	Yes	306	11	21.1	0.6-801.9	ns
Contact to placenta	Yes	247	9	1.6	0.02-117.0	ns

3.5. Clinical manifestation of zoonoses in humans

Four out of five participants with brucellosis IgM-antibodies reported illnesses of more than one year duration, thus no acute illnesses. Nevertheless, back pain around the kidneys was reported by three out of five. In comparison, only 70/847 other participants mentioned this symptom (Fisher exact test p=0.005). Results of physical examination (fever, splenomegaly, hepatomegaly, pale conjunctiva) were not different for brucellosis seropositive and seronegative participants. As for brucellosis, individuals with antibodies against *Coxiella burnetti* did not show different results of physical examination and reported symptoms as other participants.

3.6. Manifestation of zoonoses in livestock

Out of a total of 67 cows with a history of abortion, six with one and four with two abortions were brucellosis seropositive (Fischer exact test p=0.051). Brucellosis positive serological status of cattle was a significant risk factor for abortion (OR 2.9, 95% CI 1.2-7.1, adjusted to number of births and cattle breed). A total of 18.5% brucellosis seropositive cows had a history of abortion. Previous abortion and brucellosis serostatus were significantly correlated only for cattle and no correlations were found for Q-fever serostatus and abortion.

Hygromas of livestock, usually involving the inflammation of the precarpal bursa, are considered to be closely related to brucellosis infection (especially in chronically affected herds) in tropical countries (Perreau, 1956). In our setting, hygromas were only seen in two cattle herds and animals of these herds did not show higher brucellosis seroprevalences than animals in other herds.

Ticks transmit Q-fever to livestock. Twenty percent of camels were infested with ticks (mostly in the perianal area), which was significantly more than found in cattle (10%), and camels also had an higher tick burden with 19% of camels with more than 10 ticks per animal versus 7% of cattle. Fulani reported efforts to reduce the tick burden of their cattle using smoke, picking of ticks or acaricide treatments.

4. Discussion and conclusions

Brucellosis infection of nomadic pastoralists in the Chari-Baguirmi and the Kanem was not frequent, but with a seroprevalence of 2% also not negligible. This human brucellosis seroprevalence is comparable e.g. to Mongolia, where brucellosis is considered as an important public health threat (Roth and Zinsstag, 2001). Most seropositive Fulani cattle were identified during the first sampling in May/June 1999. We do not think that this represents a seasonal variation because we should have seen the same trend during the next dry season. Seroprevalences of different livestock species kept by nomadic pastoralists were all comparatively low, with the exception of cattle (seroprevalence of 7%). In contrast, an earlier serological study of cattle in sedentary herds of Southern Chad, found brucellosis seroprevalences between 20% and 30% (Domenech et al., 1982). However, brucellosis infection of cattle seems to be in general more prevalent in the more humid regions south of the Sahel. Our results on cattle seroprevalence are in accordance with other results obtained in the Sahel zone (Gidel et al., 1974; Akakpo and Bornarel, 1987). Q-fever prevalence was below one percent of pastoralists. However, to our knowledge, the very high Q-fever seroprevalence of camels (73%) has not been reported in the literature so far. We only identified one out of 125 nomadic pastoralists as being seropositive for toxoplasmosis, in contrast to the results of a Sudanese study reporting seroprevalences of 40% and 45% in nomadic and settled communities, respectively (Ilardi et al., 1987a). As to livestock, based on the literature available (Osiyemi et al., 1985; Bekele and Kasali, 1989), we would have expected higher prevalences in small ruminants (especially in sheep) than in cattle, but such a distribution pattern was not confirmed by our observations. Toxoplasmosis infection had never been reported in Chad, neither in humans nor in animals. A high variability of inter-visit camp member composition was observed. This dynamic of nomadic camps likely led to non-correlated relationships between infection in animals and infection in people. Therefore, studies to determine the most relevant livestock sources among species should be conducted in more stable populations.

Three-forth of participants had a complaint of respiratory illness, alimentary disorders or malaria (Daoud, 2001). Thus, the impact of the zoonotic diseases tested on health status of the study populations seemed to be comparatively marginal and interactions of signs of brucellosis with symptoms caused by other disorders are probable. Four out of five participants with brucellosis IgM-antibodies as well as 4 of 5 with antibodies against acute phase proteins of *C. burnetti* reported a non-acute illness. This is in contradiction with the expectation of more recent infections of brucellosis and Q-fever. A weak correlation between clinical symptoms and serology results was also observed by other authors for brucellosis (Lefèvre et al., 1970; Alballa, 1995; Maichomo et al., 1998). Possible non-specific reactions due to cross-reactions e.g. with *Yersinia spp*. which can cause false-positive *Brucella* RBT results must also be taken into consideration (Chart et al., 1992; OIE, 1996).

Milk plays an important role as staple food in nomadic pastoralist societies and is an important source of vitamin A for nomadic pastoralists (Zinsstag et al., 2002). However, uncooked milk may also be a source of infection with milk-borne zoonoses such as brucellosis, Q-fever, but also bovine tuberculosis. The two young seropositive Fulani children may have acquired brucellosis infection through consumption of raw milk. Furthermore, zoonoses may be acquired through professional hazard of obstetric work, by direct contact with blood and placentas of infected animals. Although women also assisted at deliveries of livestock, men did obstetric work more frequently. This may explain why more men were brucellosis seropositive in this study than in other sub-sahalian populations (Gidel et al., 1974). The source of infection of camel breeders remains unclear. Some antibody titres in small ruminant and camel sera may have been below the detection threshold of the test or consumption of dairy products from cattle purchased on markets was more frequent than reported by camel breeders. More *Brucella* strains from livestock need to be isolated and characterised. Nomadic pastoralists showed high-risk behaviour with consumption of raw milk and involvement in obstetric work, and it can be speculated that actually not more pastoralists were brucellosis seropositive, because only few active brucellosis infections occurred in livestock.

Typical clinical signs of brucellosis in cattle are well known to Fulani nomads, but they did not associate the disease in cattle with that in humans (Krönke, 2001). Out of 49 Fulani questioned on the symptoms of the livestock illness *bakkale*, 12 mentioned swollen testicules, 20 infertility of cattle, 26 frequent miscarriages and all 49 swollen knees (hygromas). However, it must be mentioned that not all animals with hygromas are brucellosis sero-reactors (Perreau, 1956).

Q-fever affected camels and small ruminants contributed to infection in humans. Being a camel breeder was a significant risk factor for human Q-fever seropositivity. Afzal and Sakkir (1994) as well as Elamin et al. (1992), in their studies on zoonotic infections of camels in the United Arab Emirates and in Sudan, respectively, stated that camels are to be considered as an important source of zoonotic diseases, namely Q-fever and toxoplasmosis.

Nomadic pastoralists pay attention to keep contacts between different livestock herds (including local herds) in the surrounding of watering sites as low as possible. Nonetheless, also extensively bred nomadic livestock may also be infected when purchased, or infected animals kept on behalf of foreign owners are introduced into a herd. This was observed in the only cattle herd reported to consist of animals newly gathered from different markets.

With the data available on age, births and abortions of cattle, approximately 1 out 10 abortions may be suspected to be due to brucellosis. Furthermore, Domenech et al. (1985), who also observed good knowledge of breeders on livestock abortions, stated that Q-fever (and chlamydiosis) only played a minor role in cases of abortion in comparison to brucellosis. As a matter of fact, they found higher seroprevalences of Q-fever among animals with no history of abortion as compared to animals with miscarriages. This finding is in accordance with our study.

4.1. Zoonoses and interventions in nomadic settings

Cooking of milk can prevent many cases of zoonotic diseases in an epidemic situation. Young children are most susceptible to brucellosis as well as bovine tuberculosis and, therefore, it can be recommended that at least this age group receives boiled milk. Communication of information on the hazard of zoonotic diseases among nomadic pastoralist populations is necessary. Key messages underlining e.g. the necessity of cooking milk, quarantining newly purchased animals, separating animals having aborted, and controlling ticks (mainly of camels) need to be formulated in a way which can be easily remembered. Local knowledge, experiences, metaphors and images of the daily life of nomadic pastoralists can be used for successful communication. With regard to growing fresh milk markets in cities, where milk is delivered by nomadic pastoralists and local sedentary herds, programmes of food hygiene to protect urban citizens, including the pasteurisation of dairy products, should be implemented where milk ring test of bulk milk is repeatedly positive.

Acknowledgements

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Chapter 8

Serum retinol of Chadian nomadic pastoralist women in relation to their livestocks' milk retinol and β-carotene content

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Summary

Human serum retinol and livestock milk retinol levels were assessed as part of a study on the health status of Chadian nomadic pastoralists and their livestock in close partnership between Chadian public health and livestock institutions. Of the examined women (n = 99), 43% (95% CI 33 – 54 %) were deficient (0.35 µmol/L < x < 0.7 µmol/L) and 17% (95% CI 10 –26 %) severly retinol deficient (<0.35 µmol/L). None of the interviewed women (n=87) reported the consumption of fruit and only two of fresh vegetables in the past 24 hours. Milk is the almost exclusive source of vitamin A for these populations. Goats (n=6) had the highest average milk retinol level [329 ± 84 µg/kg (mean ± SEM)], followed by cattle (n=25; 247 ± 32 µg/kg), and camels (n=12; 120 ± 18 µg/kg). Milk retinol levels did not differ between the rainy and dry seasons. Human serum retinol depends significantly on livestock milk retinol levels (partial slope 0.23; 95% confidence interval 0.008 – 0.47). Our study supports the use of goat and cow milk as an important source of vitamin A in pastoral nomadic settings. However, the levels still require to be complemented further by promoting green leafy vegetables, fruits and supplements.

Introduction

Human and veterinary medicine share the same paradigms and should not be viewed as separated. This was stated by the German pathologist Rudolf Virchow (Saunders, 2000) at the end of the nineteenth century. A similar concept, "the one medicine", was promoted by the American epidemiologist Calvin Schwabe (Schwabe, 1984). This unifying view is specifically justified in extensive pastoral environments. Nomad pastoralism is a highly adapted, sustainable way of life in an ecosystem that could otherwise not be used (Bile, 1997; Schlee, 1992). In Africa alone, 20 to 30 million people live as nomadic pastoralists, whose migration follows seasonal patterns. Nomadic pastoralists and migrants appear to be most vulnerable for exclusion from the health system and their health status in terms of mortality and morbidity is virtually unknown (Loutan, 1989).

To investigate health status and service utilisation of Chadian nomadic pastoralists, we have set up a transdisciplinary team of geographers, anthropologists, microbiologists, veterinarians and physicians (Schelling *et al.*, 2000). In close partnership between Chadian public health and livestock sectors, this team simultaneously investigates the health status of nomadic pastoralists and their livestock repeatedly following their migration cycle. As part of these studies, human serum retinol was included in the assessment to estimate the occurrence and severity of vitamin A deficiency (VAD). Fruits and vegetables contribute only very little to the daily menu of nomadic pastoralists (Holter, 1988) and milk is very likely the most important source of vitamin A of these populations. Cow and camel (*Camelus dromedarius*) milk retinol levels were measured because fresh and fermented milk are major dietary components of these people (Jacks *et al.*, 1999), but it is not known to which extent they contribute to their vitamin A supply (McCormick and Elmore-Meegan, 1992; Lechat *et al.*, 1976).

The daily consumption of milk and cereals cover the human needs of fat, protein and vitamins (Loutan, 1989). Nevertheless, the amount of intake may vary strongly due to season, place of stay and socio-economical factors and thus may make nomads particularly susceptible to develop avitaminoses (Swift *et al.*, 1900; Galvin, 1992). Lechat *et al.* (1976) report VAD in Niger during and after a drought period. Recent reports from Côte d'Ivoire show VAD in children and adults despite sufficient dietary supply (Staubli-Asobayire, 2000) xerophthalmia is reported from Sahelian Senegal and Mali (Farbos *et al.*, 1995; Rankins *et al.*, 1993), Djibouti (Resnikoff *et al.*, 1992) Sudan (el Bushra, 1992) and Cameroon (Gouado *et al.*, 1998).

There is hardly any information on vitamin A deficiency and related diseases in Chad with the exception of a report by Resnikoff (1988) on epidemiological aspects of xerophthalmia. He found a prevalence of bitot spots (XIB) of 0.67% in sedentary children under ten years of age. In Chad, vitamin A supplementation is ongoing by governmental and non-governmental bodies (Heinimann H. pers. commun.), but the current status of VAD is unknown.

Material and Methods

Population sample

With the help of randomly chosen representatives of two ethnic groups, Arab and Fulani, household leaders were randomly contacted. These feriks (nomadic camps) were visited in October – November 1999 (end of the rainy season) and in March - April 2000 (dry season) (Schelling *et al.*, 2000; Daoud *et al.*, 2000). The Arab camel and cattle nomads sampled migrate up to 400 kilometres between the areas of Dourbali and Massenya, Chari-Baguirmi province (dry season) and the southern part of Kanem province (rainy season). The Fulani cattle nomads have their dry season grazing areas on the south-eastern shore of Lake Chad and move towards Karmé and Moito in the eastern direction during the rainy season. Within the 30 feriks, an age- and sex-stratified sample was collected. Selection within the household was first based on ethical considerations and secondarily on randomisation criteria. All people were informed about the study and the sampling procedure. Clinically sick people in the study sample were treated for free. The study protocol is in accordance with Chadian national ethics policy and the Swiss Tropical Institute ethical guidelines.

Clinical examination and interviews

Clinical examination for general health status (Daoud *et al.*, 2000) and for clinically obvious eye signs of VAD were carried out by a public health physician of the Ministry of Health and are based on the WHO assessment scheme (WHO, 1996b). Dietary patterns, vaccination coverage and occurrence of selected diseases such as measles, diarrhoea and respiratory tract disorders were be collected during personal interviews of children and adults. Data on health status will be reported separately.

Handling and selection of blood samples

Venipuncture was done with a 5 ml Vacutainer® tube. Whole blood was centrifuged with a mobile centrifuge. Serum was immediately cooled in a cooling box on ice in 2 ml tubes and protected from light with aluminium foil. One millilitre of serum was requested for retinol and carotenoid analysis. This volume was not available for young children. Therefore, a random selection of 100 women in reproductive age (out of 420) was made (Table 8.1). Sera of selected women was aliquoted at the laboratory in 1 ml tubes for transportation.

Milk samples

Milk samples were obtained from pooled morning or evening milk from animals in the same ferik. In each ferik the milk of 5 sheep, 5 goats, 7-10 cattle and 3-8 camels was aliquoted in 10 ml tubes and frozen protected from light. Milk samples were also collected in traditional N'Dama cattle herds in central Côte d'Ivoire in the framework of a study on the potential for milk production of the V-Baoulé region (Knopf *et al*., 1999). Samples were from individual animals or were pooled within a herd.

HPLC analysis

Blood and milk samples were transported frozen to Roche, Basle, Switzerland. HPLC analyses of blood serum was performed according to Aebischer *et al*. (1999). Milk samples were saponified and then analysed for retinol by normal-phase HPLC as described in (Manz and Philipp, 1988). For determination of β-carotene, milk samples were prepared as in (Manz and Philipp, 1988) but the final n-hexane extracts were evaporated, the residues re-dissolved in ethanol/tetrahydrofuran (9 : 1; V : V) and the solutions analysed by reversed-phase HPLC according to Schierle *et al*. (1995). The calibration of the HPLC system was performed according to the external standard method. The coefficient of variation of the entire assays was below 10%.

Data Analysis

Descriptive and general linear mixed model procedures were done with STATA$^{(TM)}$ and SAS$^{(TM)}$ (proc mixed). Linear regression models with random effects for the between herd variation were fitted on human retinol levels to assess possible association with covariates measuring livestock milk retinol and β-carotene levels. These models were extended to take into account the measurement error in the covariates by fitting a Bayesian model in Winbugs 2000 (Gilles *et al.*, 1994). The error in the livestock milk retinol measurement was derived because the overall livestock milk retinol levels within a herd was measured from milk obtained by pooling milk samples of a number of animals within herd. The animal sample size varied from herd to herd introducing an error in the animal retinol measurement. Dichotomous categories for serum retinol were defined at a cut-off level of 0.7 µmol/l for logistic regression of risk factors. Risk factors included in the analyses were: Season (rainy, dry) ethnic group (Fulani, Arab), type of livestock breeding (cattle, camels), age (in years), number of births, frequency of milk consumption (less than daily, daily), type of milk (cattle, camel, small ruminants, combination), liver consumption (none, 6 months, monthly, weekly), butter consumption (yes, no during past 24 hours). Values of retinol and β-carotene below the limit of detection were set to zero.

Results

The sample size of Chadian human serum samples and cattle or camel milk and corresponding serum and milk samples within one ferik are presented in Table 8.1. We collected on average 1.7 (1 – 4) human serum samples in 32 feriks. In addition, six and one pooled milk samples were from goats and sheep, respectively. In Côte d'Ivoire 26 samples were from individual animals (n = 11) and from bulk milk (n = 15).

Table 8.1 Sample size and composition

Type of sample	Species	Fulani cattle breeders Chad	Arab cattle breeders Chad	Arab camel breeder Chad	N'Dama cattle Côte d'Ivoire
Human serum		58	13	28	
Livestock milk	Cattle	17	8		26
	Camel			12	
	Goat	4		2	

Human serum retinol and dietary habits

Of the 99 examined women, two out of five were retinol deficient (0.35 µmol/L < x < 0.7 µmol/L) and nearly one of five severely retinol deficient (< 0.35 µmol/L). In a 24h dietary recall study on 87 of the 99 women, none reported fruit consumption (October-November 1999 and March-April 2000). Fresh vegetables are consumed by 5% of 40 women questionned during the dry season, but 80% had a sauce including dried vegetables (gumbo). Vitamin A deficiency classes [high deficient (< 0.35 µmol/L), against deficient (0.35 µmol/L < x < 0.7 µmol/L) and not deficient (x > 0.7 µmol/L)] (McLaren and Frigg, 1997) were related to 24 h food frequency recalls using logistic models. They showed a signifcant lower intake of cereals and milk ($p < 0.05$) in women with a serum retinol <0.35 µmol/L. The spectrum of human serum carotenoids is presented in Table 8.4. Milk consumption quantities seem highly uniform with 85% (n=83) indicating a consumption of a quarter coro (approximately 500 ml, daily). Non provitamin A carotenoids consist mainly of Lutein. The provitamin A carotinoid β-cryptoxanthin has very low levels in Chadian women. In this sample, serum retinol levels are correlated with serum β-carotene ($p = 0.002$) and α-tocopherol ($p < 0.05$).

No clear relationship of health status and clinical signs of VAD could be observed, Out of all examined women, five presented with a poor health. Of those, three had serum retinol <0.35 µmol/L and two were between 0.35 µmol/L and 0.7 µmol/L ($p < 0.05$). Hematocrit values are related to logarithmic transformed levels of serum retinol ($p < 0.05$).

Livestock Milk

In Chad, goats had the highest average retinol levels (mean; standard deviation 329 µg/kg; 205 µg/kg), followed by cattle (mean; standard deviation 247 µg/kg; 160 µg/kg) and camels (mean; standard deviation 120 µg/kg; 62 µg/kg). Milk of camels contained only half of the retinol content of cow milk (Table 8.2). While milk retinol differed highly between camels and cows ($p < 0.001$), no difference could be seen between the rainy and dry seasons (Figure 8.1) within these two livestock species. Mean retinol levels (Table 8.2) in cow milk samples from Côte d'Ivoire (mean; standard deviation 324 µg/kg; 163 µg/kg) are borderline higher ($p < 0.095$) than in Chad (mean; standard deviation 247 µg/kg; 160 µg/kg) and as high as in Chadian goat milk (mean; standard deviation 329 µg/kg; 205 µg/kg). Cow milk samples from Côte d'Ivoire contain more than twice β-carotene (mean; standard deviation 392 µg/kg; 147 µg/kg) compared to Chadian cow milk samples (mean; standard deviation 167 µg/kg; 165 µg/kg). Milk of camels contained virtually no β-carotene. Levels of milk β-carotene did not vary between seasons. Milk analyses were done between one to four month after sampling.

Within this time period β-carotene should remain stable (Aebischer *et al*., 1999). Retinol and β-carotene levels in Chadian and Ivorian cow milk samples are presented in Figure 8.2 and Table 8.2. With exception of one high β-carotene value (900 µg/kg), which is from a pooled milk sample of nine cows, Chadian retinol and β-carotene values were generally below the Ivorian samples. The regression of milk retinol to milk β-carotene of the pooled (Chad and Côte d'Ivoire) samples has a slope of 0.69 µg retinol/kg to 1 µg β-carotene/kg. The slopes for the Chadian samples and those from Côte d'Ivoire are not significantly different (p=0.077).

Human serum retinol and livestock milk

Human serum retinol is significantly related to milk retinol levels if random effects models include milk retinol and β-carotene (Table 8.5) The covariate measurement error had no influence on the estimates of the fixed effects parameters, that is the β-carotene and retinol levels. For this reason we report the results obtained from the simple model (Table 8.5). Human serum retinol levels in our study do not depend on the type of milk (cow, camels) but it has to be considered that in most cases milk is consumed from several species. Human serum retinol levels depend on seasonal variation. Levels in April are on average 0.219 µmol/L (95% Confidence Interval 0.007 – 0.430) lower than in October-November.

Figure 8.1 Milk retinol levels in µg/kg with 95% confidence limits (bars) by livestock species and season

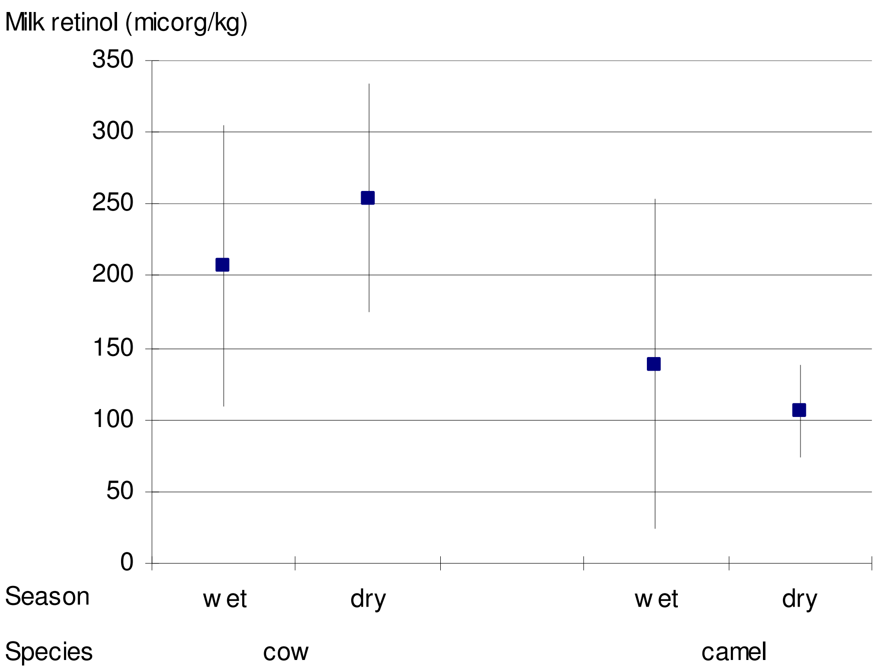

Table 8.2 Average Vitamin A and β-carotene content of cow, camel and goat milk in µg/kg (1 L = 1.03 kg) and corresponding average retinol equivalents (µg RE)*

Species	n	Mean	Standard error	95% Confidence interval	
Chad					
Cattle					
Retinol	25	247	32	180	313
β-Carotene	25	167	33	98	234
Retinol Equivalents		274			
Camel					
Retinol	12	120	18	79	160
β-Carotene	12	9	9	0	27
Retinol Equivalents		121			
Goat					
Retinol	6	329	84	113	545
β-Carotene	6	0			
Retinol Equivalents		329			
Côte d'Ivoire					
Cattle					
Retinol	26	324	32	260	387
β-Carotene	26	392	29	335	446
Retinol Equivalents		389			

*(µg RE = µg retinol + 0.167 * β-carotene µg (West and Eilander, 2001))

Figure 8.2 Relationship of cow milk retinol (µg/L) and β-carotene (µg/L) in Chad (diamonds, slope ———), Côte d'Ivoire (dots, slope -----) and Egypt (stars). (Values from Egypt are adapted from Elmoty and Elmossalami (1967)).

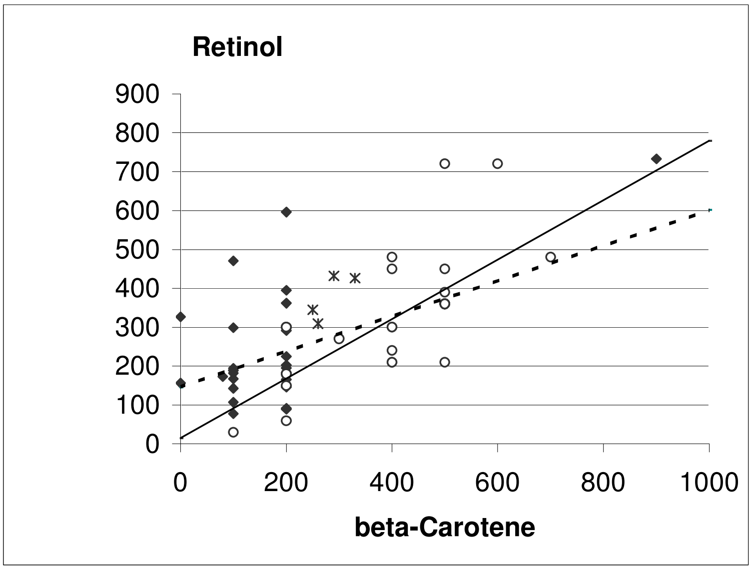

Table 8.3 Serum retinol in Chadian pastoral nomadic women (n=99).

Level of retinol deficiency (McLaren and Frigg, 1997)	Proportion	95% Confidence interval
x >0.7 µmol/l (normal)	0.40	0.30 - 0.50
0.35 µmol/l < x <0.7 µmol/l (deficient)	0.43	0.33 - 0.54
x <0.35 µmol/l (severly deficient)	0.17	0.10 – 0.26

Table 8.4 Relative proportions (%) of carotenoids in sera (n = 57) of pastoral nomadic women in Chad in comparison to standard sera (McLaren and Frigg, 1997).

Carotenoid	Chadian women mean (95% confidence limits) µg/L	% (weight)	Standard sera % (weight)
α-Carotene	1.6 (0.6-2.6)	2	4
β-Carotene	12.8 (7.9-17.6)	15	20
Cryptoxanthin	0.4 (0-1.3)	0	30
Lutein	60.9 (43.6-78.1)	69	15
Lycopene	2.2 (0.5-3.9)	3	27
Zeaxanthin	10.1 (7.3-13.0)	11	4

Table 8.5 Linear model of human serum retinol on livestock milk retinol levels with a random effect for the between camp variation (σ_h^2) in the human retinol levels.

Parameter	Estimate	95%CI	
Intercept	113.5	52.43	174.7
Retinol	0.23	0.008	0.47
β-Carotene	-0.17	-0.39	0.05
Season	62.73	2.14	123.5
σ^2 (between individual variation)	90.88	71.11	112.90
σ_h^2 (between camp variation)	11.13	0.005	62.73

Discussion

Human health

The proportion of 60% VAD in our study (Table 8.3) is alarming and confirms Resnikoffs' clinical observations 17 years ago (Resnikoff, 1988) by biochemical measurements. Our estimates are close to estimates of 65% VAD (<0.7 µmol/l) by Lechat *et al.* (1976) after the drought disaster in Niger in the early seventies and assessments in neighbouring North-Cameroon (Gouado *et al.*, 1998). Jacks *et al.* (1995) reviewed the literature of milk consumption among Tamasheqs in Mali. Following the drought periods in the early seventies and eighties, energy intake from milk fell from over 50% to less than 25%. At the same time, daily Vitamin A intake from milk per person dropped from over 500 µg to under 200 µg. Our findings of a very high proportion of VAD in Chadian nomadic pastoralists are in line with this decreasing trend of vitamin A supply from milk. On the other hand, if compared to milk intake prior to the drought disasters, the results by Jacks *et al.* (1995) show that the potential vitamin A supply from milk for nomadic pastoralists nearly covers WHO recommendations (see below). The role of malaria on the seasonal variation of human serum retinol should be further investigated. We found no clinical signs of xerophtalmia and night blindness in the examined women, but these signs occur mainly in children (McLaren and Frigg, 1997). Xerophtalmia should be further investigated in nomadic children in Chad. However, the high proportion of retinol deficient women may affect infant mortality (Semba *et al.*, 1998). In contrast to McLaren and Frigg (1997) we found large proportions of lutein and zeaxanthin but low proportions of β-cryptoxanthine among the human serum carotenoids. This may be due to the consumption of maize (Quackenbush *et al.*, 1961).

Livestock Milk

Livestock milk retinol and β-carotene clearly reflect β-carotene content in the fodder (Jacks *et al.*, 1999). Our estimates of cow milk retinol levels, even in the dry season are in the same range as cows fed on green grass in Mali (Jacks *et al.*, 1999) and Egypt (adapted from Elmoty and Elmossalami (1967) in Table 8.2) and in the same range as in temperate areas (Kirchgessner, 1982). The Fulani cattle in our study have access to green pasture around Lake Chad also during the dry season. During the rainy season they move towards watering holes surrounded by less green pasture. This may explain the higher values we observed during dry season in the absence of significant seasonal variation. The nomadic way of life thus maintains relatively constant supply of β-carotene for the animals and in consequence of vitamin A in their milk. Retinol content in camel milk in our study is in line with levels reported by Farah *et al*. (1992). They are higher than those reported by Jacks *et al.* (1999). The high values of retinol in goat milk confirm earlier findings (Holter, 1988; Elmoty and Elmossalami, 1967). However, goat milk was not analysed on a larger scale in our study. Our study supports the recommendation of Jacks *et al.* (1999) to use goat milk for children also in the Chadian nomadic setting but we recommend the use of cow milk, too. In contrast to goats (Holter, 1988; Elmoty and Elmossalami, 1967) and camels (Farah *et al*., 1992), cattle convert β-carotene much less into retinol. This may indicate different physiological pathways or different enzyme activities of retinol synthesis in these species. Our findings show that even in Côte d'Ivoire with abundant green grass, there is no sign of a plateau of retinol values which would indicate a down regulation of the retinol synthesis pathway with increased β-carotene intake as demonstrated so far in rats (Bachmann, 1999). The single high β-carotene value in Chad is a pooled sample of nine animals. These may have grazed green grass that is available at this period of the year on the islands in Lake Chad. Other animals close to Lake Chad do not go on the islands and only have access to non-green grass. This helps to explain why these had so much lower β-carotene values.

Nutrition and Interventions

The diet of the population studied consisted almost exclusively of millet, rice and maize with milk and milk products. Despite of the observation that 70% of the respondents consumed butter during the past 24 hours and almost all women consumed liver at least once during the past 6 months, their serum retinol levels indicate an intake of retinol below the dietary intake recommendations. McCormick and Elmore-Meegan (1992), mention the importance of milk as a source of vitamin A to Maasai in Kenya. Our study demonstrates a relationship of human serum retinol levels and milk consumption frequency and suggests a relationship with milk retinol and β-carotene levels. This joins recommendations by Chamoiseau *et al*. (1992) in Mauritania and Nnanyelugo (1984) in Nigeria. Milk consumption can be recommended as a source of retinol in pastoral nomatic settings because the absorption of milk retinol is much more certain than the conversion of plant β-carotene into retinol. Moreover, fruit and vegetables are not in their dietary habits. Considering our estimates of average retinol (247 µg/kg) and β-carotene (167 µg/kg) content in cow milk we estimated the average total vitamin A content of cows milk in retinol equivalents at 274 µg RE/kg (Table 8.2). Based on recommended daily intake (i. e. for children < 6 years, 400 µg RE (McLaren and Frigg, 1997)), consumption requirements can be estimated. Children should thus drink nearly 1.5 L milk daily to cover their daily requirement entirely from milk. This relatively high amount could be lowered when milk of small ruminants of higher contents is available, whose levels are in the same range as breast milk of pastoral nomadic women (Schmeits *et al*., 1999). It is clear that at the present stage of milk production, these levels of consumption cannot be achieved. Pregnant women in nomadic settings should complement their milk consumption with other dietary sources (i.e. liver). But in these nomadic populations who have almost no other source of vitamin A in their diet, the contribution from milk is significant and probably prevents vitamin A deficiency disease symptoms.

We conclude that livestock milk is an important source of vitamin A to particular population groups. But, despite the comparatively normal vitamin A content in the animals milk, human VAD is frequent and other sources of vitamin A are needed either by supplementation or improved dietary intake. Our ongoing studies on the health status of nomadic pastoralists revealed very low levels of vaccination coverage in children and women (Daoud *et al*., 2000). Retinol supplementation could be added to vaccination campaigns, as already recommended by WHO (Goodman *et al*., 2000). This work shows that human serum retinol, as indicator of human health depends on livestock milk consumption and on milk retinol levels. Work by Jacks *et al*. (1999) demonstrates the dependence of livestock milk retinol levels on fodder β-carotene levels in a similar setting in Mali. Consequently, in pastoral nomadic settings, parameters of human health status expressed as serum retinol levels depend directly on their livestock and the fodder they find in a marginal ecosystem.

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Chapter 9

Morbidity and nutrition patterns of three nomadic pastoralist communities of Chad

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Submitted to *Acta Tropica*

Abstract

As a part of an interdisciplinary research and action programme, morbidity and nutritional patterns were assessed in three nomadic communities: Fulani and Arab cattle breeders and Arab camel breeders, of two provinces in Chad. The predominant morbidity pattern of Chadian nomadic pastoralists (representing approximately ten percent of the total population of the country) had not been documented so far. A total of 1092 women, men and children was examined by a physician and interviewed during two surveys in the dry season and one in the wet season. Participants with no complaint were rare. Pulmonary disorders (e.g. bronchitis) were most often diagnosed for children under five years of age. Of the adult participants, 4.6% were suspected of tuberculosis. Febrile diarrhoea occurred more often during the wet season when access to clean drinking water was precarious. Malaria was only rarely clinically diagnosed among Arabs during the dry season, whereas Fulani, who stayed in the vicinity of Lake Chad, were also affected during this period. A 24-hours dietary recall showed that less Arab women than men consumed milk during the dry season (66% versus 92%). Malnutrition was only documented for 3 out of 328 children (0 – 14 years). Although Fulani and Arab women reported comparable birth rates, Fulani women reported more live children. The overall proportion of children not surviving was 0.2 for Arab women in childbearing age but only 0.07 for Fulani mothers. Further research on child mortality (with detailed life histories of deceased children) as well as on mother and child care is necessary. Efforts towards the improvement of access to health services for nomads should be integrated within the health, education and development systems.

1. Introduction

Morbidity and nutritional patterns of nomadic pastoralists may differ from the settled agropastoralist populations living in the same zones of the Sahel. Studies to determine the predominant diseases and nutritional status among nomads are rare or dated and, therefore, the health status of nomadic pastoralists in the Sahel is not well known (Swift et al., 1990). Yet, such information is crucial for the definition of research priorities and appropriate health policies for nomadic people in order to reduce health inequalities. Furthermore, the heterogeneity of nomad populations makes it necessary to identify the groups or sub-groups who carry the highest burden of disease and their predominant diseases prior to designing a strategy to deliver efficacious health care (Tanner et al., 1993). In the Sahelian zone, an estimated 16% of the 35 millions population are mobile livestock breeders (Bonfiglioli and Watson, 1992).

Reports, for the most part by physicians working in a nomadic setting, have described morbidity patterns of nomadic patients (Epelboin and Epelboin, 1975; Green, 1979). Few analytical studies on morbidity compared the frequency of selected diseases among settled agropastoralists to that in nomadic pastoralists. Nomadic groups showed higher rates of treponemal infections than settled agricultural groups in Mali (Chabasse et al., 1983). Ilardi et al. (1987b) emphasised the rarity of intestinal parasites among Somali nomads when compared to the sedentary population. Loutan and Paillard (1992) suggested that transmission of measles was low among Tuareg nomads of Niger and that these may act as a reservoir of susceptible individuals due to their low vaccination coverage. Nomadic mobility and dispersion, dependant on season, influence the spread of infectious diseases, such as measles (Loutan, 1989). Seasonal morbidity patterns of semi-nomadic Fulani differed considerably from those of settled Rimaibe of Mali (Hilderbrand, 1985). Loutan (1989) and Swift et al. (1990) identified five main factors affecting the morbidity patterns in nomadic pastoralists: i) proximity to animals, ii) a diet rich in milk, iii) mobility and dispersion with resulting difficulties in getting and maintaining treatment, iv) the special environment (hot, dry and dusty), and v) socio-economic and cultural factors including the presence or absence of traditional healers. Chabasse et al. (1983) and Brainard (1986) found higher infant mortalities among nomadic than settled populations in Mali and Kenya, respectively. Brainard (1986) attributed lower mortality rates of crop farmers than nomadic pastoralists to variables associated with maternal diet and nutritional status, food supplements to breast milk and child care practices rather than to improvements in primary health care.

As to nutritional status, significantly lower rates of malnutrition were seen among nomadic Rendille children of Northern Kenya compared to sedentary agriculturalist children, due to the two to three times higher milk consumption of nomadic children (Nathan et al., 1996). This study did not confirm reports of severe nutritional stress in nomadic children during the dry season (Galvin, 1992). The critical period in terms of adult and child nutrition among Sahelian pastoralists is often the end of the dry season, characterised by reduced milk production of livestock, high temperatures and aridity combined with increased energy expenditure associated with pasturing and watering herd animals (Loutan and Lamotte, 1984).

In Chad, about ten percent of the total population of 7.5 millions are nomads. Their utilisation of primary health care services is occasional (Wiese and Tanner, 2000). Health indicators such as mortality or vaccination rates are not documented specially for nomads within the rural population.

The aim of this study is to give an overview of the relative disease frequencies, mortality estimates and nutritional patterns during two different seasons and among three Chadian nomadic communities. This biomedical study was part of an interdisciplinary research and action programme of the Swiss Tropical Institute in a collaboration of the Ministry of health National and the Veterinary Laboratory (Laboratoire de recherches vétérinaires et zootechniques de Farcha, LRVZ) in Chad. Results on zoonoses and vitamin A status are reported separately (Schelling et al., 2002a; Zinsstag et al., 2002).

2. Material and Methods

2.1. Nomadic groups and sampling frame

The study took place in two provinces of Chad, Chari-Baguirmi and Kanem, which were typical for the Sahelian zone. Nomadic Fulani cattle breeders, Arab camel breeders and Arab cattle breeders were chosen in order to include two ethnic groups and two different main livestock kept. The three groups were all dependent on their herds of cattle, camels and small ruminants for subsistence.

During the wet season, Fulani cattle breeders leave the zone of Lake Chad mainly because the pastures are flooded. They then use surface water in the clay plains of Chari-Baguirmi during three to four monthes. Arab camel breeders leave the zone of the Massenya flood plains (Chari-Baguirmi) after the first rainfalls, and move about 400 kilometres northwards to disperse in the Kanem. In the Kanem, they stay in remote zones far away from villages and often face severe problems with access to wells due to lack of traditional access rights. The group of Arab cattle breeders from the zone of Massenya (Chari-Baguirmi) does not move with their cattle as far north as Arab camel holders. Some camps stay all year in the flood plains of Massenya and only the young men go north with the small ruminants and cattle. In contrast to camel breeders, they have already been in that zone for about fifty years.

Camp elders were contacted randomly with the help of representatives of nomad groups and their knowledge of the geographical distribution of nomadic camps composed of varying numbers of households. Camp elders were invited to participate in the study after they had been informed about its objectives and the sampling procedure. Out of a first list of names of camp elders willing to participate, a second selection was randomly drawn. A unique identification number was allocated to each camp visited. Sixteen Fulani and 15 Arab camps were visited during a first sampling in May/June 1999 (hot dry season). Twenty-seven of these camps were visited again during a second sampling in October/November 1999 after the annual rainfalls (wet season). During a third sampling in March/April 2000, six Fulani and four Arab camps were visited for a third time. In addition, 12 Fulani and 11 Arab camps were newly included in the study.

2.2. Physical examination and data collection

A Chadian woman physician examined a cohort of 5 men, 5 women and 5 children (0 – 14 years of age), selected by random numbers, and completed a survey questionnaire during a one-day visit to each camp. A new selection of participants was made at each visit. The language of all interviews was Chadian Arabic, the first language of the physician and the Arabs. Fulani men and most Fulani women also spoke this language fluently. An interpreter was used for the few Fulani women who only spoke *fulfulde*. All sick people encountered in the camps (sometimes specially transported to the camp to receive health care) were treated free of charge, but they were not included in the study if they did not belong to the cohort. Cases that could not be treated at the site were referred to a district hospital or city clinic. The study protocol was in accordance with the Chadian national ethics policy and the Swiss Tropical Institute ethical guidelines.

Each participant was examined according to a standardised protocol. The physician registered the participants' medical history. Axillary temperature was registered, lungs and heart were auscultated, spleen and liver were palpated. Skin and ocular lesions were recorded. Blood pressure of adults was measured in a laying position. Following this examination, the physician recorded one or multiple clinical diagnoses. Clinical case definitions of diseases and conditions mainly followed the Chadian guidelines on diagnosis and treatment (DP, 1998). The clinical case definition for tuberculosis was refined with specific questions in the protocol. Clinical suspects for tuberculosis were defined as participants who had coughed longer than 15 days and had blood in the sputum, together with at least one more cardinal symptom (fatigue, loss of appetite, weight loss, chest pain, night sweats, dyspnoea), or those who had coughed for longer than 15 days and showed at least three other cardinal symptoms. Pulmonary disorders which could not be further classified were registered as pneumopathy. Venous blood was taken with 5 ml Vacutainer® tubes, with the informed consent of each participant or caretaker. Early in the morning, sputum and urine samples, if possible on two succeeding days, were collected from participants suspect of tuberculosis.

Participants or, for young children, their mothers, were asked about their age. Sometimes local events, which could be dated, were linked to important life history episodes, and the physician calculated approximate ages based on these date marks. The marital status and type of union were recorded for every person older than 10 years of age. Men and women were asked for the total number of living children and the number living children under five years. For women, the number of pregnancies and the number of live births were registered in two parts of the questionnaire to allow cross-checking and avoid erroneous reporting. Data were withdrawn from the first sampling (318 participants) because the number of live births was not available or when the number of births was higher than the number of pregnancies (4 participants). In order to avoid recall error leading to an underreporting of live births, only women of childbearing age were considered. The number of children having not survived was calculated as the difference of the number of live births to the number of live children. The children's ages at the time of death were not recorded.

Mothers were asked about breastfeeding habits, the time of adding food supplement to the child's diet, and the kind of food given. Consumption of foodstuffs over the past 24 hours (24-hour dietary recall) was recorded for older children and adults. The amount of milk consumed was estimated using the local measuring system of a *koro* (standardised calabash holding roughly two litres). The livestock species from which the milk came was recorded.

2.3. Laboratory tests

Heparinised haematocrit tubes were centrifuged for five minutes at 12'000 rotations per minute to determine the packed cell volume. Blood smears were fixed in methanol and were examined by microscopy for plasmodium after Giemsa staining at the "Laboratoire de recherches vétérinaires et zootechniques de Farcha" (LRVZ). A quality control of the reading was done at the Swiss Tropical Institute in Switzerland. Ziehl-Neelsen stained smears of sputum or urine were screened microscopically for the presence of acid fast bacilli.

2.4. Data analyses

Grouping of diagnoses in categories was done by organ systems or by condition (e.g. pain or fever/malaria). A variable "more serious disease" was created in order to distinguish participants with a more serious health problem from those with minor problems. Participants with a clinical diagnosis alone or in combination of bronchitis, pneumopathy, malaria, gastritis, abdominal colic, febrile diarrhoea, dysentery, urinary infection, arthritis and pain in the joints and back, sciatic pain, strong headache, sexually transmitted disease, and suspects of tuberculosis or brucellosis were classified as "seriously diseased". Age was categorised into four classes; young children aged 0 to 4 years, older children aged 5 to 14 years, adults 15 to 45 years and adults older than 45 years. Dichotomous recording was done for fever at a cut-off value of 37.5°C. The analyses were carried out in Intercooled STATA 7.0 for Windows (Stata Corporation, Texas, USA). Random-effects logistic regression models were used to estimate prevalences taking into account clustering within camps and to adjust for confounders (age class, sex, group, sampling).

3. Results

3.1. Predominant health problems

In total, 1092 physical examinations of different individuals were done. The sample consisted of 377 Arab camel breeders and their children, 122 Arab cattle breeders and 593 Fulani cattle breeders. During the first, second and third sampling, 407 participants, 322 and 363 participants were examined, respectively.

Fifty-two out of 1092 (4.7%) participants had no complaint and the physician recorded no abnormality. At least one clinical diagnosis was made for 1040 participants. The maximum of different diagnoses recorded was three, and the mean was 1.4 diagnoses per person. Covering 76% of all diagnoses recorded, 754 (69%) participants were registered with a "more serious disease".

Table 9.1 shows the frequencies of the disease categories for all participants and per age class. The most important category of diseases or conditions among the children in both groups (0 - 4 years and 5-14 years) was disorders of the respiratory tract. For adults of both age classes, the most important category was digestive tract disorders.

Table 9.1 All diagnosed diseases and conditions regrouped within categories per age class.

	Total	0-4 years N=175		5-14 years N=153		15-45 years N=523		≥46 years N=241	
		n	Prev.[a]	n	Prev.	n	Prev.	n	Prev.
Disorders of the respiratory system (including tuberculosis)	298	66	34.8	56	34.9	118	22.6	58	24.1
Disorders of the digestive tract	291	48	26.0	28	18.3	139	25.9	76	31.9
Febrile conditions and malaria	239	22	9.9	47	28.1	131	23.0	39	14.1
Disorders of genitourinary tract	160	2	1.1	6	1.5	119	22.5	33	12.3
Disorders of the joints	109	0	0	7	4.6	52	9.1	50	18.9
Pain	106	1	0.6	8	1.6	58	10.2	39	14.5
Skin lesions	66	12	4.5	8	5.2	38	7.3	8	2.2
Lesions of the eyes	54	20	8.8	8	5.2	15	2.1	11	2.0
Disorders of the hematopoietic system	21	1	0.6	8	5.2	8	1.5	4	0.02
Childhood diseases	14	3	[0][b]	9	1.4	1	0.2	1	0.4
Disorders of the circulation	11	0	0	2	1.3	6	0.6	3	1.2
Nutritional disorders	9	3	1.7	0	0	5	1.0	1	0.4
Disorders of the nervous system	8	1	0.6	0	0	5	1.0	2	0.8

[a] Prevalences are calculated with random-effects model.

[b] 3 children in same camp

The most frequent (n ≥ 20) clinically diagnosed diseases and conditions, representing 83% of all diagnoses, are listed in Table 9.2. Table 9.2 shows also the frequencies of diagnoses per age class, sex, nomadic group and sampling. In the order of their frequencies, bronchitis, pneumopathy, malaria and conjunctivitis were most often diagnosed for young children (0 - 4 years), malaria, pneumopathy, parasitosis and bronchitis for older children (5 - 14 years), malaria, genitourinary infections, parasitosis and pneumopathy for adults (15 - 45 years) and malaria, joint pain, back pain and pneumopathy for older adults (≥ 46 years) (Table 9.2). Parasitosis, back pain, renal colic, asthma and rheumatism were more often diagnosed for male than female participants, however, female participants more often reported headache (Table 9.2).

Meningitis and cholera were epidemic in the zone of investigation during the sampling period, however, no case of cholera was seen and only one nomadic boy with meningitis was transported for treatment to the study site. Accidents with domestic and wild animals (snake bites, scorpion sting) were not important.

3.2. Particular morbidity patterns

3.2.1. Difference between occupational group

Asthma and bronchitis were more prevalent among cattle breeders. Sixteen out of 18 participants with arthritis in the knee or coxarthrosis were cattle breeders.

3.2.2. Clinically diagnosed malaria

A peak of malaria occurred during the second sampling (wet season). Malaria was only rarely diagnosed among Arabs during the first and third samplings in the dry period (1.1 and 3.3%, respectively), whereas Fulani were also affected during these two samplings (15.9 and 24.7%).

Swollen spleen, pale and icteric conjunctiva, fever (measured) were significantly correlated to clinical malaria diagnosis and a borderline significant (P-value=0.055) was present between the clinical diagnosis of malaria and the packed cell volume. Quality control of blood smears reading suggested poor performance and the results are not presented.

Table 9.2 Prevalence rates[a] of more frequent (n≥20) diagnosed diseases and correlation with age, sex, group and sampling (multivariate analyses).

Diseases and conditions (n>=20)		Age in years				Sex		Group			Sampling		
		0-4	5-14	15-45 (baseline)	≥46	Males (baseline)	Females	Fulani (baseline)	Arab		1. (baseline)	2.	3.
								cattle	cattle	camel	May/June 1999	Oct./Nov. 1999	March/April 2000
	n	175	153	523	241	598	494	593	122	377	407	322	363
Clinical malaria	232	9.0 ***	27.2	22.2	14.1 *	20.1	19.6	25.3	5.0 ***	14.3 **	6.8	41.1 ***	11.1 ***
Pneumopathy	128	14.5 ***	15.1 ***	7.6	10.6 *	10.6	11.6	11.2	14.3	10.1	13.7	7.1 ***	11.6
Parasitosis (intestinal)	114	4.8	10.5	9.4	7.8	11.3	7.7 **	10.5	7.8	9.0	9.8	11.2	7.1
Genitourinary infections[b]	92	0.6 ***	1.3 ***	12.3	6.3 **	7.5	5.5	8.6	15.5	3.5	5.4	2.5	13.6 **
Bronchitis	80	17.7 ***	8.1	4.8	2.9	7.9	5.6	8.4	5.7	5.3	11.0	5.3 ***	4.4 ***
Gastritis	74	0 ***	1.3 **	7.1	10.0	5.6	6.1	5.3	4.1	8.0	6.6	5.1	3.6
Joint pain	60	0 ***	1.3 **	5.7	11.6 **	4.1	5.7	4.1	5.4	6.1	6.2	1.6 *	5.4
Back pain	58	0 ***	0.7 *	5.3	10.8	6.6	2.0 ***	3.8	6.4	5.1	4.4	2.9	5.8
Conjunctivitis	53	8.8 ***	5.3	2.1	2.0	4.2	4.5	4.4	6.6	4.0	6.1	1.5 **	3.4
Tuberculosis	40		1.5	4.8	3.0	4.0	3.2	3.8	4.4	4.0	2.2	4.9	4.1
Headache/migraine	39	0.6	3.1	2.9	3.7	2.2	3.4	2.4	6.6 *	3.4	5.1	0.6 **	3.0
Asthma	33	0 **	0.6	3.3	1.7	2.6	1.2 *	4.3	1.6	0.5 **	3.3	2.6	1.7 *
Rheumatism	27	0 *	2.5	1.4	4.0	3.2	1.6	2.3	0.8	1.6	3.2	0.9	0.7
Abdominal colic	27	0 *	1.3	0.8	1.5	1.0	0.5	0.7	4.3	2.0	1.2	0.9	4.0 **
Upper respiratory tract disorder	25	2.3	2.6	2.4	0.8	1.8	1.6	2.2	1.0	2.2	1.9	0.9	2.8
Amenorrhea	24	0 (**)	0 (**)	3.1	0 (***)	0 (***)	3.7	2.6	0.8	0.6	0.7	3.7 ***	1.4
Furunculosis	21	3.5 *	3.3	0.6	0.8	1.7	2.2	1.3	0	3.4 *	0.9	2.8	1.6
Afebrile diarrhoea	21	5.3 ***	0	0.3	[0][c]	1.6	0.7	0.6	0	2.1	0.8	1.1	0.2

baseline = reference category within variable; * p-value ≤ 0.05, ** p-value ≤ 0.01, *** p value ≤ 0.001

[a] calculated with random-effects model;

[b] including STI's [c] three cases in the same camp

3.2.3. Diarrhoea

Febrile diarrhoea occurred more often during the second sampling (wet season) and diarrhoea in general (afebrile, febrile diarrhoea or dysentery) was also more often (borderline significant, P-value of 0.053) reported during the wet season.

3.2.4. Tuberculosis

Sputum and urine samples could not be collected from all participants suspect of tuberculosis. On the other hand, some samples were collected from some participants not classified as tuberculosis suspects. Among the 54 participants from whom samples were collected, 18 were classified as suspect of tuberculosis. Acid fast bacilli were found in eight samples. All eight smear-positive participants reported typical signs of tuberculosis during questioning. One acid fast bacilli-positive smear derived from a ten year old boy. With the exception of coughing, he showed no further cardinal symptoms for human tuberculosis due to *Mycobacterium tuberculosis*. However, this boy had swollen cervical lymph nodes, a typical sign of bovine tuberculosis (caused by *M. bovis*) infection in people (and especially of children).

3.2.5. Childhood diseases

With the exception of two cases of mumps, all childhood disease cases (6 of measles, 3 of whooping cough and 3 of mumps) occurred among Arab children of camel holders from both sexes aged 1.5 – 10 years.

3.2.6. Skin lesions

Nearly ten percent of the participants (102 out of 1092) had some sort of skin lesion, including scars, itching without further specification of the cause, scabies, purulent dermatitis or measles. The most frequent skin lesions were dermatophytosis (ringworm), depigmentation of the skin and staphylococcal infection. Dermatophytosis occurred significantly more often during the wet season. Staphylococcal infection (furunculosis) was typically found in children and were rare in adults. Depigmenation of the skin was only found among Arab women and was never seen among Fulani.

3.3. Marital status, parity and number of surviving children

With the exception of three divorced or widowed Arab women, all mothers were either in monogamy (38.5% of Fulani and 64.3% of Arab women) or polygamy marriages (61.5% and 35.7%, respectively) and the youngest married women were 14. First pregnancy was reported at the age of 16 and the youngest mothers in our sample, two Fulani and one Arab, were 17 years old. All women in childbearing age had their first baby until the age of 25. Four out of 31 Fulani women older than 44 years had never given birth to a child, while this was not observed in Arab women.

Using age-adjusted linear regression analysis, no differences were observed between the two ethnic groups or between cattle and camel breeders for the number of reported pregnancies and the number of reported live births of all women. However, Fulani mothers older than 45 years had a mean of 6.5 living children (standard error 0.4, n = 53), Arab camel breeders 5.2 (SE 0.5, n = 25), and Arab cattle breeders 4.8 (SE 0.8, n = 6). The difference was significant (P-value ≤ 0.05) between Fulani and Arab cameleer women.

The total number of births was 672, with 78 children having not survived (11.6% of births), for women in childbearing age. Table 9.3 shows the parity means and the proportions of children having not survived per age class and ethnic group. Arab women (15 - 45 years) had more children not surviving when compared to Fulani women both with the linear and multinomial regression model (adjusted to age and number of live births, the type of union and delivery place had no significant influence). In comparison to Fulani women, the relative risks to have 1-2 children not surviving were 3.9 (95% CI 0.96-15.5) and 4.6 (CI 1.5-14.0) for Arab cattle and cameleer women, respectively, and 8.5 (CI 1.1-68.1) and 6.3 (CI 1.4-29.2) for 3-4 children.

3.5. Nutrition and nutritional status

Staple food was millet and maize, prepared from flour as porridge. It was eaten together with a stew prepared from dried vegetables (mainly ocra [*Abelmoschus esculentus*]) and sometimes dried meat. Alternatively, it was eaten with milk. For the most part of the year, milk was consumed daily, either fresh our sour. Women produced butter mostly during the wet season when milk was more abundant.

Fruits had never been consumed the previous 24 hours and are not listed in table 9.4, which shows the proportions of foodstuff consumed per age class, gender, group and sampling. Salt and sugar supply could become critical (shortage) during the wet season because distances to markets were very long, especially for camel breeders. The proportion of meat consumption is likely to be overestimated due to interference with the arrival of the research group and

Table 9.3 Mean parity and number of children not survived of Fulani and Arab women

Age groups of women (years)	No. of women		No. of live births		Mean parity		No. of children not survived		Proportion of children not survived	
	Fulani	Arab	Fulani	Arab	Fulani	Arab	Fulani	Arab	Fulani	Arab
15-19	19	12	6	4	0.32	0.33	0	1	0.00	0.25
20-24	13	11	24	32	1.85	2.91	0	6	0.00	0.19
25-29	22	25	66	79	3.00	3.16	4	15	0.06	0.19
30-34	22	13	113	62	5.14	4.77	8	11	0.07	0.18
35-39	12	8	69	53	5.75	6.63	4	11	0.06	0.21
40-44	6	8	54	57	9.00	7.13	7	12	0.13	0.21
Overall	94	77	332	287	3.50	3.7	23	56	0.07	0.20

Table 9.4 Proportions of consumed foodstuff during the previous 24 hours per age class, gender, group and sampling (second sampling Octobre/November, wet season, and third sampling March/April, dry season) and results of multivariate analyses.

	N	Age in years			Sex		Group			Sampling	
		5-14	15-45 (baseline)	>45	Males (baseline)	Females	Fulani (baseline)	Arab		2. (baseline)	3.
							cattle	cattle	camel	wet season	dry season
	502	22	328	152	278	224	282	98	122	208	294
Cereals	465	100.0	92.1	92.8	93.9	91.1	97.2	88.8**	85.3**	87.5	96.3**
Milk	456	77.3	90.6	93.4	93.5	87.5*	93.6	84.7	89.3	95.7	87.4*
Butter	168	57.9	56.7	57.9	55.0	60.0	58.4	65.1	43.6		57.1
Meat	135	22.7	28.7	23.7	30.2	22.8	24.1	44.9*	18.9	16.4	34.5**
Liver	32	10.5	10.6	11.6	15.4	4.8**	8.1	14.5	12.9		10.9
Fish	34	4.6	6.4	7.9	8.6	4.5	8.2	11.2	0**	1.9	10.2**
Fresh vegetables	21	4.6	3.1	6.6	3.6	4.9	7.1	1.0	0**	0.5	6.8*
Dried vegetables	218	63.2	75.0	74.7	76.9	70.4	78.5	85.5	48.4**		74.2
Sugar	401	31.8**	78.7	89.5	83.8	75.0	79.8	78.6	81.2	74.0	84.0**
Salt	375	59.1*	73.8	79.0	76.3	72.8	83.0	78.6	52.5**	62.0	83.7**

* p-value ≤ 0.05, ** p-value ≤ 0.01, *** p value ≤ 0.001

baseline = reference category within variable slaughtering of a goat or sheep the evening before the survey questionnaire was filled in. The gender difference of proportional 24-hours milk consumption was attributable to a substantially inferior milk consumption of women of both Arab groups during the hot dry season (73.1 and 59.4% of females versus 86.1% and 96.1% of males). In contrast, gender differences for milk consumption did not apply to Fulani. Small ruminant milk was more available during the dry season (more births of small ruminants during the early dry season) and reported consumption of small ruminant milk was significantly higher for Fulani during that period. In addition, among Fulani the quantity of consumed milk was higher during the dry than wet season (0.9 litres versus 0.6 litres per day and individual).

The childs' age, at which supplementary food was added to breast milk was on average 15.1 months for Fulani children and 10.1 months for children of camel holders. This difference was significant (P-value = 0.006). Arab women gave differentiated answers between 4 and 12 months, but Fulani women gave rather stereotype answers such as one (71%) or two years (29%). All 195 mothers questioned gave milk products during weaning time, however, Fulani mothers more often (76% versus 20%) added a dish prepared from sour milk, rice and sugar. About two-third of mothers of all groups also gave a cereal porridge. No fruits or vegetables were recorded as food supplement.

The only three protein-energy malnourished children (0-14 years, n=328) were Fulani boys aged 7 to 22 months.

4. Discussion

The main diseases and conditions among nomads of the Chari-Baguirmi and Kanem did not differ substantially from morbidity typical for the Sahelian zone such as respiratory diseases, malaria and diarrhoea. However, participants without any complaint were rare in this study. A strong difference between the proportion of surviving Fulani and Arab children was observed, with lower proportions among Arabs.

In Mali, only 20 to 45% of nomadic populations (depending on group) showed no coughing and/or mucupurulent expectoration, blood in the urine, a disorder of the eye or skin, or a low nutritional status (Chabasse et al., 1983). No direct correlation of absolute and relative disease frequencies could be done with the sedentary populations in our study. The study of Chabasse et al. (1983) suggests few differences between sedentary and nomadic populations of Mali.

The seasonal variation of diarrhoea with more cases during the wet season corresponded to a period when almost all camps used superficial standing water as drinking water rather than water from open wells. An annual rise of diarrhoea during the wet season is also seen for the entire Chad (DSIS, 2001). The wet season with its long transhumance routes and the continuous constraint of access to sufficient water for humans and animals represented a big pressure, especially for Arab camel breeders. Stress may partly explain the higher proportion of gastritis among this group. However, members of all three groups were frequently diagnosed with gastritis, which may also be due to irregular meal intakes. Specific risks of accidents with livestock, methods for milking or milk transformation, more frequent watering of animals, or transport of heavy loads for long distances could be responsible for more arthritis in the knee and coxarthrosis of cattle breeders. Childhood diseases affected mainly Arabs. This was in agreement with observations made by the health personnel and during interviews with pastoralists.

Strong mortality differences have been reported between Malian zones and between nomadic groups within one zone, although these were less distinct (Hill and Randall, 1984). The observed proportion of 11.6% children not surviving was low compared to national level of under-five mortality of 194.3 per 1000 live births (DSIS, 2001).

Cereals, meat, salt, sugar (an important energy source for both genders) and fresh vegetables were less often consumed during the wet season, sometimes due to provision problems because the camps moved in very remote zones. We have not found the very low levels of milk consumption during the dry season described by Loutan and Lamotte (1984), partly because more small ruminant milk was available in Fulani camps. Nevertheless, an important proportion of Arab women had consumed no milk within the previous 24 hours during the dry season. Galvin (1985, reviewed in Shell-Duncan, 1995) reported that Turkana mothers attempted to minimize the impact of food shortages on children by reducing their own dietary intake and preferentially feeding their children. Holter (1988) found that fruit and vegetables played no role in the diet of regularly migrating Sudanese populations. Our data suggested a similar shortcoming of fruit and vegetable consumption. A direct dependency of serum retinol (vitamin A) of nomadic pastoralist women on livestock milk retinol levels was found. Thus, milk was an important source of vitamin A (Zinsstag et al., 2002).

Extended breastfeeding, with gradual introduction of additional nutrition is associated with the child's health gain. In our settings, prolonged breastfeeding may prevent the child's uptake of contaminated food (water or milk) to a certain extent. Our data was in accordance with Loutan and Lamotte (1984) for Fulani in Niger, where at year one, half of the children ate cereals, and only half of them were completely weaned at 2 years. Islamic recommendation is that girls are weaned at the age of 23 months and boys at 24 months (Cenac and Diallo, 1987).

The Chadian physician was astonished to find so few protein-energy malnourished nomadic children. The year of the study was a satisfying year for animal breeding and milk was abundant. Nevertheless, this situation may drastically change in a drought situation (Galvin, 1992).

Time per participant was restricted beside physical examination and completion of the survey questionnaire. The nomads' working rhythm allowed for examination and interviewing only in the early morning or in the evening before sunset. Therefore, no anthropometric or in-depth data collection (e.g. on child mortality) was planned, but we rather wanted to gain a broad overview of important health issues for nomads, because very little knowledge was available so far. Diagnoses were mainly based on the clinical skills of the physician and following clinical guidelines. Clinical malaria correlated significantly to swollen spleen, fever and anaemia. Unfortunately, the accuracy of clinical diagnoses and the severity of infection could not be further demonstrated with a plasmodium index. The same physician examined all participants, thus making results comparable between and within groups and seasons. Nonetheless, over-reporting of complaints based on the hope of obtaining drugs or under-reporting of particular ailments (e.g. sexually transmitted diseases) related to shame must be considered. In the absence of a census, nomadic camps were selected in the best achievable random way. The clustering within camps could be considered with statistical models. However, random selection of participants within camps could sometimes not be well controlled because random numbers may have been exchanged to favour a "diseased" member of the camp for examination, although all sick people would have been examined after the study protocols were completed. Recall bias, the painful nature of reporting children who have died, and the reference to miscarriage when the child died before baptism after the first week of life (burying of newborns without ceremony) probably led to an under-estimation of the true proportion of lost children. Therefore, this result must be interpreted cautiously.

Policies and future research among nomadic pastoralists

Due to their marginalised status, nomads are mostly not considered for health interventions. When drugs and vaccines become short at dispensaries, nomads will be discriminated first (Swift et al., 1990; Omar, 1992; Sheikh-Mohamed and Velema, 1999). Therefore, even if a western-type treatment is sought, nomads often do not consider a visit to a dispensary. They may also arrive with advanced stages of disease at the dispensary. Priority diseases, which should be targeted by health interventions, are certainly the respiratory disorders, which were especially frequent among young children. Training of nomadic community health workers and their supply with basic drugs including antibiotics (e.g. for treatment of acute respiratory infections), anti-malarial drugs and anti-parasitic drugs for intestinal disorders could partly ensure the provision of basic health interventions. More severe cases would be referred to district hospital or city clinic (Loutan, 1989).

A prevalence of 4.6% adult participants suspect of tuberculosis is notable. This situation is deteriorated by the fact that nomadic tuberculosis patients are difficult to treat due to problematic follow-up (Caselle and Galvagno, 1992). Smear-positive patients represent the most important source of spread for the human type tubercle bacilli in a community and, therefore, the detection of acid fast bacilli in sputum is the most important criterion of diagnosis in Chad. Yet, in a previous report, only 27% of tuberculosis cases were detected with this method (Styblo, 1991). Seventeen percent of the cattle kept by our study group were *M. bovis* tuberculin reactors (Diguimbaye et al., 2002). Tuberculosis in humans caused by *M. bovis* is clinically indistinguishable from tuberculosis caused by *M. tuberculosis* (Cosivi et al., 1998). Isolation and characterisation of the mycobacterial strains is necessary to evaluate the zoonotic potential of tuberculosis due to *M. bovis*.

Arab camel breeders usually stayed in a dry environment where they had very low prevalences of clinical malaria. Their exposure to malaria infection was for the most part limited to the wet season. Prothero (1965) focused on the interaction of migration and WHO-malaria-eradication-programme (reduction of the vector population). He stated that migrants passing through a malarious area may build up and maintain a reservoir of malaria transmission. In contrast, most Fulani breeders stayed at the borders of Lake Chad during the dry season - a more humid environment favouring the insect vector - and Fulani experienced higher clinical malaria frequencies during the dry season. The region of southern Lake Chad was considered as hyperendemic malaria area in the seventies (Buck et al., 1970). A local malaria epidemic during the study period accentuated the usual malaria peak in the wet season and anti-malarial drugs were short in dispensaries of Kanem - especially so for nomads.

No greens were consumed by nomadic Rendille children (Nathan et al., 1996). If it were the rule that children are not supplemented with fruits, vegetables or meat (as the data actually suggests), children would be at risk to develop micronutrient and vitamin deficiencies. Our data has implications for the design of improved weaning and nutrition interventions among all three nomadic groups. Further research on child mortality (with e.g. detailed life histories of deceased children or traditional umbilical cord cutting methods) and child care is necessary, but also on maternal peripartal complications, management of child birth difficulties and family planning, in order to define intervention recommendations more specifically.

An improvement of water access and sanitation cannot be fully achieved by e.g. the construction of new wells alone. A new legislative framework for nomads is urgent (Lachenmann, 1991; Yosko, 2001), since traditional rights largely lost their signification. Efforts towards the improvement of access to health services should be integrated within the health, education and development systems and nomadic communities involved throughout the process. Egalitarian reasons justify efforts to develop innovative and adapted health services for nomadic people. Yet, there is a need to establish with more precision measures of health inequalities with regard to status of the rural Chadian population, including mobile and sedentary communities.

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Chapter 10

Utilisation of health services of three nomadic pastoralist communities of Chad

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Summary

In Chad, nomadic pastoralists rarely visit health dispensaries or do so only in an advanced stage of disease. Yet, patterns of health services use by nomadic pastoralists was virtually unknown. In order to assess generalities and differences between nomadic communities of health care utilisation, 1116 survey questionnaires were completed in three nomadic groups (Fulani and Arab cattle breeders, and Arab camel breeders) during two surveys in the dry season and one in the wet season. Utilisation patterns according to age class, sex, group and season were analysed for participants reporting specific symptoms or presenting defined affections (as diagnosed by a physician). Vaccination status of children and women as well as use of prenatal health care were recorded. Multiple services, traditional and western-type, were used. Apparent differences in health service utilisation between communities were mostly due to less common use of dispensaries and traditional healers by both Arab camel and cattle breeders, but Arab cameleers consulted a marabout more often than Fulani. Dispensaries were visited by one fourth of sick participants, with no significant differences between sexes. Participants with respiratory disorders went early to a dispensary for consultation and successively also used more other health services. During the wet season, use of health services was dominated by the high frequency of malaria occurrence. Dispensaries where anti-malarial drugs were known to be in short supply were visited less often. Our data suggest that young unmarried women and men had fewer opportunities to visit a marabout or a dispensary than other group members. No fully immunised nomadic child was found in the study population. Women gave birth assisted by relatives in the camps, and prenatal health care was virtually not used. The implications of mobile health services and community health workers are discussed.

Introduction

Nomadic or transhumant pastoralism in the Sahel is a highly adapted way to make use of a scarce ecosystem for livestock production (Niamir-Fuller and Turner, 1999). Bonfiglioli and Watson (1992), who have estimated a proportion of 16% of mobile breeders among the Sahelian population, are usually cited as the most recent reference. The exposure to contagious diseases and other health hazards of nomadic pastoralists is combined to infrequent use of health care structures (Wiese and Tanner, 2000; Sheik-Mohamed and Velema, 1999; Swift *et al.*, 1990). Still, knowledge on every day use of health services by nomadic pastoralist populations is insufficient.

Better access to the government health system alone, without political improvement of the situation of a marginalised population may not have the expected positive health impact (Navarro, 2000). Nonetheless, access to primary health care may prevent a number of infectious diseases. Nomadic pastoralists have had contact to modern medicine for many decades, in the end also through the appreciated veterinary services. Dispensaries in rural Chad, however, most often lack adequate infrastructure, drugs, quality of care and supervision. Therefore, they may have a weak performance as seen in other Sahelian countries (Gilson, 1995).

The geographical dispersion of groups and their spatial relationship to each other and to health services interact with other factors linked to every day constraints. Socio-economic and behavioural factors common to rural African settings influence the steps from being concerned about an illness to the decision to seek help as well as to actual utilisation of health services (Tanner and Vlassoff, 1998). Nomads have common cultures and traditions with sedentary communities. Yet, the identification of factors influencing the health service utilisation patterns typical for nomads remains an additional challenge due to the scarce knowledge of nomad characteristics.

Men's discrimination towards women, which is translated into social and economic disparities, causes a special vulnerability of women (de Bruijn, 1995). This gender disparity is - as in many other societies – an important issue in nomadic societies. Men largely control access to outside practitioners, treatments and knowledge within nomadic pastoralist communities of Chad. The access of women to health services depends on their social support system and the network they can mobilise in case of illness to receive the necessary resources for treatment (Hampshire, 2002). Women cannot visit dispensaries or outside traditional services unaccompanied and without the permission of their husbands or fathers. The lack of a male chaperone may make it impossible for women to receive the treatment they need (Tanner and Vlassoff, 1998). Katung (2001) found practical reasons to the rare use of health facilities by rural women in Nigeria such as the easy access to traditional healers or unavailability of transport.

The programme “Health of Nomads” of the Swiss Tropical Institute and the “Centre de Support en Santé International” in Chad aims at improving access of nomadic pastoralists to health care and health education, based on the perceived needs and demands of the different nomadic populations. Interdisciplinary research activities involving Chadian and European researchers and the disciplines geography, anthropology, biology, medicine and veterinary medicine started in 1998. Health does not necessarily represent the first priority of the target populations, therefore, efforts should be integrated within the health, education and development systems. Since traditional rights and contracts between the nomads and settled groups largely lost their signification, the participatory and decentralised development of a new legislative framework for nomads is urgent (Yosko, 2001; Lachenmann, 1991).

A preliminary study conducted mainly with men in three nomadic ethnic groups of Chad provided valuable information on perceived accessibility to health services and the utilisation of these. Results showed considerable variation between ethnic groups. Medical personnel reported that the few nomads who came to health centres mostly presented advanced stages of disease. Nomadic clients frequently sought to buy additional drugs for sick relatives. No nomadic child was vaccinated and the major obstacles in access to dispensaries were time and distance. Nevertheless, treatment provided by health centres was in generally perceived as effective for severe illnesses. Traditional health services (especially the marabout) were first visited as major source of relief or prevention (Wiese and Tanner, 2000). Real access to health services was evaluated in-depth in view of perceived morbidity with qualitative and quantitative questionnaires and dispensary data (Wiese, 2002).

Epidemiological data on the use of health services from men, women and children, was collected simultaneously. In order to assess differences and generalities of health care utilisation patterns based on reported symptoms and clinical diagnoses, data was collected during different seasons in three nomadic groups, which were composed of two ethnic groups (Fulani and Arabs) and two different breeding systems (cattle and camels). This research team collaborated with the Chadian Ministry of public health and the WHO office in Chad. Morbidity patterns will be reported separately (Schelling *et al*., 2002b).

Methodology and study groups

Nomadic groups

The three nomadic groups, Fulani of the lake Chad zone, Arab camel breeders and Arab cattle breeders, all Muslim, are dependent on their herds of camels, cattle and small ruminants for subsistence, either directly from animal products or indirectly from animals exchanged for e.g. cereals and sugar. The study zone in two provinces of Chad (Chari-Baguirmi in the north and Kanem in the south) was typical for the Sahel zone as described by Hill (1985).

During the wet season, Fulani cattle breeders leave the zone of lake Chad mainly because the pastures at the shore or on the islands are flooded, but also to take advantage of fresh green pastures. They use surface water in the clay plains of Chari-Baguirmi. As soon as the rainfalls stop, approximately three months later, they hurry back to the lake to arrive before access is blocked by cultivated fields. Most Fulani families have some agricultural activity themselves and a small part of Fulani of the lake Chad are in transition to semi-nomadism practising some agriculture or small-scale business, while retaining transhumant livestock breeding as their basic economy (Planel, 1996).

Arab camel breeders leave the zone of the Massenya flood plains (Chari-Baguirmi) after the first rainfalls, and move about 400 kilometres northwards to disperse in the Kanem within three months. In the Kanem, they stay in remote zones far away from villages. Arab cameleers came to the Chari-Baguirmi from Central Chad only after the last severe drought in 1985 and after the civil war. In the Chari-Baguirmi and Kanem they faced severe problems with access to wells due to lack of traditional access rights. They are very rarely involved in agricultural activities. Younger men herd young and non-lactating camels separately, while lactating camels remain with the family.

The group of Arab cattle breeders was the most heterogeneous with regard to sub-ethnic background. From the zone of Massenya (Chari-Baguirmi), they do not move with their cattle as far north as cameleers. Some camps stay all year in the flood plains of Massenya and only the young men go north with the small ruminants and cattle. In contrast to camel breeders, they have already been in that zone for about fifty years. Some Arab cattle breeders collect arabic gum, which they sell with a high profit on the markets.

Sampling

With the help of nomad representatives and using their knowledge of the geographical distribution of nomadic camps - composed of varying numbers of households - camp elders were contacted randomly. They were asked for participation in the study after they were informed about the objectives and the sampling procedure. Out of a first list including names of those camp elders willing to participate, a second selection was randomly drawn. A unique identification number was allocated for each visited camp, which was retained for all samplings. Sixteen Fulani and 15 Arab camps were visited during a first sampling in May/June 1999 (hot dry season). Twenty-seven of these camps were visited again during a second sampling in October/November 1999 after the annual rainfalls. During this period (wet season) Fulani and Arabs are involved in long transhumance movements. During a third sampling in March/April 2000, six Fulani and four Arab camps were visited for a third time. In addition, 12 Fulani and 11 Arab camps were newly included in the study.

A cohort of 5 men, 5 women and 5 children was selected with random numbers in each camp. A Chadian physician examined these individuals and completed a survey questionnaire. The language of all interviews was Chadian Arabic, the first language of the physician and Arabs. Fulani men and most Fulani women also spoke this language fluently. An interpreter was used for the few Fulani women, who only spoke *fulfulde*. All sick people (sometimes specially transported to the camp to receive health care) were treated at no charge. Cases that could not be treated on place were referred to a district hospital or city clinic. The study protocol was in accordance with the Chadian national ethics policy and the Swiss Tropical Institute ethical guidelines.

Physical examination

The physician examined each participant using a standardised protocol. Axillary temperature was registered, lungs and the heart were auscultated, spleen and liver were palpated. Skin and ocular lesions were recorded. Following this examination, the physician registered the participants' health history, recorded one or multiple clinical diagnoses and completed the survey questionnaire.

Survey questionnaire data

Demographic data

Participants were assigned to the group of i) Fulani (all cattle breeders), ii) Arab camel breeders, or iii) Arab cattle breeders.

Participants or, for young children, their mother were asked about their age. Sometimes local events which could be dated were linked to important life history episodes, and the physician calculated approximate ages based on these. Four age classes were defined: i) 0-4 years (young children), ii) 5-14 years (older children), iii) 15-45 years (younger adults and childbearing age for women), and iv) older than 45 years (older adults).

The marital status and type of union were recorded for every person older than 10 years of age as i) unmarried, ii) married in monogamous marriage, iii) married in polygamous marriage, or iv) divorced, v) widowed.

Reported symptoms and clinical diagnoses

During the first sampling, reported symptoms were recorded. For the second and the third sampling, freely reported symptoms were noted, and, a list of 36 symptoms was used to assess additional signs of illness. The mothers of young children were asked to report the symptoms of their children.

Symptoms were regrouped in 6 major reported symptom groups: i) respiratory symptoms, ii) fever and headache, iii) musculoskeletal pains with fever, iv) digestive symptoms, v) genitourinary symptoms, and vi) musculoskeletal pains without fever and without headache. Participants with more than the sampling's median number of symptoms were classified as "ill". One participant could be listed within one ore multiple major symptom group and classified as "ill".

As to clinical diagnoses, in order to minimise confusion due to multiple disorders, only those participants with a single diagnosis were assigned to a major disease class, whereby the five most important disease classes were used for analyses. A further variable “diseased” was created in order not to exclude participants with multiple diagnoses for analyses. Participants with a clinical diagnosis alone or in combination of bronchitis, pneumopathy, malaria, gastritis, abdominal colic, febrile diarrhoea, dysentery, urinary infection, arthritis and pain in the joints and back, sciatic pain, strong headache, sexually transmitted disease, and suspects of tuberculosis or brucellosis were classified as “diseased”.

Utilisation of health services

The kind of service used to address reported symptoms were recorded as i) no service, ii) dispensary, iii) traditional healer, iv) marabout, and v) self-medication. During the second and third sampling, for each service used, the order was registered as first, second, third and forth service.

Self-medication was not further distinguished between application of home remedies such as herbs or milk products (Hampshire, 2002; Wiese and Tanner, 2000) and purchased drugs from the informal private sector (without advice from a health professional). Traditional healers often prescribed herbal remedies and they also had high abilities in treating fractures and joint traumas (Aliou, 1995). The marabout offered oral and written prayers for any protective and curative purpose.

All participants were asked whether they went to a dispensary in case of illness. If the answer was negative, the reasons for not using dispensaries were further defined.

Vaccination, utilisation of dispensaries during pregnancy,

The absence or presence of the typical scar on the lower arm caused by BCG vaccination was registered. All participants or mothers of children were asked whether they had been vaccinated. If the answer was positive, they were asked to show their vaccination card. Women in childbearing age were further asked whether they had been vaccinated during the last pregnancy and if they went to a dispensary during the course of a pregnancy.

Malaria prophylaxis

Patterns of mosquito net use were registered. Participants were asked if they knew the drug chloroquine or the constraints linked to its use, and if they used it in the case of malaria.

Statistical analysis

Random-effects regression models were used for multivariate analyses to control for influences of correlates and to take into account the clustered respondents per camp. The camp identification number was used as random error level and the unit of analysis was the individual respondent. The dependent variables were of dichotomous nature for logistic regression, on a continuous scale for linear regression and categorical for multinomial logistic regression. All outcomes were adjusted to age class, gender, group and sampling. With a stepwise forward approach other covariates were added. Baseline categories were usually those with the highest number. The sample was further stratified either for gender or nomadic groups if numbers per category did not fall below 10. Repeated questioning of same participants were excluded for analyses of the vaccination status or other fixed status as the use of dispensaries at any time. All analyses were done with Intercooled STATA 7.0 for Windows (Stata Corporation, Texas, USA).

Results

Sample

In total, 1116 survey questionnaires were completed (among 93 with missing data on reported symptoms). A high variation of inter-visit camp composition was found for all camps visited. Only 56 participants were examined twice and four adult participants three times. In the sample, young children (0-4 years) differed not significantly in gender and age between the three groups. The group of Fulani and Arab camel breeders were comparable for age and gender distribution. Among Arab cattle breeders, in comparison to Fulani, less young children, but more adult men were examined. The proportion of cameleers was 40% for the first two samplings, but only 20% for the third sampling due to a shift to the examination of more Arab cattle breeders. The median number of tents (representing approximately one family), adults, young children (0-4 years) and older children per visited camp was 7 (3-17), 15, 9 and 12, respectively, for Fulani, 7 (4-16), 21, 15 and 10 for Arab camel breeders and 8 (4-12), 16, 12 and 11 for Arab cattle breeders.

Reported symptoms and diagnoses

Over a hundred different symptoms were recorded, but 18 key-symptoms represented 75% of all reported symptoms (3195 key symptoms out of 4263 total reported symptoms). Fever and musculoskeletal pains were responsible for most interactions between the 18 key-symptoms. Yet, a high interaction was also observed between other key-symptoms. Headache was co-reported with 14 of 17 other key symptoms in more than 50% of cases, musculoskeletal pain together with 12 and fever with 10 other key symptoms. Almost everybody (94.7%) mentioned at least one symptom. The median number of reported symptoms per person was 2, 6 and 4 for the first, second and third sampling, respectively. Children or, for young children, their mothers reported significantly fewer symptoms than adults (mean 3.4 versus 4.4), and symptoms recorded during the first sampling were less than in the two following samplings (mean 2.2 versus 5.3). In total, 388 participants mentioned more than the samplings' median of symptoms and, thus, were classified as "ill".

Of all participants with a single diagnosis (n=682), 74% were allocated to one of the five major disease classes. The five most important disease classes were i) affection of the respiratory system, ii) febrile condition/malaria, iii) affection of the alimentary tract, iv) affection of the genitourinary tract, and v) affection of the joints. Covering 63% of all diagnoses recorded, 776 participants were categorised as "diseased".

The six reported symptom groups were chosen according to the five major disease classes. For alimentary affections, 85% of participants reported digestive symptoms. For a diagnosis of an affection of the joints, 80% reported musculoskeletal pain without fever and headache, 70% reported respiratory symptoms or genitourinary symptoms for a diagnosis of the respiratory tract or the genitourinary tract, respectively. A diagnosis of a febrile condition / malaria was correlated to reported fever and headache (69%) and/or reported musculoskeletal pain with fever (63%). Key symptoms such as tiredness, weakness, loss of weight, and loss of appetite were not considered as a symptom group due to their general attribution to ill people, their strong association with the symptom group fever and headache, and the fact that they were rarely mentioned during the first sampling. These "loss of condition" symptoms were mainly related to febrile condition / malaria.

<u>Utilisation of health services</u>

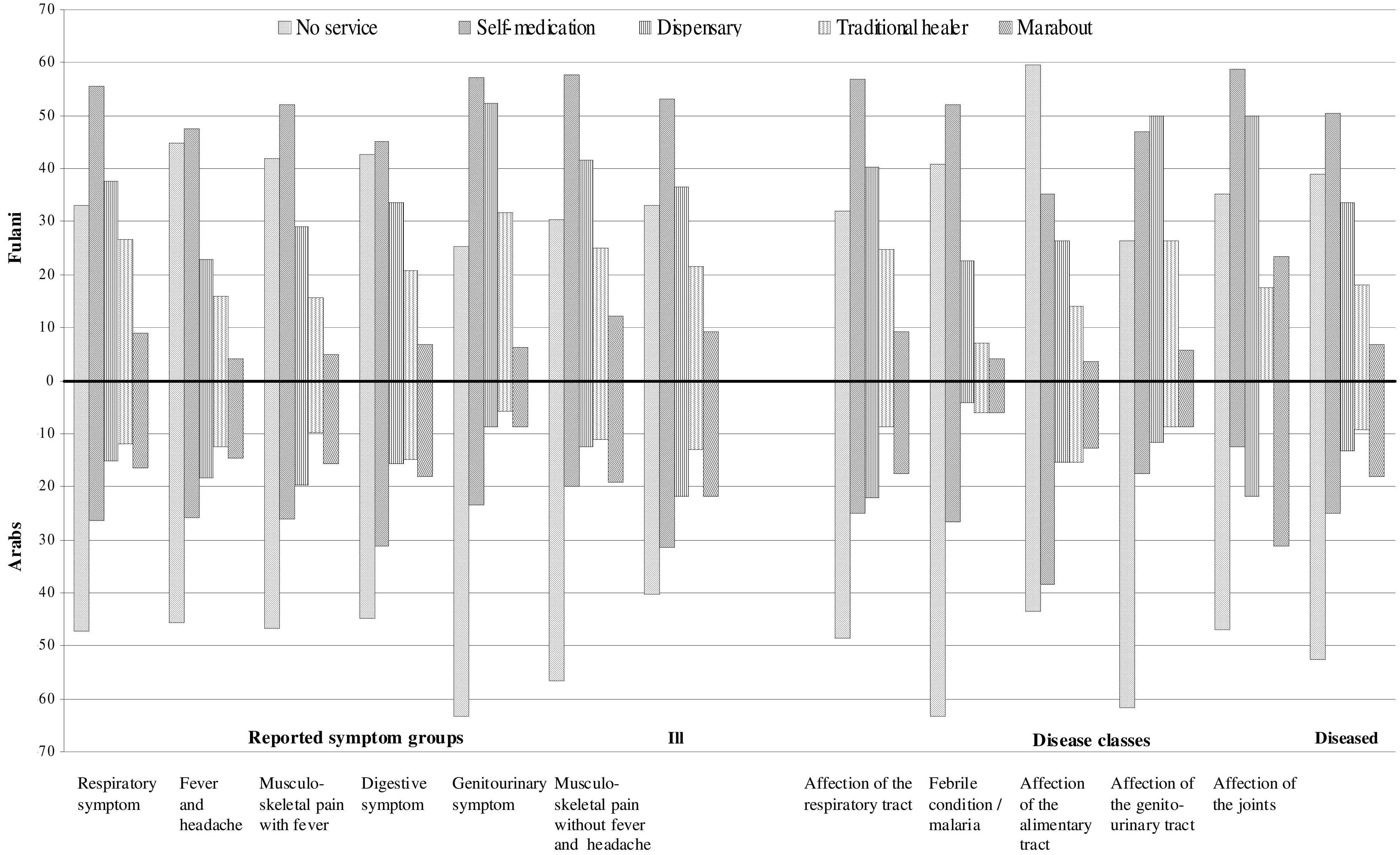
Outside services (dispensary, traditional healer and marabout) were least used for febrile conditions / malaria, likely due to the acute nature of fever (figure 10.1). Both groups consulted preferably traditional healers for the treatment of affections of the joints. The proportion of no use of any service was lowest for reported and diagnosed respiratory disorders (total of 38.9% and 38.4%) and highest for alimentary tract disorders (53.1%). Self-medication was more often applied by Fulani than Arabs.

Table 10.1 summarises age class, sex, group and sampling differences of the outside health services used per major reported symptom group. Results were obtained with multivariate analyses. With regard to differences in age class, older children (5-14 years) frequented dispensaries or the marabout, and young children the marabout, less often than adults. Older adults (>45 years) visited dispensaries more commonly than younger adults. Gender differences in the utilisation of health services, if existent, were not visible in the sample. Apparent group differences were mostly due to rarer use of dispensaries and traditional healers by both Arab groups. On the other hand, cameleers more often consulted a marabout throughout the different symptom groups. The marabout was typically less frequented during the second and third sampling. This phenomenon was limited to digestive problems for the use of dispensaries.

Strikingly, significant differences between age classes, groups and samplings, as seen for symptom groups, were mostly not found within major disease classes (Table 10.2).

Data of “diseased” participants allowed for stratification of age classes per group. Fulani girls (5-14 years) more often used no service or self-medication, compared to boys of same age class. Fulani women in childbearing age less often visited a traditional healer than men of the same age class. No gender differences were observed among the two groups of Arabs.

Figure 10.1 Distribution of the used health services per reported symptom group and diseases class. Stratification for ethnic groups (Fulani and Arabs).



First intervention

Participants of the three groups, who used dispensaries, went there for primary intervention in 95% of cases. The only exception was found among Fulani for joint symptoms, where the dispensary was second or third choice for one third of them. Participants with respiratory symptoms more often went first to a dispensary. The same was observed for women after sex stratification. The marabout was significantly less often visited first for genitourinary symptoms. As seen for symptoms, within the 5 major disease categories, those with a respiratory disease rather went first to a dispensary than to use no service. In contrast, those with a febrile disorder or an alimentary tract disorder significantly less often went first to a dispensary.

Further health services after first intervention

Among the six reported symptom groups, significantly more participants with respiratory symptoms looked for more than one other service to attenuate their illness. The higher use of different services was also true for clinically diagnosed respiratory tract disease compared to febrile condition and alimentary tract disorder. Males and females (after sex stratification), who first went to a dispensary with a respiratory disorder, or were “ill” or “diseased”, used more other services (2 or 3) afterwards than participants with a febrile, alimentary tract or joint disorder.

Table 10.1 Significant differences in the use of outside health services within reported symptom groups based on age class (0-4 years, 5-14, 15-45 [baseline], >45), gender (males [baseline], females), group (Fulani [baseline], Arab cameleers, Arab cattle breeders) and sampling (first [baseline], second, third). Multivariate analyses.

* p-value ≤ 0.05; ** p-value ≤ 0.01; *** p-value ≤ 0.001

D: dispensary; **M**: marabout; **H**: healer; **T**: traditional service (marabout or traditional healer, when one below n=10); **S**: self-medication.

		Respiratory problem	Fever and headache	Musculoskeletal pain with fever	Alimentary tract symptom	Genitourinary problem	Musculoskeletal pain without fever and headache
	n	325	309	289	370	131	268
Age class (baseline 15-45)	**more**	D >45**		D >45**	H >45*		D >45***
	less	D 5-14** M 0-4* M 5-14*	D 5-14**	M 5-14**	D 5-14* M 0-4**		
Sex (baseline Males)	**more**						
	less						
Group (baseline Fulani)	**more**	M A. camel**	M A. camel**	M A. camel**	M A. camel***		M A. camel*
	less	D A. camel** D A. cattle*** H A. camel**			D A. camel** D A. cattle**	D A. camel*** D A. cattle** T A. cattle*	D A. camel** D A. cattle** H A. camel* H A. cattle**
Sampling (baseline 1. samp)	**more**						
	less	M 2. samp.*** M 3. samp.**	M 2. samp.*		D 2. samp.*** D 3. samp.* M 2. samp.** M 3. samp.*		M 2. samp.* M 3. samp.*

Table 10.2 Significant differences in the use of outside health services within major disease classes based on age class (0-4 years, 5-14, 15-45 [baseline], >45), gender (males [baseline], females), group (Fulani [baseline], Arab cameleers, Arab cattle breeders) and sampling (first [baseline], second, third). Multivariate analyses.

* p-value ≤ 0.05; ** p-value ≤ 0.01; *** p-value ≤ 0.001

D: dispensary; **M**: marabout; **H**: healer; **T**: traditional service (marabout or traditional healer, when one below n=10); **S**: self-medication

		Disorder of the respiratory tract	Febrile condition / malaria	Disorder of the alimentary tract	Disorder of the genitourinary tract	Disorder of the joints
Baseline	n	177	121	95	68	66
Age class (baseline 15-45)	**more**	D >45 (p=0.054)				
	less	D 5-14*		D 0-4* T 0-4* T 5-14		
Sex (baseline Males)	**more**					
	less					
Group (baseline Fulani)	**more**	M A. camel (p=0.052)				
	less	H A. camel*		D A. camel*		
Sampling (baseline 1. samp)	**more**					
	less		D 2. samp.*	D 3. samp.***		

Marital status and number of children

Table 10.3 shows the frequencies of health services used according to marital status of "diseased" adult men and women. No unmarried woman used a dispensary. Girls are already old enough to be married at the age of 13. This stratum should thus also be considered for analyses. When the data of additional 10 women ≥ 13 years were added to analyses, unmarried women significantly less often used dispensaries. Stratification of the two ethnic groups further demonstrated that unmarried Fulani women less commonly visited dispensaries, as well as unmarried and divorced/widowed more rarely used traditional services. As to Arab women, divorced/widowed women less often used a dispensary. When "ill" (based on reported symptoms) instead of "diseased" (based on physical examination) women were analysed, unmarried and widowed/divorced women less often went to a dispensary (data not shown). As was seen for women, unmarried "diseased" men less often used dispensaries. The type of union (monogamous versus polygamous) was not influential for women. This was in contrast to men, where the type of union was an important factor for health care use. Polygamous "diseased" men more often used dispensaries, healers and marabouts than monogamous men. "Ill" polygamous men went more often to the marabout (data not shown). No differences of services used were found among "diseased" women with different numbers of children alive. Analyses within stratified ethnic groups solely showed that Arab women with no children applied more self-medication. "Diseased" men with no children less often used dispensaries in comparison to men with 3-6 children (data not shown).

Table 10.3 Differences in health service utilisation between marital status of "diseased" women (**f**) and men (**m**). Results of level of significance were adjusted to group and sampling and were calculated separately for women and men.
* p-value ≤ 0.05, ** p-value ≤ 0.01, *** p value ≤ 0.001

	Married				Unmarried		Widowed or divorced	
	monogamous (baseline)		polygamous					
Gender	f	m	f	m	f	m	f	m
n	122	181	112	83	8	35	25	7
No service	45.1	41.4	37.5	28.9	75.0	60.0*	56.0	42.9
Dispensary	27.9	23.2	32.1	47.0*	0	5.7*	16.0	14.3
Traditional healer	10.7	14.4	19.6	32.5**	0	14.3	0[a]	28.6
Marabout	17.2	11.1	14.3	19.3*	12.5	11.4	8.0	0
Self-medication	35.3	40.3	46.4	51.8	25.0	31.4	32.0	14.3

[a] p-value = 0.087

Reasons for never attending a dispensary

More than half of participants questioned (469/904, not including young children 0-4 years) never went to a health centre in case of illness. The non-users did not differ in sex, but the proportions were higher among children (5-14) and lower among older people. It was more common for Arabs to never go to a dispensary (Fulani 41.6%, Arab cameleers 58.2% and Arab cattlemen 79.1%). Only single causes for non-use were recorded. More than 50% of answers included for "far away" (29.5%) and "no time" (26.4%). The distance was especially (significantly more) important for Arab camel and cattle breeders. Mostly older people criticised that services were too expensive (8.2%). Children and women were sometimes not allowed by parents or husbands to go to a dispensary (4.1%). Only few Arab and Fulani men (in total 9) stated that a bad quality of care is offered at dispensaries.

<u>Young children and women in childbearing age</u>

Use of dispensaries, measles and vaccination of young children

Of 194 young children (0-4 years), 52 had visited a dispensary, but only three Fulani and one Arab mother could show a document provided by the health centre. Eleven children had a history of measles infection. Four Fulani and two Arab mothers could show a vaccination card of their child. The six children with a card and BCG scar were in 4 of 37 camps (11%).

One other child without reported vaccination or vaccination card had a BCG scar, as the 6 children with a vaccination card. No recording of other than BCG vaccination was seen in vaccination cards and therefore, not one child was fully immunised. Mothers of seven other children without vaccination card and BCG scar said that their children had been vaccinated (they may have been vaccinated e.g. against poliomyelitis during national vaccination campaigns, but did not receive a vaccination card).

Use of dispensaries and vaccination during pregnancy

Five 16-30 year old women had gone to a dispensary during a pregnancy (none of them could present a document). Four women in childbearing age (n=198) possessed a vaccination card, and two had been vaccinated against tetanus during their last pregnancy.

Place of delivery and assistance at birth

All questioned nomadic women had given birth to their younger child in the camp, whereby a female relative had cut the umbilical cord in 95% of the cases, or a neighbour (3.5%) or a traditional midwife (for three Fulani women, 1.5%).

<u>Use of mosquito nets and chloroquine</u>

Use of mosquito nets

Virtually everybody (99.5%) used a mosquito net for the night. Fulani used it all year and Arabs (95.5%) exclusively during the wet season. Only three percent of respondents stated that children or women after parturition alone used the net. One male Arab had heard about insecticide treated nets (ITN) through radio broadcasting and two Fulani women knew about their existence, but did not remember the source of information.

Chloroquine

Chloroquine was widely (78%) known as treatment against malaria (but children or older people and females were less informed). Of those knowing chloroquine, 98% took it when they had malaria. The remaining 9 participants did not take it because chloroquine caused them to vomit, they did not have the money to buy it (2 Arab women), or they never had malaria.

Discussion

Utilisation of health services

The status Fulani accorded to a health service does not necessarily correspond to the perceived outcome of the intervention (Krönke, 2001). Furthermore, the perceived success rate for all treatments was low (Hampshire, 2002). Respondents of our study used a combination of traditional and modern treatments. Multiple services were used in response to failure of a specific treatment or, more likely, in an opportunistic way. General traits of differences in age, gender, group and sampling for outside health services utilised (tables 10.1 and 10.2) were less accentuated for the major disease classes than for observed symptom groups. Many of the results of the preliminary study (Wiese and Tanner, 2000) were confirmed with this epidemiological study, while adding results of utilisation of health services by women and children.

Reported symptom groups were used to describe the perceived ill-being. Symptoms may have been given in expectation of treatment (e.g. reporting of headache to receive an aspirin to mitigate pain of somebody else), thus an over-reporting of symptoms was possible. Clinical diagnoses seemed to be more reliable than symptoms for categorisation of participants, but still represented a substantial simplification of the real status. Utilisation of health services was analysed retrospectively with a symptom group or a disease as a starting point. The success of a particular service to cure the disease can thus not be derived. Indeed, for these participants all treatments had not succeeded so far. People who had been ill and successfully cured are not considered in the sample. However, they may have used particular services, which would then be under-represented in our sample (e.g. self-medication or use of a dispensary for malaria). The marabout was uncommonly seen first (especially for genitourinary problems) or consulted at all, with the general exception of Arab cameleers. From other reports, one would have expected a higher use of marabouts (Hampshire, 2002; Wiese and Tanner, 2000). In parallel to an over-reporting of the use of dispensaries because a medical team was present, the use of the marabout may have been under-reported. The data obtained were used to describe general features of the utilisation of health services by nomadic groups and we assumed that under- or over-reporting, although it needs to be considered, did not alter the general trends. Participants with no complaints at all were rare, and, therefore, all participants had a certain chance to be classified among one or more symptom groups, or among the "ill" group.

The highest total number of services used was seen for participants with respiratory symptoms and, in terms of ranking of consecutively used services, these participants went early to a dispensary. Respiratory tract disorders such as bronchitis, was the most important disease class for young children. Fifteen out of 43 (35%) young children, in contrast to 5/39 (13%) older children with a respiratory disease, visited a dispensary. It may be speculated that respiratory tract disorders in young children were regarded as an important indication for western-type medicine. Acute respiratory infections (ARI) without antibiotic treatment is one of the four major causes of mortality in young children in sub-Saharan Africa (WHO, 1996a). Another important cause of mortality in young children is diarrhoea with strong dehydration. Societies with humoral belief may withhold ad libidum access to fluids from children with diarrhoea due to the conviction that the "hot illness" diarrhoea should not be treated with cold foodstuffs such as milk and fresh water (Hilderbrand *et al.*, 1985). Of 60 young children (0-4) with reported diarrhoea, each fifth one went either to a dispensary, a marabout or a healer. This data suggests that mothers in our sample acknowledged the importance of diarrhoea.

In general, Fulani used more health services. The significantly more common visits to dispensaries can be explained by easier access to health facilities in the lake Chad zone, where Fulani only undertook short movements throughout eight months. In this period, longer stays at a health facility were also possible. Within the Fulani's zone of stay, a well-equipped hospital with special commodities for family members to stay exists in the northern part of Cameroon and is used by Fulani. Thus, use was made of a health facility offering adequate quality treatment combined with convenient access. Stationary treatment of a member of an Arab camp may cause more problems. Family members face difficulties to camp with their animals in the surrounding of a dispensary (usually without commodities for family members) normally located in an agriculturist village. Nomadic people were less likely to receive drugs when they were in short supply (reviewed in Swift *et al.*, 1990) which is quite often the case in dispensaries of sub-Saharan Africa (Gilson, 1995). Dispensaries need a greater flexibility to take the by-passing nomads into account by having appropriate drug stocks. Health personnel and committees of respective dispensaries should be informed on the needs of nomads to reduce their marginalisation in the nomads' zone. Half of the interviewed nomads – a substantial proportion - never went to a dispensary in the case of illness.

Participants made less use of the marabout's and the dispensaries' services during the wet season. The lack of time due to the constant pressure to move on, limitations in remote zones or blockages through cultivated field may have been responsible for this phenomenon, but also the diseases occurring at that time, which were dominated by malaria. For malaria, in general, western-type treatment (chloroquine) is bought on markets or in dispensaries. Chloroquine became short to absent in dispensaries of Kanem during the wet season because of a local epidemic of malaria, which also accentuated the usual malaria peak of nomads. Knowing that treatment against malaria was not available certainly caused the reduced utilisation of dispensaries during this period.

With regard to significantly lower use of all services during the third sampling, we believe that nomadic pastoralists waited for our team to arrive. This represents a sharp data bias, but nonetheless, it also showed what health service nomads preferred: a mobile team arriving in their camps (and offering a treatment at no charge). This bias was not relevant for the previous, second sampling, because nomads could not yet rely on our arriving.

Our data suggested that especially young unmarried women and men faced an economic problem when going to a marabout or dispensary was necessary. The high charges demanded by a marabout for consultation (Wiese and Tanner, 2000), made him less accessible for people with few resources. The type of union was indicative for men only, with polygamous men more often using dispensaries and traditional services. Solely men with higher socio-economic statuses could afford several women and were better able to pay for health services. The total number of co-wives and the rank within co-wives (first, second or following wife) is doubtlessly more important for women to mobilise attention and resources for their treatment (Hampshire, 2002). Initially, the number of wives or co-wives was asked of participants in polygamous marriage, but this question was abandoned due to frequent refusal to answer. The complex task of research work in nomadic settings was described by Randall (1994) for Mali. Socio-economic indicators could hardly be established, although researchers lived in camps for two years, and the evaluation of the camps' demography was difficult due to the unease to talk about resources but also due to time limitation of the planed study (Randall, 1994).

Young children and women in childbearing age

No fully immunised nomadic child was found among the sample. Access to children vaccination was a demand of nomads, who saw their children succumbing to measles and suffering of whooping cough. Other vaccines than measles and whooping cough were, however, less well known (Schelling *et al.*, 2002c; Krönke, 2001; Wiese and Tanner, 2000). The huge gap between BCG immmunization rates of settled (100%) and of nomadic Rendille children (6%) observed by Nathan *et al*. (1996), was likely not of this magnitude in our study zone. The rate of fully immunised settled children in this area was not higher than 15% (DSIS, 2001).

Nomadic women did not use prenatal and gynaecological health care services in dispensaries. Childbirth complications, which usually are an emergency, will be very difficult to handle with dispensary personnel. Because previous contacts to nomadic women for maternal and child care lack, health personnel is likely not very motivated to go to nomadic camps in the case of an emergency. Poor equipment, training and mean of transport of health personnel are further limiting factors. Further research is needed on child care, maternal complications, management of child birth urgencies and family planning to more specifically define recommended interventions.

Health services adapted to nomadic populations

Practical and socio-economic rather than cultural factors apparently influenced the use of health services. The impact of perceived illness and its interrelationship with the other factors in this process should be further evaluated by combining the epidemiological and the vulnerability approach in other studies. This study demonstrated marked differences between nomadic groups. Future research in nomadic groups, thus, must include as many groups as possible. Evidence from this study does not fully apply to the third ethnic group in the study zone, the Dazagada, who are e.g. more mobile as Fulani with few predictable routes of transhumance, but face less problems to access to water than Arab cameleers. Demonstration of the diversity of “nomads” may even be more valuable than the illustration of differences between one nomadic group and the sedentary population. Results, such as the zero vaccination coverage, make interventions – accompanied by research at a pilot stage – necessary without delay. Most recommendations for health interventions in nomadic settings have been implemented with more or less success elsewhere. However, an evaluation of performance is widely missing (Wyss, 1998a; Swift *et al.*, 1990).

The proportion of half of participants never attending a health dispensary was substantial. Increased quality (rather than quantity) of dispensary services offered (including an adequate stock of western-type drugs) likely would increase their utilisation by nomads. This observation was emphasised by the special situation of Fulani. A commodity for relatives to stay with diseased individuals for some days would be very appreciated. Nomads participating in health committees, which was so far not the case in the study zone, may efficiently spread the information about the dispensary's services in the community. Transportation by donkeys, horses or camels to a health facility is a lesser problem. A serious problem remains the treatment of ailments as tuberculosis and venereal diseases, which need continuous drug treatment over longer periods at a dispensary level.

Gish and Walker (1977) made an economic assessment of multipurpose mobile health services. They found that the average cost-per-likely-effective-patient-contact was eight times greater for mobile services than for static clinics. Using the mobile veterinary infrastructure during compulsory cattle vaccination for public health purposes should decrease costs of vaccination. Joint human and animal vaccination campaigns have been ongoing in the study zone since two years. Outreach vaccination services in dispensaries would not be sufficient because nomads move out of the dispensary's zone of responsibility within the minimal three months required for the entire children vaccination schedule. Health education with a special approach for women (nutrition, maternal and child care, hygiene) is most effective during vaccination campaigns right next to the camps. These additional information campaigns should focus on the information frequently requested by nomads.

The greatest advantage of nomadic community health workers (CHW) and female birth attendants is their comparatively low cost and their mobility to visit camps. Women need no special permission for consultation as for outside practitioners. Loutan (1989) as others, described CHW programmes adapted to the nomadic way of life. Bentley (1989) has described a very successful training and follow-up of CHW in remote villages. Lessons learned elsewhere should be recognised when setting up a new programme. The target community should select CHWs and birth attendants to be trained and define their tasks. The establishment of a health committee makes the community responsible for the programme rather than health structures being an outreach service of the dispensary. Programmes usually included training in nutrition and hygiene, disease transmission, recognition and treatment of common complaints. Loutan (1989) suggested that periodic additional courses be given to sustain a good quality in recognition and treatment of common diseases. Basic drugs were provided. Serious cases should, nevertheless, be referred to city hospitals or clinics. Female nomadic birth attendants could be trained. A programme needs to ensure that CHW and birth attendants remain mobile. Additional costs for long term provision of drugs and supervision have rarely been foreseen in budgets of Non-Government Organizations (NGOs) responsible for the training. The persons in charge of key dispensaries should preferably do supervision and stock keeping (Wyss, 1998a). Bollinger (2002) illustrated the problem of Fulani paraveterinarians, who could not deny granting a period of grace for payment to a person within their social network, but which in its turn was missing for the purchase of new drugs. Supervision is crucial to ensure quality but also to follow-up the book keeping. A big challenge for further research is the inclusion of directly observed treatments (DOTs) for tuberculosis to achieve better compliance and accessibility to drugs of nomadic patients.

Chapter 11

Nomadic pastoralists' perception on future joint human and animal vaccination campaigns

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Summary

Nomadic pastoralists of Chad have had experience with livestock vaccination for decades. In contrast to livestock, nomadic children were not vaccinated. We proposed that the mobile veterinary infrastructures could be extended for simultaneous vaccination of children in nomadic groups. Yet, the experiences of pastoralists with existing vaccination services and their considerations on feasibility and planning of joint vaccination services appear to be crucial for a sustainable implementation. Their attitudes were evaluated with over 100 interviews conducted with Fulani cattle breeders and Arab cattle or camel breeders in two provinces of Chad. Pastoralists did not always well distinguish treatment from prophylaxis (vaccination). This was emphasised by the wish of having their livestock vaccinated when the animals were most diseased (i.e. in the wet season). The quality of livestock vaccines was strongly questioned and therefore, many pastoralists did not want their cattle to be vaccinated within compulsory vaccination campaigns. Few breeders did not know the existence of children vaccination at all, although measles were feared. The idea of joint vaccination campaigns was appreciated. Besides the demand of vaccination for their children, more information on children vaccination was another essential wish of pastoralists. How much information from livestock vaccination is extrapolated to children vaccination remained unclear. Pastoralists recommended to propagate information on future campaigns by radio broadcasting. Once the period and zone of vaccination would be known to pastoralists, they would be willing to organise the regrouping of several camps to one vaccination site. This site would need to be in the surroundings of the camps and ensure enough water and pasture. Furthermore, campaigns should be well organised to limit time investment by pastoralists, and drugs for humans and livestock should be offered simultaneously.

Introduction

Livestock of nomadic pastoralists provides their mean for subsistence (Niamir-Fuller and Turner, 1999). Because of the paramount importance of livestock, breeding practises are already taught to youngsters and the recognition and treatment of different livestock diseases is later learnt from elders (Majok and Schwabe, 1996). Pastoralists have experience with livestock vaccination for decades. Knowledge on human diseases is not accumulated as systematically and only few members of the community acquire specific skills in treating people (Wiese and Tanner, 2000).

In rural sub-Saharan African zones, nomadic pastoralists are as vulnerable to exclusion from human vaccination services as other scattered populations, although, theoretically, their mobility could be used to better reach sparse primary health services. Nomads' vulnerability is mostly due to factors specific to their way of life and to related everyday constraints, to as well as to their marginality within countries (Schelling *et al.*, 2002d; Wiese, 2002; Krönke, 2001; Azarya, 1996). Nomads are almost never represented in health committees which inform their people on ongoing vaccination programmes (reviewed in Sheik-Mohamed and Velema, 1999). Imperato (1969) reported an overt resistance of nomads towards mass smallpox vaccination campaigns e.g. because programmes did not take into account their fear to be counted for taxation purposes or of the hardship they had to sustain in order to come to an assembly point. Different strategies to reach nomadic people for immunization purposes have been used, mainly mobile or outreach services. Sustainability, however, seems not to be guaranteed for mobile services in poorer countries due to more-fold costs in comparison to fixed services (Brenzel and Claquin, 1994; Gish and Walker, 1977; Imperato *et al.*, 1973).

In Chad, the proportion of fully immunized children is 20% for urban children, and 9% for children living in rural settings (Ouagadjio *et al.*, 1997). At least six percent of the Chadian population are nomadic pastoralists (MPC, 1995), but the prevalence of fully immunized children in three nomadic pastoralist groups of Chad was nill during a survey in 1999. Few nomadic children had been vaccinated against tuberculosis (BCG) only, and none of them had ever received a diphtheria-pertussis-tetanus, measles, and polio vaccine (Daoud *et. al*, 2000). In contrast, in the same nomadic camps, 75% of the cattle herds (compulsory vaccination) and most camels (voluntary vaccination) had been vaccinated during the last two years against anthrax, blackleg, pasteurellosis (hemorrhagic septicemia), or contagious bovine pleuropneumonia (CBPP). Therefore, the capacity of existing mobile veterinary infrastructures could be extended for simultaneous vaccination of nomadic children and costs shared between the two sectors of public health and livestock production.

To organise any intervention in nomadic communities, their approximate routes and schedules need to be known. It is known nowadays that the constraints of the target population also have to be considered for a successful and sustainable programme. Nichter (1995) summons that the best vaccination programme has only limited long-term success without active demand from the target community. This active demand seems notably crucial to ensure revaccination of the children and women. Knowledge of the experiences of pastoralists with existing vaccination services and their considerations on the feasibility and organisation of future campaigns are also essential for the sustainable implementation of innovative vaccination services.

The work presented here was conducted within a programme of the Swiss Tropical Institute on the health of nomads in Chad involving the disciplines geography, anthropology, biology, medicine and veterinary medicine. Firstly, the meaning of livestock and childhood vaccination for nomadic pastoralists, and secondly, experiences with veterinary and public health vaccination services in view of the special situation of nomadism were evaluated. These experiences led pastoralists to make practical suggestions for implementation of interventions in nomadic settings. Thirdly, the consequences of pastoralists' considerations and experiences, i.e. their behaviour toward vaccination services, are reported. These three different views on vaccinations in nomadic settings are put in perspective with their possible incorporation into joint vaccination campaigns and with concepts of western-type medicine.

Methodology

Data collection took place in two provinces of Chad, Chari-Baguirmi and Kanem, during 1999 and 2000. Nomadic camps of Arabs and Fulbe were visited based on a random or convenience selection. The three nomadic groups, Fulbe cattle breeders of the Lake Chad zone, Arab camel breeders and Arab cattle breeders were dependent on their herds of camels, cattle and small ruminants for subsistence. Fulbe only leave the zone of Lake Chad towards the clay plains of Chari-Baguirmi during the wet season. Arab camel breeders leave the zone of the Massenya flood plains (Chari-Baguirmi) after the first rainfalls, and move about 400 kilometres northwards to disperse in the Kanem within three months. It takes them approximately another 3 months to move back to Chari-Baguirmi after the wet season. The group of Arab cattle breeders is the most heterogeneous with regard to sub-ethnic background. From the zone of Massenya (Chari-Baguirmi), they do not move with their cattle as far north as Arab cameleers. Some camps stay all year in Chari-Baguirmi and only the young men go north with the livestock.

Twenty-seven Arab camel breeders, 11 Arab cattle breeders and 44 Fulbe cattle breeders were interviewed in a semi-structured way. In addition, in 5 Arab camel, 8 Arab cattle and in 18 Fulbe camps, free-ranging group discussions were conducted, whereas different issues were raised. Topics of these interviews and group discussions included the performance and desired improvements of vaccination services for children and livestock, the use of formal health facilities for treatments, and issues on animal health. Seventy further interviews with Fulbe cattle herd owners were conducted in the course of an anthropologic study evaluating illness concepts, especially for zoonotic diseases.

Group discussions were conducted with male participants and interview partners were often camp leaders or owners of livestock herds. There was a gender bias of interviewees and a gender comparison, which would have given answers to gender-specific knowledge, was not done thoroughly in this study. However, in the patriarchal target population, men were the decision-makers for access of a family member to traditional treatment or to a dispensary. Beside provision of health services, information on different treatments also remained in the hands of men (Hampshire, 2002). The women's opinion on children and women vaccination were collected more informally during the study.

Interviews and group discussions were conducted in Chadian Arabic or Fulfulde, and tape-recorded interviews were translated into French. Transcripts were analysed with the help of the text analysis program winMAX 2000 pro (BSS Berlin). In order not to loose subtleties due to translation, key phrases or terms were given in their original language and a word by word translation was done.

Results

Meaning of vaccination for nomadic pastoralists

Vaccination of livestock

The vaccines against contagious bovine pleuropneumoniae (CBPP) (*am-fach-fach* [Arabic], *hendu* [Fufulde]) and especially against rinderpest (*djederi* [Arabic], *saabow* [Fulfulde]) provided by French veterinarians in the fifties and sixties were considered as efficacious. All breeders acknowledged the success of vaccinations leading to the eradication of rinderpest within the international effort of the Pan African Rinderpest Campaign (PARC). A traditional livestock vaccination against CBPP was applied by Fulbe pastoralists, but was never mentioned by Arab cattle breeders. “We take the lungs of an animal that died of that disease and cut it in little pieces. Then we scratch the ridge of the non-affected cows’ noses and rub in the pieces of lung. So, after a scar is formed, the animals will be protected (*gniro*) for their whole life”. Fulbe breeders knew that this procedure was delicate and precaution was demanded to avoid making animals ill with its application. Nowadays, this practise has become rare. Our own observations allowed to detect about five percent of Fulbe cattle with typical scars.

Half of the Fulbe and the majority of camel breeders expressed no clear representation of the difference between the therapy (treatment) of a livestock disease and its prevention (vaccination)[1]. This misunderstanding was emphasised in the question about their preferred season for livestock vaccination. A striking proportion of participants, more Arab than Fulbe, wished to have access to vaccination services when the animals were ill, namely during the wet season or at its beginning, because most diseases, including anthrax and blackleg, occur at that time. Furthermore, this confusion was also reflected by the false idea that vaccines could be bought on markets.

The two concepts of treatment and traditional vaccination seemed to be better understood, since they are more closely related. For the traditional vaccination, a diseased animal was needed first, and, in earlier days, rinderpest vaccine was prepared from the blood of a diseased

[1] In Chadian Arabic the term “*fassidine*” exists for vaccination, but participants did not know this term. The term “*daouwi*” was used to specify treatment (*gnawndaaki* [Fulfulde]) and never used to express vaccination. “*Tanin*” meant injecting and when the name of a vaccinable disease was added this signified vaccination against the respective disease. “*Tanenam balto*”: inject against anthrax. Quite often breeders spoke of “*tanenam contact*” to describe the automatic syringe used for livestock vaccination.

animal and of a healthy goat. Therefore, it may not be obvious that diseased animals are no longer necessary nowadays to be able to protect other members of the herd in the face of a disease outbreak. This is a very important difference to modern-type vaccination, which aims at reducing the occurrence of a disease to a minimum, and if possible, at eradicating the disease. Only healthy animals are to be vaccinated, preferably before natural contact with pathogen agents.

Livestock diseases against which modern vaccines are available include blackleg (*dourdoume; amdoudoume; abouwarama* [Arabic], *balawyel; ladde; buule* [Fulfulde]) caused by *Clostridium chauvoei*, anthrax (*ambiedre; balto; abgaloum* [Arabic], *n'damadj; damol* [Fulfulde]) caused by *Bacillus anthracis*, pasteurellosis (*dedowa* [Fulfulde]) caused by *Pasteurella multocida* and CBPP caused by *Mycoplasma mycoides* var. *mycoides* (small colony type). All interviewed Fulbe knew that livestock vaccination exists, but sixty of seventy interviewees could not cite all four vaccinable livestock diseases. Principles of modern vaccination were known from information transmitted by radio, on markets or from veterinarians and, more extensively, from the experiences gathered through close observations of their animals (empirical knowledge).

Nomadic pastoralists reported that they continuously evaluated the quality of the vaccines through observation of the postvaccinal outcome in animals. Criteria used to define a good vaccine included a sufficient birth rate in the herd, a reasonable milk and weight gain, and non-affection of the animals with the diseases they were vaccinated against. The best outcome of a vaccine was the eradication of the disease. Fulbe and Arabs questioned the quality of livestock vaccines used at present. The majority confirmed that the vaccines were less efficacious than a few years (two to seven) back. Their argumentation was based on the fact that animals still could become diseased after vaccination against blackleg and anthrax. "If we refuse livestock vaccination it is because there are vaccines which do not work. Even if you vaccinate every year, the animals continuously die. Otherwise, how could a breeder refuse a good vaccine?" (Fulbe). Explanations proposed by breeders for the inefficacy of today's vaccines were many-fold. They were related to the vaccines themselves, to their faulty production, to the lack of arrival of the good ("real") vaccines, to use of expired products or to incorrect storage of the vaccines1. “I say that the producers of vaccines do not succeed each year. This is why in some years the vaccine is well made and in other years not” (Fulbe). Pastoralists stated that cattle do not support three vaccines at a time, but also that not all cattle are vaccinated. “There are breeders who select cattle for vaccination – the next year it is those cattle that were not vaccinated who will die. We breeders, we do not vaccinate every year – especially then when animals are healthy. This selection for vaccination kills our cattle” (Fulbe).

Coinciding with the introduction of the vaccine against CBPP two years ago, breeders observed additional mortality occurring in the days following vaccination. The symptoms described included a swelling around the point of injection on the neck, which became hard as wood and, finally, the animals died. A fifth of seventy Fulbe cattle herd owners interviewed claimed having had such deaths among their cattle. The private veterinarian working in the zone confirmed a cattle mortality rate after CBPP vaccination (vaccine strain T1-44) of about five percent. The phenomenon of a mortality rate around of approximately three to five percent after CBPP vaccination was also observed in other countries due to reactions of sub-clinically infected cattle or to hypersensitivity reactions (FAO, 1997).

The recent experience of nomadic pastoralists with high mortality after vaccination campaigns was only one reason promoting the stereotype of the “useless veterinarian” nowadays. Breeders who had refused vaccination were forced to vaccinate all their cattle by veterinarians escorted by military (Nahar, personal communication). Additionally, they had to provide for board and lodging to the troop. Moreover, pastoralists have known arbitrary use of power by veterinary technicians, e.g. declaring the pasteurellosis vaccination obligatory or seemingly setting the prices in an arbitrary way2. According to their opinion, they were victims of exploitation with the approval of the authorities. “We live on our livestock – nobody needs to tell us how we treat or vaccinate our livestock” (Arab cattle breeder). Two Arab cattle breeders made an allusion to numerous veterinary teams collecting blood for rinderpest vaccination surveillance. “If the doctors for the animals arrive, it is to take blood without

1 Vaccine conservation on ice, which used to impress nomadic breeders, is nowadays redundant, because new vaccines, with the exception of the vaccine against CBPP, are heat-resistant and do not need to be stored cooled. The fact that pastoralists noticed that vaccines were no longer stored on ice underlines the attention they paid to the manipulations of the veterinarians.

2 The price of 25 CFA for one vaccine dose in 1994 was raised by 25 CFA each following year until the season of 1997/1998, when a price of 125 CFA was reached. Only after that season, the price was officially set to 100 CFA per vaccination (about 0.16 Euro) for the following seasons.

treating or vaccinating the animals". "The doctors circulate around us for rinderpest, but our health and the health of our children, who are not vaccinated, are not considered. They say that they are short of time".

Apart from forced livestock vaccination, another constraint was seen in the frequent interactions of pastoralists with so called "doctor Choukous" (fake doctors). "Doctor Choukous" are drug-selling peddlers without an official permission. For nomadic pastoralists or for scattered populations, they offer a valuable service: their high mobility. These peddlers visit weekly markets in small villages and nomadic camps far away from market centres. The drugs sold are of variable, but mostly poor quality. Drugs may be expired or originate from doubtful sources outside of Chad. The bad quality of the products of "doctors Choukous" is well known to pastoralists. Nevertheless, due to the lack of access to other services, pastoralists have been repeatedly forced to buy their drugs for livestock or people with them. When pastoralists accused the bad quality of drugs or even vaccines, these had likely not always been purchased from real veterinarians or veterinary pharmacists.

Vaccination of children and women

It was common knowledge that smallpox did no longer exist due to western-type medicine. When the existence of childhood vaccines was known, it was not understood why the government would not send more physicians for vaccination nowadays to the field. The government today was thought to have to provide vaccination services.

The quality of vaccines for children was perceived as better than that of livestock vaccines. Nonetheless, a story of bad quality vaccines leading to child mortality circulated among Fulbe: "Those who have vaccinated their children complain of effects leading to child mortality. This makes us refrain from vaccinations for children – we need to rely on Allah". Some did not know that vaccination of children was free of charge. "If child vaccination is free of charge everywhere else, here you have to pay, nothing is free in Chad" (Arab cattle breeder). Others criticised the rush of the vaccination teams and it became obvious that the time offered was a quality criterion of health services. Hygiene aspects were closely related to quality aspects of the vaccine itself. The following citation shows that possible transmission of diseases through non-sterile needles was known. "They vaccinate at least 100 children with the same needle – and like this they transmit diseases to our children. This, we do not want.

Once, my child was vaccinated against measles – and five days later it became infected of measles and died of it" (Arab cattle breeder).

Four-fifth (57/70) of interviewed Fulbe men were unaware of vaccines for children and virtually none of the others could name more than two childhood diseases preventable by vaccination. A vaccine against tuberculosis was unknown, likely due to the lack of illness in children. According to a physician having vaccinated nomadic children, women demanded most often the vaccine against whooping cough to prevent suffering of their children. Women who are in charge of the well-being of their children may be better informed on available vaccines than men. "It's the women who sometimes ask for authorisation to bring the children to vaccination. Because they sell the milk in the villages, they have more contact to the sedentary people and receive also more information. They are better informed than we [the men] are" (Arab cattle breeder). Arab men also stated that women had the same knowledge as they did (i.e. no knowledge about vaccination of children). Many interviewees thought that the women were not informed. "Only we [the men] have knowledge on vaccination. They do not know anything about the health of the children" (Fulbe).

Remarks that their children suffered of measles (*amkignengneug* [Arabic], *peestel* [Fulfulde]) or whooping cough (*amhouhou; kout-kout* [Arabic], *yhorow* [Fulfulde]) because they could not have been vaccinated were recorded, such as: "We have not found any possibility for vaccination of our children. This is why four of our children died of whooping cough in this season – I acknowledge that this is due to the non-vaccination of our children" (Arab cattle breeder). The majority of interviewees of the three nomadic groups had heard about vaccines against whooping cough and measles. Seeing that their children suffered from whooping cough and that measles killed their children, nomads wanted regular visits of physicians to vaccinate. The access to fixed structures was considered as difficult. Nomadic pastoralists even had the feeling of being deliberately excluded from vaccination services.

Table 11.1 lists the different responses (evaluated semi-quantitatively) on the nature of livestock and children vaccination. Responses were regrouped in the categories of i) biomedical principles of vaccination, ii) unspecific remarks not contradicting the essence of vaccination, iii) responses in contradiction with the essence of vaccination. The responses within the three categories were distributed heterogeneously among the three groups. The statements about vaccination of children were typically comparable to those made about livestock vaccination.

Utilisation of existing vaccination services

Twenty-four out of 31 interviewed cattle holders had vaccinated their cattle during the past two years, but only 2 out of 26 had done so during the previous twelve months, even if by law cattle should have been vaccinated against anthrax, blackleg and CBPP during the last year. The longest period of non-vaccination of cattle was seven years. Eight out of nine camel breeders had voluntarily vaccinated their camels during the previous twelve months. Camel holders had frequent contacts with French military veterinarians in earlier days because military largely used camels for transportation. It seems that camel breeders appreciated the merits of vaccination at that time and have never experienced important postvaccinal mortality of camels.

Veterinary health structures usually became more important in endangering epidemic disease situations. “We, the Fulbe, we do not vaccinate our herds as long as they are healthy. We wait until a disease affects the herd before running to the doctors” (Fulbe). It has to be pointed out that some Fulbe wished to vaccinate their cattle earlier (before the wet season) in order to avoid an epidemic, but access was not always possible due to their stay in remote zones.

Table 11.1 Summary of remarks made on the nature of vaccination of livestock and children

Livestock vaccination n=62			**Vaccination of children** n=16		
Biomedical principles of vaccination					
Fulbe	22/70	(31%)	Fulbe	4/11	(36%)
Arab camel breeders	11/28	(39%)	Arab camel breeders	1/3	(33%)
Arab cattle breeders	8/21	(38%)	Arab cattle breeders	6/13	(46%)
Limited duration of protection after vaccination			▪ Limited duration of protection after vaccination		
Non-affection of livestock with diseases they were vaccinated against (specificity of vaccines)			▪ Non-affection of children with diseases they were vaccinated against (specificity of vaccines)		
Performance on healthy animals alone / worsening of the health status of vaccinated sick animals			▪ Our children were affected with measles or whooping cough because they were not vaccinated		
Other contagious diseases to be treated (if a treatment exists)			▪ Some diseases do no longer exist thanks to vaccination		
Description of traditional vaccination against CBPP					
Unspecific remarks not contradicting the essence of vaccination					
Fulbe	36/70	(51%)	Fulbe	7/11	(64%)
Arab camel breeders	9/28	(32%)	Arab camel breeders	0/3	(0%)
Arab cattle breeders	10/21	(48%)	Arab cattle breeders	5/13	(38%)
Preservation of an animals' health status			▪ Preservation of a child's health		
Lower death rates of livestock with vaccination or loss of production and deaths without vaccination			▪ Good influence on the child's health		
Listing of at least one vaccinable disease without further explanations			▪ Childhood vaccination was the same as in livestock		
Citation of prices for livestock vaccines			▪ Vaccinations for children are free of charge		
Description of different vaccines (whilst giving details on taste and consistency of the liquid as well as their mode of application)			▪ Existence of vaccines for a long time		
Responses in contradiction with the essence of vaccination					
Fulbe	12/70	(17%)	Fulbe	0/11	(0%)
Arab camel breeders	8/28	(29%)	Arab camel breeders	2/3	(66%)
Arab cattle breeders	3/21	(14%)	Arab cattle breeders	2/13	(15%)
Confusion of vaccination with treatment by biomedical definitions			▪ Vaccines against malaria and coughing		
Vaccines can be bought on markets			▪ No need of vaccination for my children because prevention of measles with the roots of a plant		
			▪ Unawareness of vaccinations for children		

Five out of sixteen Fulbe and four out of eight Arabs stated that some children in the camp had been vaccinated earlier (up to seven years back). One forth declared that children had been vaccinated during the previous twelve months. Among 122 Fulbe men with children, 26 (21%) had at least had one child vaccinated during the last twelve months. Consequently, contacts to public health vaccination services did exist, but were not frequent and children likely did not receive a full vaccination course requiring three vaccination contacts.

A woman could only visit a health centre with the agreement of her husband. Some women told us that they wanted to bring their children to vaccination sites but did not get the necessary support from their husbands. Other women did not know where to find vaccinations or had no means of transportation to overcome the distance to the health centre. A Chadian physician, who vaccinated nomadic children, stated that it was not well understood by pastoralists, why men, women and elder people do not need to be vaccinated. Especially men expressed their unease of being excluded.

Access to vaccination may also be reduced by rivalries between groups. Fulbe were informed about a vaccination campaign in the camp of the most influential Fulbe leader in the region several weeks in advance. However, another leader did not allow his people to visit the camp of his rival. Allowing this, he would have confessed that the other leader was more powerful than he was.

Constraints and suggestions for joint vaccinations

Fulbe agreed spontaneously on the idea of joint vaccination services, whereas Arab pastoralists accepted the idea only after discussions. In the following, the basic practical aspects, which may obstruct access of nomadic pastoralists to joint vaccination services, are presented and compared between the groups. Propositions to overcome these constraints are subsequently presented. Because interviewed men had more experience with livestock vaccination, most remarks were made with regard to livestock vaccination.

An important constraint of all vaccinations, and therefore presumably also of joint vaccination, was attributable to lack of information on the geographical position of the vaccination team. Only Fulbe reported that sometimes they actively looked for vaccination services. Once the position of vaccination teams were known, major obstacles to drive a cattle herd to a remote vaccination site were to find lost animals in unfamiliar zones and blockages by cultured fields. Furthermore, the transportation of many children at any given time was not guaranteed. Means of transportation for children, such as donkeys, had to be available first. Within transhumance movements, small children may be transported on a camel or an ox, and therefore, this problem does not occur. Another constraint reported was reluctance of pastoralists to leave behind an almost empty camp or well, in the absence of most men, women and children. It was emphasised by all participants that the meeting point for vaccination would need to dispose of enough water (for people and for livestock), pasture, trees to provide shadow and wood for the construction of the vaccination pens. Time devoted to vaccination was limited all year, although more strictly during periods with very frequent movements between July and December. Pastoralists declared that, at most, they might abandon their work for half a day. The price variations of the last few years led to the strong demand of fixed prices for livestock vaccination. Most Arab and Fulbe breeders declared the financing of vaccination a minor problem because they could sell a cow or a few small ruminants1. Entrusted animals of Arab breeders would not be driven to vaccination unless the owner advanced the payment – this in contradiction to Fulbe. The Fulbe expressed a great readiness to pay for good drugs and vaccines.

Propositions of nomadic pastoralists were as follows: Information on future vaccination campaigns should be directed to their representatives and the complementary mode of information transmission mentioned was radio broadcasting, and should include all necessary information for pastoralists to get organised and e.g. begin with the construction of vaccination pens for cattle. It was proposed to regroup several camps, with people and livestock of neighbouring camps joining a common vaccination point. Arab cattle breeders proposed to regroup three to four camps around the well of a selected breeder or by the Chari River. Fulbe proposed to regroup four to five camps in the lake zone with abundant water and pastures and to construct the vaccination pen next to the largest camp. Distances to vaccination sites would have to be kept short: the maximal distance to send children and cattle from the camp to another site was about three kilometres for Fulbe (with a maximum of seven kilometres) or about one hour of travelling (with a maximum of two hours). Due to their propensity to first evaluate the efficacy of new interventions, Arabs proposed that at least the first should be free.

1 The price to vaccinate 100 cattle with three vaccines represented about the value of two sheep on the market. It was said that attractive markets for selling livestock (to obtain cash for vaccinations) were during wet season (July to September).

Nomads were convinced that a better general education and information on treatments and vaccination would simplify their access to health structures in general. One specific demand was education of their children to treat people and animals.

The recommendations to render joint vaccination campaigns effective can be summarised as follows: The information on vaccination time and place has to be disseminated among pastoralists as early as possible. All interventions have to be accompanied by information campaigns to increase their acceptance. Treatment, especially of livestock, should be offered simultaneously. The vaccination site should be in the surroundings of the camps, with preference during periods without long movements. Women with children may then also have better access to their chaperons allowing them to visit an outside service. Vaccinations should be well organised to avoid long waiting hours. Time and workload for cattle vaccination could be decreased by the construction of vaccination pens. Furthermore, during discussions it became obvious that the best possible vaccination practise has to be offered. Pastoralists pay a lot of attention to different quality criteria. One bad experience of pastoralists may be enough to lose an entire group to vaccination campaigns. If any problems do occur, these should be immediately addressed and discussed with the pastoralists. In addition, in order not to exclude a part of the community, socio-demographical aspects (such as the hierarchical structures of a group, the presence of several competing leaders or absence of young children in charge of guarding a flock of small ruminants or calves) are important issues for the planning.

Discussion

Traditional ways to manage human and livestock diseases preventable by vaccination exist. The contact rates of people having measles or whooping cough with other members of the community are kept low. The efficacious traditional vaccination against cattle pleuropneumonia is comprehensively described in literature and shows its large distribution among Fulbe herders (Mesfin and Obsa, 1994; Ba, 1982).

Nomadic pastoralists had much more experience with livestock vaccination than with children. More research is necessary to demonstrate whether knowledge gathered for livestock vaccination is extrapolated to vaccination of children, - founded but also inaccurate knowledge. Remarks such as “For us, all injections made by the doctor are to heal the animals” may indicate that convincing these breeders of the necessity to vaccinate healthy children only would require adequate investment in transmission of information. To which extend childhood vaccination was known by women, especially by mothers with young children, remained unclear in this study.

Nomads received some knowledge on modern vaccines from physicians and veterinarians. However, their empirical knowledge appeared much more important. The subtly differentiated methods to judge the quality of a vaccine and the time breeders were able to talk about this topic showed its significance. Nonetheless, this knowledge sometimes contradicts the western-type medicine model. For example, the best outcome of a vaccine observed was the eradication of the disease after a few years. This was true with the success stories of rinderpest (and smallpox) eradication. However, following this criterion, vaccines against anthrax, blackleg or pasteurellosis, where eradication is not a realistic objective, could not be considered as very good vaccines because these diseases still persist1.

Besides accessibility in general, knowledge of the importance of vaccination is part of a successful children vaccination campaign. The aim remains the full immunization of children (including polio vaccination) in all targeted populations. In the light of the ongoing polio-eradication, innovative approaches to approach the “hard to reach” populations, such as scattered, transient, migrating and nomadic populations, as well as the incorporation of existing concepts already existing in the respective cultures are demanded once more (UNICEF in collaboration WHO, 2000).

It has been seen that a participatory approach in the planning of the vaccination intervention was motivating for the nomadic pastoralists, as they realised that vaccination was not only a governmental matter. The idea of a joint vaccination programme induced highly different first reactions between the two ethnic groups. Fulbe accepted it, and insisted on their willingness to do everything possible to preserve or increase the health status of their family and of their animals. Arab camel breeders spontaneously rejected the idea and Arab cattle breeders were

1 The germs of these diseases are ubiquitous (in infected animals and carcasses, but also on vegetation and in soil). Therefore, these diseases cannot be eradicated by its elimination of disease in livestock. Vaccination against anthrax, pasteurellosis and blackleg need to be applied annually to protect livestock against infection and clinical disease.

not in its favour either. Only after it was made clear that they were asked to describe how they could come to accept such vaccinations, Arabs made similar or comparable propositions as Fulbe.

Information, Education and Communication (IEC) campaigns must accompany vaccination campaigns. Even if much information is passed by from one nomadic group to the other, one should not rely on its self-spread. The highly appreciated vaccination campaigns against rinderpest were followed by recent campaigns with low acceptance. IEC may guarantee the sustainability of campaigns only when they are continuously applied (Nichter, 1995). Furthermore, the dynamics of nomads make it necessary to foresee that new groups passing by, for example coming from Cameroon, may not be aware of a vaccination programme. IEC campaigns should be structured as two-way discussion platforms. Mixed (female-male) IEC teams including members of the nomadic community should be preferred to inform mothers and fathers on the importance of childhood and motherhood vaccines for each child or woman in reproductive age, as well as to inform breeders on the ongoing importance of livestock vaccination. Possible vaccination side effects such as the scars of BCG vaccination or reactions to toxins, the limited time of vaccination teams and the importance of not selecting animals for vaccination, need to be discussed in advance. Local knowledge, good and bad experiences and metaphors in adequate proportions should be used to communicate the importance and concepts of modern vaccination.

There are convincing arguments which will be easily accepted by pastoralists, but do not necessarily follow school medicine concepts. All attitudes acknowledging principles of modern vaccination may be crucial for a good compliance with vaccination programmes as well as for the distribution of information. However, the assumption that sick animals should be vaccinated constitutes a major constraint to the correct use of vaccination services. From a veterinary point of view, it must be stressed that only healthy animals can be vaccinated and that a sufficient delay between vaccination and the wet season needs to be respected for blackleg and anthrax. It is the only way to prevent the zoonosis anthrax in people. Veterinary services have to overcome the mistrust perceived and to regain wide acceptance. The wish of nomadic pastoralists to have the veterinarian in the camp during the wet season likely rather reflected most their desire to have access to good drugs when the animals were most diseased.

Loutan (1989) described the usefulness to train public health workers in collaboration with veterinary services, because the majority of pastoralists, including women, have very good knowledge about the health of their animals. Women often have the responsibility of traditional treatment of animals, although men control the use of modern veterinary care (Niamir, 1994). The American epidemiologist Calvin Schwabe promoted the term "the one medicine" in the sixties and described the intrinsic link between human and veterinary medicine (Schwabe, 1984). Joint treatments seemed to be generally well accepted. A private veterinarian started to deliver drugs for humans during vaccination campaigns several years ago (Nahar, personal communication). He wanted to improve the negative image of veterinarians among pastoralists and he knew of the need of nomads for health care as near to the camp as possible. This joint treatment was very well-appreciated and the pastoralists thanked him by letting him vaccinate their livestock regularly. To offer vaccination together with treatment for people and for livestock was in the logic of the nomads. Some pastoralists benefit from their own treatment, others by the treatment of the livestock. The fact that nomads often occupy vast land areas otherwise not used very productively (transhumant livestock production contributes eighteen percent of Gross Domestic Product of Chad), is in itself a more inclusively motive for including them stronger in development progress. We suggest a common policy for livestock and for children vaccination in pastoralist populations.

Chapter 12

Cost sharing through joint human and livestock vaccination campaigns among nomadic pastoralists of Chad

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Summary

The vaccination rate of nomadic pastoralist children and women was zero in two districts of Chad at the beginning of the study. In contrast, livestock had been vaccinated through veterinarians visiting the nomadic camps during compulsory vaccination campaigns. Joint human and livestock vaccination campaigns were initiated to reach nomadic children and women who so far were not covered efficiently by the National Expanded Programme on Immunization (EPI). In zone A (Gredaya), 3 out of 6 vaccination rounds were conducted in common with the veterinary sector, but in the B (Chaddra/AmDobak) only one out of 6 rounds was performed together with veterinary services. Data for cost analyses of these vaccination campaigns were collected and all costs were allocated to the sectors of public health and/or livestock production. Follow-up rates of individuals strongly influenced the costs per fully immunized child (FIC) and per tetanus vaccinated woman ($TT2^{+}$). Vaccine costs were the bulk of the costs for the public health sector. Of the total public health costs for vaccination, 6.7% and 2.8% could be shared in zone A and zone B, respectively. Considering only personnel, transportation and cold chain costs, these proportions increased to 15.1% and 4.1%, respectively. As to zone A, costs per FIC (US$ 10.7) were comparable to costs calculated for an outreach vaccination service (US$ 12.5). The costs per FIC were considerably higher in zone B (US$ 27.2). In many remote areas of Sahalian countries, almost exclusively veterinarians have access to pastoralists. Private veterinarians would be interested in more fully capitalising their transportation infrastructure by participating in campaigns including public health aspects.

Introduction

Vaccinations of children provided through the Expanded Programme on Immunization (EPI) are one of the most cost-effective health interventions, especially in developing countries (Creese *et al.* 1982; Robertson *et al*. 1985; Shepard *et al.* 1986; Jamison *et al*. 1993). Still, vaccination rates vary considerably between countries and between urban and rural zones. In rural zones, marginalized nomadic pastoralists are particularly vulnerable to exclusion from vaccination services. Nomads' vulnerability is mostly due to factors specific to their way of life and to related everyday constraints (Swift *et al.* 1990; Bonfiglioli & Watson 1992; Sheik-Mohamed & Velema 1999; Wiese & Tanner 2000).

Different strategies to reach nomadic people for immunization purposes have been used. Vaccination of nomads on markets were conducted as a part of the overall mass vaccination efforts towards the end of smallpox eradication campaigns, however it was difficult to reach children and women, who did not visit the market sites (Imperato 1969). Médecins du Monde (1998) have established primary health care tents along nomads' routes. Mobile services have been used to reach nomads, but were in general more costly. Imperato *et al.* (1973) demonstrated eleven-fold costs per vaccinated nomadic child with mobile vaccination teams and the average costs per fully immunized child (FIC) with mobile teams were 2.3 higher than for static facility services in different African countries (Brenzel & Claquin, 1994).

In Chad, no nomadic child vaccinated was fully immunized during a survey among nomadic Fulani and Arab pastoralists of two districts (Daoud *et al*. 2000). Yet, most nomadic pastoralists aware of the existence of childhood vaccines wished that their children had better access to measles and whooping cough vaccination (Wiese & Tanner 2000; Schelling *et al.* 2002c). About ten percent of the total population of Chad are nomadic or transhumant pastoralists belonging to different ethnic groups. They contribute over-proportionally to the Gross Domestic Product (GDP) (ME 1998) with a livestock production adapted to the scarce ecosystem of the Sahel (Niamir-Fuller & Turner 1999). Livestock production is of great interest to the government, which is reflected by compulsory vaccinations for cattle. In contrast to nomadic children, livestock kept by nomads were largely vaccinated.

The World Health Organization (WHO) and the Food and Agriculture Organisation (FAO) suggested that an evaluation of possible synergetic effects between public health and veterinary services was crucial to improve primary health care in rural settings of poor countries (Ward *et al*. 1993; Meslin 1996). Existing mobile veterinary infrastructures could be extended for simultaneous vaccination of nomadic children and personnel or logistic costs shared between the two sectors of public health and livestock production. Joint human and animal vaccination campaigns should be less costly in comparison to single approaches of the two sectors. Such a joint approach seems to be appealing in a country like Chad, which is by most economic indicators one of the poorest countries in Africa, with limited resources for health care and disease prevention.

The EPI in Chad (Service National du Programme Elargi de Vaccination) was launched nation-wide in 1985 and is integrated into primary health care services. The programme is organised together with sub-national (district) services (Médecine Préventive et Santé Rurale) and usually supported by a Non-Government Organization (NGO) responsible for a district. Fully immunized children (FIC) receive the entire series of immunizations prior to their first birthday, or, where a backlog of unimmunized older children exists, until five years. The ideal Chadian immunization schedule calls for 6 different contacts (at birth, 6 weeks, 10 weeks, 14 weeks, 6 months and 9 months) and the country programme includes at least nine doses: one dose of Bacille Calmette-Guerin (BCG), one measles, one yellow fever, and three doses of oral polio vaccine (OPV) and diphteria-pertussis-tetanus (DPT). Women in childbearing age, and particularly pregnant women, are targeted to receive at least two doses of tetanus toxoid (TT) vaccine. Norval and Maossede (1992) found that the infrastructure and vaccines were often lacking for outreach vaccination services in Southern Chad and that children contacted with mobile services received only two of the three required DPT doses. Dispensaries only infrequently considered the by-passing nomadic population, because the amount of vaccines needed were calculated based on extrapolated demographic data of the sedentary population within their zone of responsibility. Vaccines for nomads lacked in most cases.

Joint human and animal vaccination campaigns were organised by the “Centre de Support en Santé International”, an outlet of the Swiss Tropical Institute in Chad (CSSI-ITS/T) in the two Chadian districts, Chari-Baguirmi and Kanem. This intervention project was the result of a workshop on health care provision for nomadic people with stakeholders (Wyss & Zinsstag 2000) as well as of interviews and discussions with nomadic pastoralists in their camps

(Schelling *et al*. 2002c). The ministries of public health (MOH) and of livestock production (MLP) ensured their support and gave ethical approval. Chadian authorities underlined that both ministries of health and of livestock production should take advantage from a novel intersectoral approach to make it credible and sustainable. Evaluations (economic and performance assessment) of innovative services for nomads are very rare (Swift *et al.* 1990) and, to our knowledge, have not been done for joint vaccination campaigns so far. This cost evaluation study aims at partly filling this gap and providing the information needed by authorities for decision making on resource management (Tanner *et al*. 1993; Habicht *et al.* 1999). The costs of joint human and veterinary vaccination campaigns, allocated to the two sectors, were compared to the costs of single approaches (public health and livestock sector). It was not the aim to calculate the costs of the EPI in Chad according to the WHO cost assessment guidelines, but rather the incremental use of resources was of interest.

Methodology

<u>Implementation of joint vaccination campaigns</u>

Vaccination campaigns took place in three zones and encompassed three ethnic groups of nomadic pastoralists. The participation within campaigns was voluntary. Vaccination of children and women was free of charge and the usual prices for livestock vaccination were asked from nomadic pastoralists. Severe cases of disease, which could not be treated by the medical personnel on place, were referred to district hospitals.

A total of 12 vaccination rounds were conducted between July 2000 and November 2001. Two campaigns of 3 vaccination rounds each were launched in the zone of Gredaya with nomadic Fulani (cattle breeders) of the Lake Chad area. Campaigns started with the first round before the wet season. The second round took place in southeastern direction from the lake during the wet season. The third round either was again in the zone of the lake or east of Gredaya in the clay plains of Chari-Baguirmi. Three percent of vaccinated children and women in the zone of Gredaya were sedentary (who were not excluded due to equity considerations), and 3.6% belonged to another nomadic ethnic group (Arab or Dazagada). During the dry hot season, three rounds were conducted with Dazagada (cattle breeders) in the zone of Chaddra. Another three rounds were focused on nomadic Arab camel breeders during the wet season. Coming from the south, Arab camel breeders passed the zone of AmDobak (“bottle neck”) before they dispersed again, now in the northern direction, in the Kanem.

The three village-based dispensaries in Gredaya, Chaddra and AmDobak were each staffed by a trained medical assistant and nursing staff trained on the spot. They had no motorised vehicles. The refrigerators powered by petrol or by solar panels did not have the capacity to store the vaccines needed for a complete vaccination round at a given time. AmDobak had no veterinary post and was covered by the veterinary post of Chaddra (40 km away). A trained veterinary assistant and vaccinators were present in Gredaya and Chaddra. Gredaya had a freezer and for the zones of Chaddra and AmDobak, the freezer of a bar was rented to produce the necessary ice. The available infrastructure of the governmental veterinary service alone was not sufficient for joint vaccination campaigns in the more remote zones in the absence of a private veterinarian. Therefore, an additional vehicle was placed at the campaigns' disposal. In the zone of Gredaya, the vehicle of the livestock district was used.

Output values

Output variables were i) the cost per fully immunized child (FIC - including yellow fever vaccine) aged 1 - 59 months (costs of TT vaccines were subtracted from total cost), ii) cost per fully immunized woman ($TT2^+$) (costs of other vaccines were subtracted from total cost), iii) cost per contact (children or women), iv) cost per dose, v) marginal cost per FIC and per $TT2^+$ woman at a level of 200 children and 100 women vaccinated per day (capacity limit per day). A single dose of measles, yellow fever and BCG received at the first contact may advert many disability adjusted life years (DALYs) in the target population. However, cost per FIC and $TT2^+$ are better indicators since they relate directly to the follow-up rates. As to livestock, cost per vaccinated animal (either 3 doses against anthrax, blackleg and pasteurellosis at one encounter or one dose against CBPP at another) and the cost per dose were calculated.

Costing and cost allocation to the two sectors

The cost evaluation was based on a health and veterinary service perspective. Household or societal costs were excluded. Wherever possible, unit costs based on detailed data (e.g. replacement costs, maintenance and insurance costs) were obtained as opposed to annual or aggregate costs (Gold *et al.* 1996). In order to standardise different approaches of vaccination, the same unit costs for cold chain (mobile and static), transport costs and vaccines were used for the campaigns and the dispensary-based approaches. Local prices were used for e.g. fuel or *per diems* (daily payment). Prices and costs are expressed in FCFA (Franc de la

Coopération Financière en Afrique Centrale), and results are also given in US dollars. The exchange rate was taken as 1 US dollar = 730 FCFA (December 2001).

Costs collected manually for the zone of Gredaya and the two zones Chaddra and AmDobak were computed separately. The approach used to allocate the costs to the two sectors for jointly used resources distributed the costs of the vehicle(s), fuel and guides according to the number of personnel in the field. The costs of the cold chain, the programme coordination / administration, information campaigns (social mobilisation) and the car and fuel use for preparation were distributed according to the number of vaccination rounds in each sector. Cold chain costs were charged to the livestock sector when vaccines against contagious bovine pleuropneumonia (CBPP) vaccines were used. The proportion of public health costs saved due to the sharing of costs was calculated on the basis of single campaigns of the public health sector.

Two calculations of vaccination costs of dispensary based approaches were performed. The first calculated the costs of a static vaccination service and the second the costs of outreach activities. Dispensary outreach vaccination services for dispersed villages or nomadic camps were not routinely done in the study zone because vehicles were retained for mass vaccination campaigns against poliomyelitis.

The cost of static vaccination was calculated for a period of two years. Data on time for vaccination work, salaries, vaccine transportation and storage costs as well as the numbers of vaccinations in 1998 and 1999, was based on interviews with the medical assistant in charge of the dispensary in Gredaya and on dispensary records. The questionnaire followed the Partnerships for Health Reform guidelines for cost evaluation of the EPI at the facility level (PHR 2000). Data on tetanus vaccination of women, which is rather part of maternal health service, were not available. Supervisory activities on the NGO level and the training of the personnel were not included in the costing, because they were difficult to determine.

As to the outreach service, it was taken that two campaigns of each 3 rounds of 5 days of vaccination - and two additional vaccine transportation days - were conducted within a radius of 20 km from the dispensary. The enlarged zone of a dispensary is 10-15 km, the 20 km considered the dispersion of nomadic camps in more remote areas. Costs of the outreach service were calculated with no further remuneration of static vaccination service. Personnel returned to the dispensary every evening and received no additional *per diem*. It was assumed that the medical assistant together with two vaccinators, would vaccinate 200 children and 100 women per day. This assumption reflects the capacity maximum seen during vaccination campaigns. The team started with all non-vaccinated children and women at the first round of the first campaign. Before new individuals were vaccinated, those having already received a dose were vaccinated until they had received the entire vaccination course. The averages of follow-up rates of children and women for vaccination from the 1997 demographic and health survey (DHS) for rural Chad (Ouagadjio *et al*. 1998) and the dispensary vaccination rates for the years 1997-1999 were taken as final follow-up rates.

With two private veterinarians working in the district Chari-Baguirmi, costs of all expenses for cattle vaccination campaigns were recorded in detail and verified in successive sessions, if possible with accounts. Vaccination is the main activity of private veterinarians and periods of vaccination activities of 9 and 6 months, respectively, were used. Taxes as part of the costs were not included as tax is considered as a transfer payment and not as a true economic cost. One veterinarian stated an average number of vaccinated cattle per year. Of the other veterinarian, the number of all vaccinated cattle was obtained from vaccination records over 4 years.

Cost of human and livestock vaccines

Table 12.1 shows an overview of estimated vaccine costs per dose of BCG, OPV, DPT, measles, yellow fever and TT vaccines. An amount for transport and storage costs (National personnel, investment and maintenance of the cold storage and storage losses) and the supply costs (vaccination card, syringes and needles) were added to the vaccine production costs. Three cents per dose were considered as fixed costs of the EPI at National level. A wastage rate of 10% (estimates from 2 to 15%) was included in the costing. Wastage may be caused by residues of doses in the vials and delivered but unused vials.

Anthrax, blackleg and CBPP vaccination were compulsory for cattle, but, veterinarians usually vaccinated against pasteurellosis (hemorrhagic septicemia), too. All livestock species were treated equally with the exception of small ruminants, who only needed a quarter vaccine dose. The purchase costs of livestock vaccines at the National veterinary laboratory (Laboratoire de recherches vétérinaires et zootechniques de Farcha, N'Djaména) were used.

Loss of vaccines in the field due to wastage was included with a 5% rate (estimates from 2 to 10%).

Table 12.1 Overview of the composition of the human vaccines' costs

	Reference	BCG US$	OPV US$	DPT US$	Measles US$	YF US$	TT US$	Type of cost
Purchase price per dose	PAHO (2000) / Monath *et al.*, 1993	0.093	0.072	0.0575	0.102	0.2[a]	0.0345	Variable
Transport	20% of purchase	0.02	0.02	0.02	0.02	0.02	0.02	Variable
Losses (10%)		0.0093	0.0072	0.0058	0.0102	0.02	0.0035	Variable
Personnel EPI		0.01	0.01	0.01	0.01	0.01	0.01	Fixed
Investments of cold chain / storage		0.01	0.01	0.01	0.01	0.01	0.01	Fixed
Maintenance of cold chain and electricity		0.01	0.01	0.01	0.01	0.01	0.01	Fixed
Vaccination card		0.01	0.01	0.01	0.01	0.01	0.01	Variable
Needles and syringes	UNICEF	0.13	0	0.13	0.13	0.13	0.13	Variable
Total US$ per dose		0.292	0.139	0.253	0.302	0.41	0.228	
Total FCFA		213	102	185	221	299	166	

BCG: Bacille Calmette-Guerin (tuberculosis vaccine)

OPV: Oral Polio Vaccine

DPT: Diphtheria-Pertussis-Tetanus vaccine

YF: Yellow-fever vaccine

TT: Tetanus Toxoid vaccine

[a] US$ 0.17 (WHO, 1998)

<u>Sensitivity analyses</u>

Two types of sensitivity analyses were done. The first through varying of the numbers of vaccinated children and women, the second through consideration of a range (minimum, most likely and maximum) of uncertain input costs (cost per unit) with @Risk™. These analyses were based on Spearman rank correlation coefficient calculations between input and output values generated during 1000 Monte Carlo simulation iterations.

Results

Cost profile

The distribution of the variable and fixed costs per approach of the public health (campaigns of joint vaccination, outreach and static dispensary service) and of the livestock sector (campaigns of joint vaccination and livestock vaccination of private veterinarians) is shown in table 12.2. The bulk of the costs were the variable costs of vaccines together with supply costs (syringes and needles). These cost lines led to high proportions (63-72%) of variable costs of public health and livestock approaches. In contrast to campaigns and private veterinarians, personnel costs of the dispensaries were extremely low. Personnel for administration and supervision were likely to be under-estimated because training of the personnel and supervision of the NGO were not included. A crucial measure involved in the costs of static children vaccination was the running cost of the petrol refrigerator.

Costs of the information campaigns are not detailed in table 12.2. For the dispensary approaches, no such costs were foreseen. Within the campaigns, costs for information distribution added up to 2.2% and 1.8% of the public health and livestock sector, respectively. Radio broadcasting and information campaigns on markets were also an important issue for private veterinarians and accounted in total for 1% of their overall costs.

Allocation of costs to the sectors and shared costs of vaccination campaigns

Costs could only be shared between the public health and livestock sector during four joint vaccination rounds out of a total of 12 rounds. Sharing of costs was further limited when two vehicles were used as during the first and forth round in Gredaya. Yet, the livestock sector used more personnel and had thus a higher share of the vehicles' costs. Other resources used by both sectors were guides, transportation and personnel for information campaigns, as well as administration costs. These were split for joint rounds (table 12.3).

Table 12.2 Variable and fixed costs of different public health and livestock sector approaches

	Public health						Livestock sector			
	Campaigns		Dispensary based				Campaigns		Private veterinarians	
			Outreach		Static					
Variable (recurrent) costs	FCFA	%	FCFA	%	FCFA	%	FCFA	%	FCFA	%
Personnel / administration	4’582’100	19.8	410’000	5.3	300’000	10.1	1’992’811	20.7	11’603’750	27.3
Vaccines	4’790’015	20.7	2’371’355	30.8	395’496	13.2	3’444’873	35.7	14’092’105	33.1
Transportation	997’000	4.3	422’250	5.5	173’350	5.8	433’250	4.5	3’205’000	7.5
Cold chain	641’700	2.8	103’500	1.3	720’000	24.2	44’850	0.5	780’000	1.8
Supplies	4’615’263	19.9	2’219’307	28.8	350’097	11.8	180’500	1.9	711’525	1.7
Total variable costs	15’626’078	67.4	5’526’412	71.8	1’938’944	65.1	6’096’284	63.2	30’392’380	71.4
Fixed (non-recurrent) costs										
Vaccines	1’263’797	5.5	609’507	7.9	99’993	3.4	1’476’374	15.3	6’039’474	14.2
Transportation	4’117’500	17.8	1’050’000	13.6	300’000	10.1	1’650’000	17.1	5’215’333	12.3
Cold chain	362’700	1.6	58’500	0.8	400’000	13.4	25’350	0.3	150’000	0.4
Buildings	1’800’000	7.8	450’000	5.8	240’000	8.1	400’000	4.1	750’000	1.8
Total fixed costs	7’543’997	32.6	2’168’007	28.2	1’039’993	34.9	3’551’724	36.8	12’154’807	28.6

With regard to a higher potential of cost sharing during the 6 rounds in Gredaya (3 out of 6 rounds were joint vaccinations) compared to rounds in Chaddra/AmDobak (one out of 6 rounds was joint), calculations of proportional shared costs were done for the two zones separately. Table 12.4 shows the proportions costs that could be shared, but would also have arisen for a solitary public health approach. In Gredaya, a higher proportion of personnel and transportation could be shared than in Chaddra/AmDobak. Vaccine costs are not shared, but were the bulk of the costs. The overall total of shared costs resulted in 6.7% and 2.8%, respectively. These proportions were considerably higher, when vaccine costs were excluded: 15.1% and 4.1%, respectively.

Table 12.3 Overview of the determinants used for the allocation of the costs to the two sectors

Zone	Rounds	Vaccination personnel		Number of cars	Sharing of cold chain	Sharing of other costs
		MOH[a]	MLP[b]			
Gredaya	1	3	7	2	no	yes
	2	3		1		no
	3	2	4	1	yes	yes
	4	3	5	2	no	yes
	5	3		1		no
	6	3		1		no
Chaddra	1	3	2	1	yes	yes
	2	2		1		no
	3	2		1		no
AmDobak	1	3		1		no
	2	3		1		no
	3	3		1		no

[a] Public Health

[b] Livestock Production

Cost per outcome value

Table 12.5 shows the cost per vaccinated livestock during the campaigns in Gredaya, Chaddra/AmDobak and by private veterinarians. The costs of Gredaya and private veterinarians were comparable (with slightly lower costs per dose in Gredaya because proportionally more multiple doses were given per livestock). Costs in Chaddra/AmDobak were more than twice as high.

Costs of US$ 10.7 per fully immunized child (FIC) and US$ 6.1 per $TT2^+$ woman were achieved in Gredaya, but were comparatively higher in Chaddra/AmDobak (US$ 27.2 and US$16.8) (table 12.6). These two results, which included the costs of those children and women who did not receive a full course, probably represent a best and worst case of (joint) vaccination campaigns among nomadic pastoralists. The costs per FIC and $TT2^+$ woman obtained in Gredaya were comparable to the costs of outreach service (US$ 12.5 and 4.7). This applied also for the cost per dose and cost per contact. The low attendance rate and the comparatively high variable costs of the cold storage for the static dispensary vaccination service resulted in high costs per FIC of US$ 28.5. Marginal costs were less distinctly different between Gredaya and Chaddra/AmDobak (US$ 4.7 and US$ 6.1) than other costs, but were still high for static services (US$ 10.2).

Table 12.4 Shared costs of the public health sector for campaigns in the zones of Gredaya and Chaddra/AmDobak

	Gredaya		Chaddra/ AmDobak	
Variable (recurrent) costs	Total	% shared	Total	% shared
Personnel / administration	2’379’350	10.6	2’214’250	2.7
Vaccines	3’576’533	0	1’213’482	0
Transportation	476’500	15.9	520’775	6.9
Cold chain	493’290	6.2	222’525	10.0
Supplies	3’456’900	0.2	1’158’363	0.5
Fixed (non-recurrent) costs				
Vaccines	949’580	0	314’217	0
Transportation	2’150’000	20.1	1’970’000	2.3
Cold chain	284’310	6.2	125’775	10.2
Buildings	600’000	25.0	600’000	8.3
Total costs	14’366’463	6.7	8’339’386	2.8
Total costs without vaccines	6’398’450	15.1	5’668’325	4.1

Table 12.5 Costs per outcome of the livestock sector

		Campaigns		Private veterinarians
		Gredaya	Chaddra/ AmDobak	
Total cost	FCFA	8’840’024	698’181	42’547’187
	US$	12 110	29 307	58 284
Cost per vaccinated animal	FCFA	163	370	160
	US$	0.22	0.51	0.22
Cost per dose	FCFA	75	370	96
	US$	0.10	0.51	0.13

Table 12.6 Costs per outcome of the public health sector

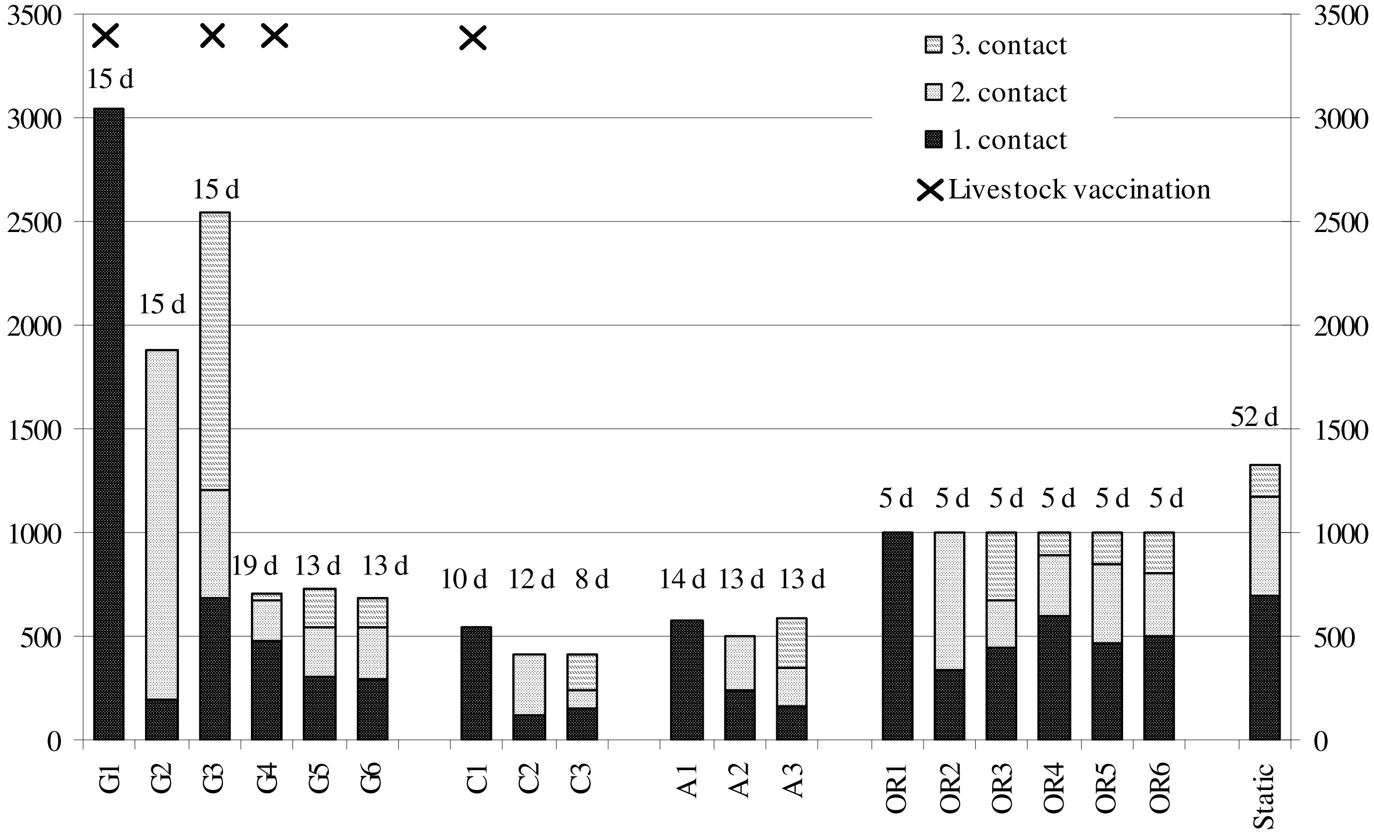
		Campaigns		Dispensary based	
		Gredaya	Chaddra/ AmDobak	Outreach service	Static
Total cost	FCFA	14’366’463	8’339’386	7’694’419	2’978’937
	US$	19 680	11 424	10 540	4 081
Measles BCG, YF		4516	1613	3344	491
Total FIC		1697	405	783	143
Total $TT2^{+}$ (no. TT3)		1679 (654)	488 (1)	899 (489)	-
Cost per FIC	FCFA	7’839	19’856	9’120	20’831
	US$	10.7	27.2	12.5	28.5
Cost per $TT2^{+}$	FCFA	4’451	12’246	3401	-
	US$	6.1	16.8	4.7	-
Cost per dose	FCFA	368	646	355	833
	US$	0.50	0.89	0.49	1.1
Cost per contact	FCFA	935	1’796	855	1’413
	US$	1.3	2.5	1.2	1.9
Marginal cost per FIC	FCFA	5’716	8’953	-	7’425
	US$	7.8	12.3	-	10.2
Marginal cost per $TT2^{+}$	FCFA	3’017	3293	-	-
	US$	4.1	4.5	-	-

Sensitivity analyses

Follow-up rates were crucial for the determination of costs per outcome. Costs per FIC and $TT2^+$ woman changed considerably with small changes in numbers of FIC and $TT2^+$achieved, which in turn were dependent on the follow-up rate of individuals. Better follow-up rates led to lower costs per contact because fewer children were vaccinated for the first time with all vaccines. In figure 12.1, the different patterns of contacted children (first, second and third contact) per round (for the static service the two years of vaccination were taken as one round). Low proportions of third contacts (resulting in a FIC) were characteristic for all approaches. Normally, as seen for the rounds in Gredaya, when starting in a naïve target population, high vaccination rates could be achieved at the beginning, but dropped with increased proportions of immunized children. More transportation kilometres and time need to be investigated to reach new non-immunized children.

The variation of the fixed transportation and building costs with @Risk™ showed a correlation coefficient > 0.2 for all public health approaches. All other cost factors had correlations less than 0.2.

Figure 12.1 Distribution of first, second and third contacts with children per vaccination rounds. G1-G6 rounds in Gredaya, C1-C3 rounds in Chaddra, A1-A3 rounds in AmDobak, OR rounds of outreach service, static vaccination service of dispensary. The days per round are indicated. Where campaign rounds were combined with livestock vaccination, these are marked with a cross at the top.



Discussion

Vaccination campaigns were performed among nomadic pastoralists having had no regular vaccination so far. The aim of this study was to evaluate to which extent costs could be saved by joint vaccination campaigns. The benefit could be shared between the two sectors of public health and livestock production. The costs were compared to single dispensary-based and private veterinary approaches to have an idea about the magnitude of the obtained costs.

We calculated that total costs of children and woman vaccination in the zone of Gredaya would be 7% more expensive if transportation, personnel and cold chain costs were not shared with the veterinary sector. Ultimately, vaccine costs cannot be shared. After their exclusion from calculations, a 15% economy in costs was obtained. Proportions of saved costs were decreased to less important 3% and 4%, respectively, in the zone of Chaddra/AmDobak with solely one joint out of six vaccination rounds. In conclusion, a maximum of joint per total rounds (in our setting two joint per three vaccination rounds) must be endeavored to obtain a meaningful benefit. Obtained vaccination coverage and cost-effectiveness of ongoing joint vaccination campaigns (combined with selling of drugs and distribution of vitamin A capsules) will be evaluated in a subsequent performance study including capture-recapture technique. Further studies will also take into account direct non-health costs and patient time costs.

Follow-up rates were crucial for the calculated costs per outcome and efforts must be increased to obtain a smaller drop-out rate. In Gredaya, after a first campaign starting in a non-immunized population, costs for the second campaign were comparable to the first campaign, but the obtained numbers of FIC were lower. The cost per FIC increased to US$ 19.6, which is distinctively higher than the US$ 10.7 calculated for both campaigns. Data was not conclusive whether livestock vaccination could mobilise more children and women for vaccination. The three rounds among Fulani would suggest an important effect, but the second round without livestock vaccination was related to a more mobile period of Fulani compared the first and third round. Fulani were contacted first in a zone of rather high concentration around Gredaya. Furthermore, a strong leader mobilised many Fulani to attend vaccination campaigns. Arab camel breeders were contacted during long transhumance movements in wet season. In parallel to Fulani, the contact rates of Arabs could be increased in a zone 150 kilometres further south with reasonable concentration of Arab cameleer camps during dry season. Whenever possible three rounds of vaccination per year should be conducted in a zone where nomadic groups are present for at least four months. As to Dazagada, they are the most mobile and dispersed of the three ethnic groups of nomads in the study zone and have no actual zone of concentration. Therefore, they may be especially at risk to be missed by vaccination services.

Mobile teams used vehicles for transportation and not camels or horses. Logistic problems maintaining a cold chain would likely occur and the limited capacity to reach remote zones effectively and prolonged campaigns may render campaigns without a vehicle practically unfeasible. Rapid assessment approaches may provide first information on routes and schedules of nomadic communities to guarantee sufficient meeting points for pastoralists and intervention teams (Wiese & Tanner 2000). In the case of vaccination interventions, this is crucial to assure revaccination of the children (and of the livestock). In order not to exclude groups within the very heterogeneous population of nomads, ongoing assessment of the routes used is necessary and intervention planning has to be kept flexible, because routes and schedules change considerably from year to year.

The joint approach with extended use of the veterinary infrastructure applies to pastoralist populations of rural areas in general. Majok and Schwabe (1996) describe further services within intersectoral collaboration, such as zoonoses, water and environmental monitoring which could be grafted upon existing veterinary services to capitalise more fully upon systems of transport, but also upon experience of and acceptance by pastoralists. In Chad, the process of veterinary privatization started in 1987 and has been supported actively by development projects funded by the European Union, the World Bank and others. After an abrupt implementation, private veterinarians lack nowadays a backing-up by a clearer legal framework as well as more political and economical commitment of the government (Arditi & Lainé 1999). Clinical services of veterinarians remain weak (breeders are willing to pay for drugs, but not for proficiency services) and other tasks such as compulsory vaccination, surveillance, meat inspection, or training seldom fully occupy private veterinarians. The cessation of those projects guaranteeing subsidies (as for vaccination against CBPP) strongly challenges the profitability of private veterinarians in less populated zones. Therefore, private veterinarians are very interested to fulfil additional tasks of health promotion into zones where, due to the poor governmental infrastructure, practically they alone have access (Nahar 2000). A contribution from the public health sector to their costs of vaccination delivery could make private veterinary services more sustainable. Furthermore, joint vaccinations had a direct potential of cost saving for the livestock sector, but are here not further evaluated.

Different immunization services tend to serve different population groups, and choosing the most cost-effective strategy at the exclusion of other approaches may not be a meaningful decision. Results obtained in South-East-Asia showed that increased use of mobile outreach services was more cost-effective in areas with a dispersed population, inconvenient transportation to clinics, or high drop-outs rates (Creese *et al*. 1982; Phonboon *et al*. 1989). With regard to calculated high costs of the static dispensary service, the same recommendation can be made for the Chadian rural setting. In order to reach more effectively the sedentary population of the study zone, outreach services should be periodically added. However, a reasonable follow-up rate must be ensured - otherwise the effectiveness is also limited. The weakness of dispensary outreach services for nomads is its limited radius of action. This may also be true for sedentary agro-pastoralists living far away from villages and these should be included in joint vaccination campaigns.

A first contact of nomads to vaccination services can be established during vaccination campaigns. Preceding or simultaneous animation and information campaigns should be an important part of vaccinations. They can easily be extended towards a more comprehensive health education (Bollinger 2002). Even if much information is passed by from one nomadic group to the other, one should not rely on its self-spread and information should be continually transmitted (Nichter 1995). Nomads are almost never represented in village health committees, which inform their people on ongoing vaccination programmes. However, an institutional change towards nomads' participation in health committees would most favourable. A part of nomads may start using dispensaries for vaccination. This prerequisites that the health personnel considered the presence of nomadic people in the surrounding and have ordered enough vaccines in advance.

In conclusion, veterinarians appear to be able to reach pastoralists in many remote areas of Sahalian countries. With a contribution of the public health sector to the costs of veterinarians for vaccination campaigns, nomadic or scattered children, who had no access to vaccination so far, could be vaccinated in the course of common actions taking advantage of the mobility of veterinarians. A common policy of the public health and livestock sector should regulate the cost sharing.

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Part IV

General Discussion and Conclusions

Chapter 13 General discussion and conclusions

Information on specific topics related to the livelihood of nomadic pastoralists is available, but very little is known about their health (Swift *et al.*, 1990). The interdisciplinary research team of the Swiss Tropical Institute initiated several projects using different approaches to study the health of nomads in Chad. This thesis encompasses aspects of veterinary and human medicine and their interrelations, evaluated mainly with epidemiological methods. The general discussion and conclusions includes methodological considerations, and discusses the main results prior to give some recommendations for interventions.

<u>Methodological considerations</u>

Selection of camps and individuals

In the absence of census data, a two-stage cluster sampling was used. A number of nomadic communities and subgroups, belonging to three main ethnic groups, were identified in Chari-Baguirmi and Kanem (Wiese, 1996). Recognising that we could not consider all communities, nomadic Fulani cattle breeders (of the Lake Chad zone) and Arab camel or cattle breeders were chosen in order to include two different types of livestock breeding systems and ethnic groups. Nomads' representatives provided first information on the approximate distribution of camps in the field. Camps within these three groups were chosen as randomly as possible using different strategies such as random selection of zones of concentration, villages (contact on market days), or cardinal points to direct the search for camps. Approximately one third of contacted camp elders did not want to participate after they were informed about the study's objectives and the sampling procedure. One entire Arab sub-group was lost due to a key person unwilling to participate. Two Fulani and one Arab camp of important leaders had to be included in the sample - not including them would have severely altered the acceptance and credibility of project. Thus, practical factors, convenience as well as representatives influenced random contact of camp elders. Certain sub-groups may not have been contacted because no representatives were available or because their camps were not accessible (e.g. Fulani camps on the islands of Lake Chad). A list with camp elders having given their informed consent to participate in the study was established prior to the first sampling. This preparatory work took more than two weeks and is documented.

Half of the camps contacted previously were visited during the first sampling. These same camps (defined by the names of camp elders) were revisited during the second sampling in order to obtain data comparable to the first sampling (same study population), but also to capitalise contacts established with representatives and camp elders (decreased risk to lose valuable working days for new selection). During the third sampling, new camps, mainly Arab cattle breeders, were contacted and included in the study. Six Arab camel breeder camps were lost for further participation because their leader presented exaggerated demands to the research groups. The follow-up of “camp elders” showed that the camp composition between our visits was highly variable – which was not expected to such an extent. The herd composition likely changed considerably also, but as animals were not permanently marked, the proportion of animals present in successive samplings could not be well determined. Individuals within one camp were not independent of each other, and clustering within camps as well as repeated visits of the same camps were taken into consideration in the statistical models.

Random numbers were used for selection of members within a camp in order to make the selection procedure transparent. However, this selection could sometimes not be completely controlled, although we communicated that diseased people and animals would be treated after the study protocols were completed: randomly selected individuals would be exchanged with ill camp members to ensure that the later would receive optimal medical attention. Nomadic pastoralists only accepted the selection procedure after a basis of trust had been established during a second and third visit, thus, frequencies of some affections may be over-estimated.

Evidence from this study cannot be uncritically applied to the other ethnic group in the study area, the Dazagada (Wiese, 2002) or other sub-groups of Fulani and Arab pastoralists. Our study demonstrated marked differences between nomadic groups for a number of dietary, morbidity and health service utilisation items and, therefore, generalised conclusions should be drawn with caution.

Physical examination, questionnaire and laboratory tests

The same physician and veterinarian examined all participants and animals, respectively, hence, making examination results comparable between and within groups and seasons. Over-reporting of complaints based on the hope of obtaining drugs or under-reporting of particular ailments due to shame (e.g. sexually transmitted diseases) is likely. Live history data of cattle and camels was only included when a name could be given for the animal. However, it remained uncertain if some questions were answered just to please the investigator. Nonetheless, we concluded that breeders had a good knowledge on the animals' history and other members were often consulted in order to give accurate answers or the inability to give an appropriate answer was declared.

The nomads' working rhythm allowed for examination and interviewing only in the early morning or in the evening before sunset. Time per participant beyond physical examination was limited. With the help of a nurse drawing blood samples and giving injections for treatments and of a veterinary technician completing the second part the questionnaire, more participants could be examined than would have been possible by one person alone. Our objective was to gain a broad overview of important health issues for nomads with the survey questionnaire. Therefore, some questions were not very detailed and information obtained on some topics was limited.

Blood smears from the first and second samplings were read at the "Service des Grandes Endémies". Virtually every participant appeared to be plasmodium positive. Therefore, blood slides of the third sampling were read at the parasitology department of the LRVZ. However, a quality control at the Swiss Tropical Institute suggested poor overall performance. The conclusion that may be drawn from these unsatisfactory results is that a reasonable quality (with the tight budget) can only be obtained by direct supervision of research participants.

As to brucellosis serology, it is known that cross-reactions with e.g. *Yersinia spp*. can cause false-positive *Brucella* RBT results (OIE, 1996; Chart *et al*., 1992). Furthermore, sensitivity and specificity of the rose bengal test may vary in different settings (Maichomo *et al.,* 1998). The ideal gold standard methods for the evaluation of serological tests are positive bacterial culture (definition of true positives) and samples from herds known to be *Brucella*-free (true negatives). Therefore, more bacterial cultures would have assisted in the process of interpreting the serology results obtained. In contrast to Switzerland, *Brucella* spp isolation is not done routinely in Chad. The implementation of the methodology for bacterial cultures for *Brucella* spp. could not be pursued early enough in the course of the study. Culture of milk samples from ring-test positive herds could have been attempted during the last sampling, but immediate transport to the laboratory was not guaranteed. Positive cultures were obtained from a cattle herd suspect of brucellosis that was settled near the laboratory.

Interdisciplinary and North-South collaboration

The strength of epidemiological approaches is to show general patterns, to compare groups in order to identify the sub-groups at highest risk and to test hypothesis. However, it tends to focus on a limited number of parameters. Studies on the individual level allow for a deeper appreciation and understanding of a community. This emphasis on the individual may render recognition of general influences difficult. Therefore, both epidemiological and anthropological vulnerability approaches are necessary to better understand the target population and the complexity of issues involved. Only interdisciplinary (systematic) research approaches allow to gain in-depth and pertinent knowledge about communities (Weiss, 2001).

Specifically, important public health diseases may not be perceived as such by the community (e.g. zoonoses) – and vice versa. Illnesses perceived as important should be integrated in health care provision programmes. Treatment-seeking behaviours may be influenced by cultural norms, e.g. the Fulani concept of *pulaaku* encompassing a high degree of self-control, may result in the use of health services only at an advanced stage of disease (Krönke, 2001). Furthermore, experienced vulnerability related to spatial, social, political-economic and ecological factors significantly influence access to health services (Wiese, 2002). Most of these issues are important in the western world as well (Hunt *et al*., 1989).

Interpretation and validity proofing of the questionnaire-derived results require interdisciplinary (two-way) interaction. Each discipline has its own methodological basis and it is sometimes difficult to efficiently combine these different approaches. New interdisciplinary and intercultural methods need to be developed (Weiss, 2001). Results obtained with different approaches may differ. These very inconsistencies should be analysed as they may have implications for future research.

The successful realisation of this study would not have been possible without the professional input of the Chadian research partners. Furthermore, their knowledge of local premises, customs, traditions and languages was indispensable for the organisation of the project. Collaboration from an early stage of planning on was extremely beneficial. A transparent common budget created mutual trust on both sides. The Chadian partners are best situated to guarantee continuity of research and interventions. Nevertheless, it may not always be easy to accept everyday constraints and divergent motivations of the other partners. These factors become better understandable once the social and institutional system of the study country is known better. The infrastructural conditions in Chad are precarious and security considerations related to the political situation rendered e.g. field visits impossible during an entire 2-month stay.

<u>Zoonoses</u>

Earlier reports showed high brucellosis seroprevalences (up to 30%) in Chad (Domenech *et al.* 1982). No active foci of brucellosis infection were found in this study, which was conducted in a dryer zone than previous studies. For cattle, brucellosis seropositivity was related to a history of abortion. A high Q-fever seroprevalence of camels such as found in this study (73%) had not been reported in the literature so far and being a camel breeder was a significant risk factor for Q-fever seropositivity in humans (chapter 7). Seventeen percent of cattle were tuberculin positive. Although mycobacterial strains belonging to the *Mycobacterium tuberculosis* complex could not yet be isolated from milk, first results human specimens indicate the presence of *M. tuberculosis* (C. Diguimbaye, personal communication). Bovine tuberculosis is suspected to represent another hazard for pastoralists (Annexe). Zoonotic infections in humans were virtually unknown, with the exception of anthrax, among Chadian Fulani. Cooking of the milk before consumption could prevent zoonotic infections such as brucellosis, Q-fever and tuberculosis in nomadic pastoralists as well as the sedentary population buying their milk from pastoralists. For an efficacious communication of the importance of milk cooking, the idea of transmission diseases by germs will probably need to be spread first. Due to lack of knowledge on microbial agents of infections, for pastoralists it may not seem obvious to cook the milk (Krönke *et al.*, 2001).

Simultaneous sampling of humans and animals should be repeated in populations less variable than nomadic camps to more distinctively demonstrate the involvement of different livestock species in the infection of people. Such data could then be tested with novel deterministic

Susceptible-Infected-Recovered (SIR) animal-animal and animal-human transmission models linked to effectiveness and economic assessment (Roth and Zinsstag, 2001).

Morbidity

Morbidity patterns of three nomadic pastoralist communities are described in chapter 8 based on diagnoses made by a physician after clinical examination of study participants. Digestive disorders were the most important disease class and included mainly parasitoses and gastritis, with fewer cases of diarrhoea (in total 5% of participants). Pulmonary affections were frequent, e.g. bronchitis in young children (18%) and a notable 4.4% of adult participants were found to be suspect of tuberculosis. Arab cattle and camel breeders were severely affected by malaria during the wet season. Suspected clinical malaria was prevalent among Fulani, who stayed in the vicinity of Lake Chad during the dry season, during both dry and wet season. All 12 children diagnosed with measles, mumps or whooping cough were Arab cameleers children. Asthma and bronchitis were diagnosed more often among cattle breeders of both ethnic groups than among Arab camel breeders. Although Fulani and Arab women reported comparable birth rates, Fulani women reported more children alive. The overall proportion of lost children was 0.2 for Arab women in childbearing age but only 0.07 for Fulani mothers. These indicators are important information for the definition of research priorities and of appropriate health policies for nomadic people. Further research on child mortality (with detailed life histories of deceased children) and child care is necessary, but maternal peripartal complications, management of child birth difficulties and family planning should also be evaluated in-depth.

Nutrition and vitamin A

Human serum retinol concentrations were significantly correlated to livestock milk retinol, illustrating the significance of milk as a dietary component for Chadian nomadic populations. The serum retinol levels of women were generally low and 17% of women were classified as severely retinol deficient (< 0.35 μmol/L) (chapter 8). In accordance with Holter (1988), fruits and vegetables were rarely consumed among pastoralists of the three communities studied. Data of a 24-hours dietary recall and on milk consumption habits showed that Arab women consumed less milk during the dry season. Fulani women probably complemented the shortage of cow milk with small ruminant milk during that period. Furthermore, malnutrition in children was rare in the study population (chapter 9). Nevertheless, the promotion of green vegetables and fruits as nutrition supplements for adults, and especially for infants and young children should be incorporated in health information campaigns.

Utilisation of health services

The initiation of the programme “Health for Nomads” derived from the observation that nomadic pastoralists rarely visit the dispensaries of Chari-Baguirmi or do so only in an advanced stage of disease. Dispensaries in rural Chad often lack adequate infrastructure, drugs, quality services and supervision. When availability of drugs and vaccines is reduced at dispensaries, nomads are likely to be discriminated and excluded from treatment of vaccination first (Sheikh-Mohamed and Velema, 1999; Azarya, 1996; Aliou, 1995; Omar, 1992; Swift *et al*., 1990). Yet, only little was known on everyday use of health services by nomadic men, women and children. Our epidemiological study provided an overview on health service utilisation patterns of sick nomadic pastoralists (chapter 9). Apparent differences between communities were mostly due to less common use of dispensaries and traditional healers by both Arab camel and cattle breeders than Fulain, but Arab cameleers consulted a marabout more often than Fulani. Dispensaries were visited by one forth of “diseased” participants, with no significant differences between sexes. Respiratory affections had an important health impact among members of all three communities. Participants with respiratory disorders apparently went early to a dispensary for consultation. During the wet season, use of health services was dominated by the high frequency of malaria occurrence. Dispensaries where anti-malarial drugs were known to be in short supply were visited less often. Our data suggests that young unmarried women and men had fewer opportunities to visit a marabout or a dispensary.

No fully immunised nomadic child was found during the morbidity study. Women gave birth assisted by relatives in the camps, and prenatal health care was virtually not used.

Joint vaccination campaigns

Pastoralists have lost much confidence in veterinarians and their abilities during the last few years. After the success of rinderpest eradication, breeders observed an increasing inefficacy of anthrax, blackleg and pasteurellosis vaccines. Deaths of cattle after vaccination against contagious bovine pleuropneumonia and visits of veterinarians solely to take blood for rinderpest serosurveillance without treating diseased animals were recurrent to complaints towards veterinary services. In contrast to frequent contacts to veterinary services in the course of compulsory cattle vaccination, but also during voluntary vaccination of camels and for the purchase of veterinary drugs, exposure to vaccination services for children was rare. We found that the existence of vaccines against measles was known, but pastoralists were distinctively less aware of other vaccines for children and women. Few breeders did not know the existence of children vaccination at all, although measles were well known and feared. Especially Arabs demanded better access to measles and whooping cough vaccination. These two diseases ranged at the second and seventh rank, respectively, of the perceived most harm-causing illnesses of Fulani (Krönke, 2001). To which extent knowledge and experiences with livestock vaccination were transposed to children vaccination remained unclear. This bears interesting implications for further research to evaluate interactions between animal and human health by use of better adapted research tools. During discussions with pastoralists, the idea of combining the services of veterinary vaccination with vaccination of children was appreciated, but nomads raised many practical considerations for its implementation (chapter 11).

As a part of a action programme which resulted from consultations of various stakeholders (Wyss, 2000), joint vaccination campaigns were conducted by the “Centre de Support en Santé International” during two years in Chari-Baguirmi and Kanem. The costs of the campaigns allocated to the two sectors of public health and of livestock production were evaluated (chapter 12). To our knowledge, costing of an intersectoral vaccination approach had not been done so far. Significant outcome differences were found between two zones (Gredaya and Chaddra/AmDobak), mainly due to distinctively higher total numbers of children and women reached per day and more vaccination rounds with veterinary services in Gredaya. In the zone of Gredaya, joint campaigns allowed the public health sector to save 7% of total costs (including vaccine costs) and up to 15% of infrastructure and personnel costs. Potential for improving vaccination campaigns, especially the follow-up of children and women, was identified. Private veterinarians would be very interested in fulfilling additional tasks of health promotion in areas where practically only they have access to (Nahar, 2000). Static or outreach dispensary-based vaccination services probably do not have the same efficiency to reach nomadic children as mobile joint vaccination campaigns.

Implications for further research

The results of this study suggest that further research is necessary in the following fields:

- Comparison of morbidity and nutrition patterns between nomadic pastoralist and sedentary communities
- The importance of bovine tuberculosis in humans should be determined through isolation and characterisation of *M. tuberculosis* and *M. bovis* strains from human and animal specimens.
- More strains of *Brucella* spp. should be isolated to determine active foci of brucellosis. *B. melitensis* occurrence needs to be further evaluated by strain isolation and characterisation, especially in cattle and camels.
- Rift Valley Fever (RVF) has never been diagnosed in Chad. Human and livestock sera collected in this study are currently tested for antibodies against RVF virus within a scientific collaboration with the Pasteur Institute in Dakar, Senegal. Results of these analyses may suggest RVF virus isolation.
- Malaria should be further assessed with blood spots for PCR based diagnosis besides blood smears.
- The divergent data on children loss in Fulani and Arab women revealed lack of detailed knowledge on child mortality (with life histories of deceased children), child care, maternal peripartal complications, management of child birth difficulties and family planning. Additionally, the role of respiratory diseases in nomadic children should be evaluated more thoroughly.
- Nomads' comments on inefficacy of anthrax and other livestock vaccines should be addressed by quality control of vaccines, theoretically including a challenge study of vaccinated animals, as well as by comparison of virulence factors of field isolates with those of vaccine strains.
- Transfer of knowledge from livestock to human health by pastoralists should be systematically evaluated.
- A performance analysis of joint vaccination campaigns should provide data on the quality of vaccination services, achieved vaccination coverage (using capture-recapture methods) and access (or exclusion) of nomadic communities to joint vaccinations. Cost-effectiveness and cost-benefit analyses would provide better insight into the benefits for

the public health and livestock sector. Such studies would be crucial in view of possible extension of joint vaccinations to other sites and countries.

- The human and animal demographic variability of mobile populations should be further assessed.
- Further analysis of the interface between human and domesticated animal health may contribute to a new conceptual framework.

Chapter 14 Interventions in nomadic pastoralist settings and inequalities in health

Health interventions in nomadic pastoralist settings

The term “participation” is a widely used, but in the absence of a precise definition, it is used in relationship with different processes (Bliss, 1999). A participatory planning process to design interventions would involve the target community from the initial planning on to final evaluation. In our case the sector of action was predefined, however, access to water and education, security issues or the health of their livestock may have equal or higher priority for nomadic pastoralists than their own health (Wiese, 2002). During two workshops on the health care provision for nomadic people, nomads’ representatives had the opportunity to present their demands, but not all nomadic groups were represented. Desirable changes will only be achievable if pastoralists participate at all stages of the process (Wyss, 1998a). Nomads participated to focused groups discussions (such as in described chapter 11 described) to define their perceived needs concerning health issues, but also to allow them to discuss their own resources and capacities. Ranking of illnesses perceived as important for individuals and communities or the definition of vulnerability related to spatial factors (including ecological, political and economic aspects) are very useful methods in this process. However, directly applicable results that can immediately be transformed into actions may be obtained only late with such approaches, especially in the nomadic context (Randall, 1994). A rapid assessment method used at the beginning of the programme in 1996, however, proved its usefulness to identify many of the important health issues of nomads, such as e.g. a zero vaccination rate (Wiese and Tanner, 2000). Such results obtained rapidly and at low costs can be directly used for the planning of interventions (Vlassoff and Tanner, 1992).

Health service interventions must tend to serve different sub-groups of the nomadic populations and one single approach will not be sufficient (Wyss, 1998a). Most recommendations for interventions listed below have been implemented elsewhere with more or less success (Swift *et al*., 1990). References to chapters of the thesis are given, where respective interventions have been discussed in more detail.

- Improvement of the quality of dispensary services (including an adequate stock of western-type drugs, reduction of waiting times and commodities for relatives to stay with hospitalised patients) appears to have a potential to increase the use of dispensaries (chapter 10). Fulani complained that people in charge of dispensaries did not know their illness (Krönke, 2001). Providing dispensaries with a list and descriptions of Fulani illnesses, as well as information about the constraints of nomads in general may also improve quality and acceptance significantly. A serious problem remains the treatment of ailments such as tuberculosis and venereal diseases, which need continuous drug treatment over longer periods at a dispensary level. A directly observed treatment short course (DOTs) for tuberculosis adapted to nomadic populations has not been tested so far (Wyss, 1998a).
- Nomadic community health workers (CHW) and female birth attendants have the great advantage of living closer to and reaching the camps and, thus they may be more accessible than outside practitioners (chapter 10). They should be provided with basic drugs such as antibiotics, anti-malarial and anti-parasitic drugs (chapter 9).
- Randall (1994) states that nomadic women are assisted by other women at parturition and, therefore, it may be more reasonable to give short-term training to many nomadic women than to give an extended training only to a few birth attendants.
- The idea of joint human and animal vaccination campaigns was appreciated by pastoralists, mostly because vaccination teams come in the proximity of their camps (chapter 11). The general feasibility of joint vaccinations was demonstrated, however, attention should be paid not to exclude groups and the follow-up of children and women for booster vaccination should be improved. Information certainly plays an important role (chapter 12). Vaccination campaigns in or near nomadic camps could easily be extended to other acknowledged services such as the selling of drugs and information campaigns (Bollinger, 2002). Vitamin A capsules were distributed during vaccination campaigns.
- We found that information on human and livestock diseases, their treatment and transmission was actively sought by nomadic pastoralists. Besides general health messages, information on dispensary services, their costs and on efficient home remedies could be included in discussion platforms (chapter 11). The transmission of appropriate informations may be as important as health care interventions themselves.
- Efforts to improve access of nomadic populations to health services should be integrated in the health, education and development systems.

Inequalities in health between and among nomadic and sedentary communities of Chad

The international demand of "Health for All" was launched at the Alma Ata Conference in 1978 and was renewed in 1995. Primary health care should play an important role to meet such a goal. Health care is not limited to providing curative services but also includes health promotion, disease prevention, rehabilitation and cure (Declaration on "Health Care for All", Antwerp, 2001). Egalitarian reasons justify efforts to develop innovative and adapted health services for nomadic people who are known to be vulnerable to exclusion from primary health care. Otherwise, is the sedentary rural population better off in terms of health and access to health services than nomadic pastoralist communities? We postulated that the sedentary population would have a better access to health services than the marginalised nomadic population. The present thesis was designed to compare the health status of different nomadic communities, as well as to evaluate zoonotic diseases of humans and livestock in the nomadic communities. For these populations, virtually no information was available on morbidity at the beginning of the study. It was thought that the health data obtained could be compared to health information available for the sedentary community. However, this information was also found to be scarce for the sedentary populations in more remote zones. This section discusses inequalities in health with a special focus on the study area.

Inequity and inequalities in health

Inequity refers to unnecessary and avoidable differences, which are in addition considered unfair and unjust. Thus, they have a moral and ethical dimension. Equity in health implies that ideally every person should have a fair opportunity to attain his/her full health potential, and, more pragmatically, that nobody should be disadvantaged and prevented from achieving this potential, if it can be avoided. Another view on equity focuses on the provision and distribution of health services to all (equal access, equal utilisation and equal health care) (Whitehead, 1990).

Health inequality is a distinct dimension regarding the performance of a health system and may be defined as variations in health status across individuals of a population (Gakidou *et al*., 2000). Health inequalities usually do not convey any message on the fairness of the differences in health between groups, as implied by the term "inequities". Inequalities can be measured directly while inequities cannot (Mackenbach and Kunst, 1997). Relative and absolute poverty are important factors based on strong evidence of inequalities in health status and access to health service between the poorest and richest quintile of the population in most countries (Gwatkin, 2000). However, others feel that a broader focus should be chosen since inequality concerns social disadvantages due not only to poverty. Gender-specific, socio-cultural and economic factors, ethnicity (ethnic minorities) and other factors such as geographical setting can worsen the ill-effects of poverty (Caldwell, 1979, Hill, 1985; Braveman, 2000; Gupta, 2000). Hill and Randall (1984), Hill (1985) and Defo (1996) described the influence of ethnicity, maternal characteristics (particularly traditional practices such as nutritional and socio-economic factors including female education) on the health and survival chances of children in Sahelian countries. The lack of a consensus on indicators of the magnitude of health inequalities is evident. Morbidity and mortality rates of different socio-economic and ethnic groups have been compared or correlated (Mackenbach and Kunst, 1997; Wagstaff, 2000; Brockerhoff and Hewett, 2000), and life expectancy (Gakidou *et al.*, 2000) as well as indicators of health service use and financing (Castro-Leal *et al.*, 2000; Makinen *et al.*, 2000) have been used to compare inequalities within and between different (less developed) countries.

Inequality in health or in access to measures that ensure it can create discontentment and inter-group enmities that disturb the social order within a country (Alleyne *et al.*, 2000). Effective respond to inequalities in health will often require action outside the health sector, such as promotion of maternal education to significantly reduce differences in child mortality due to areal and socio-economic factors (Caldwell, 1979; Defo, 1996).

Health inequalities in Chad

Chad compared to other countries

A ranking of under-five mortality rates assigns Chad to the 14th position of all countries in the order of decreasing mortality rates. For Chad, 198 deaths under five years of age are registered out of 1000 live births. In comparison, Switzerland is placed on the last (187th) rank with an under-5-mortality rate of 4 per 1000 (UNICEF, 2001). Longevity and per capita income are not necessarily congruent. Income exerts a positive influence, and yet – because of the variation of other factors, such as the priorities set in medical facilities, public health care and basic education, a higher income alone does not make an individual or a community more able to avoid premature mortality and escapable morbidity (Sen, 1999). Tanzania, for example, has Gross National Product (GNP) per capita a comparable to Chad, but is listed at the 30th position of the UNICEF under-five mortality ranking.

Urban – rural inequalities

In many countries, studies have found higher mortality rates in rural than urban areas. In Chad, the under-five mortality rate is lower for the urban than for the rural areas (190 versus 204 per thousand live births). Health care facilities are unevenly distributed in Chad, clustered in urban areas and scarce in poor rural zones, where 20.5% of the population belong to the poorest quintile in comparison to only 1.6% in urban areas (Ouagadjio *et al*., 1998). More than half of the rural Chadian population (three-fourth of the total population) is not effectively reached by the existing health services because they do not live within a health centre's zone of responsibility (Document de Politique Nationale Sanitaire Révisée, 1997). Proportions of fully immunised children differed distinguishably between urban (20%) and rural (9%) settings of Chad. Rural-urban differences are likely correlated to factors such as access to health services, environment, socio-economic and educational status (especially for women). Children of women with basic education were more likely to survive in comparison to women with no education at all (182 versus 205 / 1000) (Ouagadjio *et al*., 1998), and women with a basic education are more often found in urban than rural settings (40.8% versus 14.8%) (DSIS, 2001).

Health inequalities among rural communities of Chad

Differences are evident across the socio-economic gradient in the rural Chadian population. The immunization coverage of the poorest quintile was very low in comparison to the richest (4.1% versus 21.1%). The same was true for the frequency of antenatal care visit to a trained person (11.2% versus 57.3%) (Gwatkin *et al*., 2000). Data for these analyses derived from the demographic and health survey (DHS) of 1996/1997 including nearly 4000 rural household interviews. Unfortunately, this data does not distinguish between groups with sedentary or nomadic lifestyle, but, it is likely that only few nomadic households were included in the study due to their difficult access. With regard to numerous livestock herds kept by nomadic pastoralists, nomads are considered to be rich by the sedentary agro-pastoralists or crop farmers of the same areas. This may be true to some extent. Nonetheless, livestock cannot be easily converted into cash without endangering the continuity of mobile livestock herds and livestock prices may vary considerably. In addition, many members of a nomadic camp composed of several families live from one herd (Galvin, 1992). Even "pure pastoralists" often need other activities than livestock breeding to provide them with an income source independent of the livestock economy (Niamir-Fuller and Turner, 1999). Therefore, no final conclusion can be drawn on economic differences between the nomadic and the sedentary population.

Nomadic children may be better nourished than those of sedentary crop farmers (Nathan *et al.*, 1996). Preliminary mortality rates of nomads obtained in this study are comparable to or lower than the Chadian average. But nomads had virtually never used vaccination or antenatal care services. The concept of static health centres with zones of responsibility implies that the targeted population stays within a defined geographical zone, thus this concept is not adapted to mobile populations. Furthermore, nomads are not represented in village health committees informing their people on the services offered at dispensaries. However, overall vaccination or antenatal care coverages are also very low for the sedentary rural population. According to the last census in 1993 and extrapolated to the year 2001, the dispensary of Gredaya in the study area, staffed with one nurse and one assistant, catered a sedentary population of at least 21’000! Forty percent of the households in rural Chad live outside a 15 kilometres radius of the next health facility (Ouagadjio *et al.*, 1998), but, because no motorised vehicles are available, facilities rarely offer outreach services to more effectively reach the sedentary population. Although part of the sedentary population may have easier access to health services than nomads, one should consider all communities for any health intervention with a general poor access to health services in remote zones.

<u>Addressing health inequalities by use of research and interventions in the study zone</u>

Research

There is a need to establish some measures of health inequality in the rural Chadian population with more precision. In future research projects, it would be interesting to compare features of nomadic and sedentary populations (stratified to those living in villages and those further away). The socio-economic model traces the roots of ill-health far beyond health services, to such determinants as income and education as well as to infrastructure, environment and lifestyle. This model was supported by the political drive towards decentralisation which made the collection of these data to determine resource allocation possible. In times of growing conflicts between nomadic people and crop farmers, institutional aspects of resource management cannot be ignored.

Health interventions

Community participation in primary health care to increase the effectiveness of interventions may be easier to achieve with a sedentary population than with a nomadic community. Nonetheless, health committees for and with nomadic communities should be established to define the tasks of a health programme and to take responsibility for it. The participation of nomad representatives in the committees of static health facilities would be preferable, but seems also more difficult to achieve.

Intersectoral collaboration between the public health and livestock production sectors should be feasible in any pastoral community. Sedentary as well as nomadic pastoralists can be reached with a joint human and animal health service approach, specifically with vaccination campaigns and other services grafted upon. While these mobile mixed teams would be working in the more remote areas, crop farmers should not be excluded from health interventions.

Chapter 15 Validation of the concept of „one medicine“

Humans and domesticated animals share many characteristics such as their anatomical and physiological systems, as well as causative agents, pathogenesis and pathology of diseases. In early cultures, especially in pastoralist societies, priests or shamans were the first to observe the relationship between human health and animal diseases. Human and veterinary medicine were previously part of one field or medicine, but they have become separated for over 300 years with the advance of modern science. The old concept of “one medicine” - the integrity of animal and medical sciences - was most thoroughly described by Calvin Schwabe (Introduction pp. 15 - 18). "One medicine" – the combination of human and animal health - was the framework of the present thesis and directed us in the definition of our research and intervention objectives and subsequently determined the samplings, measures and outcomes. In this section, the usefulness and the added values of this framework are discussed.

Due to the vastness of the concept “one medicine” touching on very different aspects such as health and well-being, economy, environment and society, only a selection of topics could be dealt with in the course this thesis. We concentrated on interactions between humans and livestock and excluded human – pet interactions, animal ethics and animal rights, livestock breeding, labour capacity of animals, and effects of livestock breeding on the environment. The relationship between people and companion animals is evaluated increasingly comprehensively mainly in industrialised countries, e.g. the influence of pets on the physical and psychological health of older peoples. The use of laboratory animals or of animals’ for food production is subjected to ethical discussions with representatives from medical professions, pharmaceutical companies, philosophers, animal right activists and many more. Our moral, culture and tradition influence our definition of animal ethics, and thus, depending on the cultural setting, the focus of the discussion may change considerably. The first cloning experiments of animals have introduced a new dimension to the ongoing discussions. The supporter of this new technology underline its potential for standardised high quality animal production, for example to produce human proteins of medical interest such as peptide hormones (transgenetically introduced into the animals and shed into the milk of sheep or cows). Beside production, the work force of animals (e.g. draught horses and oxen, shepherd dogs) is also an important economic factor. Environmental consequences of livestock production world-wide and specifically in the Sahel are also stand far-reaching outcomes of human and animal interactions, but were not further evaluated in this thesis.

The concept “one medicine” has shaped most of our research questions for the studies with nomadic pastoralists of the Sahel having close human-animal interrelationships (Introduction pp 2 - 6). This thesis has addressed the following topics at the interface of human and animal health:

- Transmission of selected zoonotic diseases from livestock to pastoralists (chapter 7)
- Nutritional aspects (milk consumption patterns and milk as a source of vitamin A) (chapters 8 and 9)
- Health services (perception and implementation of joint vaccination services) (chapters 11 and 12)

How did the joint human and animal health approach contribute to our understanding of diseases (specifically of zoonoses) or to the design of possible health interventions in a nomadic setting? We observed that a team offering medical care for both people and livestock was highly appreciated by pastoralists and, thus, the acceptance of intersectoral studies or interventions was high after pastoralists had been informed about the objectives of the study and the intervention design. At a given time, some pastoralists benefit of the dispensed treatments, others more by the treatment of their livestock. To offer vaccination together with treatment for people and livestock at the same time was in the logic of the nomads.

Typically, the occurrence of zoonoses in humans is directly related to that in livestock. Few previous studies have examined the occurrence of a zoonotic disease simultaneously in humans and animals. Although the affected livestock species and vectors are well known for nearly all important zoonoses, their relative involvement in disease transmission to humans is not well studied in different populations. The sampling of pastoralists together with different livestock species revealed that cattle and camels were more important for brucellosis and Q-fever transmission, respectively, than small ruminants (chapter 7). These were unexpected results, which may be used for better focused control and information strategies. The acceptance of control measures is likely to be facilitated by communication of potential livestock production losses due to zoonoses.

A diet based on livestock products represents another direct relationship between animal and human health (nutritional status). Provision of foodstuffs, namely of milk, can become critical when animals show a reduced live weight production or several lactating cows or camels have a reduced milk production due to their suffering from diseases or to lack of enough water. Mothers may attempt to minimise the impact of food shortages on children by reducing their own dietary intake and preferentially feeding their children. Only three protein-energy malnourished children were seen among all examined nomadic pastoralist’s children (0-14 years, n=328) (chapter 9). The year of the study (April 1999 to April 2000) was a satisfying year for animal breeding and milk was abundant. An increase of livestock’s body condition scores during the year of sampling was documented. However, this situation may drastically change in a drought or severe disease situation. Another direct dependency of human – animal health status was found for vitamin A. Serum retinol (vitamin A) of nomadic pastoralist women correlated to livestock milk retinol levels. Thus, milk was an important source of vitamin A (chapter 8). This correlation was validated as the result of parallel examination.

Some specific human morbidity results could be explained with livestock breeding habits, e.g. camel breeders try to stay out of humid zones (especially zones with clay soils) to avoid arthropod-borne livestock diseases, but also to limit the risk of foot and leg fractures of their camels. Therefore, in contrast to cattle holders, camel breeders usually stay in a dry environment where they have low prevalence rates of clinical malaria. Their exposure to malaria infection is limited to a short period when rainfalls are heaviest (chapter 9). This example shows that the community’s capabilities to overcome ill-health may be conditioned by the care they take of their animals.

Pastoralists more vividly acknowledge the success-story of rinderpest-eradication as a result of vaccination than the eradication of human smallpox, equally obtained by vaccination programs. In contrast to vaccines against human diseases, pastoralists have long-term and continuous experience with livestock vaccination. One should build on the existing knowledge on livestock vaccination to communicate the importance of vaccination for children and women (chapter 12).

We foresee to progressively extend the concept “one medicine” to joint health services. Intersectoral collaboration has been often limited to disease (zoonose) surveillance and control (capitalising resources for research, monitoring and control). The joint human and animal vaccination campaigns stands for a novel intersectoral approach that has not been evaluated systematically so far, except for the first evaluation done in the framework of this thesis. This intervention with mobile teams offering human and livestock vaccination in remote pastoralists’ zones was highly appreciated by pastoralists and they participated actively. Cost sharing and saving between the two sectors was demonstrated (chapter 12). Furthermore, mixed teams appear to be best able to meet the needs and demands of pastoralists such as the possibility to buy good quality drugs for people and for livestock.

Last, mutual learning from the other medicine and from other scientific professions in general, is achievable with various collaborations in research and implementation. All disciplines have a different understanding of requirements for interventions. These requirements must then be compared with the perceived needs and demands of the target population.

Recommendations for further interdisciplinary research at the interface of human and animal health in pastoralist communities

The question remains how future research projects should be designed to further evaluate and extend the conceptual framework of “one medicine” to promote better health, improve the environment and lead to the best social outcomes. Several points can be submitted for reflection:

- Focus more on the significance of the socio-economic effects of zoonoses, e.g. through the use of transsectoral economic models or cultural epidemiological approaches.
- More comparative studies on nutritional status between pastoralists and crop farmers, including also micronutrients.
- Studies on antibiotic residues in food products from animals, promotion of the prevention of transmission of drug-resistant pathogens to humans.
- Evaluation of the consequences of human illness on livestock care and thus on animal health.
- More evidence (systematically evaluated) should be provided to demonstrate and communicate common health concepts for people and animals (transfer of knowledge on animal care to human health and vice versa) as has been done for zoonoses (Krönke, 2001). This information can be used for the design of IEC (Information, Education and Communication) campaigns.

- Assessment of the distribution of perceived threats from livestock diseases and zoonoses may show new perspectives beside the economic or DALY view.
- The willingness and motivation to co-operate between sectors, obstacles of co-operation, necessary policies (national or international) should be assessed in studies with the aim to define new intersectoral collaborations. It would be interesting to compare very different countries, e.g. Chad with Switzerland (where sectoral thinking is more rigid).
- Conflict research is crucially needed mainly in resource management, land degradation, restricted access to and availability of fresh water. Martin Wiese (2002) demonstrated that the increasing importance of conflicts between pastoralists and crop farmers significantly reduced their well-being.
- Measures to achieve sustainability of livestock production in the Sahel

These suggested further analyses of the interface between human and domesticated animal health may contribute to a reviewed framework of the concept “one medicine”.

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LA TUBERCULOSE CAUSEE PAR *MYCOBACTERIUM BOVIS*: RESULTATS PRELIMINAIRES OBTENUS CHEZ LES PASTEURS NOMADES FOULBES ET ARABES DANS LE CHARI-BAGUIRMI AU TCHAD[*]

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Résumé

Les contacts étroits entre les pasteurs nomades et leurs animaux favorisent la transmission de zoonoses. Dans le cadre d'un nouveau projet réalisé chez les nomades Foulbés et les nomades Arabes du Chari-Baguirmi et du Kanem, l'accent a été mis sur le dépistage de certaines zoonoses, notamment la tuberculose bovine, la brucellose et la fièvre Q. Les résultats préliminaires présentés couvrent la tuberculose. La proportion de tous les cas de tuberculose chez l'homme causée par *Mycobacterium bovis* d'origine bovine n'est pas connue. La mise en évidence d'une exposition antérieure à des bacilles tuberculeux a été effectuée par la tuberculination de 10 bovins dans chacun des 19 troupeaux visités au cours d'un premier échantillonnage. Quarante et un pour cent des bovins se sont révélés positifs. Le test de tuberculination comparatif (*M. bovis* / *M. avium*) a été appliqué au cours d'un deuxième échantillonnage dans 13 troupeaux. Un taux de 17% (95% intervalle de confiance 10 - 23%) de résultats positifs a été observé avec ce test qui provoque une réaction plus spécifique en cas de tuberculose d'origine bovine. Dans les 16 campements foulbés et les 15 campements arabes visités, des crachats ont été collectés chez toute personne présentant des symptômes de tuberculose. Des bacilles acido-alcoolo-résistants (BAAR) n'ont été mis en évidence que chez une femme. Le fait que plus de 95% des pasteurs nomades interrogés consomment du lait cru, le risque d'infection avec la tuberculose bovine est présent. De ce fait, une information adéquate sur les comportements à risque permettrait de diminuer la fréquence de transmission de la tuberculose à l'homme ainsi que d'autres zoonoses. L'importance de la caractérisation des souches mycobactériennes incriminées est indispensable.

Introduction

Les experts estiment que 2.1 millions de cas de tuberculose humaine seront rencontrés en Afrique subsaharienne en l'an 2000. Ce chiffre représente une augmentation de 41% par rapport aux estimations de 1995. Les estimations corrigées par l'Organisation Mondiale de la Santé (OMS) prennent en compte une grande proportion de cas non-reportés (Dolin et al., 1994). La tuberculose chez les adultes est une maladie provoquée par un seul agent pathogène (*Mycobacterium tuberculosis*), et qui, parmi les maladies infectieuses, cause le taux de mortalité le plus élevé chez l'homme. Une partie des cas de tuberculose est néanmoins causée par *Mycobacterium bovis* d'origine bovine. Par définition cette tuberculose est une zoonose, à savoir une maladie transmise à l'homme par l'animal et inversément. Une corrélation entre un

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contact étroit avec les bovins et le taux d'infection chez l'homme et les bovins a été constatée (Mposhy et al., 1983; Cook et al., 1996).

Le rôle attribué à *M. bovis* dans l'augmentation des cas de tuberculose en Afrique est mal défini parce que les fréquences relatives des différentes formes de tuberculose ne peuvent être déterminées sans l'isolement et la caractérisation des souches mycobactériennes. En Afrique, le taux d'isolement de *M. bovis* par rapport à *M. tuberculosis* chez l'homme varie entre 0.4% et 36% selon les diverses publications (Cosivi, 1998). Chez l'homme, la tuberculose bovine ne peut pas être distinguée cliniquement de la tuberculose causée par *M. tuberculosis*. Les formes extra-pulmonaires comme la lymphadénite cervicale, les lésions intestinales et la tuberculose dermale chronique sont très fréquentes, surtout chez les jeunes et particulièrement chez les enfants (Pritchard, 1988). Ces formes de la maladie peuvent cependant aussi être causées par *M. tuberculosis*. L'examen microscopique des frottis ne permet pas de différencier les diverses souches du complexe *M. tuberculosis*, comprenant entre autres *M. tuberculosis*, *M. africanum* et *M. bovis*.

D'après le Plan National de Lutte contre la Tuberculose au Tchad, le taux d'incidence annuel en 1990 était de 60 à 120 cas de tuberculose pulmonaire à microscopie positive pour 100'000 habitants (cité par Massenet et al., 1994). En 1996, sur 8220 examens de dépistage, 1992 cas de tuberculose ont été détectés, parmi lesquels 1517 cas de tuberculose pulmonaire (dont 1174 cas à microscopie positive) et 323 cas de tuberculose extra-pulmonaire (DSIS, 1996). Il est peu vraisemblable que ces résultats puissent être repris pour les nomades, vu que ces chiffres de dépistages ont été obtenus des laboratoires situés autour des plus grandes agglomérations du pays. Les centres de santé éloignés réalisent parfois des dépistage dont les résultats échappent au système d'information sanitaire. Jusqu'à présent, l'isolement et l'identification de mycobactéries ne sont effectués par aucun laboratoire de diagnostic au Tchad.

On estime que l'infection par *M. bovis* est moins virulente chez l'homme qu'une infection par *M. tuberculosis*. Ce qui n'est pas le cas chez les personnes immuno-déficientes. Chabasse et al. (1983) supposent que la situation de la tuberculose chez les pasteurs nomades au Mali est déterminée par l'absence de tout traitement, la proximité avec le bétail et le mauvais état nutritionnel. De plus, l'épidémie du Virus de l'Immunodéficience Humaine/Syndrome d'Immuno-Déficience Acquise (VIH/SIDA) peut aggraver la situation de la tuberculose (Raviglione, 1997).

Une forte consommation de produits laitiers peut avoir un effet positif sur l'état nutritionnel, cependant elle comporte un certain risque d'infection par des agents de zoonoses comme ceux de la brucellose, la tuberculose ou la fièvre Q. Là où la tuberculose bovine est présente, la consommation du lait cru est la cause principale de lymphadénite cervicale, de tuberculose abdominale et d'autres formes de tuberculose extra-pulmonaires. La contamination du lait se fait normalement déjà à l'intérieur de la mamelle. Le lait peut aussi être contaminé après la traite par des excrétions bovines et humaines. Il faut noter que des vaches cliniquement saines peuvent aussi excréter des mycobactéries (Okolo, 1992). Plusieurs auteurs ont isolé *M. bovis* et *M. tuberculosis* dans du lait vendu sur les marchés (cité par Pritchard, 1988 et Kleeberg, 1984). Le lait ne présente donc pas seulement un risque d'infection pour les éleveurs eux-mêmes mais aussi pour les consommateurs. Le lait acidifié ou bouilli ne contient en revanche plus de mycobactéries infectieuses (Kleeberg, 1984). Par contre, le beurre et le fromage produits avec du lait cru restent une source de mycobactéries infectieuses. La viande est seulement considérée comme une source d'infection si elle n'est pas bien cuite.

Les éleveurs peuvent s'infecter en inhalant les aérosols contaminés et sécrétés par des bovins affectés. Ils développent alors la tuberculose pulmonaire typique et peuvent par la suite infecter des bovins de la même manière. Un autre mode de transmission de l'homme à l'animal se fait par les urines. La transmission de souches bovines d'homme à homme est décrite mais est considérée comme un événement rare. Chez les bovins, la forme de manifestation principale de la tuberculose causée par *M. bovis* est respiratoire, et la propagation d'un bovin à l'autre se fait par voie aérienne.

Un nouveau projet a été mis sur pied dans le but de décrire la prévalence de certaines zoonoses comme la tuberculose, la brucellose ou la fièvre Q d'une part chez les pasteurs nomades arabes, dont la plupart sont chameliers, et d'autre part chez les Foulbés, traditionnellement éleveurs de bovins au Chari-Baguirmi et au Kanem. Ce projet est constitué d'études conjointes réalisées par un microbiologiste, un médecin et un vétérinaire sous le thème de "L'interface entre la santé humaine et animale chez les nomades en Afrique de l'Ouest: vers 'une seule médecine'", et il est financé par le Fonds National Suisse de la Recherche Scientifique (FNRS). Il représente, en outre, une composante du programme "Santé des Nomades" appuyé par l'Institut Tropical Suisse qui a mis sur pied un réseau de recherches multidisciplinaires.

Objectifs

* Description des fréquences relatives des différentes formes de tuberculose chez les pasteurs nomades et leur bétail obtenue par des examens cliniques et de laboratoire ;
* Etablissement de facteurs de risque pour la transmission de la tuberculose bovine entre l'animal et l'homme ;
* Isolement et caractérisation des germes responsables de la tuberculose chez les hommes et chez les animaux.

Matériels et méthodes

Echantillonnage

Deux des trois ethnies nomades présentes au nord du Chari-Baguirmi et au sud du Kanem à savoir les Arabes nomades et les Foulbés participent au projet. Quinze campements par ethnie ont été sélectionnés de manière aléatoire et par convenance. Les chefs de campement ont été informés précédemment de la nature de l'étude et l'échantillonnage ne se fait qu'avec leur consentement. Il s'agit d'enquêtes répétées dans les mêmes campements retenus après sélection. Chaque campement (unité primaire d'un échantillonnage en grappe) est visité quatre fois, soit deux fois par an pendant 2 ans pour tenir compte des différentes saisons. Puisque la santé humaine et la santé animale sont étudiées simultanément, l'équipe de terrain est composée d'un médecin, d'un infirmier, d'un vétérinaire, de 2 techniciens vétérinaires, dont l'un est chargé des travaux de laboratoire. Un échantillon fixe de 15 personnes (5 hommes, 5 femmes et 5 enfants) et de 20 animaux (10 bovins ou 10 chameaux, 5 chèvres et 5 moutons) est sélectionné dans chaque campement visité. Une nouvelle collecte d'échantillons est effectuée à chaque visite.

Des crachats et des urines sont collectés chez des personnes présentant une symptomatique de fatigue, d'amaigrissement et de toux avec expectoration ou toux de plus de quinze jours, ainsi qu'une lymphadénite cervicale. Les échantillons de crachat et d'urine recueillis sont envoyés au laboratoire tous les 5 jours. Au cours du premier échantillonnage, une éventuelle exposition antérieure des bovins à la tuberculose est mise en évidence par un test de tuberculination intracutanée en injectant la tuberculine ("purified protein derivative", PPD) provenant du *Mycobacterium bovis*. Dans le cadre du deuxième échantillonnage, le test de tuberculination a été élargi, pour des raisons de comparaison, en utilisant en plus de la tuberculine *Mycobacterium bovis*, la tuberculine de *Mycobacterium avium*, la souche principale responsable de la tuberculose aviaire mais pouvant aussi causer des réactions non spécifique chez les bovins. Afin de mesurer les réactions provoquées par l'injection des tuberculines, l'épaisseur des plis de peau aux sites d'injection est enregistrée avant l'injection et après 72 heures avec un pied à coulisse. L'échantillonnage chez les animaux se fait de préférence chez les femelles en lactation pour avoir la possibilité de prélever aussi du lait.

Parallèlement, dans le but d'isoler et de caractériser des souches mycobactériennes, des spécimens tels que des échantillons de tissus et de ganglions prélevés sur des carcasses d'animaux affectés ; de même les crachats et l'urine de patients suspectés seront collectés respectivement à l'Abattoir Frigorifique de Farcha (AFF) et à l'Hôpital Général de Référence Nationale (HGRN) à N'Djaména.

Analyses de laboratoire

Les frottis de lait, de crachats et d'urine préparés sur le terrain sont colorés selon la méthode de Ziehl-Neelsen et soumis à la recherche de bacilles acido-alcoolo-résistants (BAAR) dont les bacilles tuberculeux font partie. Tous les échantillons collectés (crachats, urines et lait) sont décontaminés par la méthode N-Acétyl-L-Cystéine Hydroxide de Sodium (NALC) avant d'être ensemencés sur les deux milieux suivants:
- Löwenstein-Jensen avec glycérine
- Löwenstein-Jensen sans glycérine mais avec 0.5% de pyruvate de sodium

Les cultures seront observées chaque semaine pendant 8 semaines d'incubation. Les colonies visibles seront prélèvées et passées sur milieux gélosés (Middlebrook 7H10 avec glycérol et Middlebrook avec pyruvate de sodium). Tous les milieux inoculés sont maintenus durant au moins 12 semaines pour s'assurer de l'absence de colonies. L'identification physique et biochimique comprend diverses étapes. Après le passage des cultures la recherche de BAAR dans les colonies se fait par la coloration de Ziehl-Neelsen. Au cas où ce résultat est positif, on procède à un test de croissance, suivi d'une incubation à différentes températures. La vitesse de croissance, la production de pigment et la photoréactivité sont observées avant de procéder à l'identification des souches par des méthodes biochimiques. Les trois tests biochimiques letest de la catalase, la recherche de niacine et la réduction de nitrate. Après la caractérisation biochimique des souches isolées, il est prévu l'extraction de l'acide désoxyribonucléique (ADN) des génomes des bactéries et leur amplification par la méthode de réaction en chaîne à la polymérase (PCR, Polymerase Chain Reaction). La séquence des fragments amplifiés servira à la classification ultérieure des souches et, par ailleurs, il est prévu de comparer les différentes souches isolées chez l'homme et chez les animaux.

Résultats préliminaires

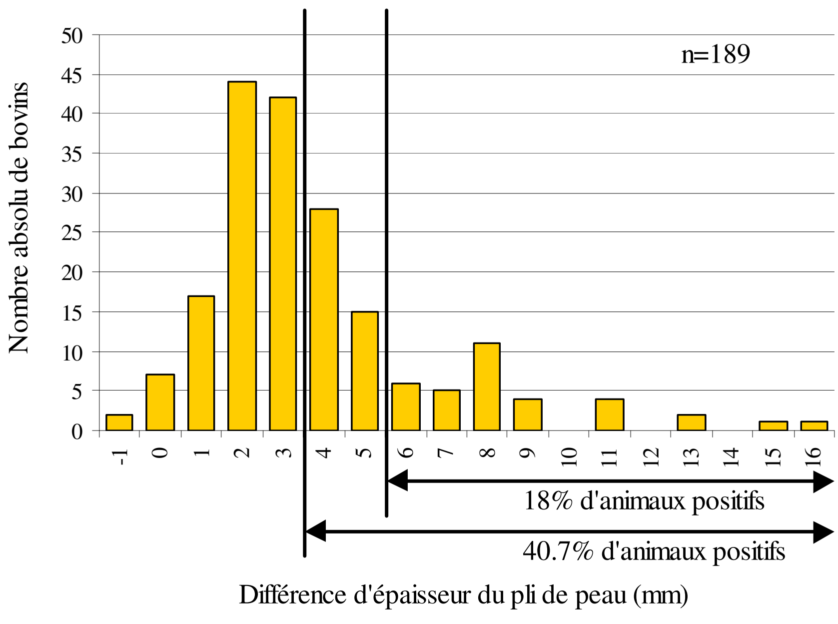
Deux échantillonnages sur quatre ont été réalisés. Au cours du premier échantillonnage, 15 campements de pasteurs arabes, dont 12 étaient des chameliers et 3 des bouviers, et 16 campements de Foulbés ont été visités. Dans le cadre du deuxième échantillonnage, qui a été effectué 5 mois plus tard, 12 campements arabes et 15 campements foulbés ont pu être visités à nouveau.

Tuberculination

La figure 1 présente la distribution en valeurs absolues des 189 bovins tuberculisés avec la tuberculine de *M. bovis* par rapport à leurs réactions cutanées en millimètres (différence entre les deux mesures des plis de peau). Un taux de résultats positifs supérieur à 40% (95% intervalle de confiance entre 33.7% et 47.8%) a été obtenu en considérant un épaississement du pli cutané de ≥ 4 mm comme un résultat positif. Sur dix bovins testés par troupeau lors du premier échantillonnage, au moins un animal a réagi positivement au test dans 17 des 19 troupeaux examinés. Le taux de résultats positifs a aussi été examiné en prenant 6 mm comme valeur limite d'épaississement du pli cutané. En effet, la distribution des réactions suggère la présence de nombreux cas de réactions non-spécifiques parmi les animaux montrant un épaississement du pli cutané situé entre 4 et 6 mm. Avec cette valeur limite plus élevée, au moins un animal ayant réagi positivement au test a été trouvé dans 13 des 19 troupeaux.

Les résultats de la tuberculination comparative réalisée dans 13 troupeaux au cours du deuxième échantillonnage sont décrits dans la figure 2. La répartition des différences de réaction entre les sites d'injection de *M. bovis* et de *M. avium* est représentée. Cette différence doit être d'au moins 3 mm pour qu'une réaction soit considérée comme positive pour *M. bovis*. En plus, une réaction minimale de 4 mm est nécessaire au site d'injection de *M. bovis*. Selon ces critères, un taux de positivité de 16.9% (95% intervalle de confiance: 10.4% - 23.5%) a été calculé. Au moins un animal réagissant positivement au test était présent dans 10 des 13 troupeaux visités. Le nombre maximum d'animaux avec une réaction positive parmi les 10 bovins tuberculisés dans un seul troupeau était de 6.

Fig. 1 Répartition des 189 bovins par rapport à leurs réactions vis-à-vis de la tuberculine provenant de *M. bovis*. Deux limites de positivité, une à 4 mm et une autre à 6 mm, sont représentées.

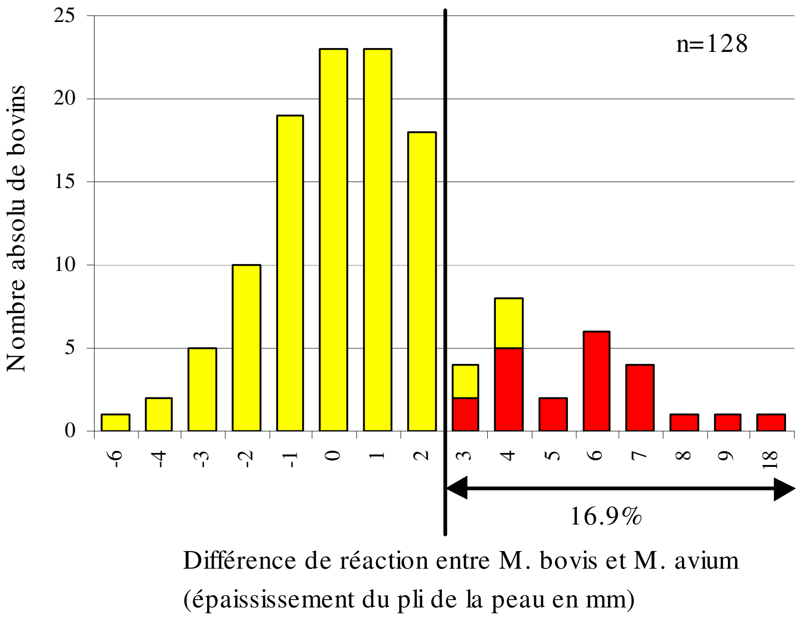


Frottis
La recherche de bacilles acido-alcoolo-résistants (BAAR) par microscopie a été effectuée sur 26 frottis de crachat et 390 frottis de lait préparés pendant le premier échantillonnage. Seule une femme foulbée a été trouvée avec un crachat positif aux BAAR.

Isolements
Les premiers isolats de mycobactéries à partir de crachats et d'urine sont en culture mais n'ont pas encore été définitivement identifiés.

Consommation du lait cru
L'interview des pasteurs nomades a permis de déterminer que 96.5% (95% intervalle de confiance: 93% - 99.9%) des personnes interrogées consomment du lait cru.

Fig. 2. Répartition des différences entre les réactions à *M. bovis* et à *M. avium*. La limite de positivité de *M. bovis* en comparaison avec *M. avium* est fixée à une différence de 3 mm. Les positifs doivent en plus avoir une réaction minimale de 4 mm au site d'injection de *M. bovis* et sont représentés par des colonnes plus foncées.



Discussion et conclusion
Tout en sachant que les résultats des tests de tuberculination sont soumis à diverses contraintes, le taux d'animaux positifs à la tuberculine de *M. bovis* dans les troupeaux examinés semble être important. Les résultats de tuberculination du premier échantillonnage ont été confirmés par ceux du deuxième échantillonnage. *M. tuberculosis* n'est pas très virulent chez les bovins, néanmoins cet agent peut agir comme sensibilisateur non spécifique et une réaction croisée avec *M. bovis* ne peut pas être entièrement exclue.

Seuls les bovins ont été tuberculisés. Les chameaux ont été exclus du dépistage pour une raison de spécificité insuffisante pour une étude menée dans une population à prévalence inconnue. La prévalence de *M. bovis* a été décrite dans des surveillances réalisées en abattoir, surtout en Egypte (Faye, 1997). Ces études indiquent que l'infection des chameaux est transmise par des bovins.

Kazwala et al. (1998) ont cultivé du lait positif aux BAAR et ont démontré que sur 31 laits contenant des mycobactéries, deux isolats seulement ont été identifiés comme *M. bovis*, tandis que presque 90% des isolats se sont révélés être des mycobactéries atypiques. Il faut cependant aussi considérer qu'un seul excréteur de mycobactéries pathogènes peut contaminer le lait mélangé de plusieurs animaux.

En revanche, le fait que seul un frottis soit positif sur les 26 crachats examinés de personnes présentant une symptomatique de tuberculose est encourageant. Néanmoins, le crachat n'est pas le seul spécimen à examiner lors d'une recherche des infections par *M. bovis*. Il convient également de prendre en compte les formes extra-pulmonaires, surtout chez les enfants. L'importance de l'identification des souches à l'intérieur du complexe *M. tuberculosis* doit être soulignée. Un laboratoire équipé recevant les spécimens adéquats (urine, selle, liquide de lavage abdominal) aura la possibilité de dépister l'incidence, voir même une épidémie de tuberculose due à *M. bovis*. Il serait préférable qu'un laboratoire de référence unique prenne en charge aussi bien le domaine humain qu'animal pour l'isolement des mycobactéries causant la tuberculose. En même temps, les cultures permettront de soumettre les mycobactéries à des tests de susceptibilité aux antibiotiques, ceci a son importance compte tenu du fait que *M. bovis* est très souvent résistant à plusieurs médicaments habituellement utilisés dans le traitement de la tuberculose.

La prophylaxie des zoonoses chez l'homme passe par la lutte contre les maladies de l'animal grâce à des mesures de contrôle telles que l'identification des bovins réagissants à la tuberculine suivie de leur élimination du troupeau, combinées avec la pasteurisation du lait. L'incidence de la tuberculose bovine dans les pays industrialisés a pu ainsi être considérablement réduite (Pritchard, 1988). A cause des conséquences de l'infection par *M. bovis* sur la santé humaine et animale, une surveillance de la maladie doit être envisagée dans les pays où elle est présente. Un programme de lutte contre la tuberculose bovine peut se révéler coûteuse dans un pays en développement comme le Tchad. De plus, une telle lutte n'est souvent pas considérée comme primordiale par les autorités, car d'autres maladies animales causent plus de pertes économiques chez le bétail et sont par conséquent beaucoup plus reconnues comme dangereuses et à combattre. Les cas de maladie chez les humains ne sont que rarement inclus dans ces prévisions d'intervention. Des alternatives moins chères que les programmes établis dans les pays industrialisées, comme la surveillance dans les abattoirs où les cas de maladie sont retracés dans les troupeaux, peuvent être envisagées dans un but intermédiaire, tout en étant efficaces. Malheureusement, de telles mesures semblent difficiles à établir pour la surveillance des troupeaux nomades, étant donné que les vaches laitières ne sont que rarement conduites aux abattoirs. De fait, une information adéquate sur les comportements à risque peut servir à diminuer la fréquence de transmission de certains zoonoses. L'information portant sur la prévention d'une infection doit être communiquée aux autorités pour être intégrée dans les programmes d'éducation et dans la prévention à de différents niveaux (écoles coraniques, contacts avec les médecins, infirmières et vétérinaires). Si l'on réussit à passer le message que seulement du lait bouilli doit être donné aux enfants dans les campements, bien des risques pourront déjà être réduits. Une vaccination BCG chez les nouveaux nés peut servir comme prophylaxie partielle. La couverture vaccinale dans les populations nomades est faible et devrait être améliorée à l'aide d'un programme élargi de vaccination conçu spécifiquement pour les populations nomades.

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